Environmental change and its impact on migration in Bangladesh

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Abstract

Environmentally-induced migration is a key issue for many parts of the world. Bangladesh is a clearly defined region where such a social problem could take place due to a range of environmental processes. Bangladesh, especially the delta section, has already experienced both rapid environmental change from natural disasters such as tropical cyclones and floods, and more slow change due to rising sea levels and river bank erosion. This thesis examines the physical background to environmental change in Bangladesh and explores, through 355 questionnaires and the same number of in-depth interviews, the social impact of this, both in the regions directly affected, but also in the internal migration destinations. Most of the country's rivers have shown discharge increases over the last few decades; this is particularly notable on the main river system at Bahadurabad through which 60% of the discharge passes. However, the mean flow downstream at Harding Bridge shows statistically significant decreases in the dry season due to the construction of the Farakka dam in the 1970s. The frequency, and severity, of monsoon flooding has been increasing in recent decades, in line with the general increase in river flows. These changes increase the frequency of river bank erosion. As a case study the region of Mehendiganj on the main channel is chosen, where the eastern end of the island is eroding rapidly, at a rate of ~3.2 $km^2 yr^{-1}$ during the period 1972-2012. From interviews in both this region and the coastal region subject to threat from cyclones and storm surges, coping mechanisms of local people to environmental change, including displacement and migration, whether temporary or permanent, are investigated. The differential response of people remaining near their homes, moving to regional centres, or migration to major cities is investigated. The impact of increasing migration on the destination communities is also considered.

The current study provides evidence that environmental change directly causes migration. Environmental change is more strongly related to short distance migration. Long-distance moves are generally affected by other drivers while environmental drivers are secondary or background drivers in this case. Long-distance moves are generally undertaken for financial and social reasons, in particular where there is a pre-established migrant network. Thus, the displaced poor were found to not move far, because of a combination of factors relating to the social and economic advantages of

re-establishing themselves locally. However, many respondents were found to have been displaced multiple times, which increases the probability that they will be forced further afield, most likely to urban areas, as environmental refugees.

The study also presents a new understanding of the role of environmental change in causing migration and its relation to societal consequences. Therefore, the concept of vulnerability to environmental change, adaptive capacity and migration process has been applied. The study developed vulnerability Index (VI) to assess environmental change vulnerability in the four coastal rural sub-districts and the two cities in central region. The VI compared the various regions' vulnerability to adaptive capacity, sensitivity and exposure and differential vulnerability. The results suggest that both permanent and non-permanent migration processes have a close relation to vulnerability and non-permanent migration has a close link to adaptive capacity. The study found that the sub districts of Shyamnagar and Mehendiganj may be more vulnerable in terms of sensitivity and exposure and less adaptive capacity, whilst Mehendiganj is more vulnerable in terms of exposure to hazards than other sub-districts. These two vulnerable regions also have shown higher number of migrants, from Mehendiganj as permanent migration whilst from Shyamnagar as non-permanent migration. Therefore, migration is a significant approach for reducing vulnerability to environmental change by increasing adaptive capacity. Similarly, as migration destinations Dhaka is more vulnerable in terms of sensitivity, exposure and adaptive capacity than Comilla. The findings of this research confirmed that poor migrants are the most vulnerable in the city. This group has less adaptive capacity than old migrants or poor local people due to low level earning, limited access to resources and location and settlement pattern.

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Note1: All sources have been denoted for figures and tables unless provided by the authors.

Note2: In chapter 3, I have use word ‘We’. Here ‘We’ refers to me, my friends and my brother as they assisted in conducting fieldwork.

Dedicated to

My Parents, Md Sirajul Islam Sarker & ShumsunNahar Bagum.

My Grandfather: Md Hafiz Uddin Sarker (Paternal) & Aftab Uddin Ahmed (Maternal).

My Grandmother: Amena Bagam (Paternal) & Farida Bagam (Maternal)

My great grandfather: Lab Gaji Sarker

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Abbreviations

ADB	Asian Development Bank
AR4	Fourth Assessment Report
BBS	Bangladesh Bureau of Statistics.
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
BISS	Bangladesh Institute of International and Strategic Studies
BAL	Bangladesh Awami Legue
BNP	Bangladesh Nationalist Party
BTCL	Bangladesh Telecommunications Company Ltd.
BRTA	Bangladesh Road Transport Authority
BEPZA	Bangladesh Export processing Zone Authority.
CoCC	Comilla City Corporation
CHT	Chittagong Hill Tracts
CS	Cyclonic storm
CPP	Cyclone Preparedness Program
DCC	Dhaka City Corporation
DWASA	Dhaka Water and Sewerage Authority
D	Depression
DD	Deep Depression
EPZ	Export processing Zone
EACH-FOR	Environmental Change and Forced Migration Scenarios

FAO	Food and Agriculture Organization
GBM	Ganges Brahmaputra Meghna
GCC	Gulf Cooperation Council
GIS	Geographic Information System
GMTED	Global Multi-Resolution Terrain Elevation
GoB	Government of Bangladesh
HH	Household
IWM	Institute of Water Modelling
IPCC	Intergovernmental Panel on Climate Change
IOM	International Organization for Migration
JRC	Joint River Commission
KDA	Khulna development Authority
KCC	Khulna City Corporation
LDC	Least Development country
MTL	Mean Tidal Level
NOAA	National Oceanic and Atmospheric Administration
NWDA	National Water Development Agency
OCHA	The office for the coordination of Humanitarian Affairs
RAJUK	Rajdani Unnayan Kartripakkha
RSL	Relative Sea-level Rise
RMMRU	Refugee and Migratory Movements Research Unit
PWD	Public Works Department
SAFE	The Solidarity Centre and Social Activities for Environment

SLR	Sea Level Rise
SAARC	South Asian Association for Regional Cooperation
SMRC	SAARC Meteorological Research Centre
SCS	Severe Cyclonic storm
SCSH	Severe Cyclonic storm with a core of Hurricane winds
TC	Tropical Cyclone
UNEP	United Nations Environment Programme
BFFEA	Bangladesh Frozen Foods Export Association
UNITAR	United Nations Institute for Tarring and Research
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UN	United Nations
UNHCR	UN High Commissioner for Refugees
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
VI	Vulnerability Index

Bengali terms

Aman	Group of rice varieties grown in the monsoon and harvested after the monsoon season.
Aus	Group of rice varieties grown in the pre-monsoon and harvested after the monsoon season.
Basti	Slum
Bowali	Traditional honey collector in Sundarbans forest
Barind	Undulating uplands with red/yellow clay soils of Northwest Bangladesh
BDT	Bangladesh Taka (Currency of Bangladesh).
Bhiga	A unit of land measurement popularly use in Bangladesh. A Bigha equals one third of an acre
Boro	Dry season rice, grown from December to April
Gher	Prawn/Shrimp farming land
Char	Newly accredited land
Jupri	A jupri is a very small and temporary house, typically four feet by three feet, by four feet height (literally, slum)
Kalbaishakhi	Thunderstorms or the north-westerly wind
Khas jomi	Government-owned land
Kharif I	Season typically from March to June

Kharif II	Season typically from July to October
Katha	A unit of land measurement popularly use in Bangladesh. A katha equals 720 square feet.
Mowal	Traditional goalpatha (Nypa leaf/mangrove plam) collector in Sundarbans forest
Monga	A seasonal food shortage which creates seasonal hunger and is close to famine
Pre-kharif	a season before kharif II typically from March to June
RAJUK	Rajdani Unnayan Kartripakkha (Capital Development Authority of Bangladesh)
Rabi	Dry season, typically from November to February
Sundarbans	Tidal mangrove forest lies in Bangladesh and India
Sharee	Sharee is a traditional women wear in Bangladesh
T aman	Transplanted aman rice, typically from July to October
Thana	A thana is an equivalent of an upazila (literally, Police station) (see appendix 1)
Union	Unit of a upazila (see appendix 1)
Upazila	Sun-district (see appendix 1)
Zamindar	Feudal local landlord
Zila	District (see appendix 1)

Chapter 1

Background to thesis

1.1 Introduction

Environmental change-induced migration is a key issue for many parts of the world. Due to changes in both population and environment, scarcity of resources is becoming more widespread. Future climate change is expected to severely affect people's livelihoods worldwide through intensification of natural disasters (Black et al., 2011a). This may lead to increased migration as a coping mechanism and increased societal crisis. Densely populated, with high poverty levels and rural communities greatly dependent on natural resources, Bangladesh is clearly defined as such a place where environmentally-caused migration to urban areas has increased recently. This is from a mix of both rapid environmental change, from natural disasters such as tropical cyclones and floods, and slower change due to rising sea levels, salinity intrusion, coastal and river bank erosion. Over forty million people live in the coastal regions and they will be hit hardest due to such environmental changes. In addition, people in affected areas have limited capability to adapt to climate change due to poverty. Therefore, Bangladesh has had to introduce a range of strategies to cope with these environmental threats (Walsham, 2010). Climate change and environmental disruption play an increasingly important role to induced migration in Bangladesh (ADB, 2012) and more specifically, at three distinct levels: livelihood and economy, quality of public services, and the presence of challenging environmental conditions which all play key roles in causing internal migration in Bangladesh (Marshal and Rahman, 2013). Moreover, internal migration in Bangladesh is increasing (Black et al., 2008) in particularly from rural to urban areas. If a city becomes too crowded and ceases to function effectively, poorer people will start to migrate to India or other neighbouring countries and there is a high risk of violent conflict as India is fencing the border. Some estimates predict that by 2050 Bangladesh will have about 15 million environmental refugees (Myers, 1993). Therefore, climate change causes not only environmental problems, but also economic, political and social issues. It is essential to understand the future Bangladesh may face due to global warming and how people may react to the changes that are predicted to occur. Though environmentally generated migration in Bangladesh is significant, there has been limited research conducted into the influence of climate change on migration and its wider implications (IPCC, 2014a).

1.2 Overall context of Bangladesh

Bangladesh is one of the most densely populated countries in the world and, according to the 2011 Census, has 149 million people living in an area of 145,452 km^2 (Hutton and Haque, 2004). Most of the country consists of flat plains, except for the hills in the southeast (Figure 1.1).

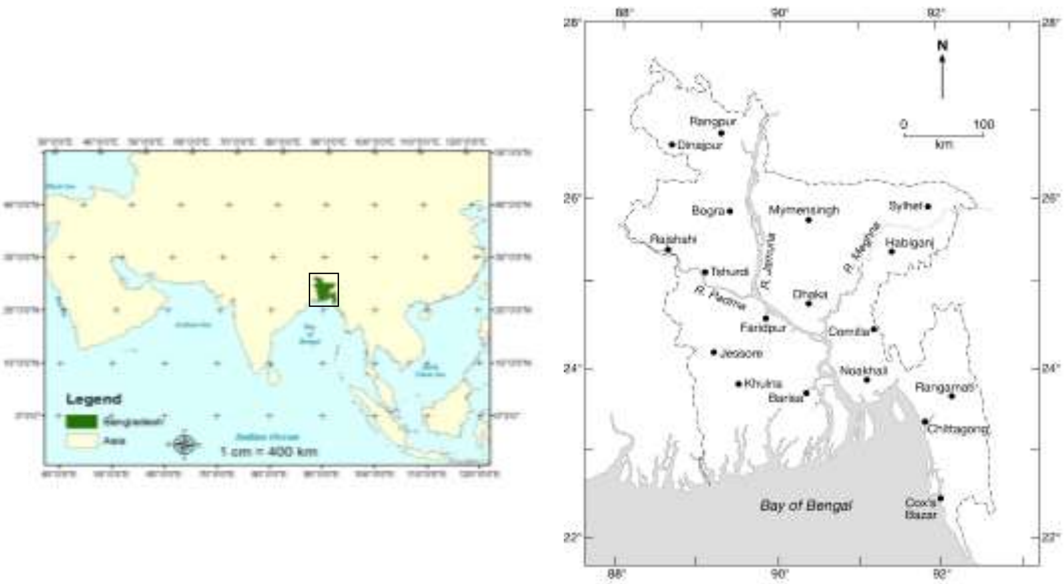

Figure 1.1: Location of Bangladesh

Due to the dominance of agrarian resources and the slow pace of the non-agriculture sector such as industrialisation and the service industry, the majority of the inhabitants in Bangladesh, approximately 77%, still live in rural areas (Hutton and Haque, 2004). In 2013, the GDP per capita was $US 957 according to the World Bank. Poverty is a key characteristic of the country with over a third of people living in such conditions (Agrawala et al., 2003). Half of these people face even more difficulties as they live in extreme poverty, often without a source of fixed income (World Bank, 2002; as noted by Toufique and Turton, 2002). Over the last 30 years however, poverty levels in Bangladesh have significantly reduced. "Whilst the proportion of population living below the poverty line was as high as 74% in 1973-74, between 1991-92 and 2000, the incidence of national poverty declined from 50% to 40%, indicating a reduction rate of 1% per year" (Sen, 2003; as noted by Lemos et al., 2011: 7). This figure declined further by 2010 (BBS, 2010a). In recent times, Bangladesh has been doing better with a reasonable rate of economic growth, improving social indicator levels and strengthened resilience to environmental shocks (Hulme and Moore, 2007: 1). But climate-related declines in food productivity will have an impact on livelihoods and exports, which could increase poverty levels again. For instance in Bangladesh this could cause a net increase in poverty of 15% by 2030 (IPCC, 2014a).

Bangladesh lies on the Himalayas-Ganga-Brahmaputra river system, which drains into the Bay of Bengal and is one of the world's largest highland-lowland interactive systems (Messerli and Ives, 1984). About 80% of the land surface is plain (Brammer, 2000). The plain is intersected by numerous rivers and their distributaries, tributaries, *Khals* (small channels) and backwaters (ADB, 1994: 7). The main focus of the fieldwork component of this thesis is on the GBM delta, also named the Bengal delta or Sundarbans delta. It covers 100,000 km^2, and is the world's largest delta (Delta Alliance., 2009). Approximately two-thirds of the delta resides in Bangladesh, covering an area of 60,500 km^2 (Delta Alliance, 2009). These geographical settings make the country's environmental conditions diverse and complex (Brammer, 2000). The diversity is aggravated by small-scale complexity and variations in ecological conditions from year to year, including the variable incidence of floods, drought, tropical cyclones, salinity intrusion, sea level rise, subsidence, changes in upstream river discharge, and erosion of coastal embankments that all pose serious threats to the natural resource base and livelihood opportunities of coastal communities in Bangladesh (Brammer, 2000; GoB, 2008).

1.3 Outline of the environmental and social impact of climate change in Bangladesh

Bangladesh is ranked as one of the most climate vulnerable countries in the world (IPCC, 2014a: 18). Bangladesh is repetitively affected by natural hazards, mainly floods, droughts and cyclones (Herrmann and Svarin, 2009). In the last 50 years, nine major cyclones have hit the coast of Bangladesh (Rabbani et al., 2013).The resulting climate stress and shock can exert a heavy toll on lives and livelihoods (Black et al., 2008: 29). In 2007 tropical cyclone Sidr killed 3000 people and affected about five million households and 0.7 million hectares of crop land (Rabbani et al., 2013). Once every ten years roughly one-third of the country gets severely affected by floods, while in catastrophic years such as 1988, 1998 and 2004 more than 60% of the country has been inundated i.e. an area of approximately 100,000 km^2 for a duration of up to three months (CEGIS, 2002; Brouwer, 2007: 313), displacing one million people (Herrmann and Svarin, 2009). In a normal flood year, 18 percent of the country is covered by flood water (Hutton and Haque, 2004). Due to the geographical location of Bangladesh on the delta of the GBM river system, which has 300 small and big perennial tributaries and distributaries, it also highly vulnerable to the effects of flooding and river bank erosion (Hutton and Haque, 2004: 42). Every year 100,000 people become homeless due to river bank erosion in Bangladesh (RMMRU, 2007). It could become more severe as the IPCC reported in 2007 that glaciers in the Himalaya are receding faster than in any other part of the world; they feed seven rivers in this region (Rai et al., 2005), among which are the two big rivers Ganga and Brahmaputra, which lead into the Bay of Bengal through Bangladesh. Moreover, MMD-IPCC FAR Scenario A1B models show a median increase of 3.3°C in annual mean temperature and 11% precipitation median increase by the end of the 21st century in South Asia (Christensen et al., 2007). According to the IPCC fifth assessment report, the loss of life and property associated with floods is highest in India and Bangladesh. The report also expresses that Asian port cities that could be at most risk in terms of population and assets exposed to coastal flooding will be Kolkata, Mumbai (India) and Dhaka (Bangladesh) (IPCC, 2014a). Furthermore, World Bank (2000) projected that if the sea level rises by 1 metre it will destroy the whole Sundarbans (the region along the delta coast). Two million Bangladeshis live directly on honey, shellfish, crabs, fish and wood of the Sundarbans (Butzengeiger and Horstmann, 2004). All these are recognised factors driving vulnerable people to move because of trouble securing access to sustainable livelihoods under conditions of climatic event (Hear et al., 2012). Therefore, Bangladesh is one of the few countries in which natural hazards are the main cause of population movement (Piguet, 2008).

1.4 Features of migration patterns in Bangladesh: the socio-political context

Migration is one of the most pressing issues in Bangladesh. Both the poor and non-poor alike pursue migration as a livelihood strategy The economic and social drivers of migrants vary and their choice of destination is highly dependent on the levels of benefit and risk that different places offer (Siddiqui, 2003: 1). Furthermore, moving to cities has become a common coping mechanism for people affected by natural disasters which acts as a push factor for migration (Black et al., 2011a) and has environmental implications brought on by increasing pressures on the environment (Walsham, 2010). These pressures are also creating environmental problems in the slums of cities (Walsham, 2010). Moreover, in recent decades, the increase in productivity in the non-agriculture sector motivated significant structural changes for Bangladesh's economy (Herrmann and Svarin, 2009). But still, agriculture is the major livelihood for rural communities in particular and it has accounted for a quarter of the total GDP, making the economy relatively sensitive to climate change and variation in climate. According to BBS census 2011, 63% of the total the population are between the ages of 15 and 60. A large number of this economically active population living in rural areas are engaged in low income livelihoods, and seek better income jobs in the non-agriculture sector in cities (Herrmann and Svarin, 2009).

Therefore, the large flows of domestic migration are generally caused by the combined effects of negative environmental impact and insufficient economic circumstance (Herrmann and Svarin, 2009). It is therefore clear that environmental drivers are working together with economic forces in causing migration in Bangladesh (ADB, 2012). "Environmental factors will be an increasingly important component of people's migration decisions over the course of the 21st century" (Walsham, 2010: xi). The economically active population also tend to migrate abroad to seek better employment opportunities. According to a survey undertaken by BBS (2010a), 86.88% of external migrant's ages to fell between 15 and 44. Recently, international migration with official channels has been increased. Thus, remittance flows have also increased for the last 25 years by an annual rate of 10% (Black et al., 2008). However, in the context of Bangladesh, environmental drivers play a greater role in influencing internal migration rather than international migration (Walsham, 2010). Therefore, this study concentrates on internal migration in Bangladesh.

Political drivers directly affect migration in a number of ways (Black et al., 2011b). Bangladesh has a long history of political migration (described in chapter 4). The country first experienced conflict induced migration during the partitioning of land that led to the creation of India and Pakistan. It has connection with the creation of Bangladesh. Thus, it is worthwhile to have a historical perspective when trying to understand past migration in the socio-political context of the country. A short summary of this political context is discussed below.

Population movements between East and West Bengal predate the colonial era (Kniveton et al., 2013). The partition of British India in 1947 led to a great human crisis within the region. This partition was based on religious majorities, but resulted in mass migration and much violence during the birth of the two independent states: India and Pakistan. Some two million refugees died during the migration across Pakistan's borders (Hey-demann, 1988). These borders were established hastily without adequate consideration of the new nation's economic viability. During the partition, Hindus and Sikhs opted to move from Pakistan whereas twelve million Muslims left India for Pakistan (Hey-demann, 1988). At the same time some 864,000 Muslim migrated to East Pakistan from India, while three million Hindus migrated to India from East Pakistan (Rahim, 1988). Bengal became further divided into two countries through this communal partition: West Bengal, which was included within India, and East Bengal, included within Pakistan as the province of East Pakistan.

Two events in the late 1970s sparked a political crisis between West and East Pakistan (Beachler, 2007). One was the storm surge of November 1970, and another was the election of December 1970. The 1970 cyclone occurred less than 4 weeks before the elections in early December 1970 which preceded the separation. The cyclone followed a particularly serious monsoon which led to increased levels of flooding and fatalities in the country earlier in the year. The storm surge height reached 10 metres, and caused an inundation of nearly all the low-lying coastal areas (Kabir, 2007). The loss of life was estimated to be 300,000-500,000 (Kabir, 2007). On the 19th of November, students held a march in Dhaka protesting against the slowness of the government response to the disaster (Durdin, 1971). This demonstration finally sparked the War of Liberation (and a wider Indian-Pakistani conflict) and culminated with the creation of the new state of Bangladesh. This was one of the first times in modern history that a natural disaster was a key trigger for civil war (Richard, 2005).

Since gaining independence in 1971, Bangladesh has experienced numerous forms of government, including military rule (World Bank, 2010). The longest ruling military regime was led by Lieutenant General Hossain Mohammad Ershad and ended in late 1990. This pressure led to Hossain Mohammad Ershad stepping down and handing over power to a caretaker government. A parliamentary system was re-introduced in 1991. Since 1991, the power has alternated between the country’s two major political parties, the Bangladesh Awami League (BAL) and the Bangladesh Nationalist Party (BNP), in each of the last four elections (World Bank, 2010). Nevertheless, the transition to democracy has not been all smooth. During the political transition periods in 1996, 2006 and 2013, there was political unrest in Bangladesh as all opposition political parties demanded a caretaker government leading up to the new election. “The risk of social unrest also remains, due to fact that poverty rates are high, and the fruits of economic growth are not redistributed equally. Political tensions and a tense social climate weigh heavily on investment (adaption to climate change, risk reduction, the fight against poverty etc.), though the country already suffers in terms of lack governance, and corruption” (Raillon and Geoffroy, 2010: 10). Moreover, this political crisis affected livelihoods in both industrial and agricultural sectors due to the breakdown in communication in the transportation system, which had a negative impact on the country’s economy. The crisis affected mostly those who were poor, and living a hand to mouth existence. Thus, political drivers play a significant role both directly and indirectly influencing other important drivers.

1.5 Past studies of environmental- generated migration

1.5.1 Studies beyond Bangladesh

A of growing body of academic papers has been published on environmental change and human consequences within recent years, however, the vast majority of studies are concerned with the effects of drought or changing rainfall patterns on migratory behaviour in sub-Saharan Africa (Black et al., 2011a; Van der Geest, 2011). A considerable amount of research has also focused on understanding the biophysical dimensions of disaster vulnerability, but these studies provide little insight into the socially created vulnerabilities that make people and places more or less susceptible to environmental hazards (Cutter et al., 2003; Myers et al., 2008) and few studies have place emphasis on climate change as a specific environmental factor leading to migration (McLeman and Smit, 2006; Perch-Nielsen et al., 2008). In recent years, however, attention to environmentally induced migration (ADB, 2012) and our consequent understanding of the ways that the human population is vulnerable to environmental hazards has grown substantially (McLeman, 2010). Frequent droughts and water scarcity, causing declines in both livestock and agricultural production

(Beley and Sugulle, 2011), is expected to increase domestic and cross-border migration in Africa and Asia (Kolmannskog, 2008) and international migration to the US particularly from Central American countries such as Mexico (Feng et al., 2010; Munshi, 2003) or El Salvador (Halliday, 2006). Cases of rural-urban, agricultural migration within some sub-Saharan African countries has already been noted (Kelly, 1991), as has the correlation between declining rainfall and rising migration from southwest Mexico to the USA (Munshi, 2003). A different view was expressed by Jonsson (2010) following his review of case studies on environmental change and migration in the Sahel, where it seems that environmental stresses do not necessarily lead to migration. This is usually because migration, particularly long-distance and international migration, requires resources that are often insufficient during times of drought (Henry et al., 2004a; as noted by Jónsson, 2010). In Mali migration during times of drought was found to be limited to short-distance rather than international destinations (Findley, 1994; Van der Geest, 2009; as noted by Jonsson 2010); thus, environment is not alone as the driver that creates migration. “Migration is a multi-causal phenomenon: even in cases where the environment is a predominant driver of migration it is usually compounded by social, economic, political and other factors” (Walsham, 2010: ix). Whilst some researchers argue that the environment can be a primary driver (Perch-Nielsen, 2008) “viewing migration as an adaptive response to different combinations of economic, social, political, demographic and environment ‘drivers’, it becomes clear that it may be sensitive to climate change in a variety of ways” (Black et al., 2011a: 431-432). Thus, many drivers combine to influence human spatial behaviour and migration sensitivities, and these vary significantly among regions and social groups (McLeman and Smit, 2006).

The concept of vulnerability and its key functional elements (exposure, system sensitivity and adaptive capacity), had been applied by McLeman and Hunter (2010) to explore the interaction between the climate change induced vulnerability and migration. Myers et al. (2008) investigate the relationship between social vulnerability and post disaster migration following Hurricane Katrina and Rita. They found “the places characterized by a greater number of disadvantaged populations, housing damage, and to a lesser degree, more densely built environmental were significantly more likely to experience migration following the hurricane” (Myers et al., 2008).

Kniveton et al. (2008: 7) state that “two possible approaches to understanding the causal linkages between climate stimuli and migration behaviour are: the Sustainable Livelihoods Approach which seeks to explain the responses of households to external vulnerabilities in terms of the natural, physical, financial, human, and social assets and different coping strategies available to households; and the New Economics of Labour Migration (NELM) which addresses directly why individuals migrate in the context of household decision-making. Whilst these approaches present some important perceptions, their outcome on the climate change-migration nexus are not yet conclusive (Schmidt-Verkerk, 2011: 89). It is likely that one of the reasons for the lack of conclusive results is that existing approaches try to isolate climate stressors from other factors that influence the decision making process in migration (Schmidt-Verkerk, 2011). Although Lee’s (1966) push-pull model regarding decision making factors is unclear about how these different factors interact with each other to inform migratory behaviour, and the role of the environment factor as a socio-economic driver (IOM, 2009), Renaud et al. (2011) offer a decision making framework to address the gap. The new conceptual framework by Black (2011b) and Foresight (2011) is functional to distinguish between different types of migratory outcomes. Their proposed framework is applicable to both international and internal migration and highlights the role of decision making choices (Black et al., 2011b). It considers this in relation to the role of family, households’ characteristics, and barriers and enablers of movement (Black et al., 2011b).

The IOM (2009) examined the complex link between migration, climate change and the environment. Since the early 1990s, IOM has carried out programmes to address this challenge in more than 40 countries in the Pacific, Latin America Asia and Africa (IOM, 2009). Another piece of relevant research was carried out by The EACH-FOR (2009). This project investigated environmental change and forced migration in 23 case studies. The research explored the question of whether environmental factors act as drivers for people to migrate due to effect on livelihoods, especially agricultural activity for example in Vietnam, where, during the flooding season, people undertake seasonal work and thus move to the city (Dunn, 2009). In Mozambique, people managed to stay in their place of origin and rebuild their houses after the tropical cyclone of 2000 and 2007, though they lost their houses, but the 2000 floods in Mozambique resulted in the displacement of thousands of people who had been living in the low-lying river areas (Stal, 2009). In Bangladesh, temporary and seasonal migration seem to be one of the most common coping mechanisms with floods, river bank erosion, cyclones and famine (Poncelet, 2009). In Ghana a scarcity of fertile land, unreliable rainfall, low crop yield and food security problems push people to migrate (Van der Geest, 2009); whilst poverty and unemployment caused totally or in part by environmental change push people to move in Egypt (Afifi, 2009).

The massive flow of migrants can have an effect on the environment in places of destination, origin and along routes of transit (IOM, 2009). For instance due to river bank erosion in Bangladesh as many as 400,000 migrants are forecasted to arrive annually from rural affected areas and many poor migrants settle in flood-prone areas (IOM, 2009). Moreover, migrants face a range of human security risks ranging from the disruption or strain of infrastructures and services, to the separation of families (Unitar, 2008). Thus, rural to urban migration spurred by environmental migration contributes to unmanaged urbanization (IOM, 2009). "Forced migration hinders development in at least four ways; by increasing pressure on urban infrastructure and services, undermining economic growth, increasing the risk of conflict and leading to worse health, education and social indicators among migrants themselves" (Brown, 2008: 10). The relationship between rapid urbanization and climate change has already been seen clearly in many studies, especially in Africa. In 2000 Africa's urban population reached 37 percent of its total, driven by an average annual growth rate of the urban population of 4.4 percent between 1950 to 2000 (Barrios et al., 2006).

1.5.2 Studies in Bangladesh

Despite much research having been done on the impacts of climate change and consequent adaptation policies in Bangladesh, few studies have specifically investigated migration as a consequence of climate change. Moreover, none of the research has investigated the relationship between climate change and migration in the context of vulnerability. Recently, several relevant works have been conducted (Black et al., 2008; Black et al., 2011a; Kniveton et al., 2013; Martin et al., 2013) as well as some collaborative works with the local organization RMMRU. In 2010, research assessing the evidence of the environment, climate change and migration in Bangladesh was conducted by Walsham (International Organization of Migration). He assessed climate change, and the environment-migration nexus in Bangladesh from existing evidence. This project also investigated migration management and related policy of the country. In addition to this, (Poncelet, 2009) carried out a project on environmental change and forced migration in Bangladesh. In 2009, research on climate change and security in Bangladesh was conducted by the 'Bangladesh Institute of International and Strategic Studies' and a 'Saferworld', where they discussed the impacts of climate change and internal migration in the country (BIISS and SAFERWORLD, 2009). A relevant piece of research was carried out by Black et al. (2011a), who set out a new approach to try and understand the relationship between migration and climate change. The applications of the approach are provided for Ghana and Bangladesh. Another relevant piece of research was conducted by Swain (1996). In this research, migration from the southwest region of Bangladesh, brought about by the building of the Farakka dam upstream from the Bangladesh border with India, was discussed.

Although there are a few studies of the affected area, most of them ignore consequences of the migrants in urban destinations. Mallick and Vogt (2013) carried out research on changes in both the origin and local destination community due to population displacement. They explained this using the social 'inclusion' and 'exclusion' concept. Other research only describes the vulnerability of destinations where poor migrants choose to stay. Braun and Aßheuer (2011) investigated the vulnerability of slum dwellers in Dhaka, and highlight the major factors behind their sensitivity to floods and their ability to adapt to the related changes. Investigations into the coping strategies of the urban poor affected by natural disasters have been carried out in some studies (Rashid, 2000; Jabeen et al., 2010).

1.5.3 Predictions for the future

Although the future climate is expected to severely affect people's livelihoods through changes to agriculture production, it is likely to also lead to increased competition over natural resources that may lead to conflict (Martin, 2009). It is argued that we are already seeing the effect of climate change unfolding in conflicts in Africa, in particular in Darfur (Nordås and Gleditsch, 2007). Conflict can occur at regional levels, as well as between states. State immigration policies also mean that even where migrants seek to cross to other states, this will often be impossible, since few have immigration regimes that recognise 'environmental migration' as either a legitimate mode of entry or an acceptable reason for resettlement across state boundaries (Findley, 2011). Indeed most countries' immigration policies specifically seek to restrict such cross-border movements, for example between Bangladesh and North East India (Findley, 2011). Bangladesh already has experience of political migration during the partition and the conflict leading to Independence in 1971, which was partially driven by the environmental crisis in 1970 accompanying a natural disaster. Thus, many investigations reveal empirically how, and under what circumstances, resource scarcity causes armed conflict, and the latter can be focused on renewable resources that are key for food production, such as agricultural land and fresh water. Thus, while past human activity cannot be used to quantitatively predict the future, I can use past events to provide an indicator of the risk of future conflicts.

1.6 Aim of the thesis

The overarching goal of the study is to provide a comprehensive understanding of the role of environmental change in causing migration and its relation to societal consequences.

In order to achieve this, the specific questions are:

I. To what extent can environmental drivers be recognised as a primary cause of migration in Bangladesh?

II. How do environmental drivers interact with other effects to create different forms of migration or to influence the individual decision-making process during migration?

III. Is migration the result of vulnerability or does it reduce vulnerability by increasing adaptive capacity?

IV. Why do some people migrate, while others stay put, though they face similar environmental problems?

V. To what extent do people move short or long distances? Who moves and why?

VI. What are the effects of migration on destination cities? What societal issues do rural migrants face in the city?

1.7 Outline of the thesis

The thesis will start by describing migration theory and its links to environmental change, as well as the concept of vulnerability, a key driver of migration. Following this, I describe adaptive capacity and migration, followed by the key factors that affect vulnerability. In chapter 3, I will give an account of my methodological approach. The chapter starts with a description of the methods used to explore the physical dimensions of the research, which included statistical analysis and remote sensing. Then I describe the methods used to investigate the human elements of the research, specifically a large scale survey which determined the reactions of three categories of people such as migrants, non-migrants and communities that received migrants. The chapter also describes the method used to link the social and physical data. The migration patterns of Bangladesh are described in chapter 4.Following this, I address the history of internal and cross-border migration in Bangladeshi region. In chapter 5, I explore the physical setting of Bangladesh. The chapter starts with a description of the hydro-meteorology of Bangladesh. I investigate the climate variability of Bangladesh, as seen through temperature and rainfall variation and river discharge. Then, I describe the environmental risk factor within Bangladesh, including floods, cyclones, river bank erosion, and sea level rise. Chapter 6 investigates the impacts of climate change on the coastal zone of Bangladesh. This chapter explains the sea level rise issue, and the frequency of cyclones, storm surges and erosion in the coastal zone of Bangladesh. Chapter 7 examines the social vulnerability of the delta to natural disasters. This chapter addresses the impact of natural disasters on the social, economic, political, cultural and traditional characteristics of the delta, concentrating on those people who are at risk and the relationship to migration. Chapter 8 explores the fate of the migrants to urban areas from Bangladesh's rural delta. This chapter is divided into two interview studies related to the geographic proximity of the urban centre to the migrants' origin: firstly, I study two divisional headquarters in the delta, Khulna and Barisal; and secondly I investigate migration to two urban districts of the central part of the country, the megacity Dhaka and Comilla. Chapter 9, highlights the evidence environmental change has a causal role for migration. Lastly, chapter 10 gives a discussion of the key finding of the thesis, and recommendations for future research.

Chapter 2

Developing an approach of environmental change and migration

2.1 Introduction

"Hippocrates and Aristotle believed that characteristics of the natural environment determined the habitability of a region by humans and the characteristics of people were shaped by attributes of the natural environment in the place in which they live" (Livingstone, 2000; McLeman and Smit, 2006: 32).

The relationship between migration and environmental change is a multifaceted concept. Migration naturally has numerous causes, and environmental factors are interwoven with complex array of social and economic factors, which themselves can be influenced by environmental changes. Thus, it is important to know under what conditions vulnerable people decide to move, or choose to stay, or force to stay or move. What drivers motivated the migration? What is tipping point of decision making process? What condition people choose migration due to a failure of adaptation (Boano et al., 2008; Barnett and Webber, 2010; Renaud et al., 2011) and migration itself to build adaptive capacity? (McLeman and Smit, 2006; Renaud et al., 2011) or create societal crisis in cities that are prone to environmental risk (Foresight, 2011). These answers are incompletely considered in migration research (McLeman and Smit, 2006).

I begin the chapter by discussing an overview of migration theory. Theoretical perspectives have been analyzed on the basis of the push-pull and economic models. The second part of the chapter then moves onto drivers of migration (economic, social, demographic and political driver). The third part of the chapter discusses the key concepts of vulnerability, adaptive capacity and migration. Then the section moves on to factors that influence vulnerability. The fourth part explains the different types of migration both in rural and urban areas. Finally, the fifth part of the chapter discusses past studies of environmental generated studies.

2.2 Over view of migration theory

Although a significant body of literature has attempted to understand the causes of human migration, employing concepts from economics, sociology, geography and political science (Kniveton et al., 2009: 48), the inter-linkage between human migration and environmental change in standard theories of migration, is largely absent (Laczko and Aghazarm, 2009; Black et al., 2011b). This is particularly so within many core publications (Piguet et al., 2011). Nevertheless, a number of overviews of migration theories for example by Massey et al. (1998) highlight six separate bodies of work (neoclassical economics; the new economics of labour migration; segment labour market theory; world system theory, social capital theory and the theory of cumulative causation), suggesting that the causes of migration essentially differ regionally and given different empirical circumstances (Black et al., 2011b: S5). Thus for there has been no effective integration of these approaches into one universal theory (Schmidt-Verkerk, 2011). This has resulted in a significant problem for researchers trying to theoretically frame their research design (Schmidt-Verkerk, 2011), in particularly for those who working on migration as a cause of environmental impact. When asked about their reason for moving, migrants generally cite economic or social factors and rarely mention environmental factors (Black et al., 2011b). Certain theories do suggest that economic factors at a micro or macro level are the result of environmental stresses, which can lead to migration (Schmidt-Verkerk, 2011). More recently many researchers have tried to establish a relationship between migration and changing climate patterns. But many of the debates on climate change and migration focus almost entirely on displacement and perceive migration to be the problem (Black et al., 2011b). However, 'one way of approaching the climate–migration relationship is to begin with the concept of vulnerability' (McLeman and Smit, 2006) that I have used in my thesis. I will return to this discussion (see section 2.5). The following paragraphs describe an overview of migration theory.

The theoretical understanding of internal migration in Bangladesh can be categorised into two broad areas. Firstly, 'push-pull' factors, under which movements are governed by a balance of attracting and resisting factors, notably those on offer by Ravenstein and Lee (1966) and the factors that determine the decisions to migrate (presented by Lee, 1966). The second category consists of economic models rooted in productivity and livelihood differentials, notably those offered by Lewis (1954) and Harris and Todaro (1970) (Marshall and Rahman, 2013).

Push-pull factors

The first model of the theory of migration was established by geographer Ernst Georg Ravenstein in 1885 and 1889). He researched internal migration in Great Britain and found several factors affecting the process of migration, such as distance and population sizes of the origin and destination regions of the migrant (Conrad, 2010). He also found that migration is more common over short distances, the flows of migration are dominated by rural to urban migration and that the major direction of migration is from agricultural areas to centres of industry and commerce (Wondimagegnhu, 2012, Conrad, 2010; Grigg, 1977). He concluded that migration was ruled by a “push-pull” process where unfavourable conditions in one place “push” people out and favourable conditions in an external location “pull” them in (Wu, 2003). Many researchers have re-used, reviewed, revised and developed Ravenstein’s push-pull process of migration. Lee (1966) revised Ravenstein’s nineteenth century laws on migration and proposed a new analytical framework for migration (Haas, 2008: 8). In a ‘Theory of Migration’, Lee referred to the fact that “Ravenstein has been much quoted and occasionally challenged… Nevertheless, his papers have stood the test of time and remain the starting point for work in migration theory.” (Lee, 1966: 48-47; as noted by Lydersen, 2011). There are strong chains for the use of Ravenstein’s principle in a Bangladeshi context.

Lee (1966) identified four causal factors that determine migration decisions and the processes. They are as follows: 1) Positive and negative factors associated with the place of origin (employment opportunity, living conditions, climate, culture, leisure accessibility, level of discrimination, etcetera. 2) Similar positive and negative factors associated with the place of destination 3) Intervention obstacles (physical and political barriers such as distance, oceans or deserts, and migratory laws); and 4) Personal factors (personal or household characteristics and personal sensitivities, intelligence, awareness, knowledge about the potential receiver population and family ties (Kumpikaite and Zickute, 2012, Lydersen, 2011) (Figure 2.1). Lee (1966) also mentions the variable characteristics of migrants, where people respond differently to plus-minus factors at the origin and destination and where people’s different capabilities to cope with intervening obstacles and differ depending on personal factors. Although Lee’s analytical framework is commonly referred to as the ‘push-pull’ model, he did not apparently formulate the term (Passaris, 1989; Haas, 2008).

However, his 'push-pull' model is commonly used in study of migration (Wang, 2010) and has become the dominant migration model in the secondary and university education (Haas, 2008).

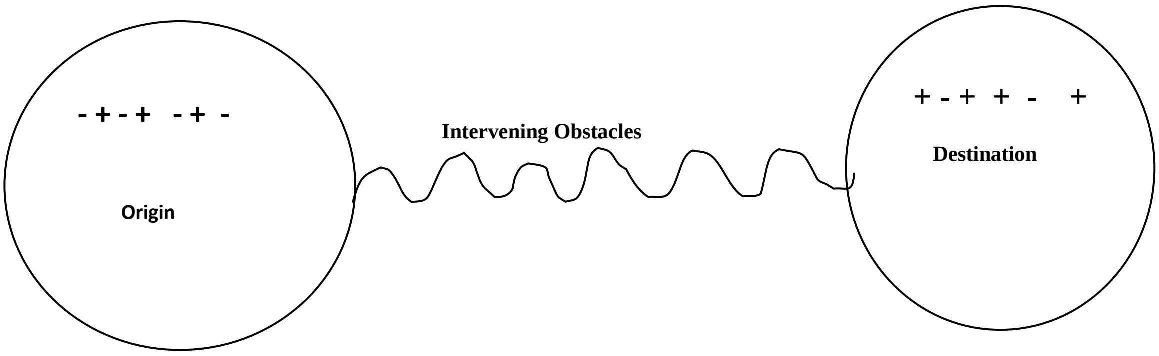

Figure 2.1: Origin and destination factor and intervening obstacle in migration (source: Lee, 1966: 50)

Others have also studied the link between environmental change and migration by using Lee's (1996) concept of the 'push-pull' framework. Black et al. (2011b) and Foresight (2011) developed a framework that aims to encompass the range of drivers that may affect the volume and direction of migratory patterns across the various analyses at which migration can be considered. Usually, the framework considers the impact of both direct and indirect environmental drivers on migration (Figure 2.2).

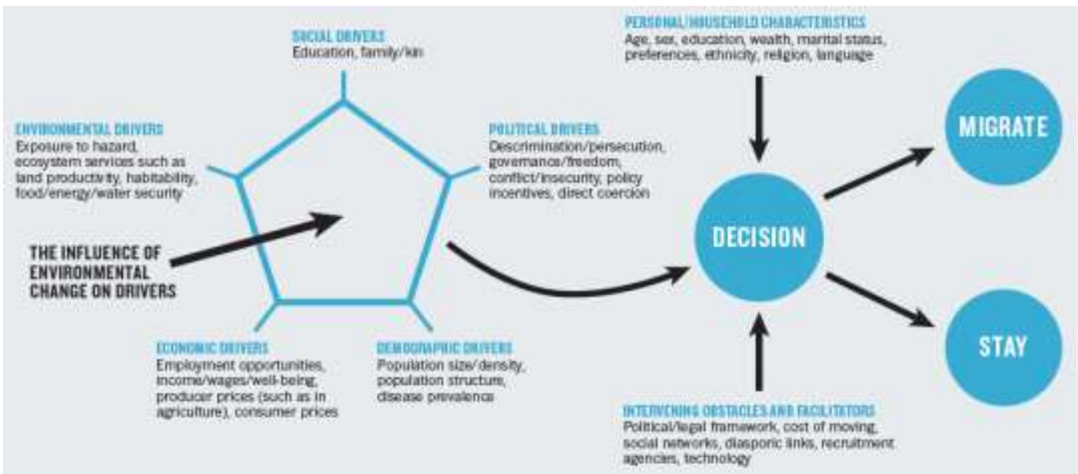

Figure 2.2: The drivers of migration (sources: Black et al., 2011c)

Push-pull explanations have been cited most frequently in the context of rural to urban migration in Bangladesh (Marshall and Rahman, 2013) as this is the most common form of migration in Bangladesh (Afsar, 2003). The above theories could be relevant to a Bangladeshi context, due to the strong expansion of the non-agricultural sector and in particular, the advanced manufacturing and service sectors (Herrmann and Svarin, 2009) which that pull many Bangladeshis from the agricultural areas to the centres of industry and commerce, such as, Dhaka and Chittagong. Landlessness, poverty and unemployment, as well as the chance to earn income from non-farm sectors, push rural people to migrate to the city (Toufique and Turton, 2002). On the other hand, the main pull factors that attract rural Bangladeshis to urban areas, are the higher wages of non-agriculture, at employment industry and services (Herrmann and Svarin, 2009). Moreover, the frequent recurrence of natural disasters have negative impacts on agricultural production, and also cause important internal flows, in many cases, pushing people living in coastal rural, or river bank areas of Bangladesh to urban centres (Herrmann and Svarin, 2009). It has been found that forty percent of migrant workers migrated from just five of sixty-four districts of Bangladesh (Siddiqui, 2005), which are particularly prone to flooding and environmental events (ADB, 2012). “It is clear those environmental drivers are working together with economic forces in causing migration in Bangladesh” (ADB, 2012: 33).

Economic model

One of the oldest and best known theories of migration is the neoclassical economic theory (Massey et al., 1993). This economic approach can be differentiated through macro and micro level models (Marshall and Rahman, 2013). Such migration occurs because of geographical differences in the demand and supply of the labour market (Massey et al., 1993, Haas, 2008). The main arguments of these approaches revolve around wages (Kurekova, 2011). The differential in wages causes workers from low wage countries to move to countries where higher wages are available (Massey et al., 1993). For example, every year a significant number of labourers migrate to GCCs countries from Bangladesh, due to higher wages, employment levels and standards of living in those countries (Hear et al., 2012). According to neoclassical economic theory, a region with a shortage of labour and high demand will have high wages that pull labour from labour-surplus regions (Wu, 2003). Due to the subsequent migration flow, the supply of labour in high wage regions increases and as a result wages in the region decrease. Conversely, the supply of labour in low- wage regions declines and as such wages increase (Bauer and Zimmermann, 1999). “As opposed to this macro theory, which seeks the causes for migration at the state level, the micro theory of neoclassical economic argues that migration is a consequence of individual choice trying maximise their income” (Schmidt-Verkerk, 2011: 71).

Massey et al. (1993) argue that skilled people select places for migration where their skills can be most readily applied in the work place. However, in order to receive a higher income, certain investments need to be made, such as travelling costs, maintenance while searching for paid work, as well as a willingnesss to experience and adapt to a new environment (Massey et al., 1993). The neoclassical theory of migration, extended by a new economic labour migration, argues that migration is determined less by isolated individual actors, and more by other social units, particularly families, households or even larger groups (Zohry, 2002). However, the two approaches share common ground in that both conceive migrants as realistic agents who try to increase their financial income (Schmidt-Verkerk, 2011: 79). “Stark later expanded on traditional economic theories of migration, suggesting that migration decisions made at the household level can reflect not only the income maximising behaviour of migrants, but also household attempts to minimize exposure to risk and highlight the role of remitances in achieving this goal” (Stark, 1991; as noted by McLeman and Smit, 2006: 38).

Although these approaches are generally applied to international migration, the principle could be applied alomost equally in the context of internal migration (Zohry, 2002), in particular rural-urban migration. In many places in rural Bangladesh remitances from migrant members have replaced agriculture as the major sources of household income. Thus this income source can minimize exposure to risk, particularly if livelihoods (agricultural sector) are at threat due to environmental deterioration.Toufique (2002) found that 80 percent of income was derived from ouside the village under study. His study also showed that the poor also migrate and send remitances.

The Todaro (1969) and Harris and Todaro (1970) models, which are some of the earliest models of migration, describe and show how rural-urban migration occurs in a dual economy, whereby the urban sector ‘pulls’ the male labour force from rural areas

(Dugbazah, 2007). According to this theory, migration is not caused by push factors (Schmidt-Verkerk, 2011). Todaro postulates that migration proceeds in response to urban-rural wage differences rather than actual differences in wages (Todaro, 1980). According to the Todaro model, rural migrants may not find employment immediately upon arrival in the city (McCatty, 2004), while flows of rural-urban migration cease when equilibrium arises, and wages and rates of unemployment are balanced (Marshall and Rahman, 2013). The key hypothesis of the Harris and Todaro model is that migrants respond primarily to economic incentives, earning differentials, and the probability of getting a job at their destination, all of which are key influences in the decision making process of migration (Dugbazah, 2007). "Problematically, the key variable –geographically disaggregated real wages and unemployment and under employment levels - are hard to come by in most LDC contexts (including Bangladesh)." (Marshall and Rahman, 2013: 11). Afsar (2000) also found Todaro's perspective on the urban labour market to be less relevant in the context of Bangladesh. New migrants find jobs more quickly, particularly poor and unskilled migrants. Half of this group who settled in slums, found work within one week, and three-quarters of them found employment within month (Afsar and Baker, 1999). Most poor migrants secured their first job using social networks (Afsar, 2003). The poor migrants diversified their livelihood and enjoyed higher incomes compared to the situation they faced in rural areas. Hossain et al. (2000) found that poor migrants moving to Dhaka were able to improve their earnings at a much higher rate than those who stayed in rural areas.

Lewis (1954) offered a classical model of migration decision making for developing countries (Marshall and Rahman, 2013). His model is tends to be based on the concept of a dual economy, comprising of a traditional backward sector (agriculture) characterized by unemployment, and a modern industrial sector (urban-based non-agricultural) characterized by full employment (Zohry, 2002). The model represents the process of rural-urban labour transfer as an integral element (Mears, 1997), in particular from an agrarian to industrial society. Migration is considered an 'equilibrating mechanism', which, through the transfer of labour from labour surplus to labour shortage sectors (non-agricultural) will help establish wage equality across the two sectors (Zohry, 2002). The marginal productivity of labour zero or very low in the backward sector (Mears, 1997), while there also tends to be an abundant supply of labour (Marshall and Rahman, 2013). Herrmann and Svarin (2009) found non agricultural productivity in Bangladesh to be significantly higher than agricultural labour. This perhaps explains why agricultural workers seek more productive and well-paid employment in the non-agricultural sector. Their study also found agricultural productivity has increased between 1980-1983 and 2000-2003, coinciding with a decrease of non-agricultural labour productivity. “Yet, in the latter period the labour productivity and thus the earning potential in non-agricultural sectors was still almost four times as high as the labour productivity and earning potential in agriculture. In accordance with classical theories of the dual economy, these differences in labour productivity and earning potentials help to explain the non-agricultural bias, which is also increasingly associated with an urban bias.”(Herrmann and Svarin, 2009: 10). Thus, Lewis’ (1954) model has a strong resonance with the patterns seen in Bangladesh in recent years (Marshall and Rahman, 2013).

2.3 Key drivers of migration

Most people in the world do not want to move unless they are pushed or pulled to move for a range of reasons across different spaces (Hammar and Brochmann, 1997). Thus, different reasons affect various types of migration patterns. Various types of migration involve various migration experiences. For example, an internal migrant will have different experiences to a political refugee (Wu, 2003). The decision to move or stay is highly complex as it is usually dependent on numerous push factors relating to the place of origin, in addition to pull factors specific to the place of destination (Warner, 2010).Thus, the response to environmental change is complicated and combines concerns regarding physical change, socio-economic factors as well as a variety of other factors. The five factors given by Black et al. (2011b) and Foresight (2011) (Figure 2.2) play a significant role in the migration dynamics of Bangladesh (Martin et al., 2013). Based on Bangladesh, a schematic construction of this process is given in figure 2.3.

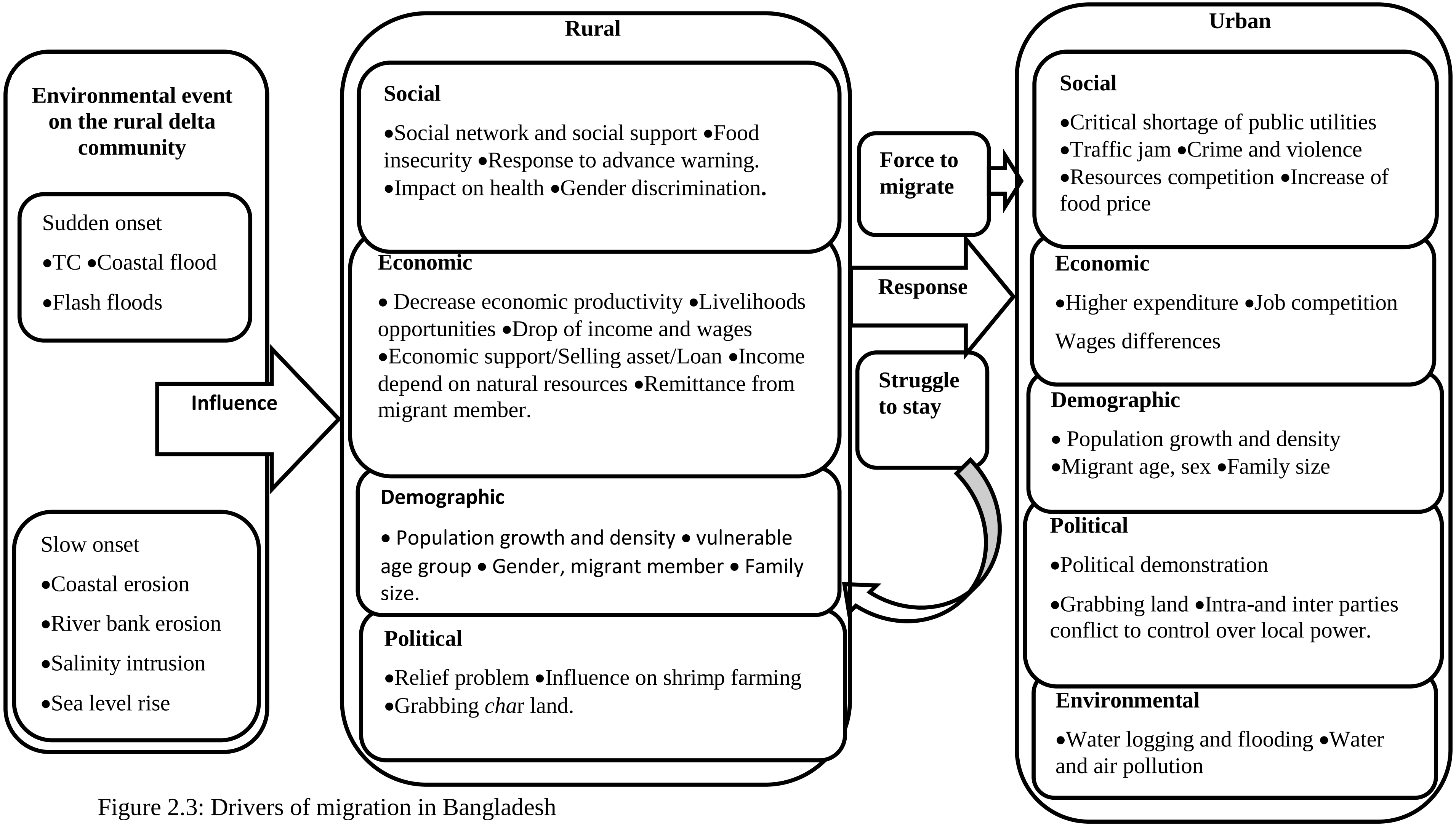

Figure 2.3: Drivers of migration in Bangladesh

2.3.1 Economic drivers

Economic drivers play a vital role in causing migration (Haas, 2008). Economics has a direct effect on internal migration (Black, 2011b). Economic drivers include livelihood opportunities and income differentials between places (Black et al., 2011b), with this being particular relevant for rural- urban migration in Bangladesh due to wage disparities (Mohit, 1990). This is consistent with 'push-pull models' noted in the literature which suggests that migrants were pushed from their countries or regions by low incomes, and pulled by better prospects and opportunities in other areas. This has sometimes been conceptualised as an equilibrium model, which initially focused on internal migration and suggested that migration would result in a balancing out of these disparities (Lee, 1966; Harris and Todaro, 1970; as noted by Hear et al., 2012: 7). According to the report of EACH-FOR (2009), most experts consider economic reasons to be the major driver influencing migration in Bangladesh (Poncelelet, 2009). Inability to sustain a family caused through low income is a key reason for internal migration in Bangladesh. For example, floods and droughts during the *monga* season in the Northwest region, and salinity and cyclones in the Southwest region, has led to a reduction in income from agriculture and perpetuates poverty, and this has been found to have a strong influence on people's decisions to migrate to cities in these regions (Poncelet, 2009). Furthermore, non-agriculture income grew six times faster than agricultural income (Afsar and Baker, 1999; Afsar, 2003; Black et al., 2011a) and jobs are more secure in urban areas than in rural areas (Afsar, 2005; Black et al., 2011a). Many slum case studies suggest that it rarely takes more than a couple of days to find employment in the informal sector and begin sending remittances home (Afsar and Baker, 1999; Afsar, 2003; Black et al., 2011a), particularly in Dhaka. According to Centre for Urban Studies (2006), 60% of migrants start jobs within one week of arriving in an urban centre, though income could well be below the poverty line (Martin et al., 2013).

2.3.2 Social drivers

Social factors are another important driver of migration. Social drivers are often presented as secondary, whereby people look for a better life and dignity by making use of particular networks (Poncelet, 2009: 9). Social networks facilitate migration in Bangladesh, in particular internal migration through interpersonal ties and the ties of kinship and friendship (Massey, 1990). Female migration due to marriage is also common in Bangladesh. Boer (1981) surveyed 486 people in a village in Comilla district, Dhoneshor, and found that there had been 158 in-migration and 150 out-migrations from this village due to marriage. Another common migration driver in Bangladesh is education. Due to lack of facilities in rural areas many Bangladeshis move to cities for educational purposes, where they tend to stay to search for a good job after completing their studies. Eventually most get a permanent job and settle in the city, although they still own houses and land in rural areas.

2.3.3 Demographic drivers

Demographic pressure indirectly influences migration, most likely due to interactions with other drivers, particularly economic drivers (Black et al., 2011b). Demographic pressure is a significant driver in Bangladesh as it is one of the most densely populated countries in the world (Figure 2.4), while the country also has limited natural resources. The average population density in Bangladesh is 1051 per km^2 (according to BBS census, 2011). Thus it contributes to difficulties in securing sustainable livelihoods, particularly for those dependent on land (Hear et al., 2012: 17). Moreover, the population is increasing rapidly (Figure 2.5). According to BBS census 2011, the population of the country was 149.7 million in 2011. After the Liberation war of 1971 the population growth rate was high (~2.5 %yr^{1}) (Rasheed, 2008). However, this has decreased in recent decades, down to 1.37 %yr-1 in 2011. According to the Bangladesh Planning Commission (2013), the working age population (15-64) is 95.58 Million (one third of the total population) of whom 76.6% are from rural areas (BBS, 2011). Economic migrants are typically young, poor and male, however this is changing significantly, with a reported increase in recent years in the demand for female labour in readymade garments factories in Dhaka and other metropolitan areas (Black et al., 2011a: 442). There are 5,400 garments factories in Bangladesh, employing 4 million workers, most of which are women (ADB, 2014). This industry contributed $20 billion (or 16.6%) of the country’s total GDP in 2013, mostly due to exports (ADB, 2014). However, in 1998 GOB (1998) estimated that one third of the working population was either unemployed or underemployed (Siddiqui, 2003). While, the growth rate of the labour force is 3.6 % per year (2006-2010) (Bangladesh Planning Commission, 2013), more than double that of the population growth. However, the international migration has kept unemployment rates unchanged since the 1980s (Siddiqui, 2003), these being 4.3% between 1999 and 2000, 2002-2003 and 2005-2006, and 4.5% in 2010 (Bangladesh Planning commission, 2013).

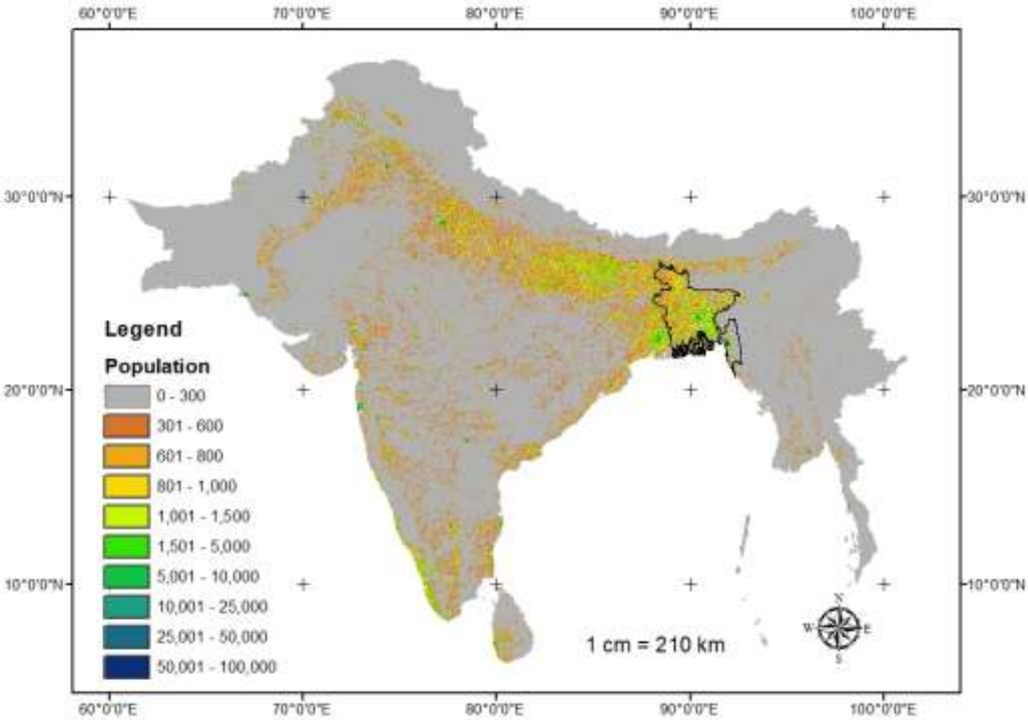

Figure 2.4: Population map of South Asia showing inhabitants per km^2 (Landscan data, 2007 – website source: http://web.ornl.gov/sci/landscan/).

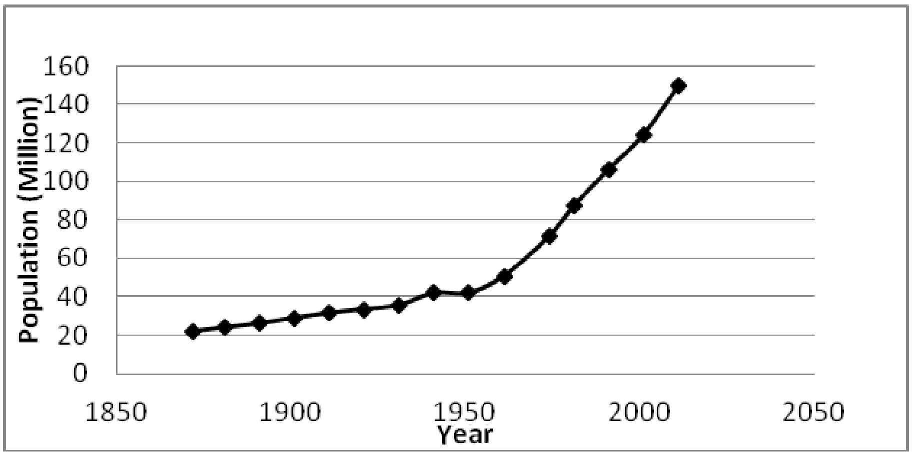

Figure 2.5: Population of Bangladesh from 1872 - 2011 (data sources: BBS, Rasheed, 2008; Rashid, 1991).

In Bangladesh most economic migrants were young males, however recently this has changed significantly with the increase in demand for female workers in the readymade garments sector (Afsar, 2003). The age of 75% of the temporary migrants, and 50% of the permanent migrants, who moved to Dhaka was between 15 - 34 in 2000 (Afsar, 2000).

2.3.4 Political drivers

Political drivers directly affect migration in a number of ways (Black et al., 2011b). Displacement or 'forced migration' may be triggered by the breakdown of governance structures or the emergence of violent conflict (Foresight, 2011: 45). Bangladesh has a long history of political migration. Political security is often cited as a driver of long-term or permanent migration, as well as being a primary motivation for cross-border migration into India, where (Shamshad, 2008) estimated fifteen million Bangladeshis to be living illegally (as noted by Black et al., 2011a: 443). The Bangladeshi goverment does not agree with this claim however. This is described in more detail in chapter 4. Evidence suggests that initial displacement tends usually to be local and short term in nature, and there is no evidence for mass migration occurring across border zones (Walsham, 2010). Irregular migrants are likely to face substantial difficulty in accessing post-disaster humanitarian support making it unlikely that many people would choose to cross the border in the immediate aftermath of an event (Walsham, 2010). Moreover, India controls the border. The border region with India contains some of the areas of greatest environmental vulnerability, particularly in south-west (my study area) and north-west (Walsham, 2010). The people of the western border districts of Bangladesh share more or less a common culture, language and religion with people in neighbouring India (Siddiqui, 2009). This could encourage people to move to safer neighbouring regions in India if extreme environmental change was to occur in the future due to climate change (see chapter 4). Political tension within the country also affects the livelihoods of poor people. Thus, this can also indirectly influence the decision made by the people to move both internally and externally.

2.3.5 Environmental drivers

Environmental factors are one of many that drive migration (Walsham, 2010). Environmental drivers have both direct and indirect effects on migration decisions.

“Climate change is expected to affect the movement of people in at least four ways: 1) the intensification of natural disasters – both sudden and slow-onset - leading to increased displacement and migration; 2) the adverse consequences of increased warming, climate variability and of other effects of climate change for livelihoods, public health, food security and water availability; 3) rising sea levels that make coastal areas uninhabitable; and 4) competition over scarce natural resources potentially leading to growing tensions and even conflict and, in turn, displacement” (Walsham, 2010: ix). According to Foresight (2011), there are six dimensions of climate change (sea level rise, tropical storms and cyclones, rainfall, temperature, changes in atmospheric chemistry, melting of glaciers) and two non-climatic dimensions (land degradation and coastal and marine ecosystem degradation) that have potential effects on the drivers of migration. These effects will vary from place to place (Black et al., 2011b). McLeman and Hunter (2010) state that climate variability and climate change related exposure most commonly related with migration can be differentiated into two types: ‘sudden onset’ and ‘slow–onset’ phenomena. The slow-onset disasters such as sea level rise, coastal erosion, drought, and salinity intrusion can impact pre-existing systems of production and livelihood patterns, which, in turn, can lead to different patterns and types of migration. Sea level rise will lead to higher risks of coastal and inland flooding together with increased coastal land erosion and greater salinization of low-lying farmland (Foresight, 2011; Black et al., 2011b). Sea level rise is considered to affect migration because, as land is lost, emigration will increase (Leatherman, 2001; Perch-Nielsen, 2008). The increased salinity caused by coastal flooding and storm surges has the potential to decrease the productivity of agricultural land and/or damaged agricultural assets, ultimately affecting livelihoods. These combined effects reduce household income, motivating affected people to move to cities in the form of seasonal, temporary or circular migration. However, such migration has positive and negative effects on both local coping capacity and the environment in areas of origin and destination (IOM, 2009).

According to (Piguet, 2008: 6) “Bangladesh is particularly vulnerable to the impact of climate change and one of the few countries in which natural hazards are the main cause of migration”. Migration associated with both rapid and slow-onset events is likely to be internal in nature, with movements being rural-rural or rural-urban in Bangladesh (Laczko and Aghazarm, 2009: 22). According to the EACH-FOR survey

(2009), experts stated that environmental factors do not directly influence decisions to migrate in Bangladesh (Poncelet, 2009). However, after interviewing the target population, EACH-FOR (2009) findings appeared to show that there were direct and indirect links between environmental and climatic disasters on the one hand and economic factors on the other (Poncelet, 2009). However, there is clearly migration in Bangladesh that is directly related to environmental stress (Black et al., 2011a), in particular river bank erosion. Several studies (Zaman, 1991; Hutton and Haque, 2004, RMMRU, 2007) report that people are directly displaced by river bank erosion. In a study of the Kazipur rural sub-district, Hossain (1984) recorded that one-tenth of river bank erosion induced displacement involved moving to urban areas in an attempt to re-establish livelihoods (Hutton and Haque, 2004). Though river bank erosion is a strong driver of migration, flooding is not associated with long-term mobility trends in Bangladesh (Gray and Muller, 2012) because most flat plain land in Bangladesh faces flooding every year. Farmers in Bangladesh have thus adapted well to these regular floods. Flood affected people tend to return after abnormal catastrophic floods. But Kniveton et al. (2013) compared the relationship between average sub-districts flooded in 1998 and the population growth rates for 1991-2001 and 2001-2011 in Bangladesh. The report stated that those sub-districts affected by flooding of more than 75% of the area in 1998 would on average have a 33% lower population growth in 2001 than those sub-district where land was affected by flooding by 25% or less. Population growth rates for the above scenario are similar in 2011, but not significant (95% level). In especially rural areas of those sub-districts, population growth in more flooded area (75%) is 65% more than the less flooded areas (25%). These sub-districts are mostly located near river banks, and are highly prone to flooding and riverbank erosion. Though people can return following flooding, or stay by utilising their traditional knowledge, affected households cannot return if their houses have been engulfed by the river. This could be one of the main reasons for the growth rate decreasing in these rural sub-districts.

Tropical cyclone and storm surge floods are typical examples of sudden onset events that have the potential to cause considerable damage to infrastructure, property and loss of life leading to migration and displacement (Piguet, 2011; McLeman and Hunter, 2010). There is data on immediate local displacement resulting directly from tropical cyclone as well as short-term out migration, but much less evidence on long-term migration patterns (Walsham, 2010). Thus, frequent cyclones are one of the main drivers of migration in Bangladesh (Martin et al., 2013). Following cyclone Aila in 2009, many were forced to migrate to other cities due to losing their assets and livelihoods, and this particularly affected the poor (Mehedi, 2010).This type of event can lead affected people to be displaced internally over short periods of time rather than longer term (Piguet et al., 2011). However, this short-term temporary displacement from such an event can lead to permanent migration (Warner, 2010). For example, many poor migrants settled in cities after Aila, but it is unclear to what extent the early flow of seasonal migration from tropical cyclone Aila has been converted into permanent out-migration (Walsham, 2010). Similar examples can be seen outside of Bangladesh, as many displaced people could not return home after several months or years following the Asian tsunami in 2004, and Hurricane Katrina in New Orleans in 2005 (Warner et al., 2010). This is linked to the fact that victims, who predominantly live in poor countries like Bangladesh, lack the resources to move and tend to stay where they are or only move a short distance (Piguet, 2011: 7). Long distance movement is predicted by perceived and actual declines in agricultural productivity (Massey et al., 2010), as well as general poverty and hunger, as seasonal movement is frequently witnessed in the drought prone district to the Northwest (Martin et al., 2013) Dhaka, or even further afield in cities such as Chittagong. Thus, disaster-related migration is short term and more strongly related to short-distance moves than long distance moves (Massey et al., 2010; Kniveton et al., 2013). The evidence for this has been provided in chapter 9, section 9.2. There is evidence to suggest short-term, internal migration can be initiated through various socio-economic contexts by environmental stresses and shocks, and that international migration flows following such events can increase or decrease, depending on the socio-economic and psychological contexts, and barriers to migration of those exposed. It is important to remember that the measurement of environment–migration linkages is sensitive to the data available, and the ways in which analyses are performed (Kniveton et al., 2009). Paul (2005) interviewed 291 respondents from tornado affected areas of northern Bangladesh, and found that no out migration occurred because of the 2004 tornado due to the efficiency of disaster aid (Schmidt-Verkerk, 2011; Paul, 2005). Conversely, many poor black residents of New Orleans were not able to leave after Hurricane Katrina hit (Schmidt-Verkerk, 2011).

2.4 The role environment factors may play in influencing action in migration

Environmental factors figure as silent determinants of the migration decision-making process (Massey et al., 2010), but the conceptualisation of these factors as a primary cause of migration or forced displacement has been questioned (Black, 2001). An initial conceptualisation of migration decisions was first proposed by Renaud et al. (2007) to determine whether or not migration is induced fully or partly by environmental factors. Their classification considered a number of factors, including the nature of the environmental phenomena and help available for mitigating the impacts of the event. Coping capacity is significant in their classification, which they link to assistance or help available to help cope with environmental degradation of the affected community (Renaud et al., 2007). They distinguish between three types of migrant: environmentally motivated migrants (EMM); environmentally forced migrants (EFM); and environmental refugees (fleeing, forced to migrate). 'The approach examines the circumstances leading to a decision to move, including the state of the environment, and the coping capacities and adaptive abilities of those individuals or communities affected' (Renaud et al., 2011: e7).

2.5 Conceptualizing key concept: vulnerability, adaptive capacity and migration

An early concept of vulnerability was observed in the context of resistance to the physical structures of natural disasters; however more recent observations relate vulnerability to characteristics of social and environmental processes (Cardona et al., 2012). "It is directly connected, in the context of climate change, to the susceptibility, sensitivity and lack of capacities of the exposed system to cope with and adapt to extremes and non-extremes event" (Cardona et al., 2012: 70). "In most cases, vulnerability is described in term of the potential to experience harm or from some event or condition, and this potential is related to factors that affect the likelihood of the even or condition occurring and the ability to cope with event if and when event occurs" (McLeman and Smit, 2006: 34). According to the IPCC (2007a) vulnerability consists of three basic conceptions such as exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Adger, 2006). Sensitivity is how affected a system is after being exposed to the stress (Engle, 2011), and the adaptive capacity represents a system that adjusts to the stress, mainly to lessen the negative impacts and take advantage of the opportunity (Engle, 2011). Exposure and sensitivity collectively explain the potential impact. If a system is highly exposed and sensitive to environmental change, this does not necessarily mean a vulnerability to environmental change as the capacity of a system to adapt is not taken into consideration (Fellmann, 2012). Therefore, in order to investigate the possible reactions of a system to environmental change, vulnerability assessments are often connected with adaptive capacity (IOM, 2009). Thus, a system is vulnerable if it is exposed and sensitive to the effect of environmental change and concurrently has only weak adaptive capacity (Thomas, 2012). The system is less vulnerable, if it is less exposed, and less sensitive with a stronger adapting capacity (Smit et al., 1999; Smit and Wandel, 2006; Fellmann, 2012).

Adaptive capacity varies considerably among regions, countries and socio-economic groups and will vary over time (Smit and Pilfosova, 2003). The highly vulnerable regions, communities or countries are those which have little capacity to adapt due to their limited economic resources, low levels of technology, poor information and skills, poor infrastructure, weak institutions, inequitable empowerment, and lower level of access to resources (Smit and Pilifosova, 2003). Thus, adaptive capacity has been found to be highly responsive to economic conditions, social relationships, cultural norms, and political and institutional arrangements (Adger and Kelly, 1999; Smit and Wandel 2006; McLeman and Hunter, 2010). The study of environmental change and variability evaluation has proceeded to address the need to predict how communities will adapt to changing environmental conditions (Hahn et al., 2009). Migratory behaviour to environmental change may be treated as one of the possible way by which people adapt to the adverse impact environmental change (Lemos et al., 2011). Although, recently several studies have made an effort to conceptualise vulnerability to environmental hazards (ADB, 2012) and many attempt to bridge the connections between the social, natural, and physical sciences, and are dedicated to exploring new methodological challenges (Polsky et al., 2007; Hahn et al., 2009), very few of them consider the relationship between climate change and migration in the context of vulnerability (Myers et al., 2008). Many of them rely on the IPCC working definition of vulnerability (described above) (Hahn et al., 2009). Based on this concept of vulnerability, McLeman and Hunter (2010) examine the relationship between climate change and vulnerability through a review of various case studies.

These are based on dry season migration in the West African Sahel, hurricane related population displacement in the Caribbean basin, winter migration of snowbirds to the US sun-belt and the 1930s drought migration on the North American Great Plains. Using similar concepts, (McLeman and Smit, 2006) looked at the migration behaviour in rural eastern Oklahoma in the 1930s and found both migrants and non-migrants to vary in terms of their economic, social and cultural capital endowment (Perch-Nielsen et al., 2008) including the scale of vulnerability of individual and families. There are debates about whether migration is an adaptation process or a failure of adaptation. Though many researchers see migration as an adaptive response to the increased stresses or shocks that may result from climate change (Laczko and Aghazarm, 2009; as noted by Black et al., 2001), others consider it the end result of failed adaptation (Boano et al., 2008; Barnett and Webber, 2009; as noted by Renaud et al., 2011), especially for poor people who lack of capacity to adapt to natural hazards (Kate, 2000). This is particularly the case for poor people whose livelihoods relied on natural resources and failed to adjust to natural hazards (Campana, 2010). Vulnerability and adaptive capacity are portrayed as non-linear patterns. Thus, as a coping strategy, migration may reduce environmental and socio-economic vulnerability (Warner et al., 2010). Therefore, environmentally induced migration can be considered as a function of exposure and adaptive capacity in a particular time and place and related to a specific climatic stimulus (McLeman and Smit, 2006; Black et al., 2011b). Adger et al. (2007) argues that migration due to the impacts of environmental change can be specified as the limits of adaptation strategies, but that non-permanent migration itself can be can be considered an adaptation strategy (Warner et al., 2009). This is because migrants have been found to strengthen the resilience of a community and increase their adaptive capacity by sending back remittances which acts as an important source of investment (Zehetner, 2013). Thus, internal migration plays an important role in reducing poverty, and is a catalyst for economic development (Deshingkar and Grimm, 2005). A survey on Hatia, an island situated off mainland Bangladesh, found just over a fifth of households (22%) to use migration as a coping strategy following tidal surges, and 16% following river bank erosion (Foresight, 2011: 13). My research follows the IPCC working definition to assess and compare the vulnerability of study areas. I will demonstrate this approach for the study areas which have been found to be highly exposed to the impact of climate change and are also socially and economically vulnerable. I briefly discuss in chapter 8 what the tipping points are that lead to migration being either a failure of adaptation, or lead to migration playing a vital role for building up adaptive capacity by reducing poverty.

2.5.1 What is vulnerability?

According to (UNISDR, 2005), vulnerability is the condition determined by economic, social, physical and environmental factors or processes which increase the susceptibility of a community to the impact of a hazard.

According to the IPCC's (2007) definition, vulnerability in the context of climate change is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC 2007a). In short, vulnerability is a function of the character, magnitude, rate of environmental change and variation to which a system is exposed, as well as the sensitivity of communities or socio-economic system that are affected and their adaptive capacity (IPCC, 2007a; McLeman and Hunter, 2010).

In this thesis I will define vulnerability as a function of exposure to the impacts of environmental change, in particularly climate change, arguing that the sensitivity of communities, household, individuals or socio-economic systems to stress leads them to various types of migration, while they are unable to cope with the adverse effects of such impacts of climate change. It is also notable that non-permanent migration may itself build capacity to adapt in those exposed, such that reduced vulnerability is a result of increase adaptive capacity (Adger, 2006; O'Brien et al., 2008; Brooks et al., 2005; Chambers, 2006; Chindarkar, 2012; McLeman and Hunter, 2010) (see the Figure 2.6).

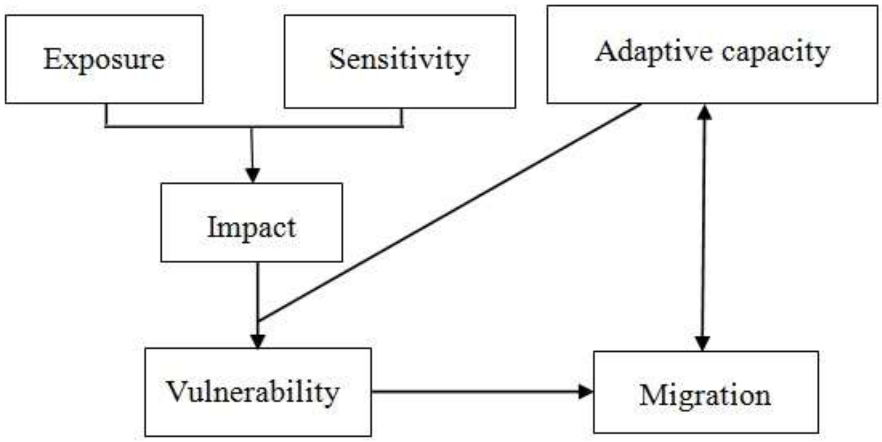

Figure 2.6: Concept of vulnerability and migration.

2.6 Factors influencing vulnerability

It is essential to understand how vulnerability is caused, how it increases and how it builds up, in order to manage natural hazards effectively (Cardona et al., 2012). Vulnerability is not due to a single cause, but rather is the outcome of a number of interconnecting drivers, including economic, social, political, cultural, demographic and environmental processes. Other important factors include the distribution of wealth, demographics, social networks, migration, employment patterns and access to technology, information and knowledge. In addition to this, societal values, governance structures and limited access to political power and representation also influence vulnerability (IPCC, 2014a, Cutter et al., 2003). Thus, it is the product of intersecting social processes that results in inequalities in socio-economic status, income, and exposure, including for example, discrimination on the basis of gender, class, ethnicity and (dis)ability (IPCC, 2014b). Through a combination of these factors and their context-specific dealings, they form a multidimensional vulnerability, with differential capacities and opportunities specific to individuals, households and communities (IPCC, 2014b). Due to an incomplete consideration of the interactions between economic, social and cultural factors to date, understanding future vulnerability, exposure and responses of interlinked human and natural systems is challenging (IPCC, 2014b). However, the intensity of vulnerability in a region is dependent on the extent to which these drivers are sensitive to environmental change and how much vulnerable people of the region have the capacity to cope. Thus, developing nations like Bangladesh are much more vulnerable than wealthy industrial nations, or developed countries (Brookes et al., 2005), as wealthy nations are better planned and prepared to bear the cost of adaptation to climate change impact and risk (Smit et al., 2001). Thus, in this research, poverty (Brouwer et al., 2007)and social status positively loaded (Cutter et al., 2003) as important indicators. Poverty determines both exposure to environmental hazards and vulnerability, as well as constraints to adaptive capacity (Brouwer et al., 2007). Generally, poor people tend to be more exposed to environmental events than wealthy people (Brouwer et al., 2007). The result of Brouwer et al. (2007) confirms the positive relationship between enviromental risk, poverty and vulnerabilty in Bangladesh. Moreover, poor households are more likely to stay near the river, and thus face more risk (Brouwer et al., 2007). A set of indicators have been used to investigate the vulnerabiltiy in study area (see section 2.6).

2.7 Environmental change vulnerability assessment

Measuring vulnerability is complex. It is dynamic, varying across temporal and spatial scales and accounts for a range of factors (Vincent and Alexandre, 2012). Vulnerability assessments use a variety of methods to combine the relationships between humans and their physical and social surroundings (Hahn, 2009). Vulnerability assessments have been used in a variety of contexts including the USAID Famine Early Warning System (FEWS-NET) (USAID, 2007), the World Food Programme's (World Food Programme, 2007) and a variety of geographical analysis combining data on poverty, health status, biodiversity and globalization (Chen et al., 2006; Hahn et al., 2009; O'Brien et al., 2004). In the 1960s and 1970s, researching social indicators of vulnerability was a popular topic within the social sciences, with volumes written on theoretical and methodological concerns (Cutter et al., 2003). Researchers and organizations have used several different methods to combine indicators (Hahn, 2009). The United National Development Programme's Index provides indicators of poverty and gender among nations (UNDP, 2000), as well as life expectancy, health, education and living standards in a later version (UNDP, 2007) to gain better overall picture of human well-being. "The U.S. Environmental Protection Agency (2002) used a small set of environmental indicators to track progress in hazardous remediation" (Cutter et al., 2003: 245). However, there is no consistent set of indicators used to measure vulnerability to natural disasters, in spite of repeated attempts (Cutter et al., 2003).

A set of commonly used composite proxy indicators are used to quantify vulnerability in this current study (Felmann, 2012) (Table 2.1). These indicators have been used to measure exposure to natural hazards and climatic variability, household and regional demographics, social, economic, and political characteristics that shape adaptive capacity, food insecurity, livelihood, water stress, poverty and sensitivity to climate change impact (Hahn et al., 2009). In the south west region of Bangladesh there are three crucial factors to consider: i) the effect of climate change on livelihoods (agricultural sector); ii) poverty; and iii) migration that is used as a livelihood strategy. Thus, migration can be used as a process of adaptation to environmental hazards. To quantify the scale of vulnerability, this research considered economic, social, demographic, political and physical factors. These factors include a range of indicators. Social assets refer to the social network of family, friends or relatives, water access, food security, and social support during the natural disaster. Economic assets refer to wages, income, livelihood diversification and remittance to increase adaptive capacity. Demographic assets refer to age and gender. Physical and political assets refer to institutional support, warning and associated collective action to reduce vulnerability (Brouwer et al., 2007). As vulnerability is driven by a range of drivers, (Adger and Vincent, 2005) recommended that context-specific techniques for assessing and quantifying vulnerability be used (Ahsan and Warner, 2014). The problem of devising vulnerability indicators is a scale issue (Adger et al., 2004; Brouwer et al., 2007). Variation in social and economic vulnerability to natural disasters can be explained at individual or community level (Brouwer et al., 2007). According to Adger (1998), individual (or household) vulnerability is determined by access to resources and the diversity of income sources, as well as by social status of individuals or households within the community. But collective vulnerability of a country, region or community is determined by other factors (Adger, 1998), but similar indicators are often used for both levels of analysis (for example, income is either measured at individual household level or a region) (Brouwer et al., 2007). The present study measured vulnerability at sub-district level and describes the indicators below.

Table 2.1: Factors and indicators used in vulnerability index.

Sensitivity	**Adaptive capacity**
Demographic: Most vulnerable age group, gender.	**Demographic**: Most productive age group for migrants, migrant member, Potential migration for work.
Social: Food insecurity, decline of social-economic movement, water stress and land conflict.	**Social:** Social network, social support. traditional/local knowledge.
Economic: Unemployment in males, access to credit with high interest (credit for migrate work). Households selling assets to migrate for work, Household below poverty level, Household income depends on natural resources.	**Economic:** Remittance, livelihood, access to credit without interest, non-farm activity.
Political: Relief miss-distribution, *char*-land and land occupied.	**Political:** Institutional support.
Physical: Vulnerable housing, poor access to safe water, landless households.	**Physical:** Access to safe water, cyclone shelter and brick built houses and housing tenure.

Children and elderly people are the most sensitive age groups to natural disasters (Cutter et al., 2003). This study will concentrate on three age groups: under 15; over 60 (these are the two most sensitive groups); and 15-59 (the least sensitive group). The 15 to 59 age group are the economically active population and play an important role in migration patterns. According to the 2011 census, 63% of the total population of Bangladesh are between the ages of 15 and 59, and the majority of them live in rural areas. They tend to move to urban areas. It is also important that most migrants, in particular non-permanent migrants, are included in the second group.

The current study considers poverty as an important determinant of individual or household vulnerability to environmental risk because it is directly associated with access to resources which affect both baseline vulnerability, and the ability to cope with the impacts of extreme events (Adger, 1998). Poverty both limits adaptive capacity and increases socio-economic vulnerability (Brouwer et al., 2007), meaning that the poor face more environmental risks than wealthy people (Brouwer et al., 2007). This study determines the respondents' poverty level by using various indicators (see chapter 3, section 3.4.4).

Moreover, the natural dependence on economic activity is also highly sensitive to environmental change, thus it is an essential factor of vulnerability that is constituted by reliance on a narrow range of resources leading to social and economic stress within livelihood systems (Adger, 1998). "These stresses are manifest instability and increased variance in income and risk of failure of particular sources, and in social instability as manifest through for example, the impact of migration" (Adger, 1999: 254). Despite an increase of non-agricultural activity and structural changes in the economy of Bangladesh, agriculture still accounts for 21% of GDP and continues to account for the largest proportion of the workforce (World Bank, 2007). Thus, decline in rural production is likely to cause large-scale migration to urban areas (Black et al., 2008). Remittances from migrants to the households left behind are generally undertaken for the purposes of reducing dependency and enhancing livelihood security and opportunities (Adger, 1999; Ellis, 1998; Stark, 1991). On the other hand, growing migration from rural–urban areas can be a sign of weak rural resilience and less coping capacity, and thus higher vulnerability (Vincent, 2004). Households in rural areas coped with environmental disasters by reducing expenditure, selling assets and borrowing (Lemos et al., 2013: 7). Thus, access to credit with and without interest and support from NGOs and the government are significant components that can influence vulnerability, particularly in post-disaster periods.

Social networks and social support is an important asset for migration. Migration should become progressively less selective in terms of the socio-economic characteristics of the migrants as network connections increase the possibilities for migration and reduce the physical and emotional costs of migration (Massey et al., 1993; Reniers, 1999: 679). Family, relatives and friends provide information and help about the destination, including jobs and housing opportunities Masssey et al.,1993;

Seto, 2011) Afsar and Baker state (1999), prior to migration, poor migrants invest their time and energy in contacting friends, relatives and neighbours in Dhaka. Consequently, with the help of their social network, three-quarters of these migrants secured their first job, and one-third of them had information about the job before arrival in Dhaka (Afsar, 2003: 3). Many families use migration as an investment and expect cash remittances from migrants (Mabogunje, 1990). These remittances play an imperative role in increasing adaptive capacity**.** Thus, social networks and migrant members who send remittance are also vital elements.

Food security is an indicator of the scale of the vulnerability. Natural hazard induced food insecurity in Bangladesh is more severe than in almost all other countries (Herrmann and Svarin, 2009). Bangladesh already has a history of food shortages post-disaster which leads to increases in the price of food. Due to this, poor people were unable to buy food. There have been 14 reported food shortages in Bangladesh between 1998 and 2008, of which thirteen were caused by flooding and subsequent effects (Herrmann and Svarin, 2009). Other than food security, water stress, land conflict and the decline of social-economic movements are sensitive issues that decrease adaptive capacity. Thus these are also taken into account as indicators of social drivers.

House ownership, housing quality and the situation in a settlement is an important component of physical vulnerability to immediate environmental events (Cutter et al., 2003; Brooks et al., 2005), particularly for rural Bangladeshi communities. Because most of the houses are built with low quality materials in rural Bangladesh, they are very sensitive to tropical cyclones and many poor households are located near to rivers. It is also notable that migrants from rural areas are likely to be poor and live in hazard-prone areas in poor quality housing (Adger et al., 2004). This is one of the main problems that migrants face concerning a lack of low cost, good quality housing in Bangladesh (Afsar, 2003).

2.8 The reality of environmentally-induced migration

The term 'environmental refugee’ was first introduced by Lester Brown of the World watch Institute in the 1970s and later defined by El-Hinnawi (1985) to portray people displaced due to an environmental reason (Massey, 2010; Black, 2001). Jacobsen (1988) and Myers (1997) have quantified the number of environmental refugees, but

Black (2001) argued that there are no environmental refugees. A number of other scholars have also challenged the term refugees (Black, 1998; Black, 2001; Kibreab, 1997; McGregor, 1993) UNHCR, IOM, OCHA have all criticized the term refugees in relation to environment stressors (Renaud et al., 2011), as the 1951 Convention mentioned the Status of Refugees (Refugee Convention) offers protection to individuals who are persecuted by a government or regime, societal groups, or individuals, on one of the five convention grounds (race, nationality, religion, membership of a particular social group, or political opinion (UNHCR, 2006; as noted by Renaud et al., 2011: e12). The term refugees defined in this way is not appropriate for describing those who are displaced by environmental stressors (Warner et al., 2011). Thus, in order to protect people from environmental events, several researchers have attempted to develop the idea that a new category of refugees is needed (Warner et al., 2010) to address the issue more scientifically and systematically (Warner et al., 2010) and to debate on a professional basis (Renaud, 2007). Hugo (1996) and Bates (2002) suggest the concept of 'environmental emigrant' instead, as environmental change is a factor that drives involuntary migration. This term became popular to environmentalists, ecologists, and development activities (Massey et al., 2010; Suhrke, 1994).

The debate among scholars, social scientists and international bodies has moved on to distinguishing environmental migrants from a general category of migrants, where the decision making process of migration is influenced by environmental change to some extent (Leighton, 2010: 325). Renaud et al. (2007, 2010) identified three categories of environmental migrant (mentioned in the section 2.4). Warner et al. (2010) used the term 'environmentally induced migrant' to characterise cases where people have to move due to environmental stressors. However, the distinction between these various types of migration patterns is a challenge due to the simultaneous consideration of space and time, dynamic human attitudes and internal and international characteristics of migration (Leighton, 2010). The current study uses several names for migration which are described in the next two sections.

Since the concepts of migration and displacement are often interwoven, it is also necessary to distinguish between these two different types of movement. In the wider literature, the term 'migration' is used as an umbrella term to cover both voluntary 'migration' and involuntary 'displacement' (Foresight, 2011). "Whilst it may be confusing in places to refer to migration and displacement as two forms of 'migration', this reflects the fact that these words are used interchangeably within the wider literature" (Foresight, 2011: 35). Migration is "the relocation of people within space that involves their permanent or temporary change of residence" (Mafukidze, 2006: 103) and, displacement is where a person is suddenly forced to leave his or her habitual residence (IOM, 2009). This is characterized by movement to the nearest safe location and is the most common response to immediate threat (Raleigh et al., 2008). Such migrations cause temporary displacement, but are not usually permanent as these migrants often return home after the event (Raleigh et al., 2008). Cyclone victims, for example, could be defined as displaced as these people have the opportunity to return or rebuild their houses following the cyclone. However river bank induced displacement could be considered forced migration because the victims of river bank erosion will have lost their houses and possessions. It means that they will never return their home and have permanently moved. This research considers migration induced by both cyclone and river bank erosion as forced migration if the victim moves permanently even if it is a short distance. In addition, terminology of displacement has been used as temporary movement or taking shelter during the event who return their home after the event.

2.9 The vulnerability of rural areas and possible migration outcomes

In this thesis I have distinguished the various types of migrant who are dependent on the decision making process, which is shaped by the nature and intensity of environment changes and its impact, vulnerability and capacity to adapt to such impacts. This leads affected people to move or stay (Figure 2.7). I hypothesised various patterns of migration such as environmentally motivated socio-economic migration, environmentally forced migration, displacement and traditional rural-urban migration from rural affected areas (origin).

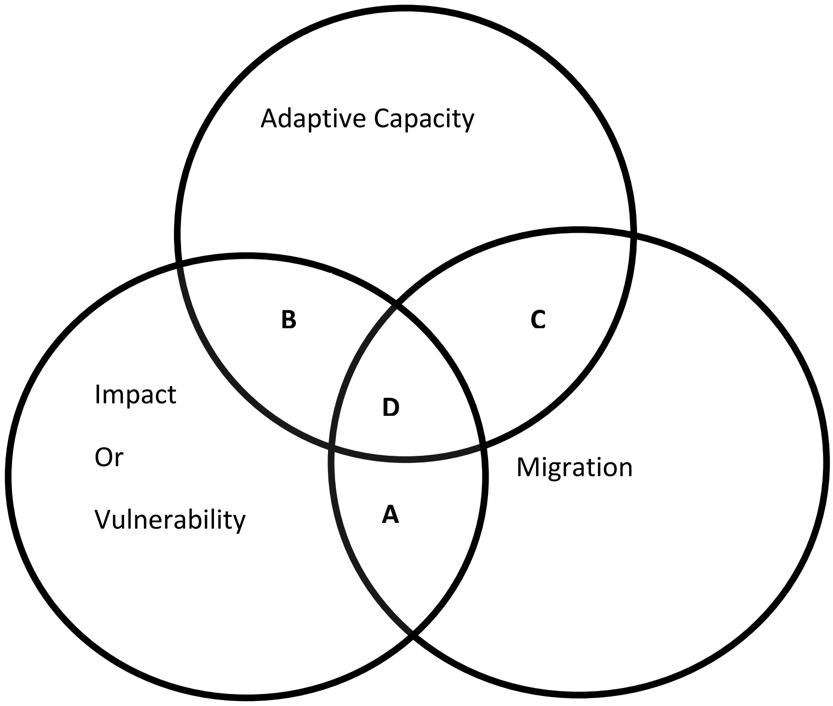

Figure 2.7: Various types' migration from rural vulnerable area (origin). Idea is based on the diagram of conflict, poverty and environment by Raleigh (2011)

A: Environmentally forced migration or force to stay.

B: No migration

C: Socio-economic migration or traditional rural-urban migration

D: Environmentally motivated migration

The most dangerous situation is A, where affected people have no option but to leave in order to avoid the worst environmental deterioration (Renaud et al., 2011). But the ability to migrate as an adaptive strategy is not necessarily reachable to all, (McLeman and Smit, 2006). People with less social and financial capital can get trapped in their regions in environmentally vulnerable and degraded settings (Kniveton et al., 2013, Foresight, 2011). Thus, many poor people are unable or unwilling to relocate; the Foresight report argued that this group are a hidden 'trapped population'. This group will face the greatest risk, which may be exacerbated by maladaptation polices designed to prevent migration (Black et al., 2011c). It is very important to understand why other people are forced to stay or choose to stay though they are similarly vulnerable to environmental stress. In situation B, those who have the adaptive capacity and face environmental challenges may not migrate. This group is mainly middle class. In situation C, all types of class of people are included. This is traditional internal migration. This type of migration takes places from rural to urban in Bangladesh due to population pressure, a lack of economic opportunities, debt and pull factors such as urban growth and increase in productivity in the industry and service sector (Walsham, 2010). Moreover, most of the economically active population living in rural areas, are encouraged to seek better employment opportunities in non-agricultural sectors in urban in Bangladesh (Herrmann and Svarin, 2009: 2). In situation D, this group is similar to group C, but face environmental hazards that have negative impacts on agricultural production. Thus, they are largely motivated to move due to environmental challenges. The last two types of migration are mostly temporary and seasonal. As an example, following tropical cyclone Aila there was a major increase in seasonal migration from affected areas, with an estimated 100,000 people moving from the four sub-districts south west of Bangladesh alone (Walsham, 2010). Also, slow onset environmental events affect on agricultural productivity which lead to decisions to move to Bangladeshi cities (Walsham, 2010). These types of migrations have contributed to an increase in adaptive capacity.

2.10 The vulnerability of urban areas and urban migrant-receiving areas

Many people in the world are already migrating from rural to urban areas, in some cases motivated by environmental factors. However, it also the case that cities themselves are at risk from environmental hazards (Adger et al., 2012), in particular cities that are located on flood plains are vulnerable, as well as those in low elevation coastal zone dry lands, and mountain regions where inundation, reduced availability of water resources and threats to health produce negative experiences for residents (Foresight, 2011). Many cities, such as Dhaka, already face urban flooding and water logging most years. Such cities are growing rapidly due to rural-urban migration trends, as well as being increasingly threatened by environmental events (Foresight, 2011) such as coastal and riverine flooding as well gradual changes such as a shortage of water due to rainfall decreases and glacial retreat (Adger et al., 2012).

According to Foresight (2011), one potential future scenario is that approximately 190 Million additional people will live in urban coastal floodplains in Africa and Asia

(Adger et al., 2012). As an example, “Dhaka is an important destination, but with the more than 16 million residents itself highly vulnerable to socioecological degradation and to the impact of climate change” (Alam and Rabbani, 2007). Indeed, “Dhaka’s vulnerability to flooding and cyclonic events brings into doubt its role as a destination for the displaced- temporary or permanent” (ADB, 2012). However, vulnerability to migrants’ varies on the basis of migrant’s adaptive capacities. There are also many poor people who have no capacity to adapt in rural affected areas, and such as make the decision to move to the city. Therefore, as I discuss in chapter 8, there are various form of migration and also different types of migrant, who are motivated and categorised by five drivers which were revealed from analysing the decision making process. There is also evidence to suggest rural-urban migration plays a significant role in poverty reduction and that the economic dynamism of informal settlements offer employment opportunities for rural-urban migrants which in turn, can lead to poverty reduction (Adger et al., 2012: 2). Thus, migration is a significant issue for diversification processes in rural Bangladesh (Toufiq and Turton, 2000).

2.11 Conclusion

Overall this chapter describes the theoretical perspectives and key concepts of the research.

My research objective is to study the linkage between environmental changes, in particular climate change, and migration within the concept of vulnerability that I viewed as a function of exposure, sensitivity and adaptive capacity to hazards

The research approach considered three key concepts; environmental change, adaptive capacity and migration. Linking back to the aims of this thesis (see chapter 1, section 1.6), my central hypotheses are:

I. Environmental drivers are the main cause of migration from environmental change impacted areas in Bangladesh.

II. Environmental drivers interact with other effects to create different forms of migration or to influence the individual decision-making process during migration.

III. Migration is the result of vulnerability.

IV. Economic affordability, social networks, social support, traditional culture and livelihood influence people to move or stay, although they face similar environmental problems.

V. Environmental drivers effect the mobility of poor people. Specifically, poor people are more likely to migrate shorter distances (locally) than longer distances.

VI. Migration has significant effects on urban areas in the context of societal issues. Poor migrants are at high risk in urban areas in the context of adaptive capacity, sensitivity and exposure.

The research carried out to explore these hypotheses took the form of fieldwork and showed that migration occurred due to environmental change. Usually, people below the poverty line live in vulnerable conditions in both rural areas and slums in the city. They can move to take advantage of better opportunities easily. I concentrate on those poor who are less mobile, and who might be displaced and forced to migrate over short-distances. From the vulnerability index, a comparison of localities has been set up in relation to migration. Migrant families and non-migrant families were verified to measure their adaptive capacity. From this point of view, my research addressed how and under what circumstances migration plays in increasing adaptive capacity. The research also considered the societal crisis occurring due to migration into urban areas. The reaction of non-poor and local respondents provided useful evidence to back up this hypothesis.

Chapter 3

Methodology

3.1 Introduction

The previous chapter described migration theory and its links to environmental change. This chapter introduces the research process and methodology. Methodologies on researching environmentally induced migration are weakly connected in many studies because; migration naturally has numerous causes as well as being interwoven with different drivers (Piguet et al., 2011) (described in the previous chapter). Thus, I faced a methodological challenge from the beginning of the research to link environmental change and its impact on migration. As such, in order to answer the research questions, I explored physical changes using statistical regression analysis of meteorological variables and remote sensing data**.** In response to environmental events and changes, qualitative methods were used to obtain respondents' reactions both in rural and urban contexts**.** I have also set up some indicators to construct an index of vulnerability to compare different localities. I began the chapter with a description of the physical area of study. Then I begin the human dimensions of the study that cover the general context of the fieldwork, selection of study areas, sampling methods, and key issues for interviews. Following this, I draw a linkage between the social and physical element of my study. I also discuss some modifications that I made to the sampling methods, my fieldwork experience, the strengths and limitations of the fieldwork, and the methodological challenges of the research.

3.2 Mixed approaches for physical and human geography research

The research combines physical and human geography using qualitative and quantitative approaches. Table 3.1 shows data both type of geography with quantitative and qualitative data. However, details data sources and methods have been discussed in a separate section below.

Table 3.1: Quantitative and qualitative data (different colour has been used to display physical and human dimensions).

<table>
<tr><th colspan="2">Quantitative Assessment</th><th colspan="2">Qualitative Assessment</th></tr>
<tr><td rowspan="2">Physical dimensions</td><td>Hydro-meteorological data, tidal gauge data and cyclone and depression data</td><td rowspan="2">A standardized semi-structured, open-ended, in-depth interview (face to face interview).</td><td rowspan="4">Human dimensions</td></tr>
<tr><td>Remote sensing data (Landsat Image and GMTED)</td></tr>
<tr><td rowspan="2"></td><td>Census data</td><td>Focus group</td></tr>
<tr><td>Individual and household questionnaire survey</td><td>Observations</td></tr>
</table>

3.3 Physical dimensions: data source and methods

The investigation of the physical geography of the area under study is based on various sources of secondary data that includes hydro-meteorological data, tidal gauge data and cyclone and depression data. The time series of average monthly temperatures (1948-2010) and total monthly rainfall (1948-2009) for 24 selected stations in Bangladesh were collected from the Bangladesh Meteorological Department (BMD). There was some data missing from this source. Data gaps were filled by linearly interpolating from neighbouring temporal points, however years with large data gaps have been excluded.

Bangladesh is split into seven regions determined by the physiography of the country and its response to the general climatic patterns discussed in appendix 2. These regions are shown in figure 3.1, along with the location of the climate and river discharge stations within each region.

The daily river discharge data of seven stations has been collected for different times subject to availability from the Bangladesh Water Development Board. The seven stations are Bahadurabad (data from 1956-2006), Kaunia (data from 1960-2006), Harding Bridge (data from 1934-2006), Baruia (data from 1967-2006), Kanairghat (data from 1970-2010), Sheola (data from 1970-2011), and Bhairab (data from 1980-2010). These stations have been considered because Bahadurabad, Kaunia, Harding Bridge, Kanairghat, Sheola are located near the Indian border and are vital sources in order to calculate river discharge from upstream. Furthermore, Baruia, and Bhairab are the confluence point of Ganges and Jamuna (Brahmaputra) and Meghna and old Brahmaputra (Figure 3.1). There is some missing data from April 1971 to March 1972 for all stations, and also in 1995, 1999, 2003 and 2004 for Baruia and 1981 and 2001 for Sheola. Short data gaps were filled by linearly interpolating across the gaps using the same technique as for the monthly temperature and rainfall. Years with large data gaps have been excluded as they were for monthly temperature and rainfall. At Bhairab, only the monsoon season has been considered due to the high number of data missing in the non-monsoon seasons. The seasonal and temporal variability of climate data and river discharge for the selected stations of the Bangladesh sections of the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna basins have been examined using regression analysis to investigate the linear trends over the period.

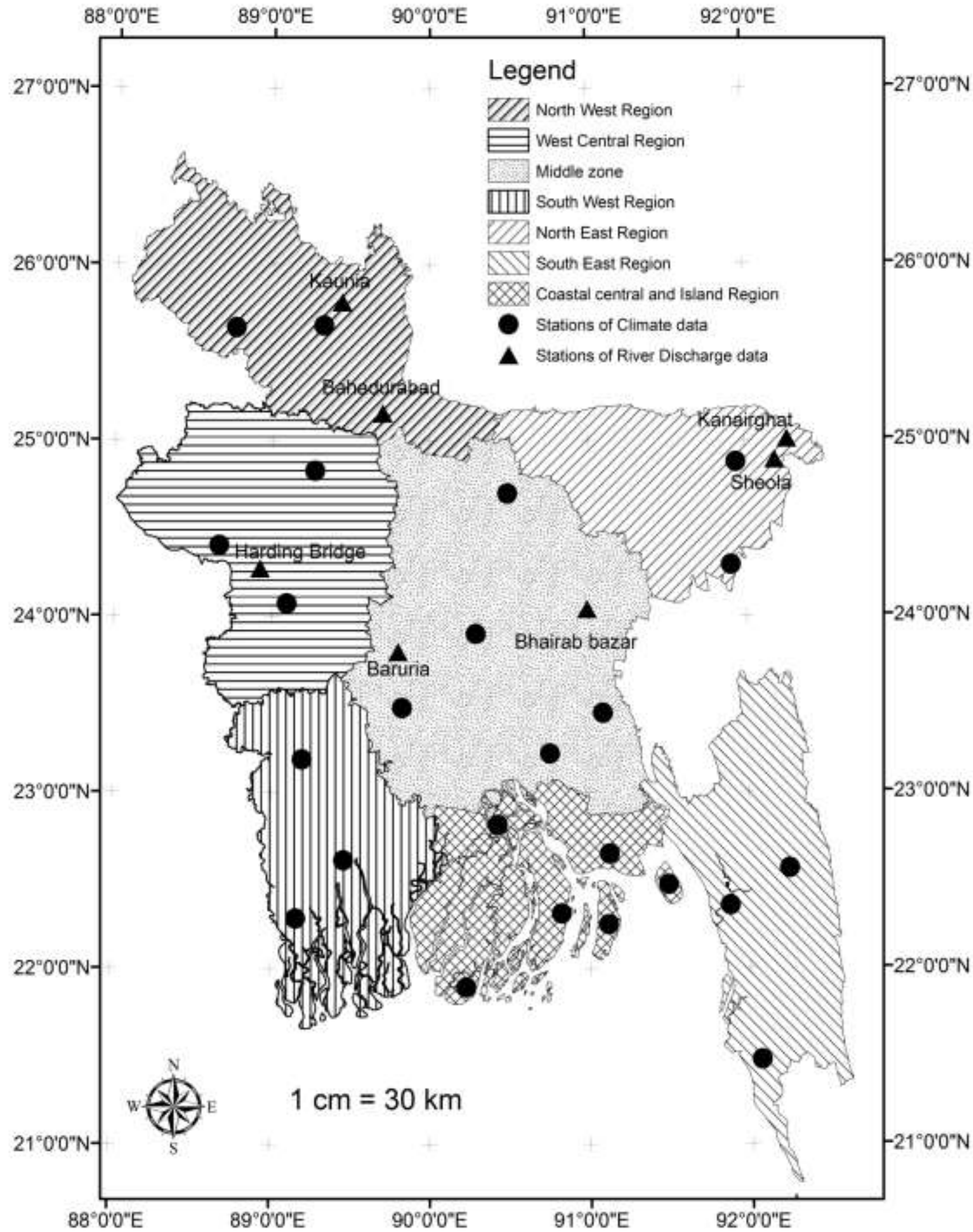

Figure 3.1: Location of the stations of rainfall and river discharge. For a description of the different regions see appendix 2.

Mean tidal data for four stations has been collected from the Bangladesh Inland Water Transport Authority (BIWTA). These include: Hiron Point (1977-2010), Khepupara (1977-2008), the Char Changa (1977-2005) and Cox's Bazaar (1977-2008): Of the four stations, the first three stations are located on the Ganges-Brahmaputra-Meghna delta coastline, while the last one (Cox's Bazaar) is located on the south eastern coast (Figure 3.2). Figure 3.2 also contains a hydrological classification of the GBM delta, as described in section 6.2.

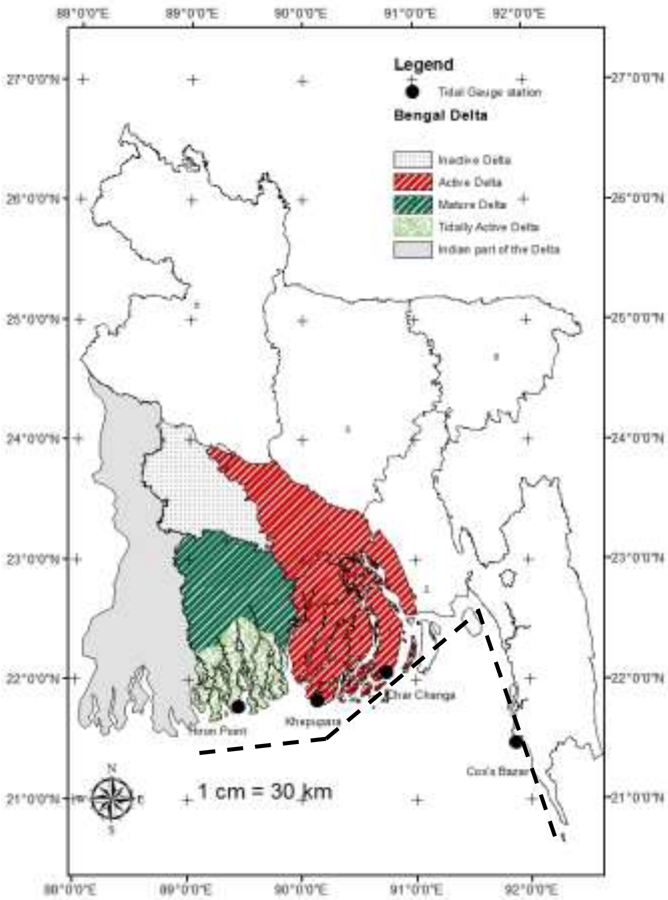

Figure 3.2: Hydrological classification of the GBM delta (dashed line shows the west, central and east part of the coastal zone).

Global Multi-Resolution Terrain Elevation Data 2010 (GMTED 2010) has been used to examine the potential sinking of land in the scenarios of an increase of sea level of 50 centimetres, 1 metre and 2 metres respectively. The value was reclassified into 2 classes, below 50 centimetres or above 50 centimetres marking two different types of colour to make more visible (Figure 6.2a). Similarly, for 1 metre and 2 metres scenarios have been calculated (Figure 6.2[b and c]). The population census of 2011 was collected from the Bangladesh Bureau of Statistics (BBS). The population of the southwest coastal area was subsequently computed for each of the three different sea-level scenarios. Calculations have been shown in table 6.4.

34 years' worth of data (1974-2007) on monthly cyclones and depressions formed in the Bay of Bengal and crossing the different parts of the coast was collected from the Bangladesh Meteorological Department (BMD). Appendix 3 shows their classification of cyclones.

Remote sensing from a series of satellite images can be used to examine the change in land use and land cover over time and scale (Laczko and Aghazarm, 2009). This is now being widely used to identify and quantify river morphological analysis (Sarma et al., 2007; Islam, 2013). Satellite-image studies of the Ganges-Brahmaputra-Middle-Meghna rivers show that an area of 1063 km^2 has been lost due to erosion between 1982 and 1992, while the accretion amounted to only 193 km^2 (Siddiquee and Hoque 2011). An analysis of the bank lines of the Jamuna river derived from time-series satellite images shows the river has been widening since the early 1970s but the early rate seems to have reduced significantly since the late 1990s (Sarker et al., 2003).

Geological Survey's (USGS), Earth Resources Observations and Science (EROS) centre over a period of forty years (1972 to 2012). These are 1972, 1973, 1980, 1988, 1999, 2003, 2004, 2009 and 2012. These periods have been chosen on the basis of availability in dry season. The data were extracted in dry season because there are highly seasonal variations in rainfall and river discharge between the dry and wet seasons in Bangladesh (see the chapter 5, section 5.2 and 5.5.1). These satellite images derive from different Landsat instruments, from Landsat 4 onwards. The satellite images of an area of 2640 km^2 (60 km x 44 km) of the lower Meghna basin have been analysed for the rate of erosion and accretion of land using ARCGIS 10.

Linear regression technique was applied to investigate the trends of temperature, rainfall, sea level rise and the frequency of cyclones.

3.3.1 Classification of season

Bangladesh has a tropical monsoon climate characterized by a relatively cool, dry season from November through February, a pre-monsoon hot season from March through May, the rainy summer monsoon from June through mid-October and a short and mild autumn season from mid-October to mid-November (Ahmed and Kim, 2003). Due to monthly average data, in this thesis December- February is conceptualised as ‘winter’, March-May as ‘pre-monsoon’, June-September as ‘monsoon’ and October –November as ‘post-monsoon’.

3.4 Human dimensions: general context of fieldwork

A survey is not just a particular technique for collecting data: questionnaires are very widely used but other techniques such as face to face in depth interviews, observations and focus groups can also be used in social research (Vaous, 2014). Research with respondents was conducted in two key ways: firstly through questionnaires, which are usually completed using pencil and paper by respondents and another is interviews (Trochim, 2006). Factual questions such as ‘what is your age?’, or ‘have you moved?’ or ‘do you have social networks?’ (see questionnaire in appendix 4) are best dealt with by questionnaire survey but anything that requires depth or investigation is not suitable, and requires open-ended questions in a questionnaire to write the answer (Gillham, 2000). Examples of such questions in this study include: ‘did you face any environmental problem that influenced you taking the decision to move?’ ‘What types of environmental problem have you faced? Why?’ (see questionnaire in appendix 4). “However, people often can’t be bothered to make an adequate response here: the task of writing being involved” (Gillham, 2000: 13). Moreover, many rural poor respondents in the developing country context like Bangladesh are not literate enough; many of them cannot read or write. Thus, both questionnaire and interview were completed by the author acting as interviewer. Conducting interviews and questionnaire surveys at the same time with the same set of respondents ensured time efficiency. In relation to environmental change and migration dynamic research, the questionnaire survey can be combined with a number of open-ended questions allowing respondent to provide complete qualitative data on a number of topics (Robson, 2010).

Interviewing is one of the most useful qualitative techniques. This is a powerful way to achieve insight on particular social matters enabling the researcher to understand the experiences of the individual (Seidman, 2006: 14). An interview is a guided conversation. It seeks to cover both factual and interpretive aspects, although interpretive data is more difficult to analyse (Kvale, 1996). The key task in interviewing is to know the meaning of what the interviewees say (Kvale, 1996). “One advantage of qualitative methods in exploratory research is that use of open-ended question and probing gives participants the opportunity to respond in their own words, rather than forcing them to choose from fixed responses, as quantitative methods do" (Mack et al., 2011: 4). Interviews may also be valuable as a follow-up to chosen respondents' questionnaires or from focus groups, for example, to further examine their replies (McNamara, 1999). A face-to-face interview has its challenges, namely that the interviewer has to ensure the discussions stays on topic without biasing the results.

Qualitative interviews have been categorised in a variety of ways, such as; structured interviews, semi-structured interviews, unstructured interviews and focus groups (Robson, 2011). Semi-structured interviews have a list of questions or fairly particular topics to be covered, often referred to as an interview guide, but the interviewee has a great deal of flexibility in how to answer (Bryman, 2012: 471). This also produces and modifies further unplanned questions from what the interviewee says (Robson, 2011). However, the semi structured interview varies significantly in the quantity and quality of evidence that is being created (Terry, 2011). To understand the linkage between physical characteristics of natural resources and human interaction with environment this method can be useful (Robson, 2010).

For this work, the human element of the research was carried out through a standardized, open-ended interview (face to face interview), some closed ended questions and three focus groups to determine the reaction of the three categories of people: firstly, those who might be displaced and be forced to migrate; second, migrant people who have already migrated to the central part of the country as a destination due to job availability, food security and other resources; third, the communities that receive these migrants. The questionnaire survey was carried out to collect numerical data in relation to migration patterns and social vulnerability. Questionnaire surveys and quantitative information from the interviews contribute to a) produce a vulnerability index for urban and rural areas; b) distinguish individuals for whom environmental factors are the primary driver of migration; and c) generate individual and household information (Orchard et al., 2015). This included: age, occupation and landownership, the number of family members, and the number of earning members in a household. In depth semi structured interviews were conducted to investigate comprehensive information in relation to environmental change induced migration. Life histories and the experience of respondents, especially older, female respondents, female heads of household and families who have sent family members elsewhere for jobs along with the views of poor households are given priority in the research and an enable an elaborate picture of how the environmental change impacts on migratory behaviour to be developed (Schmidt-Verkerk, 2011). This also generates poverty level, food, water and livelihood security, shelter and experience of crime or conflict**.** Semi structured interview clarified a) reason for moving and not moving and its relationship with distance; b) nature of migration; c) how environmental drivers interact with others to create different forms of migration or to influence the individual decision- making process; d) whether migration is the result of vulnerability or whether it reduces vulnerability by increasing adaptive capacity and e) societal issues in regards to migration.

In a focus group, more than one person at a time is interviewed to collect qualitative data. There is an emphasis in the questioning on a particular fairly tightly defined topic, and the accent is upon interaction within the group and the joint construction of meaning (Bryman, 2012: 502). Yet a focus group can have advantages and disadvantages (Schmidt-Verkerk, 2011). This system is easier, faster and less costly for data collection and it produces more information. However, a key challenge of this method is to maintain the control of the group, which may be difficult for the researcher. In this project focus groups were gathered for interviewing in homes and work places. Ten to twenty people gathered together and the questions were open-ended, allowing them to generate different types of answers. This technique was used to draw upon respondents' attitudes, feelings, beliefs, experiences and reactions in ways that would not be feasible using other methods (Gibbs, 1997). In this research, focus groups provided similar content to interviews and provided a discussion of the social crisis participants encountered in their new home, competition for jobs, shelter and resources with the local respondents. The focus groups also provided information on the attitude and reaction of local respondents against the migrants.

3.4.1 Key issues for interviews and designing the questionnaire

In rural areas the topics cover the pattern, scale and reason of movement in particularly focusing on poor vulnerable people. Questions included: how environmental change impacts on migration?; who migrates due to environmental change?; where they move (distance related)?; who are unable to migrate and reasons for not being able to move, although they face similar environmental problems?; who are the vulnerable people in the study areas? Research also attempted to identify vulnerable regions using indicators to make relationships with migration and adaptive capacity. How do environmental drivers interact with other effects to create different forms of migration or influence the individual decision-making process during migration?

In urban areas, the topics covered within interviews of migrants ranged widely. The core of the interviews sought information on the reasons for their migration, any social problems they encountered in their new home, and the local competition for jobs, shelter and resources. The topic of conflict in their place of origin was also broached. This could be ethnic conflict, individual or political conflict, conflict in the family, conflict in the community and competition for resources like land/water/shelter/jobs. During interviews of the receiving communities, individuals were asked about a number of issues. These included the following: 'how did they view migrant people?'; 'where do they think the area receives migrants from?'; 'are there any differences in attitude toward migrants from different regions?'; 'are they (the hosts) facing any problems they consider is associated with migrants and if so, what types of problem?' They were also asked about their perception of conflict relating to the migrant community: ethnic conflict, individual conflict, political conflict, conflict in the family, conflict in the community, and competition for resources.

Three comparable questionnaires were constructed for migrants, migrant-receiving communities and non-migrants (Warner, 2011). Each questionnaire consisted of three sections. One general section that contains the profile of the respondent and household, a second section designed with specific objectives (Brouwer et al., 2007) and a third section for further opinions of respondents, as well as thanking them for their time. The questionnaire was written in Bengali in a very easy and understandable manner. An English copy of the questionnaire has been included in appendix 4.

Shorter closed questions were used in the questionnaire for ease. These questionnaires were used as a start point for in depth interviews, sometimes lasting around 40 minutes. In order to statistically generalize the research, the original plan was to select 200 households for each study area, and a few dozen interviewees were planned to select to gain a cross-section of experiences. It was necessary to reduce the sample size for questionnaires and draw on the same set of respondents for the interviews so the fieldwork could be completed in the time available. Ultimately more interviews were conducted than originally planned. This meant that the volume of transcription and analysis was challenging but did have advantages. Since both the questionnaire surveys and in depth interviews were conducted at the same time with the same set of people, sometime the word interview refers to both processes and these people who undertook the interview and questionnaire session are referred to as respondents. However, those who took part in focus groups are referred to as participants (Dixon et al., 2014).

3.4.2 Rationale for selection of the study area (rural and urban)

Two separate periods of fieldwork were carried out. The first phase was undertaken from November to mid-December 2010 and the second from the end of October to the end of November 2011. In the first phase, the two cities of Dhaka (a mega city) and Comilla (a medium sized city) were selected as sites for interviews and questionnaires with migrants, and hosts. Both reside in the central, most economically developed part of the country (Figure 3.3). The first study site was Dhaka, the capital and most populous city of Bangladesh, as well as the district and divisional headquarters. It is a centre of commerce, finance, education, health care, media, and professional services. Thus, Dhaka is an attractive destination for migrants. Dhaka is bounded by two major rivers, the Brahmaputra and the Meghna (Huq and Alam, 2003), as well as numerous smaller rivers and *khals*. These include Buriganga to the south, Turag to the west, Tongi *khal* to the north and Balu to the east (Huq and Alam, 2003). The city has been rapidly expanding due to its political, economic and cultural importance (Ahsan, 1997). The second study area is the medium-sized city[1] Comilla. Comilla is a historic city which traditionally had one of the most vibrant urban centres, largely due to its strategic location, providing a link between the country's two largest cities, Dhaka and Chittagong (Muzzini and Aparicio, 2013). Comilla has a large cluster of footwear

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[1] **Note:** The definition of medium-sized cities is a subject of debate (Kim, 1987). It depends on the scale one looks at (Giffinger et al., 2007). In a Bangladeshi context Comilla could be considered a medium size city based on its population size.

manufacturers (Muzzini and Aparicio, 2013), and is also well known for textiles and cottage industries. Most of the city is over 10 metres above sea level and therefore tends to be a flood-free area (Figure 3.3).

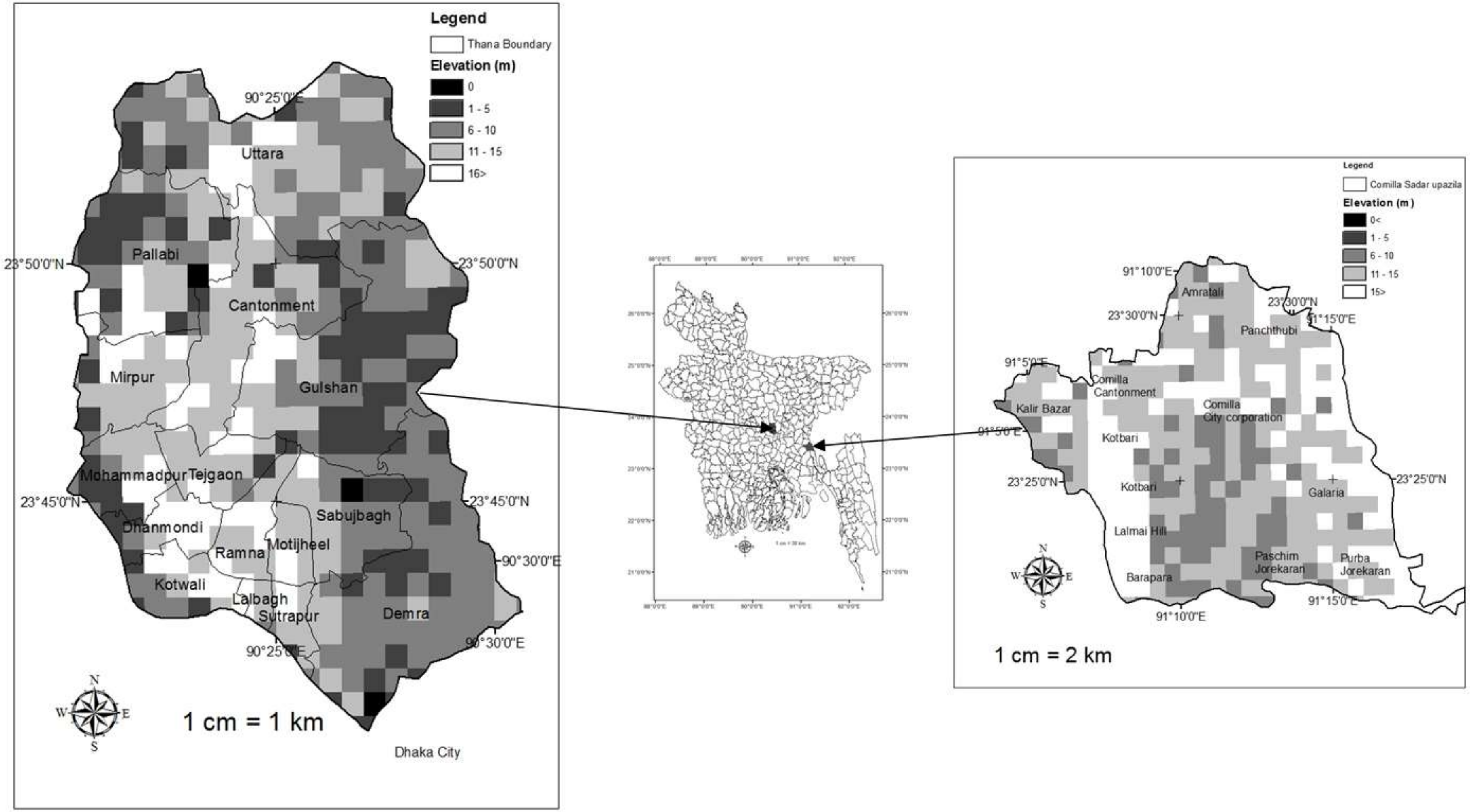

Figure 3.3: Location of Dhaka (left) and Comilla city (right); [Global Multi-Resolution Terrain Elevation Data 2010 (GMTED 2010) has been used to examine elevation of these two cities]

In the second phase, rural communities and urban communities in the delta have been selected (Figure 3.4). People in rural areas have a low capacity to adapt to environmental change due to their poverty and dependency on the local environment. This can influence such people to migrate from rural to urban areas. The former were the two divisional headquarters of the delta: Khulna and Barisal city. The two divisional headquarters were selected because these are the potential first destination for internal migrants, being in relatively economically developed regions. In order to study rural communities, four *upazila* were selected, located in the hinterland of these headquarters: Tala and Shyamnagar *upazila* of the Satkhira district, which is in the very southwest of Bangladesh, adjacent to West Bengal, India; Sharankhola *upazila* of the Bagerhat district which is exposed to the sea, and belongs to the Sundarbans forest; and Mehendiganj *upazila* of the Barisal district which is on the lower Meghna. These four sub-districts are affected by different types of environmental events (Table 3.1).

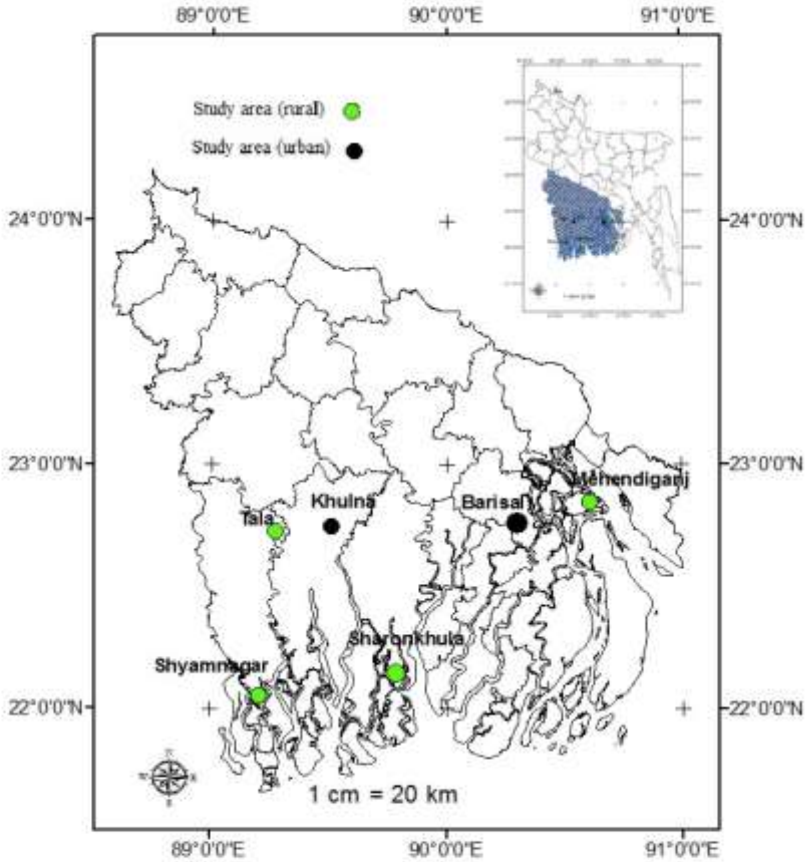

Figure 3.4: Location of study site in the delta region (separate maps demonstrating the effects of environmental event are included in appendix 5[a-d]).

Table 3.2: Impact of different environmental events on different places.

District	*Upazila*	Gradual climatic stress/slow onset event			Sudden climatic shocks/sudden onset event			
		River Bank erosion	Coastal erosion	Salinity	Tropical cyclone	Coastal flood due to storm surges	Flash flood	flood
Barisal	Mehendiganj	Higher						Medium
Bagerhat	Sharankhola		Medium		Higher	Lower		
Satkhira	Tala						Higher	
Satkhira	Shyamnagar		Medium	Higher	Higher	Higher		
The intensity of climatic stresses and shocks is based on observation and respondents' interviews.								

Khulna is a delta city of 45.65 km^2 lying on the banks of the rivers Rupsha and Bhairab (Murtaza, 2001). It is the divisional headquarters of the Khulna division (chapter 8, figure 8.2). Khulna is the third largest city in Bangladesh after Dhaka and Chittagong (Hoque et al., 2010). During 1950-1970, a large-scale industrial unit was developed in this district (Mia, 2002) which made it a commercially and industrially important place. The country's second seaport and site of the only ship-building yard, Mongla port, is also located within the Khulna division. Though some of the industries have closed down since then, the city's importance again increased upon the opening of a shrimp processing factory in the late 1980s (Mia, 2002). The city is also the gateway to the world's largest mangrove forest: the Sundarbans. This area attracts tourists and nature photographers from home and abroad. All these factors add to the economic base for Khulna.

Barisal is a river port city of 20 km^2 (BBS, 2012). It is the headquarters of Barisal Division and situated in central southern Bangladesh (see chapter 8, figure 8.2). It is situated at one of the most important geographical location of Bangladesh as three large rivers - the Ganges, Brahmaputra (Jamuna) and Meghna - pass through Barisal before merging on their way to the Bay of Bengal.

3.4.3 Sampling method

Different types of sampling methods were carried out for collecting data in both rural and urban areas. Both probability and non-probability sampling methods were chosen in collecting data such as individual or household questionnaire surveys, in-depth interviews and focus group. A convenience sample based on spatial clusters was used to identify respondents in both rural areas and slum areas in the city, and could be considered pseudo-random. Non-probability sampling methods such as snowballing, purposive and convenience methods were chosen in urban areas as it was appropriate for research during which the population of interest is not fully visible, and in cities like Dhaka, it is often difficult to find climate induced migrants (Warner, 2011). "This sampling method is used in studies of 'hard to find' populations or 'any small population for which it is impossible to construct a sampling frame'" (Bernard 2000, 2011; Flick 2009; as noted by Warner, 2011: 12). However, these sampling methods were used based on the context of the different places and situations. For example, to find local people in Dhaka is very difficult as the majority of the people in the city today have migrated from all over the whole country for a variety of reasons. Many of them have permanently settled and are addressed as locals. However, there is one small area named old Dhaka (locally known *Puran* Dhaka) where most of the people are non-migrants, and are known as *Dhakya*. But to find out the attitudes of local people about migration to the city, in particularly climate induced migration, is more difficult in the old city. Thus, within Dhaka, a range of areas were chosen for fieldwork in order to give a socio-economic cross-section. These were Gulshan Banani, a higher class area (Figure 3.3 left), and the middle class areas of Khilgaon, Goran, Meradia and Madartek (Figure 3.3 left). A commercial area named Motijheel was selected for interviewing some officers. Respondents who had migrated before the 1980s were considered as local.

To obtain a sample of poorer people, Wapda Banani lake slum, a road side slum in Banani, Korail slum in Gulshan and Banani, a slum on the roadside and alongside the rail-line in Khilgaon and Malibagh, and a small slum in Goran were selected for fieldwork. These slums were selected at random. Pseudo-random convenience sample was used to select the respondents from the slums by pre-selecting areas and approaching as many potential respondents in these areas as possible. This was less time consuming and also feasible approach to conducting interviews with slum-dwellers in Dhaka. Moreover, most of the slum dwellers are rickshaw pullers, house-maids, day labourers, van pullers, construction workers, garments workers and beggars. Many of them are not available during the day. Thus a simple random sampling method may have missed lots of respondents. As an example, there were 15 households in one slum, and among them only five households were available during the interview time. Simple random sampling method in that slum may have selected a maximum of 2 or 3 households available for interview, but possibly none. The slum-dwellers alongside the rail-line in Khilgaon and Malibagh, were higher in numbers, where simple random sampling is possible even though some slum-dwellers were not available and this slum is safe from crime related activity due to it is located in open place but it is unsafe as trains are passing through slum. Thus, front, middle and last part of the slum were chosen, with each part containing a small group of people.

Safety was also an important factor. For example, there was a very big established slum in Banani lake (Figure 8.5). Due to time limitations and for safety reasons it was not possible to research inside the slum.

The sampling method used in slums is likely to have produced an accurate ratio of the extreme poor and poor. However, the percentage of the lower, middle and upper class in urban will not be represented accurately due to non-probability sampling methods used. Nevertheless, some determinants were used to confirm the social status of respondents (see the section 3.3.4).

In the same way, to find migrant people in Comilla was difficult as the majority of the people in Comilla are local. Thus, migrants were selectively chosen using different methods such as snowball techniques and purposive and convenience methods. Poor migrant households in Comilla city were selected without knowing their poverty level, which was determined later. Gangchor, Garjonkhola, Chok-bazar, and Pathuria-para (mixed area) in the eastern part of the city were selected for interviews and questionnaire surveys, as this is where the city is expanding and the population is increasing, as well as being located physically close to India (Figure 3.3). Poor migrant workers and local poor workers in a work place were selected in separate focus groups.

Convenience sampling was also used in rural areas. Households in rural areas are very dispersed, with many household having no road, the only access being through the aisles or terraces of paddy fields. However, the *union*s selected in each sub-district were in the most affected areas and contained a large proportion of the target population. Thus, samples were taken from these spatial clusters to obtain the greatest number of respondents. Each *union* was divided into five parts (or groups) to cover the whole *union*. These parts were roughly equally divided without measuring making use of the help of a local bike driver. For example, if a *union* length is 1 kilometre, the distance between two parts is roughly around 200 meters. All of the household and individuals were interviewed in selected parts. The situation in Mehendiganj was bit different as in the Ulania *union* the centre chosen is more like an old town with both rural and urban conditions. Gobindapur *union* was a rural area and a very small area of this *union* remains as the most of it has been eroded. Thus, only one part of the Gobindapur and four parts of Ulnaia were selected instead. All households found in that selected area were invited to participate in an interview and questionnaire session. No respondent refused to take part in the research process. Moreover, many willingly participated without expecting remuneration. It should also be noted that each individual respondent represented his or her family.

Due to safety reasons, it was not possible to visit Gabura *union*. However, it was possible to conduct some interviews and questionnaires by telephone conversation. Gaffer and Giasuddin Hasan and Mehedi Jaman helped to arrange the interviews and questionnaire session. To reduce the bias they were instructed to select respondents following the same methods used for other regions.

Though lower, middle and higher class people were selectively chosen in urban areas, they were not selectively chosen in rural areas. This has been described above. Due to being selectively chosen, the ratio of the lower, middle and higher classes will not be accurate for the urban samples, but it is more unbiased for rural areas. However, though the focus of this research is on affected poor people in rural areas or migrant poor in urban areas, the reaction of non-poor classes is also important, particularly in the city. However, in rural areas socio-economic status was determined by four indicators (see the section 3.4.4). These determinants were also used to measure the extreme poor.

A total of 173 questionnaires and the same number of in-depth interviews were conducted in Dhaka and Comilla together. Among them 52 (30%) were local and 121 (70%) were migrants (Table 3.3). The number of respondent**s** in Dhaka consisted of 21 (18%) local and 94 (82%) migrant people, whereas 31(53%) local 27 (47 %) migrant people in Comilla city (Table 3.3). Three focus groups were completed for the fieldwork in cities, one in Dhaka and two in Comilla**.** Only 18 people (Table 3.3) were interviewed in Khulna and Barisal collectively to provide a snapshot of this destination region (Figure 3.4). Khulna and Barisal Division lies in the southwest and south-central of Bangladesh respectively (Figure 3.4). A total of 182 questionnaires and the same number of in-depth interviews were conducted in rural areas (Table 3.4).

Table 3.3: Number of respondents and their social status in Dhaka and Comilla city. The income bands were determined as outlined in section 3.4.4.

Urban district		Types of respondent	Income class			Total	Average size of family member
			Poor class		Non-poor class (middle/upper class)		
			Poor	Extreme poor			
Central region N=173	Dhaka N=115	Migrant	26	60	8	94	4.1
		Local	8	2	11	21	
	Comilla N=58	Migrant	6	19	2	27	5.6
		Local	21	2	8	31	
Coastal headquarter N=19	Khulna N=7	Migrant	1			1	---
		Local	2		4	6	
	Barisal N=11	Migrant	8		1	9	
		Local	1		1	2	

Table 3.4: Number of respondents on the basis of socio-economic status in rural delta community.

Rural community		Sample size (N=182)					Average size of family member	Average age of migrant member
Upazila	*Union*	Upper class		Lower class		Total		
			Middle class	Poor	Extremely poor			
Sharankhola	Royndee	0	8	21	14	43	5.5	32
Tala	Jalalpur	1	16	32	16	65	4.5	--
Shyamnagar	Gabura	0	7	9	11	27	5.7	30
Mehendiganj	Gobindapur and Ulania	5	10	21	11	47	5	28
Total		6	41	74	58	182	5.2	30

3.4.4 Determination of socio-economic status

An important variable within the interviews and questionnaire surveys is the socio-economic class of the respondents. Respondents were divided into four classes: extremely poor (below poverty level); poor (above poverty level); middle class; and upper class. Usually, people below poverty level live in vulnerable conditions both in slums in the city and in the rural areas. The research concentrated attention on poor, rural people who are less mobile, and who might be displaced and forced to migrate. From this point of view, four indicators were chosen:

1. Food: Rice is the staple food of Bangladesh. The number of meals eaten in a day to was used to categorise socio-economic class, especially poor and extremely poor. Using an average 2250 calorie per day requirement for an adult, and a typical meal of a combination of lentils or vegetables, fish and rice, if anybody can easily eat two meals in a day they are deemed to be middle class. Those who hardly meet this condition are poor, and those who sometimes can meet it or take one meal a day or even experience starvation, are extremely poor.

2. Shelter: Those who live on government land such as embankments are deemed extremely poor. Those who have at least a house are poor. Those who have a house and can easily meet their basic needs are middle class.

3. Land: Marginal farmers or those who are landless and cannot meet basic needs are extremely poor. Those who have some agricultural land but whose numbers of family members make it hard to meet basic needs are poor, while those who can easily meet their basic needs are middle class.

4. Household income: Female-headed households or even male-headed households with a large number of family members who cannot meet their basic needs are extremely poor, even if they earn money. Some households, whose husband and wife both work, if they hardly fulfil their basic needs, could be considered poor. Those households with 6 family members or more where everybody earns, or most of the family members engage in income-based activity, can easily fulfil their basic needs and can save some money for the future, can be considered as middle class.

Summaries of the socio-economic class assessments in each of the four *upazila*s chosen are shown in table 3.4. The occupations of the respondents are shown in table 3.5 and the age/gender distribution in table 3.6.

Table 3.5: Number of respondents on the basis of occupation/livelihood.

Occupation of the respondents	A	B	C	D	Total
Businessman person	1		2	3	6
Small businessman owner	3	3	2	3	11
Police officer			1		1
School teacher	2	5	1	6	14
Student	1				1
Blacksmith		1			1
Van puller			1		1
Unemployed	4	6	4	2	16
Bakery shop worker			1		1
Bike driver (locally known carrying passengers)		1	1	1	3
Housewife (who help husband in farming and livestock)		21	10	2	33
Bowali or *Mowal* (see Bengali terms for meaning)	2	1	16		19
Fisherman	2			5	7
Farmer (crops and vegetables)		19	4	12	35
Day labourer	3			2	5
Agriculture labourer		6		6	12
Labourer in Brickfield	3				3
Barber				1	1
Doctor				1	1
Lecturer in a college				1	1
Multiple job	5				5
NGO Staff				1	1
Caretaker				1	1
Upazila education officer				1	1
Total	27	65	43	47	N=182

A = Shyamnagar, B = Tala, C = Sharankhola, and D = Mehendiganj

Table 3.6: Number of respondents according to age, gender and disability

Respondents	Sharankhola	Tala	Mehendiganj	Shyamnagar
Women	10	24	3	1
Older people (aged 60+)	5	6	2	4
Man	26	35	35	22
Disabled respondent	1			
Total	43	65	40	27

Determining the social status of individuals in urban areas was necessarily different from the rules followed in the analysis of rural communities**.** Target people were divided into two broad income levels: upper/middle class and lower class. This was assessed by an individual's profession. Different occupations like beggar, rickshaw puller, building worker/labourer and house maid, were considered lower class, whereas a business man, landlord and officers in different organizations were assigned to the upper and middle class category (Table 3.6). In Dhaka city, higher and middle class people were additionally assessed by where they were living. For example if a respondent lives in the non-slum areas of Khilgaon, Goran, Meradia or Madartek, where the average monthly house rent is 15000 BDT (£125; as of 2010), this household was classified as middle class. However if they lived in Gulshan Banani or Baridhara, where the average monthly house rent is 30,000 BDT (£250; as of 2010), he/she was defined as upper class. Moreover, landlords of middle class areas could be classified as upper class. However, higher class households could be found in middle class areas, as determined by household income (see below). In this research, however, lower class households were concentrated on. A rough estimate of monthly income (at 2010 levels) applicable to the socio-economic division into lower class, middle class and higher class for the different urban areas studied is: for Dhaka, below £120, £120 to £300 and above £350 respectively; for Comilla £100, £100 to £250 and above £250; for Barisal £90, £90 to £200 and above £200; and £80, £80 to £200 and above £200 for Khulna city. However, this banding was not applied to every household. An estimate of household income was ascertained through conversations with people. For the lower income classes individuals were further divided into poor and extreme poor households using the three indicators (food, shelter, household income). Households near the roadside, in slums or the train station are considered as extremely poor as they cannot meet the basic need for shelter. It is noted that slums were also found in both upper and middle class areas in Dhaka city.

Table 3.7: Occupation of the respondents in Dhaka and Comilla city

Study area	Occupation	Local respondents	Migrant respondents
Dhaka N=115	Beggar		27
	Rickshaw-puller		13
	Building worker/day-labourer		2
	House maid	8	41
	Businessman person	2	1
	Landlord	4	
	Officer	4	3
	Waiter		1
	Small businessman owner	2	
	Student	1	2
	Garment worker		1
	Brick breaker		1
	Contractor for construction worker		1
	Auto rickshaw driver		1
Comilla N=58	Rickshaw puller	2	13
	Building worker/day-labourer	17	6
	House maid	0	1
	Businessman person	4	1
	Officer	2	1
	Factory worker	6	5

3.5 Linkage of the social and physical data: (vulnerability assessment)

In order to explore the links between the physical and social data together, the current study constructed an index of vulnerability using averages taken from the three IPCC dimensions; exposure, sensitivity and adaptive capacity (Heltberg and Bonch-osmolovskiy, 2010). These three dimensions were further sub categorised into six ‘driver, which included demographic, social, economic, political, physical and environmental themes. Each of these ‘drivers’ contained indicators that were relevant to that particular theme. In total 33 indicators were used for the rural index, while 21 were used for the urban index. The indicators incorporated a range of economic, social, demographic, political and physical driver, which were used to assess the vulnerability of certain groups to environmental change.

The research standardised the values twice (see the chapter 7, table 7.4 and 7.5). Firstly, as there were different numbers of respondents in different rural areas, where possible the indicators have been converted to a percentage so they can be directly compared. Secondly, due to each indicator being measured on a different scale, it is important to standardise each index value (Hahn et al., 2009) to aid with comparison. Thus, the values of all indicators were normalized using a linear transformation into the 0-1 interval (Heltberg and Bonch-Osmolovskie, 2010: 9). To measure the value, life expectancy from the human development index was used, which consists of the ratio of the difference of the actual life expectancy and pre-selected minimum and the range of pre-determined maximum and minimum life expectancy (UNDP, 2007; Hahn et al., 2009: 76).

The formula is given below:

Index = (observed-minimum)/maximum-minimum),

$$I'_{sd} = \frac{(I_{sd} - I_{min})}{(I_{max} - I_{min})}$$

Where, I'_{sd} is an index for the *upazila* (Sub-district),

I_{sd} is the original indicator value for the *upazila* (Sub-district),

I_{max} is the maximum value

I_{min} is the minimum value

Vulnerability index (VI): V = E+S+ (1-AC).

Where, E = exposure, S = sensitivity, AC = Adaptive capacity

The calculation is shown in appendix 6(a and b).

Limitations of data accessibility played a vital role in the construction of the vulnerability index (Vincent, 2004). There were fewer indicators in urban areas than rural areas. This is because the percentages of many indicators in my survey for cities will not be accurate. Thus, to construct the Vulnerability Index for the city only census data could be relied on. In general, in a developing country like Bangladesh, the census data are poor quality and not detailed enough (Barber et al., 1997) to use indicators to set up an index to compare different localities. However, for urban areas, an interpretation of the survey data and census data together was used. Using census data and questionnaire data together could be useful to describe both cities under research.

The work of Hahn et al. (2009) is used to discuss the strengths and weaknesses of the vulnerability index.

- As the indicator score was standardized using maximum and minimum values for the studied population, the measurements may not be compared with other future research if those are not carried out using the same method (Hahn et al., 2009).

- "One advantage of this method is the reduction of a reliance on climate models and projections which, despite recent advances, are still presented at too coarse a scale with too high degrees of uncertainly to be useful for regional analysis" (Heltberg and Bonch-osmolovskiy, 2010: 7)

- This vulnerability data considered individual and household levels primary data to quantify the indicator, thus this approach does not suffer from the limitation of the secondary data (Hahn et al., 2009).

- The current research could not consider two important indicators such as female headed households, who are very sensitive to climate change and literacy rate that increase adaptive capacity, because these were not included in the questionnaire, though some household member informed me of their presence. Although, the literacy rate from census data was used it was not possible to use female headed household from other sources. If this study were repeated it would helpful to adjust the questionnaire to take this into account.

This vulnerability index can be applied to project future vulnerability by duplicating the study in a similar location over time and by replacing the value of the indicators that are expected to change, which would finally recalculate the overall index (Hahn et al., 2009). For example, if migration increases, more remittances help reduce vulnerability as remitances improve adaptive capacity. Similarly, the improvement of the cyclone waning system reduces vulnerbility. Coversely a reduction of household income can increase sensitivity, and as such increase vulnerability. However, it may be possible to calculate the effect on the community's climate vulnerability by comparing the baseline vulnerability index with a newer version (Hahn et al., 2009: 6). This provides an in depth understanding of relation between migration and vulnerability.

3.6 Measure of migration

Measuring environmentally induced migration is challenging, in part because no quantifiable description exists (Doos, 1997; Warner, 2011). A systematic and comparable time series of internal migration records are not available in Bangladesh, with the exception of international migration (Warner, 2011) (described in chapter 4, section 4.7). Thus, it is difficult to measure different forms and types of internal migration, and specifically to quantify environmental induced migration. Decisions to migration are complex and related with different types of drivers (as described in chapter 2). Thus, to measure environmentally motivated or induced migration, a series of indicators were asked during the questionnaire surveys and interviews. The indicators may have been answered in certain questions (e.g. have you ever moved or moved due to an environmental event?), or they might be observable facts such as: have any of your family members/relatives/neighbours/friends moved due to environmental event? Or there might be combination of these (Bernard, 2011) such as 'where, why, and how did you move?' or 'do you know anybody that moved like you?'

In this study the number of the migrants was calculated and converted into percentages. The percentage of migrant people/families for each sub-district was then calculated to compare migration figures for different sub-districts. The short distance and long distance migrant or any member of a household were also calculated separately.

The results of this will intend to examine and identify the environmental effects of categorising the type of migration. The implications of the outcome could contribute to the extent that environmental drivers are a primary reason for migration (see chapter 7 section 7.8); the extent to which environmental driver effects distance of movement, and the extent to which environmental drivers could be secondary or background drivers. Moreover, the results of the temporary and seasonal migration (non-permanent migration) are one of the important indicators playing an important role in influencing the vulnerability index value that were determined by a range of factors including demographic, economic, social, political and environmental ones. Moreover, an assessment between vulnerability and migration of four rural areas could provide an understanding as to whether migration reduces vulnerability by increasing adaptive capacity, or alternatively migration is the sign of vulnerability.

Furthermore, changes to the population between the two national censuses in 2001 and 2011 were used as a vital source of analysis of migration. “This is used as a proxy for migration driven population change – the standard (and somewhat problematic) assumption being that change above/below the national growth rate are the result of inward/outward migration. This is a somewhat problematic assumption, as population growth will vary between areas based on cultural and social factors and fertility and fecundity ratios” (Marshall and Rahman, 2013: 12). But in recent years, annual population growth rates have been falling (Marshall and Rahman, 2013). However, the change between national population growth rate and growth rate of the study areas could be useful to get net migration.

3.7 Selection of variables

The current research defined independent variable environmental change, and the dependent variable is its effect on migration. It is difficult to determine whether migration would not have occurred in the absence of environmental change (Warner, 2011) as the rural sub-districts selected have experienced different degrees of environmental change. Therefore it has been separated out to the household with more experience of, or that are more affected by environmental events and to households that do not face environmental events or are less affected by them. Respondents near the coast (defined as within 1 kilometre), or facing saline water, are highly affected by environmental events. Households displaced due to river bank erosion have been categorised as highly affected, whereas non-displaced households do not usually face environmental events.

Since the aim of the section is to implement regression analysis to investigate if environmental change has any statistically significant impact on decision of migration (dependent variable). Households were coded 1 if it was highly affected by environmental change and 0 if not. Similarly the households were coded 1 if any member of the household moved out or the household was displaced (in the case of river or coastal erosion), and 0 if not. The result has been discussed in chapter 7, section 7.8.

3.8 Limitation of the fieldwork: a discussion of the strength and weakness

Different types of data collection methods have their advantages and disadvantages. “While some evaluators have strong preferences for quantitative or qualitative techniques today the prevailing wisdom is that no one approach is always best, and a carefully selected mixture is likely to provide the most useful information” (Frechtling, 2010: 73-74). A significant challenge when collecting qualitative data regards perfect boundaries. “Because qualitative research is conversational, it is essential for data collectors to maintain clear boundaries between what they are told by participants and what they tell to participants” (Mack et al., 2011: 11). Thus, it is requires a well trained and qualified interviewer. Quantitative data, on the other hand may provide a general picture but lack depth. It may not provide sufficient information on context. It can lead to an assumption that the “facts” are true and the same for all people all the time (Hughes, 2014). For example, in response to the question, “is migration taking place from highly environmentally impacted areas or not?” quantitative data may specify categorically that 28% of people migrated from highly environmentally impacted areas (see chapter 7, section 7.8). It also provides data which are comparable between different communities and different location (ACAPS, 2012). But it will not provide an answer to “How do environmental drivers interact with other effects to create different forms of migration or to influence the individual decision-making process during migration?". It fails to take account of an in depth description of the experience of migration related to environmental change. It fails to capture people's unique ability to interpret their experiences, construct their own meaning and act on these (Hughes, 2014). To gather this type of information qualitative data is useful. This provides the answers to question of 'why' and 'how' affected people are impacted by environmental change (ACAPS, 2012). Thus, in this thesis, both the questionnaires survey and in depth interviews were conducted at the same time with the same set of respondents. This ensured time efficiency during the fieldwork. But due to the large number of respondents the volume of information was very large making it difficult to transcribe and reduce data after the interview (Mahoney, 1997). Moreover, getting the interviews and discussions accurately translated and transcribed turned out to be one of the biggest challenges of the fieldwork (Terry, 2011: 68). One of the strength of the fieldwork process was my positionality. Being from Bangladesh, I did not require an interpreter, but rather I directly organised and conducted every single interview and questionnaire survey. Many research projects like EACH-For face difficulties in translation and interpretation from the local dialect and language (Warner, 2011). They had to work with local researchers and experts as partners prior to the fieldwork commencing (Warner, 2011: 20). Hence, a big budget and a great deal of time were required. But, I was able to translate questions into Bengali and also asked the questions in an informal and understandable local form. For example many rural Bengalis would not understand the standard Bengali term for migration ('*Ovigamon*'). But I was able to utilise the local form accent. I encountered many words like this. Schmidt-Verkerk (2011) faced language problems during the first week of their interview process in Mexico. She had to adapt to a local form of Spanish to interact with participants in order to understand people's livelihoods (Schmidt-Verkerk, 2011). Terry (2011) describes a situation where difficulties were faced after hiring transcribers, as they complained that they had trouble understanding local accent. Moreover, "translating and transcribing is very time consuming and there was quite a long delay between finishing the last interviews and obtaining the first transcriptions" (Terry, 2011: 68). Furthermore, Terry (2011) finally, found many cases of inaccurate translations after random checks by her assistant. Thus, it is much easier and less time consuming for native researchers than overseas researchers to conduct fieldwork. For example, due to language problems and being a white foreigner, a colleague of mine conducting research in Argentina was unable to reach his target participants. Conversely, another white, British colleague of mine was able to collect very useful data in Nepal by actively learning some local language, culture and manners. If an outsider researcher, they need to build up local knowledge, they need to understand the manner, culture and expectations. One of my strength was that I am a native and had spent a great deal of time previously interacting with migrant and displaced peoples, and already had this knowledge.

Each of the interviews and questionnaire surveys, which were all conducted in Bengali, were recorded so could be listened to a number of times to aid in-depth analysis. This was helpful when it became necessary to change the direction of the thesis as the material consists of a huge amount of information. After each day of fieldwork the interviews were listened to again and summaries written for each respondent immediately so aspects of the interview would not be forgotten. Notes were made in Bengali and then translated into English after coming back to the UK.

All the questions were included in the same layout for both methods. Due to this set up it was difficult to separate out some of the questions of the interview questions from the survey questions (see appendix 4). Usually data were recorded in the questionnaires coded the answer yes/no next to the questions. However, based on the facilities, situation and due to time restriction, sometimes the answer was recorded using the same code (yes/no) but putting the serial number of the question in a notebook for each respondent. This information then cross-checked with the audio recording. Quantitative data were recorded as an excel database. Although the current study conducted open-ended and close-ended questions, quantitative information has also been produced from qualitative data. Following the data collection, interview data and questionnaire data were analysed separately (Harris and Brown, 2010).

The research had been conducted 4 years after tropical cyclone Sidr, 2 years after tropical cyclone Aila, 4 month after the flash flood and very recently after a river erosion event. Though it is difficult to identify the migratory impact of these particular events, people could clearly remember the event (Warner, 2011). Moreover, 26 respondents of the Shyamnagar (sub-district) were added in 2014 through telephone conversations, but still people could remember the event. Some calculations, such as the average wage of day workers or agricultural workers, utilised data from 2011 rather than 2014 to make level with the other region. This could bring some bias as people may not be able to accurately recall their 2011 wages. However, an average was calculated. One disadvantage of face to face interviews is that they are time-consuming (Mack et al., 2011). During the fieldwork, many respondents took much time. Many respondents would often talk about their life stories or unnecessary talk that was not related to the research. For example, one respondent took 41 minutes to undergo an interview that was expected to take half an hour on average. At times participants were encouraged to talk more when something interesting was mentioned. For example Pizos Mrida, from Gabura *union*, was talking about international migration and seasonal migration so was encouraged to talk about seasonal migration, especially seasonal migration to India. Thus, this was an opportunity to collect information previously unknown to the researcher that was crucial for project design, data collection and interpretation of other data (Mack et al., 2011: 15)

The fieldwork in urban areas (Dhaka and Comilla) was straightforward but in rural areas was more challenging as these were remote areas of the coastal community. Moreover, the vulnerable rural areas are located in very remote places with limited communication infrastructure. Access was by bus on very bad roads, and in some places required crossing rivers by boat. Due to high numbers of passengers in the buses there was often only standing room for long periods of time. Moreover, to go to Mehendiganj there were no roads so access was by steamer. Furthermore, due to unavailable accommodation in the *union* it was not possible to stay in the village and the area was not safe for staying overnight. It was necessary to travel to a nearby town to stay at a hotel. Due to safety considerations it was not possible to travel to the very remote island of the Gabura, which is the most affected region of the coastal area. However, questionnaire surveys and interviews of twenty-seven respondents in this area was possible by mobile phone.

The fieldwork was conducted during the day, particularly in the slum due to safety reasons. Male respondents and women respondents in employment in the RMG were not available as it was during working hours. Due to higher male employment, the percentage of male respondents is less than women respondents in the city.

Telephone conversations proved to be very difficult for a number of reasons. Firstly, there were difficulties in building trust with respondents. Many did not feel confident enough to talk and help from a third person was required, to help them understand the nature of the research. One of the respondents even ignored me. One respondent refused to provide his full name. Some of the respondents may have felt uncomfortable giving their names when asked for their permission to record the interview.

Some questions arose during the fieldwork, which highlighted the importance of conducting a pilot study before the interview and questionnaire survey, as this could have been useful for updating the questionnaire. Due to budgetary problems and self-funding, this was not possible. For example, before the fieldwork, it was not known that people from Shyamnagar move seasonally to work in brickfield in a group.

During the data collection some respondents were found to be illiterate that were more difficult to interview and ask a questionnaire survey. In this context, one strength of the data collection was that it was possible to modify the questions in order to make them clear and understandable. For instance, one respondent named Safia Khatun was confused with a question about salinity increasing. In order to get a more comprehensive response they were asked about the difference between salinity now and 10 years ago rather than a straightforward questions like, 'is salinity increasing?'. The participant's confusion about this question in particular arose due to there being seasonal climatic variations between dry and wet season in the study area, there are variations in saline water throughout the year; which means during transition periods from the wet to dry season salinity increases and vice versa.

Sometimes, judgments were made to address bias in answers. For example, one household in Mehendiganj was landless, but mentioned they were not landless. The family had built their house in *khas jomi* (government land) so they feared to say they live in *khas jomi*. Many poor respondents described that they are extremely poor, as they thought they might be provided with financial aid.

3.9 Ethical consideration

Ethical issues arise from the social background and from the type of questions the researcher asked the respondents (Sufian, 1998: 5). "The main ethical exigencies were the need for confidentiality, including among household members; the avoidance of pressure or coercion when asking respondents to cooperate; ensuring that respondents were not inconvenienced; avoiding researcher bias" (Terry, 2011: 69). In accordance with the rules and regulations of the University of Sheffield, I was required to sign an ethical form for the fieldwork (Appendix 7[a and b]). Before interviewing, it was necessary to make the participants understand the purpose of the interview, the identity of the interviewer and give a clear explanation of ethical safeguards (Corti et al., 2000; Brydon, 2006). It was also necessary to obtain permission before recording and taking of pictures of the respondent. Typically the length of the interviews was between five to forty minutes. A digital voice recorder, or mobile phone, was used to record the interview, and notebooks were used in support. The attitude of the respondents was very friendly and they were happy to talk to me. Although most of the respondents gave their permission to use their name, a few of them did not give permission. However, in order to be consistent all names of the respondents have been replaced with a pseudonyms.

3.10 Impact of researcher on research: participation, positionality and reflexivity

There was a big difference between rural and urban areas, with regards to culture, infrastructure and facilities in Bangladesh. Having grown up in an urban area, I am well acquainted with an urban way of life. Thanks to family ties, and spending time in rural areas, I was also familiar with rural life in Bangladesh prior to the study. Those experiences have helped to prepare for the rural areas, due to similar culture and customs. As a local to Dhaka and Comilla city, I was very familiar with both cities. This also helped me to recruit some local people such as friends and relatives or using snowball methods. In Dhaka, fieldwork was also undertaken at my home. My residence was frequented by numerous beggars, many of whom were migrants to the city, and some agreed to be interviewed and undertake a questionnaire session.

This approach enhanced the respondents participation resulting in access to substantial data from beggars. Some of the beggars recently migrated due to river bank erosion and some of them migrated from coastal areas due to experiences of tropical cyclone and coastal erosion. That said, many of the respondents migrated from non-delta region due to poverty. This data was still useful for understanding migrant vulnerabilities in the city. Whenever I got on any rickshaw, I asked rickshaw-pullers to participate in an interview. No rickshaw-puller refused to talk to me. One rickshaw-puller named Sirajul Islam who moved to Dhaka temporarily in a slum due to tropical cyclone Aila, provided very significant information about tropical cyclone Aila induced migration. Many rickshaw-pullers moved from Northwest Bangladesh to Dhaka and Comilla. They provided very important data in the process and they drew on migration and their contribution to increase adaptive capacity back home.

I was also waiting for *Eid* (2010 *Eidul-Adha*) festival day, as on this day Muslims such as myself provide meat to the poor people who are not able to buy meat. As I know many poor people will knock on the door for meat, I was waiting for those poor to provide meat and offer them to participate in both interviews and questionnaires. Though a very high number of people came to collect meat I was able to get very few people as most were in a hurry to collect meat from other houses. However, one female respondent spoke to me. She had moved to Dhaka due to environmental events such as coastal erosion and tropical cyclone. Though conversation was small, it was still useful data. However, these opportunities turned out to be exceptional sources of data. Furthermore, one of our house maids helped me to arrange an interview and questionnaire session of group of poor females at my home. She collected them from some small slums which are located near my house. I have provided them biscuit, tea and 10 BDT (£0.09) each. Many of them migrated to Dhaka a long time ago. Thus, I considered many of them as local. Apart from old Dhaka, it is generally very hard to find local people in Dhaka (described in sampling method section). I deliberately added these female respondents in order to gain a comprehensive understanding surrounding their reactions to new migrants. Mostly poor female respondents faced conflict of some social services such as using cooking by combined oven or collecting water from one access. Thus, this data was very useful to gain an understanding about the vulnerability of poor migrants.

As mentioned before, I am familiar with rural life, and we (my brother and I) planned thoroughly in order to reach our target people. As soon as we arrived in *upazila* main centre (like town centre) we hired a bike driver for the whole day. Driving a motor-bike with passengers is an occupation in many rural areas in Bangladesh that is completely different in cities. In cities people drive motor-bikes as a private vehicle. However, two passengers can sit in a motor bike. It is a very useful vehicle for remote areas as some roads were very narrow and muddy. Moreover, it was faster. A local bike driver acted as our guide. He was able to take us to remote areas of the villages (at least two villages in a *union*). Bike driver also participated in the interview and questionnaire session.

I come from an educated background and during the fieldwork I carried with me a camera, audio recorder, notebook and bag with a water bottle (Figure 3.5). Thus I was placed in a different position to my participants (Sultana, 2007) in both rural areas and the slums in Dhaka. However, my dress code was typical for the area: jeans, shirt/t-shirt. Though I am Bangladeshi, still I am an outsider in the rural areas I chose for my fieldwork.

Figure 3.5: Interviewing in the Gobindapur *union* of Mehendiganj

Many rural respondents thought I was a reporter, or associated with an NGO'. In Mehendiganj, one respondent even asked me which channel I worked for. Thus, many addition respondents gathered to discuss and talk in the middle of the interview. Many respondents also assumed I could provide financial aid (Etienne Piguet, 2010). In Dhaka, many slum-dwellers, thought we (my friend and I) were from a government authority, looking to demolish the slum. Even after explaining my research, one respondent did not believe me. In the slum in Banani, another respondent thought I was reporting crime and conflict related problems due to the questions I was asking, and having shown an interest in the societal crisis of poor migrants. In one instance I was forced to cut my interviews in the Korail slum short, due to clashes that started as I was interviewing there. Respondents were nervous, and many stated they did not know anything as they thought I was reporting the clash. In this situation, I was unable to convince people I was researching environmental induced migration. Thus, I decided to leave that particular slum.

I tried to speak the local language when interviewing, as this helped people to talk more openly (described in section 3.8). Most of the time I interviewed in open public places. While I was interviewing women, I requested my brother keep his distance, as rural women in Bangladesh feel shyness when talking to men, particularly unknown men. I did not start the interview by asking my target question. Rather, I was open to conversation and allowed them to talk to me. For example, one women respondent was processing fish for cooking during the interview session. Before going to my target question I asked a few informal questions about what she was doing, such as where she got the fish from and how she was going to cook it'. Another female respondent in the slum was also cooking, so I started chatting with her about that.

When conducting research on rural coastal areas that were affected by natural disaster, it was noticeable that many of the local respondents were keen to speak to me, and greeted me upon arrival. In Sharankhola, one very old respondent hugged me as I was researching his area and asking him questions. Another respondent started crying and describing his life story, as he had lost his daughter due to tropical cyclone Sidr. In Mehendiganj when we went to one school, we were immediately taken to the headmaster's office. The Headmaster of the school understood my research and was very happy that I had chosen to conduct the research in this area. He helped to arrange a group interview, while also providing tea and biscuits for the participants. Teachers and some local residents of Ulnaia (Mehendiganj *upazila*) from the middle and upper classes participated in this interview session. It was an extremely informative session, as I collected vital data, and gained a greater knowledge about the Ulanian and Gobindapur *union.*

Without spending any extra time I was able to interview very few people in Khulna and Barisal city. For example, while I was having breakfast in a restaurant in Khulna city, I was able to talk to a few people. One example was Nyab, who migrated from Shyamnagar and was working as a waiter in that restaurant, and provided significant information about cyclone Aila induced displacement and migration following cyclone Aila. Similarly, while we (my brother and I) were waiting for a bus to return

Dhaka, we entered a restaurant in Barisal and found that most of the waiters were temporary migrants from coastal areas. They were asked if they would take part in an interview, which we conducted after getting their permission. Subsequently, they arranged and participated in interviews. While I was travelling to Mehendiganj from Barisal city, I interviewed two people in the steamers (types of transport in the river) who were from Barisal but originally migrated from Mehendiganj and Hizla due to river bank erosion. Similarly while I was travelling back to Barisal city, I interviewed another person in the steamers. Though the numbers of respondents from these two cities was small, it was still extremely important for the research. Moreover, my target population were rural vulnerable migrants from these cities, and during the course of my research I gained adequate numbers of participants from these groups.

3.11 Data accuracy

As mentioned in section 3.10, many respondents thought I was associated with an NGO or a reporter or government authority. This had an impact on collecting inaccurate data. To collect accurate data more questions were asked to try to clarify further about the research. Sometimes, a judgement call was made as described previously.

Some calculations of census data for Comilla were found to be incorrect. To verify this population data from Bangladesh Bureau of Statistics was used which is the most authentic source to analyze population movement. Surprisingly, it was found that that annual growth rate of the population of the Comilla Adarsha Sadar *upazila* (the main town) is decreasing at the rate of -1.37%. However, this research has shown that this is an artefact of boundary redrawing in 2008. At that time Comilla Sadar *upazila* (that covered 280.95 km^2 before 2008) was split into two *upazilas*. One, Comilla Adarsha *upazila*, covers only 142.78 km^2, and another, Comilla Sadar Dakshin *upazila*, covers 209.97 km^2. The latter was formed from 138.17 km^2 of Comilla Sadar *upazila* and 70.78 km^2 of Laksham *upazila*. The annual growth rate for these two *upazilas* was calculated by examining their area populations at the time of the 2001 census. The population of the Comilla Adarsha Sadar *upazila* for 2001 was found, assuming the density at that time was uniform over the *upazila*, was 311,428. This gave a growth rate between 2001 and 2011 for the Comilla Adarsha *upazila* of 7.1%, which was higher than the national average. The growth rate of Comilla Sadar Dakshin *upazila* was calculated in a similar way as 400,053 in 2001. According to the census of 2011 the population of the *upazila* was 427,391, giving a growth rate of 0.68%. This *upazila* contains a mixed environment of urban and rural components, so that migration is much less likely to this *upazila*.

Moreover, despite migration to Khulna, according to the 2011 census the population had decreased, but the reason is not clear. This issue has been described, in the chapter 8 section 8.2.

The report EACH-FOR 2009, Poncelelet (2009: 1) mentioned, "the existing literature and the institutions proved of little help to gather data on Bangladesh due to the fact the data changes very quickly and there are no systematic tools to collect it. ….when discussing documented out-migration with the authorites, I was never given official data, for it appears this does not exist or is not sufficient reliable."

There is no official documented figure of internal migration in Bangladesh. Thus, the growth rate of the study area was compared with the national average to get net migration (discussed in the section 3.6).

3.12 Conclusion

This chapter deliberated the methodological approaches used during the fieldwork in Bangladesh. Mixed Methods, an integral approach for physical and human geography has been applied to explore the relation between environmental change and migration. A set of methods was employed to progress the methodological approach, in particular the study develops a conceptual and methodological approach of vulnerability to environmental change, adaptive capacity and migration process. The study developed vulnerability index (VI) to assess environmental change vulnerability in the four coastal rural sub-districts and the two cities in central region. It looked at the procedure of data collection and analysis. The study investigated environmentally generated migration with a number of methodological challenges such as strengths and weaknesses of the study, data accuracy and ethical challenges of the research process. The various sampling methods that have been applied in this study reinforced each other, minimized bias errors and improved the reliability of the research. The next chapter discuss about migration pattern in Bangladesh.

Chapter 4

Profile of migration pattern of Bangladesh

4.1 Introduction

The previous chapter describes the methods and the methodological approaches. This chapter is a synopsis of migration patterns in Bangladesh. Traditionally, migration flows in Bangladesh can be characterised into four types such as international, cross-border, short-term contract international and long-term permanent settlements in western countries (SCMR et al., 2013). Internal migration is very common but is dominated mostly by rural-urban migration flows compared to rural-rural or urban-urban migration. This chapter starts with describing a short history of migration in Bangladesh, moving on to migration and past political settlement; internal and urbanisation; cross-border migration. Then the chapter moves on to livelihood diversification and migration. Finally this chapter discusses profiles of survey district.

4.2 Short history of migration

Bangladesh has a long history of both in-migration and out-migration. Sri Lanka's Sinhala population are thought to have migrated there centuries ago from the territory that now constitutes Bangladesh (Siddiqui, 2003) Atish Dipankar, a tenth century Buddhist religious scholar and saint, who brought earth dam construction techniques to the Chinese, was also from Bengal (Siddiqui, 2003). In 1344, a number of spiritual religious Muslim personalities (Aulia) like Sha jalal, a celebrated sufi Muslim came to Chittagong and Sylhet from the middle east to spread Islam in Bengal (Islam, 2014). In the eighteenth century, when the British developed the tea industry in the northeast region of Bangladesh they brought contracted labour from different parts of India (Siddiqui, 2003; Shamsuddoha and Chowdhury, 2009). Again when colonial policies destroyed Bengalis' jute and cotton industries, and the market for fine muslin collapsed, one million people from east Bengal mainly from Rangpur, Bogra, Pabna, and Mymensing, migrated to Assam (North-east India) and introduced flood-plain agriculture activity there (Ahmed, 2000; Siddiqui, 2003). During the British colonial period, many of them migrated to Mynmar (Burma) and India for employment opportunities (Islam, 2014).

The major internal population movement of the British colonial period are from landed aristocracy from the different parts of the East-Bengal (Bangladesh) to Calcutta (west Bengal, India) (SCMR et al., 2013). The direction of the movement of the workers also was from Uttar Pardesh (India) to Sylhet (Bangladesh), from Orissa (India) and South India to urban areas of the east-Bengal (Bangladesh); also and agricultural workers moved from greater Mymensingh and Sylhet (Bangladesh) to Assam (India), and railway workers moved from Maharastra and Bihar (India) to different part of East-Bengal (Bangladesh) (SCMR et al., 2013). Economic migration in the agricultural sector and marriage are significant causes of migration from India to Bangladesh and more recently, professional-level economic migration has been taking place in the manufacturing and service sectors (SCMR et al., 2013: 3) (see also section 4.5).

Before 1947, many people migrated from Bangladesh to Britain to work on British merchant ships (SCMR et al., 2013). The majority of them came from the district of Sylhet, in north-eastern Bangladesh (Ullah and Eversley, 2010). As sailing ships ceased to be used, steamships took their place, and men from Sylhet worked mostly in the engine rooms (Ullah and Eversley, 2010). Seamen from Noakhali (in southeast Bangladesh) worked on the decks, with a number of other sailors from Chittagong (in southeast Bangladesh). This flow of migration continued even after independence of India (SCMR et al., 2013, Islam, 2014).

4.3 Migration and political settlement

A massive amount of migration occurred between Bangladesh and India during the partition of British India in 1947. This included hundreds of thousands of Bihari, from the State of Bihar (a neighbouring state of British India). Immediately after the independence of British India, a high number of refugees crossed into West Bengal (India). Broad estimates suggest that about 1.5 million Muslims migrated from West Bengal and Bihar to East Bengal in the two decades after the 1947 partition of India (Chatterji, 2010). More large-scale movement came in 1971 during the Bangladesh Liberation War. Around 10 million refugees from East Pakistan crossed the border into India during the early months of the war (Rahim, 1988). After independence, Bangladesh received some 100,000 stranded Bangladeshi from former West Pakistan (Rahim, 1988). After independence in 1971, many Bihari became stateless in

Bangladesh. Another major couple of influxes came in the last three decades, namely from Rohingya Muslims of Burma. These people are an ethnic, linguistic and religious minority group in Burma, and are ethnically related to the *Chittagonian* Bengalis just across the border in Bangladesh. They have been classified as stateless since 1982 (Bahar, 2014), as they are viewed as illegal immigrants by the Burmese government, even though they have been living in the area since the 12th century (Bahar, 2014).

4.4 Internal migration and urbanization

Urbanisation is the increase of population in urban areas as a result of migration from rural areas, driven by economic, social, political and environmental and technological factors. In 1901, the urban population in urban in Bangladesh (East Bengal) was only 0.7 million (Rasheed, 2008) whereas according to the 2011 census, it was 27.4 million (BBS, 2011). The urban population increased dramatically following both partitions (1947 and 1971), rising from 1.82 million (1951 census) to 6.27 million (1974 census) (BBS, 2003). According to the Centre for Urban studies, Dhaka (2001), the growth rate of the urban population is 4.8 per cent per year (Walsham, 2010).

Internal migration is dominated by rural-urban migration flows, largely due to the two largest cites Dhaka, one of the fastest growing mega-cities in the world and Chittagong. Such migration accounts for about two-thirds of all urban growth since 1971 (Black et al., 2011a; 2008). Other cities like Rajshahi, and Khulna also attract populations from the rural areas (Rasheed, 2008). A 2005 survey conducted by Centre for Urban Studies in low income settlements found that a large proportion of slum residents in the city corporation towns had migrated from other districts or adjoining districts. Dhaka attracted a large number of migrants from nearly 28 districts (Marshall and Rahman, 2013: 7; Walsham, 2010), 53% of these came from five districts: from Barisal 2.7%, Faridpur 9.2%, Comilla 9.1% Mymensing 7.3%, Rangpur 4.6% (Walsham, 2010). A further study conducted by the Centre for Urban Studies in 2007 in slum areas found that in Dhaka, 31.9% slum dweller came from coastal belt and 4.6% came from north eastern zone (*monga* affected area) (Marshall and Rahman, 2013). It notable that these districts are in areas prone to natural disasters such as floods and cyclones as well as river erosion and drought Barisal for instance is highly vulnerable to floods, cyclones and river erosion (Walsham, 2010).

4.5 External migration migration

Bangladesh is one of the major labour exporting countries in the world and concerns with the effects of environmental factors and climate change on overseas migration are becoming increasingly visible within academic and policy literature (Walsham, 2010). It is currently estimated that number of external migrants per year is in excess of 600,00 and the level of inward remittance is approaching a staggering 10% of Bangladesh's GDP (Marshall and Rahman, 2013). Thus, external migration plays a significant role in reducing the unemployment rate and in contributing to National GDP. Over the last decade there has been steady progress in raising per capita income and significant achievement in alleviating poverty (ILO, 2013). It is notable that the Northeast region in particularly Sylhet is an expensive and affluent area due to foreign remittances from UK, as a very high number people settled in the UK from Sylhet (see section 4.2).

Although current migration in Bangladesh is mainly internal, there are tendencies for some poorer people to cross the border. There are substantial flows of legal, temporary migration to India from Bangladesh due to better education, medical treatment, tourism and for business purposes. There are also opportunities to obtain employment visas to enter India legally but for unskilled worker there is no legal channel to enter India (Varughese, 2013). One of the respondents from Varughe's 2013 study said "if I go legally, I can only get a visa for three months, whereas with no papers I can stay as a long as I want if I am not apprehended." A questionnaire interview was conducted by Swain (1996) in 1993-1994; who showed that out of 52 of the Bangladeshi migrants to India, 43 traced from the Khulna (Southwest region) who were interviewed in India, 41 left their homeland due to environmental problems: 13 due to loss of agriculture, 10 due to reduced fish catch, 11 because of river bank erosion and 7 because of flood-related damage. Out of 41 environmentally forced migrants, 40 migrated after the Farakka barrage was commissioned. Another study found that many Bangladeshis from villages on the Indian-Bangladeshi border often moved as temporary measure for work, trade and to recover post-disaster (Kniveton et al., 2013). This study found people from the Chorpka and Durlogpur of the Chapai Nawabganj district of central west Bangladesh crossed the border of India five kilometres away as temporary migrants or day labourers to work in the paddy fields or to trade goods and cattle (Kniveton et al., 2013). According to an estimate by the West

Bengal police department, around one thousand people cross the border each day and enter West Bengal (Datta, 2004), although it is uncertain how many stay or return to Bangladesh after having temporary employment (Datta, 2004; as noted by Black et al., 2011a). The Group of Ministers Report in 2000 said that cross-border migration had been occurring over five decades and it had been estimated, there are about 15 million illegal migrants from Bangladesh (Shamshad, 2008). However, this figure does not have any empirical basis and is therefore highly contested (Black et al., 2011a). The Border Security Force (BSF) disclosed that in 2006 alone, 8196 persons were arrested trying enter India illegally from Bangladesh (Das, 2006). However, since 1995 more stringent border controls have restricted irregular and illegal migration, particularly in the case of Muslims attempting to migrate from Bangladesh (Kniveton et al., 2013; SCMR et al., 2013). Nonetheless, large numbers of Hindus choose to migrate to West Bengal if the livelihood and integration opportunities are seen to be better than those in urban Bangladesh (SCMR et al., 2013).

In recent years, on the basis of newspaper reports and information from the immigration department, many professional and skilled Indians have temporarily migrated to Bangladesh along with tradional migration through marriage and seasonal agriculture migration to work in high salary jobs in Bangladesh (Sikder and Khan, 2007: 27). The industries have included garments factories, shrimp firms, poultry and fishing firms, sugar mils, textile and leather industries, steel and re-rolling mills, pharmaceutical industries, telecom industries, natural resources exploration, bevaerge compnaies, adult firms, the railway sector, construction frims, school and colleges (as teachers) hospitals (as doctors, nurses and technicians), hotel management, chefs and as hair dressers and beauticians (Sikder and Khan, 2007: 27).

The foreign ministry, based on immigration clearance estimates put the number of skilled and professional Indian workers at roughly 100,000, although this is likely to be a significant under-estimate (Sikder and Khan, 2007). Occasional newspaper reports note seasonal migration in the areas in which Bangladesh borders India (Sikder and Khan, 2007). It is also true that people in the border area share the same cultures and there are also some have relatives in India and some are in Bangladesh, thus, movement between both countries is very common. Sikder and Khan (2007) found that due to decline of the wages in agrciultural labour, many Indians cross the border to worker in agriculture sector, local hotel and resturant businesses local barber shops and grocery shops in the border area of Bangladesh. At the same time they also found that during the harvesting time, due to availability of cheap labour from India, the wages declined in Bangladesh motivating Bangladeshi workers to migrate India too. Thus, this movememnt of migrants is a two way process.

Evidence has suggested that due to environmental events that the initial displacement is noticeably localised and short-term in nature and there is no evidence for mass migration across borders, where irregular migrants experience difficulty (Walsham, 2010: 30). These irregular migrants would experience difficulty if attempts were made to access post-disaster humanitarian aid (Walsham, 2010). The border region with India contains some of the areas of greatest environmental vulnerability, particularly in the south-west (my study area) and north-west (Walsham, 2010). The people of the western border districts of Bangladesh share more or less a common culture with people in neighbouring India (Siddiqui, 2009). This can encourage these people to move to a neighbouring country to a safer region, if extreme environmental changes occurred in the future as a result of climate change.

4.6 Livelihood diversification and migration

Most poor people in Bangladesh are engaged in informal, low-income jobs with limited productivity (IFAD, 2014). Agriculture is major industry in particular for rural communities. Thus, the performance of this sector has an overwhelming impact on major macroeconomic objectives such as employment generation, poverty alleviation, human resources development and food security (GoB, 2014). Agriculture has accounted for 21 % (BBS, 2008) of the total GDP and employs 45% (2008) of the total workforce in Bangladesh (CIA, 2011). Rice is the single most important product of the agriculture of Bangladesh. It is the staple food of Bangladeshis. Around 80% of croplands are used for rice production (Islam, 2009). Due to environmental change the farming pattern is also changing (Martin et al., 2013). This effect will be particularly noticeable on rural households who are strongly dependent on agriculture and its farming system and are mainly subsistence farmers who rent their land. Thus, migration from rural areas to cities, is motivated predominantly by income diversification (Martin et al., 2013). In the recent decade agriculture has decreased (51.7% in 2002-2003, 48.1 % in 2005-2006 and 47.3% in 2010) and non-agriculture has increased (48.3% in 2002-2003, 51.9% in 2005-2006 and 52.7% in 2010) (BBS, 2011). “The rate of agriculture in income composition of rural households has declined from 59% to 44% between 1987-1988 and 1999-2000, at the same times the share of service and remittance in income has grown from 35% to 49 %” (Afsar, 2005; Martin et al., 2013: 7). This significant increase of the labour force once employed in the agricultural sector to now the non-agricultural sector is related to an increase in migration from rural to urban areas (Herrmann and Svarin, 2009) as the urban sector, dominated by non-agriculture activities, now contributes over 65 percent to the GDP as opposed to only 21.77 percent from the agricultural sector (BBS, 2008) (BBS, 2006). As an example, day labour (agri) and self-employed (agri) are 25.7% and 31% in rural respectively and day labour (non-agri) and self-employed (non-agri) 22% in and 27% in urban respectively (BBS, 2011) (Table 4.1).

Table 4.1: Percentage of the household by main sources of income [sources: Labour force survey, 2010 by BBS (2011)].

Sources of Income	Bangladesh	Urban	Rural
Total	100	100	100
Self-employed (agri)	25.5	6.3	31.3
Self-employed (non-agri)	18.9	27	16.4
Services	14.9	35	8.8
Day labour (agri)	21	5.4	13.5
Day labour (non-agri)	15.5	22.1	13.5
Others	4.2	4.1	4.2

4.7 Migration profile of fieldwork districts

In 1941, before the partition of the Indian subcontinent, Khulna had a population of only 34,000 (BBS, 1992). At Partition in 1947, a large number of Muslims from India migrated to the then East Pakistan, and many of them settled in Khulna (Mia, 2002). This can be seen in the 1951 census, when the Khulna population was recorded at

42,225 (KDA, 2013). The city then grew rapidly in the 1950s and 1960s as its importance increased. The population was recorded at 128,000 in the 1961 census (BBS, 1992). This rapid growth, encouraged by the migration of many Bihari from India, led to a slum being created in Khalispur thana (Mia, 2002); (a *thana* is an urban equivalent of an *upazila*). In the 1950s a large newsprint factory (Khulna Hardboard Mills), several jute mills, and a big power station were built in this area, leading to further increases in the population of the district. Though industrialization nearly stopped in 1968 (Billah, 2001), following labour unrest (Mia, 2002), after Independence in 1971, the population of Khulna continued to rise and migrant people had to seek alternative employment to the traditional industries. This led to clashes between Bengali and Bihari labourers in 1971 (Mia, 2002). Since then, the shrimp farming industry has developed quickly and a processing plant was built in Khulna. Over the last two decades, 30,000 people migrated to Khulna city due to losing their land for shrimp cultivation (Mia, 2002). It is estimated that some 25,000 workers are employed in processing in Khulna, Satkhira, Bagerhat and Jessore (SAFE, 2012). By the census of 2001, the population of Khulna had grown to 770,498, more than 10 times what it was 50 years earlier.

Dhaka is the most important receiving place in the history of migration in Bangladesh (Ahsan, 1997: 51). It has been expanding fast due to its political, economic and cultural importance (Ahsan, 1997). It is noteworthy that in the past, Comilla, Dhaka and the Noakhali districts had net emigration to other cities, especially to Chittagong. For example, *Dhakya* (as citizens of Dhaka are called in colloquial Bangla) had been immigrating to different cities for several centuries as petty shopkeepers and itinerant salesmen (Rashid, 1991). They controlled the cloth trade in Bengal, outside Calcutta (Rashid, 1991). Noakhali Barisal and Comilla districts have long been amongst the most literate areas in Bangladesh, and this tendency for greater education led to more job opportunities for emigrants. However, in recent years, the flow of people migrating to the city has increased.

4.8 Conclusion

The chapter described overall migration patterns in Bangladesh with a particular focus on domestic migration. The study also emphasises urbanization and livelihood diversification as well as rural Bangladeshi movement to cities in either traditional ways or involuntary migration. However, the increasing frequency of natural disasters would be one of the important causes of environmentally generated migration. Thus, evidence of migration within Bangladesh could provide an understanding on how environmental change is likely to affect migration, and then this approach could be applied to explore the likely effects of environmental change on different migration flows from Bangladesh (Schmidt-Verkerk, 2011). The next chapter describes of physical setting of Bangladesh.

Chapter 5

Physical setting of Bangladesh

5.1 Introduction

The previous chapter described the pattern of migration in Bangladesh. This chapter discusses the physical feature of Bangladesh. Bangladesh is significant for its hydro-morphological setting, being known as “the land of rivers”. About 80% of the land surface is plain (Brammer, 2000) and most of the country lies below 10 metres elevation (Figure 5.1). Due to low-lying land and geographical location Bangladesh is highly vulnerable to flooding, river bank erosion, and sea level rise and storm surges. The chapter starts by examination of recent climatic variability by exploring the temporal and spatial variation of mean temperature, rainfall, and river discharge. Then, I describe the environmental risk factors within Bangladesh.

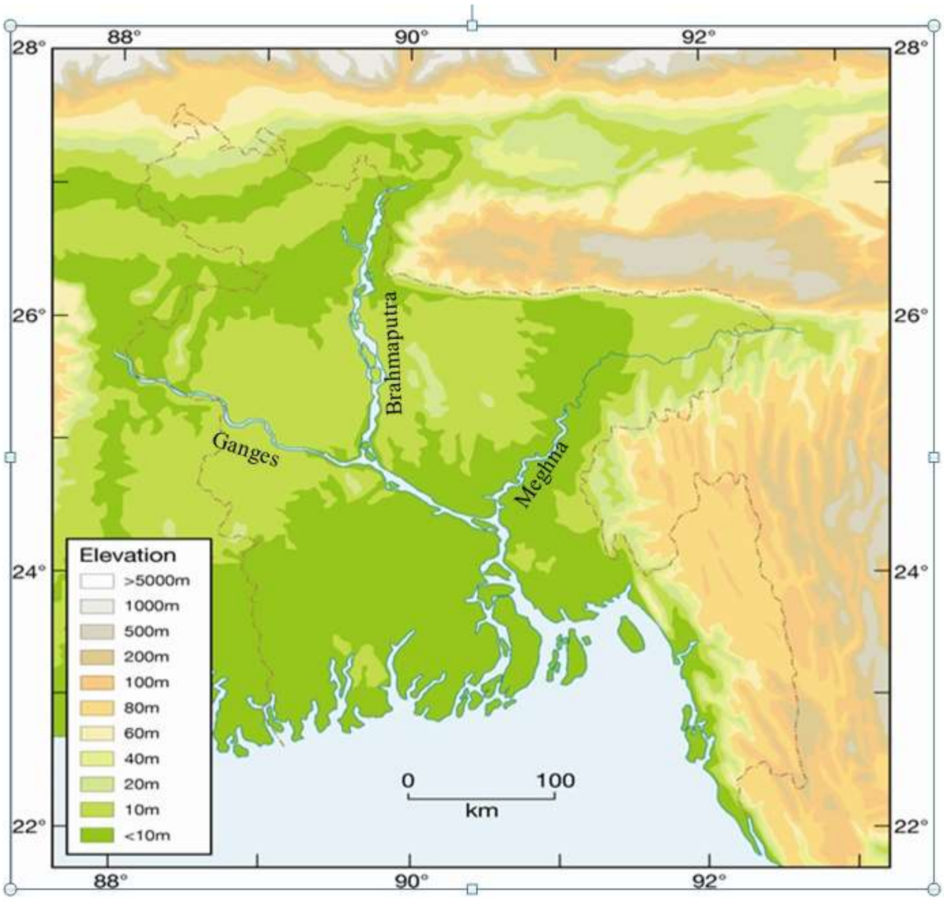

Figure 5.1: Elevation map of Bangladesh

5.2 Climate of Bangladesh

The climate of Bangladesh demonstrates tropical to subtropical characteristic in temperature with warm to hot summers and mild to cool winter (ADB, 1994). The climate is influenced largely by monsoon and moderately by pre-monsoon and post-monsoon circulation (Agrawala et al., 2003).

In winter, two branches of the jet stream are anchored by the Himalayas, one to the north and the other to the south (Figure 5.2a). The southern branch of the jet stream causes subsidence in the atmosphere in the north-western part of India and consequently, a centre of high pressure develops there, while low pressure develops over the relatively warmer Indian Ocean. As a result of this pressure distribution, winds flow from the interior of India toward the Indian Ocean, in what is known as the winter monsoon circulation. A stream of cold air from this high pressure enters Bangladesh during the winter, resulting in a dry season. January is the coolest month in Bangladesh. In this season the mean minimum temperatures vary from 12^{o}C to 16^{o}C whereas mean maximum temperature varies from 24^{o}C to 26^{o}C (Sarker, 2005). The pre-monsoon season is a transitional period during which the northerly or north-westerly winds of the winter season gradually change to the southerly or south-westerly winds of the summer monsoon (Ahmed, 2003). During the early pre-monsoon season, a narrow zone of air-mass discontinuity lies over Bangladesh, which extends from the southwest corner to the northeast corner of the country. This line of discontinuity separates the warm, moist air coming in from the Bay of Bengal and the hot, dry air flowing from the interior of northern India(Huq, 1974; Ahmed and Karmakar, 1993; Ahmed and Kim, 2003; Ahmed, 2004) resulting in high temperatures and the occurrence of thunderstorms and tornadoes. April is the hottest month in Bangladesh, with mean maximum temperatures varying from 30^{o} C to 35^{o}C.

In the summer monsoon season a centre of low pressure develops over the western part of India because of the intense heating of the landmass, while high pressure develops over the relatively cooler Indian Ocean, and the Inter-Tropical Convergence Zone (ITCZ) of the North Indian Ocean moves to the north (Figure 5.2b).

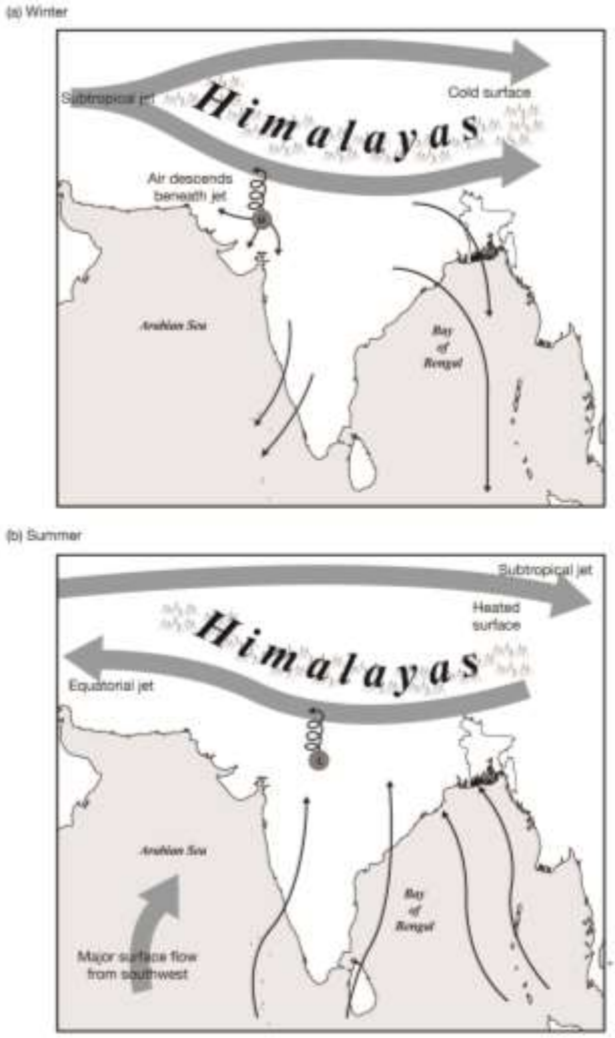

Figure 5.2: The airflow patterns over southern Asia in (a) winter and (b) summer

As the trough associated with the ITCZ moves to about 25°N over India at the height of the summer, the release of latent heat in the upper troposphere, as well as the heating of the Tibetan Plateau, causes a north-south temperature and pressure gradient and the development of an easterly jet stream at about 150 hPa (Robinson and Henderson-Seller, 1999). The summer monsoon flow enters Bangladesh in late May or early June, and continues to flow toward the centre of low pressure that lies over the western-central part of India. The temperature during this season is slightly lower than during the pre-monsoon season. June is the hottest month of this season. Heavy and prolonged rainfall characterizes the season, caused by tropical depressions that enter the country from the Bay of Bengal.

The post-monsoon (autumn) represents a transitional period similar to the pre-monsoon. With the beginning of the season, the differences in heat between land and water decrease, and the westerly of the mid-latitudes begin to move towards the south. In the course of time, some of the westerly air stream blows to the south of the Himalayas and disrupts the tropical circulation. Meanwhile, the easterly jet is dislodged by strong westerly winds above. The temperature remains mild during this season and it is more comfortable due to less moisture in the air.

5.2.1 Temporal and spatial variation of temperature

All regions of the country show their highest mean maximum temperature in the pre-monsoon season, while the highest mean minimum temperature occurs during the summer monsoon (Table 5.1). This is because the atmospheric moisture content and cloud cover are the highest during the summer monsoon season. At night, these absorb the outgoing long wave radiation very efficiently (Ahmed, 2004; Sarker, 2005).

In winter mean maximum temperature is slightly lower in the north (28.2°C in the Northwest region) and higher in the south of the country (30.8°C in the Southeast region). The Northwest and Western central regions are clearly the coolest part of the country in this season (Table 5.1). This is due to the advection of cold continental air from the northwest and the Himalayas, and being farthest north, there are shorter days than in any other region in winter. Due to the high moisture content of the atmosphere over the southern regions near the Bay of Bengal, these areas (Southeast and Central coastal and island) show the highest mean minimum temperatures (Table 5.1).

In the pre-monsoon and monsoon seasons the mean maximum temperature is highest in the central west part of the country (Table 5.1), as this region receives less rainfall (see section 5.2.1) and is furthest from the cooling influence of the sea and higher ground. Mean maximum temperature during the summer monsoon season is generally lower than the temperature during the pre-monsoon season as widespread cloud cover reduces the insolation (Ahmed, 2004). This also results in minimum temperatures being higher than in any other season. In the post-monsoon season conditions are fairly similar over most of the country (Table 5.1).

Table 5.1: Regional and seasonal temperature variation of mean maximum (Max), minimum (Min) and average temperature (^{o}C) over Bangladesh.

Regions	Winter			Pre-monsoon			Monsoon			Post-monsoon			Annual		
	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average
Northwest	28.2	8.5	18.4	37.1	16.1	26.6	35.4	22.9	29.1	32.3	15.7	24.5	33.5	16.4	24.5
Western Central	29.6	8.4	19.0	39.1	16.9	28.0	35.6	23.3	29.4	33.5	16.3	24.7	34.5	16.3	25.7
Southwest	30.7	9.4	20.1	38.1	18.2	28.2	35.3	23.5	29.4	33.6	17.0	25.3	34.6	17.6	26.1
Middle	29.5	10.1	19.8	36.4	18.2	27.3	34.5	23.0	28.8	33.0	16.0	24.5	33.5	17.4	25.5
Northeast	29.6	8.6	19.1	35.6	16.2	25.9	35.2	22.6	28.9	33.0	16.0	24.5	33.5	16.4	25.0
Central coastal and island	29.7	11.5	20.5	35.0	19.0	27.0	33.7	23.1	28.4	33.1	17.8	25.3	33.0	18.3	25.3
Southeast	30.8	12.6	21.7	35.3	19.5	27.4	34.0	22.9	28.4	32.5	18.0	25.0	33.3	18.6	26.0
Bangladesh	29.7	9.9	19.8	36.7	17.7	27.2	34.8	23.0	28.9	33.0	16.7	24.8	33.7	17.3	25.4

Temporal trends

The average temperature shows a statistically significant increasing trend since 1948 of ~ 0.1^{o}C per decade for all seasons of the year for the country as a whole, except in the pre-monsoon period. This is also true for many of its constituent regions, with some regions and seasons having greater trends, for example the post-monsoon trend in the Northeast region is more than three times the national average. The exceptions to this general behaviour are the winter and pre-monsoon seasons in the western and central regions of the country (Table 5.2). The pre-monsoon temperature has much greater inter-annual variability (Figure 5.3) because of the variability in timing of the monsoon onset, and the impact of this variability is most notable north of the southwest-northeast climate divide across the country during these seasons.

Table 5.2: Average regional temperature trend over the period 1948-2010

Average temperature trend (°C/year)					
Regions	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Northwest	0.001	-0.011	0.010*	0.011*	0.003
Western Central	0.004	-0.008	0.017**	0.019**	0.008*
Southwest	-0.002	0.002	0.015*	0.013	0.007*
Middle	0.013**	-0.002	0.019**	0.023**	0.013**
Northeast	0.030**	0.013*	0.016**	0.035**	0.022**
Central coastal and island	0.010**	0.007	0.012**	0.014**	0.011**
Southeast	0.011*	0.015	0.022**	0.021**	0.018**
Bangladesh	0.009**	0.003	0.013**	0.015**	0.010**
*Significance at the level of 95%; ** Significance at the level of 99%.					

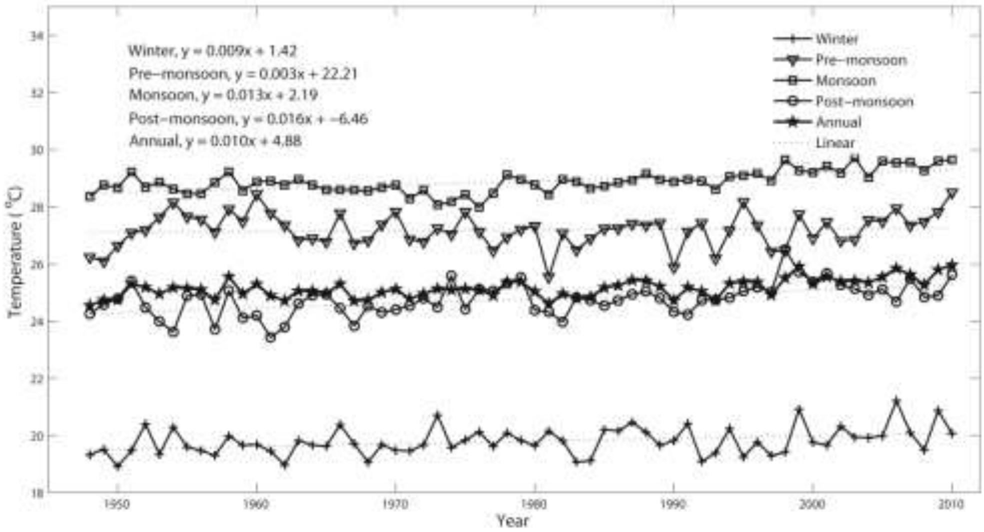

Figure 5.3: Monthly average temperature of annual and seasonal time series of Bangladesh.

5.2.2 Temporal and spatial variation of rainfall

5.2.2.1 Spatial variation

There is an extremely large seasonal variation in rainfall between the winter and summer monsoon in Bangladesh. In winter only 2% of the annual rainfall occurs, whereas in summer 70% of the annual total falls. The annual total average rainfall of the country varies spatially from 1600 mm in the west to 3200 mm in the northeast (Table 5.3). This geographical variation is accentuated in the pre-monsoon period, where rainfall varies from 263 mm in the west central region to 850 mm in the northeast region, due to the orographic features of the eastern part of the country and the entry route of the monsoon onset.

Table 5.3: Average seasonal total rainfall (mm) across the regions of Bangladesh.

Regions	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Northwest	23	339	1514	159	2036
Western Central	28	263	1189	144	1624
Southwest	40	268	1207	174	1690
Middle	35	465	1436	209	2146
Northeast	54	851	2021	232	3158
Central coastal and island	39	432	2006	290	2767
Southeast	52	608	2128	196	2984
Bangladesh	39	461	1643	201	2344

5.2.2.2 Temporal trend

Though there are large spatial and seasonal variations of rainfall in the country, rainfall variation also occurs from year to year, depending crucially on the timing of the onset and duration of the monsoon. Tropical cyclones are also variable in occurrence and distribution between years (Brammer, 2000). Nevertheless, the annual precipitation trends are positive and statistically significant for the country as a whole, and also for a number of regions (Table 5.4). The exception to this is in the center of the country (Western central and Middle zones), where there are weak downward trends. While the high inter-annual variability in rainfall (Figure 5.4) means that trends in individual seasons are mostly not statistically significant, the monsoon and pre-monsoon seasons are where the increase is mostly found.

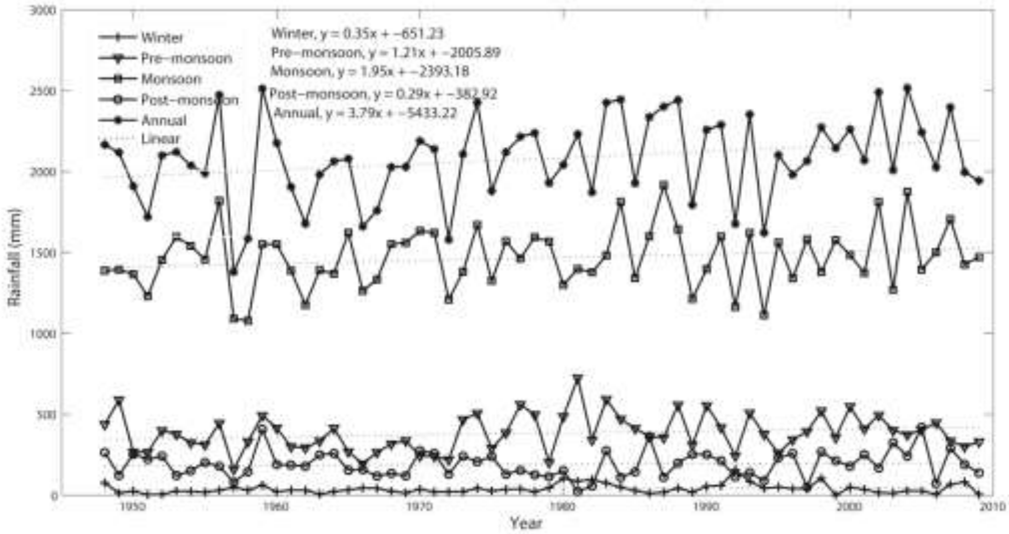

Figure 5.4: Time series of annual total and seasonal total rainfall in Bangladesh

Table 5.4: Average annual total and seasonal total rainfall trend over the period 1948-2010

Regions	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Northwest	0.24	2.09*	4.6	1.76	8.7**
Western Central	0.18	0.22	-0.72	-0.09	-0.42
Southwest	0.58	0.92	3.17	0.41	5.08*
Middle	0.08	0.051	-4.07*	-0.45	-4.4
Northeast	-0.08	3.82	3.93	-0.85	6.8*
Central coastal and island	0.23	1.76	4.87*	0.56	7.4*
Southeast	-0.07	5.61**	2.1	0.5	8.13
Bangladesh	0.35	1.21	1.95	0.3	3.8*
*Significance at the level of 95%; ** Significance at the level of 99%.					

5.4 Hydrology of Bangladesh

One of the significant impacts of climate change and climatic variability is on water resources in Bangladesh. The enormous discharge of water from the Ganges-Brahmaputra-Meghna (GBM) river system is greater than from any other except the Amazon and the Congo (Rasheed, 2008). About 90% of Bangladesh's total stream flow is generated outside its boundary (ADB, 1994). It is estimated that an average of 1.073×10^{12} m^3 of water flows annually into the country from India, while the annual rainfall volume is estimated at 0.25×10^{12} m^3, with evaporation, evapotranspiration and percolation losses accounting for 0.148×10^{12} m^3 (ADB, 1994). Hence, about 1.175×10^{12} m^3 of water is estimated to flow into the Bay of Bengal each year, 96% of which drains through the GBM delta (ADB, 1994). GBM drainage basin is shown in Figure 5.5. The total discharge of the GBM rivers varies between 1.5×10^6 m^3s^{-1} during the peak flow period following the monsoon to only 6.1×10^4 m^3s^{-1} at low flow (Hasan and Mulamoottil, 1994; Chowdhury, 2010).The water sources of the Ganges and the Brahmaputra River are rain and Himalayan glaciers. The Meghna is a rain-fed river and comes from one of the highest rainfall regions of the world.

Every year the Ganges and Brahmaputra transport 316 and 721 million tons of sediment respectively into Bangladesh (Islam et al., 1999). These sediments interact with hydrodynamic and morphological processes in the estuary leading to accretion in some places and erosion in others (Islam et al. 1999). This has caused much of the original estuary to be become filled with sediment.

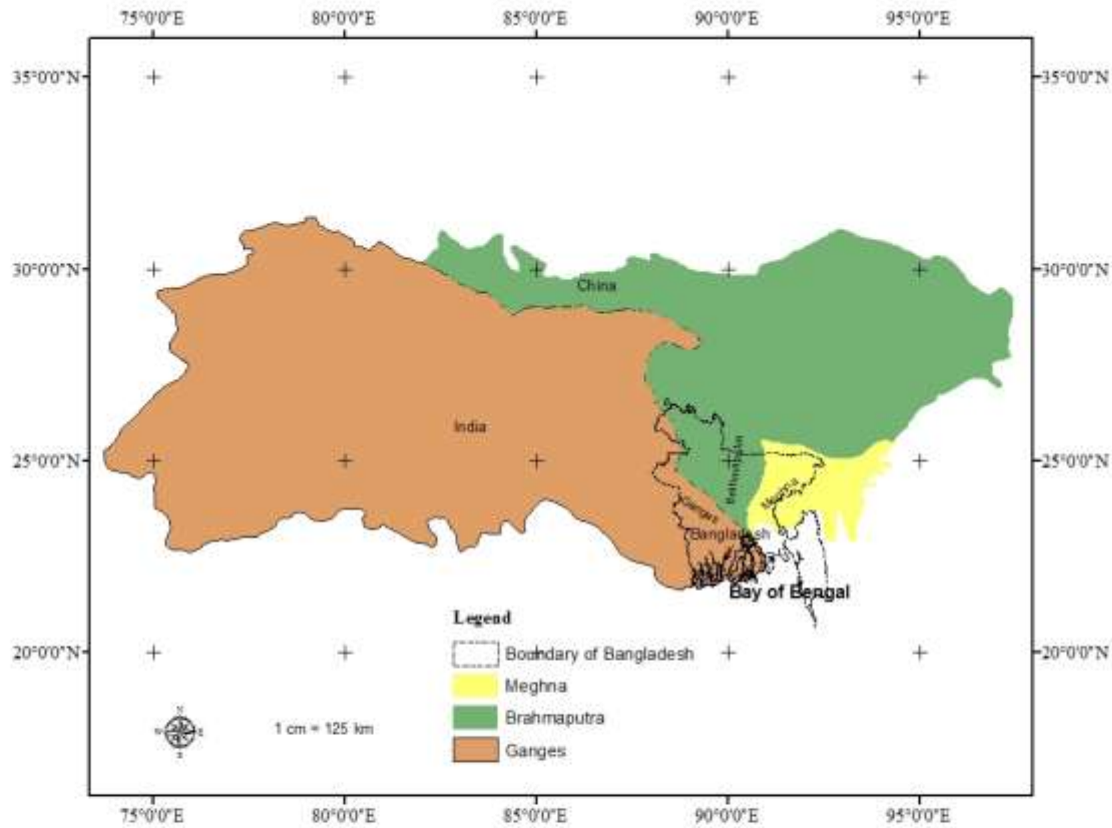

Figure 5.5: River basins of the three big rivers

In this thesis the Ganges part of the GBM delta is used as an example of processes occurring throughout, and it is where the fieldwork was carried out. The Ganges springs from 5 headstreams, all rising in the northern mountain region of India, and some of which derive from glaciers, which will be affected by climate change (IPCC, 2007b). Once across the border with India, the Ganges flows for a further 225 kilometers before joining with the Brahmaputra-Jamuna (Figure 5.1 and 5.5). This combined flow takes the name of Padma. The Padma travels 97 km in a southeasterly direction before joining with the Meghna (Figure 5.1 and 5.5), whereupon it turns in a southerly direction (taking the name Meghna) and flows into the Bay of Bengal (Figure 5.1).

The Ganges transports a great quantity of sediment (Sinha et al., 2010). This morphological character leads to a dynamic river channel, constantly evolving. Since the earliest survey by James Rennel, between 1763 and 1776, the river has moved significantly to the east (Chowdhury et al., 1996; Rasheed, 2008).

The watershed of the Brahmaputra is smaller than the Ganges (Figure 5.5) but due to its steeper slope it has a larger discharge and higher sediment transport than the Ganges (Catling, 1992). It is believed that due to the speed and volume of water, carry a heavier silt load to the downstream channel, while the Assam catchment area receives some of the highest rainfall in the world (Catling, 1992).

The bank material of the GBM channels is formed of loosely packed silt and fine sand, which is particularly prone to erosion (Sarker et al., 2003). Thus, it is highly susceptible to channel migration. An EGIS (Environment and GIS support Project) study of the Brahmaputra–Jamuna River in 1997 found that the average width of the river has increased by about 130 m per year since 1973 and appears to have been slowly widening since it adopted its current course in the early 1800s (Sarker, 2003).

The basin area of the Meghna is smaller than Ganges and Brahmaputra. It has two parts in Bangladesh: the Upper-Meghna and the Lower-Meghna. In the wet season the Lower Meghna rises, leading to flooding and river bank erosion.

5.4.1 Variation of river discharge flow

Variation of river discharge is of significant importance for agriculturally-based communities, such as those of most areas of Bangladesh, who rely on these rivers for their social, cultural, and economic activities. Annual and inter-annual variation of rainfall within, but predominantly without, the country causes the variation of river discharge flow at the different stations of the different rivers (chapter 3, figure 3.1). Monsoon rainfall dominates the flow of the rivers. Since rainfall in this season is increasing in most parts of the country, if not everywhere to a statistically significantly level (Table 5.4), as well as in the river catchments (Gautam et al., 2009), this is leading to increased flooding and river bank erosion.

The average water flow annually into the country from India through the four major rivers of the Ganges-Brahmaputra-Meghna and Teesta is estimated at 33600 m^3s^{-1}. This calculation has been made from the stations of Bahadurabad (Brahmaputra), Harding Bridge (Ganges), Kaunia (Teesta), Kanairghat and Sheola (Meghna) (see chapter 3, figure 3.1 and table 5.5). However, there is a large contrast between the monsoon and dry seasons: the mean flows are 68 800 m^3s^{-1} and 8800 m^3s^{-1} respectively (Table 5.5).

Table 5.5: Average seasonal river discharge (m^3s^{-1}) at different stations in Bangladesh. See figure (chapter 3, figure 3.1) for locations

Stations	River	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Bahadurabad	Brahmaputra	5615	9765	40036	18326	20245
Harding Bridge	Padma (Ganges)	2870	1687	24122	12045	11187
Baruria	Padma (Ganges)	7800	10724	57753	28794	28681
Bhairab	Meghna			9569		
Kaunia	Teesta	160	288	1925	626	862
Kanairghat	Surma (Meghna)	16	276	1218	363	539
Sheola	Kuhiyara (Meghna)	145	456	1511	689	769

Most of the rivers have shown discharge increases over the last few decades (Table 5.6), although only at Bahadurabad on the main river system (chapter 3, figure 3.1) is this mostly statistically significant. All seasons here except the highly inter-annually variable monsoon, show strong statistically significant increasing trends (Figure 5.6). This general variability of the monsoon flow is seen clearly in figure 5.7, which shows the proportion of the country subject to either flooding or drought annually over 1955-2007. Note the frequency, and severity, of flooding has been increasing in recent decades, while the frequency of drought has been decreasing, in line with the general increase in river flows. This variation is to some degree associated with wider climate variability. The flood years of 1954, 1955, 1974, 1988, 1998, 2004, and 2007 are likely to be related to positive ENSO, or La Niña, events, while the drought years of 1951, 1973, 1975, 1981, 1982, 1989, 1994, and 2003 are related to negative ENSO, or El Niño events.

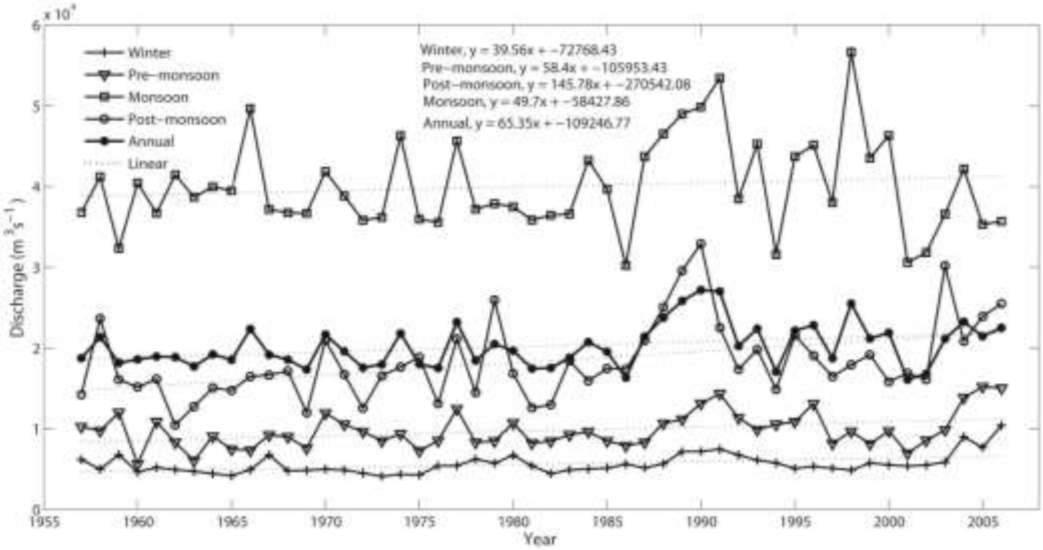

Figure 5.6: Seasonal and annual mean discharge at Bahadurabad. See chapter 3, figure, 3.1 for location

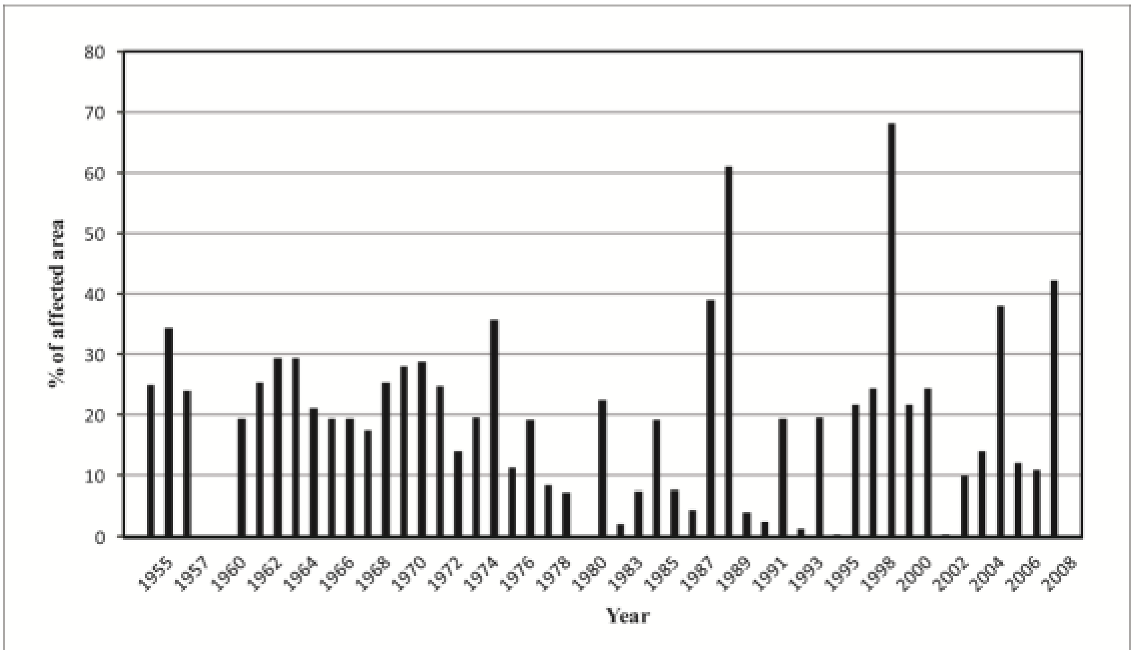

Figure 5.7: Percentage of flood affected areas in Bangladesh, 1954-2007 (data source: BWDB, 2008)

The discharge of the Ganges entering Bangladesh, however, has been complicated by the construction of a dam at Farakka, just on the Indian side of the border, in the early 1970s. The mean flow downstream at Harding Bridge shows a clear decrease in the dry season flows of winter and the pre-monsoon (Table 5.6 and figure 5.8). There are treaty arrangements to keep a fair share of the Ganges peak flow entering Bangladesh which seem to largely be working, as there is no similar net decrease in the monsoon discharge (Figure 5.8). However, the increasing monsoon flows seen at Bahadurabad (Figure 5.6) and Baruria are not visible at Harding Bridge.

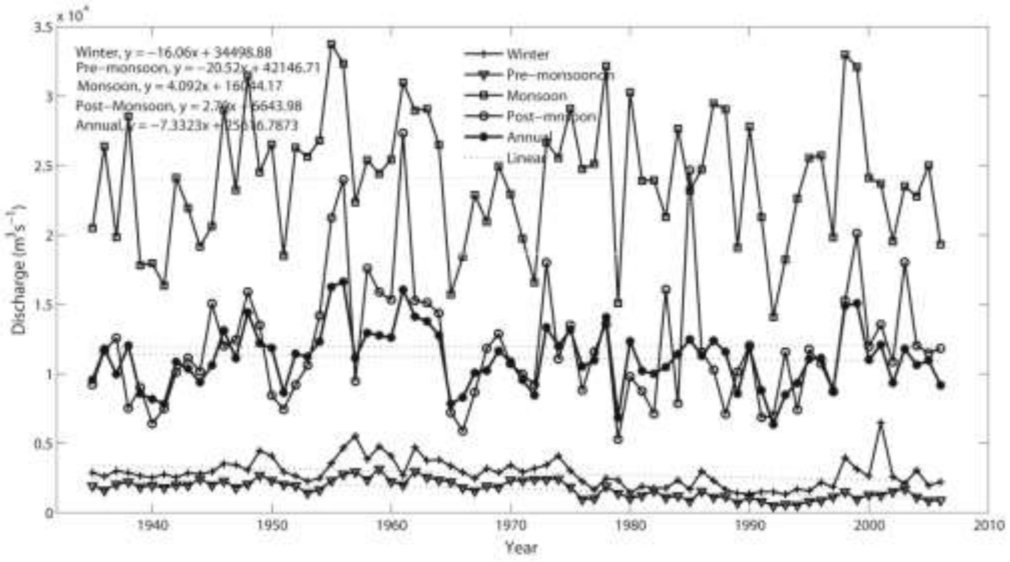

Figure 5.8: Seasonal and annual mean discharge at Harding Bridge. See chapter 3, figure 3.1 for location

Table 5.6: Trend of mean river discharge ($m^3 s^{-1} yr^{-1}$) over different stations

Stations	River	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Bahadurabad	Brahmaputra	39.56**	58.40**	49.69	145.78**	65.35*
Harding Bridge	Padma (Ganges)	-16*	-20**	4.90	2.7	-7.16
Baruria	Padma (Ganges)	7.47	26.24	113.78	133.61	68.62
Bhairab	Meghna			-81.4		
Kaunia	Teesta	-0.29	0.28	1.81	-2.00	0.84

Stations	River	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Kanairghat	Surma (Meghna)	0.22	1.45	3.72	2.02	1.99
Sheola	Kuhiyara (Meghna)	1.97	1.71	-2.07	5.00	1.06
*Significance at the level of 95%; ** Significance at the level of 99%.						

5.5 Environmental risk factors within Bangladesh

Bangladesh is highly exposed to natural disaster such as flood, drought, cyclone, river bank erosion and sea level rise due to its geographical location and hydrological characteristics (Penning-Rowsell et al., 2012). Since much of Bangladesh lies in the flat, coastal delta of the mouth of the Ganges, it is easily susceptible to flooding from both coastal storms as well as spring melt water (Legates and Soon, 201: 37).

5.5.1 Water resources and flooding

Water is the most important environmental issue for Bangladesh. Flooding is a very common and regular event in Bangladesh. Due to the flat topography, riverine landscape, and convergence of the three mighty GBM Rivers, the country is highly prone to flooding and river bank erosion every summer monsoon.

Changes to precipitation and temperature are expected to result in severe droughts and strong flooding in different parts of Bangladesh (IPCC, 2007b). This issue could be made more severe as the Himalaya's glaciers melt because they feed seven rivers in this region, among which are the two major rivers of the Ganges and Brahmaputra (Rai et al.,2005). The Himalayas have the largest concentration of glaciers outside the polar caps, covering 33,000 km^2, and providing ~$8.6x10^6$ m^3 of water annually to river flow (Dyurgerov and Meier, 1997). Roughly 10% of this comes from the melt water contribution which is vital for the dry season flows, with the remaining amount generated from rainfall (Mirza, 2007).The IPCC (2007b) reported that glaciers in the Himalaya are receding faster than in any other part of the world. Therefore, in the short term the runoff of the snow-fed rivers may increase but in the long term it will decrease (IFAD, 2009). A decrease in rainfall in South Asia during the dry season (Christensen et al., 2007) will cause more extreme drought in this region (Dash et al., 2012). Bangladesh has already experienced an increased frequency of drought in recent years (Shahid and Behrawan, 2008; Dash et al., 2012: 1462).

About 60% of the country is flood-prone (ADB, 1994). As a result of snow melt in the Himalayas and pre-monsoon rainfall in Assam and the northeast of Bangladesh, the Brahmaputra and the Meghna begin to rise in March–April (pre-monsoon season), while the Ganges starts to rise later, in May, since its catchment is in relatively drier areas during this season (Brammer, 1990). Thus, the normal sequence of flooding in the country starts with flash floods in the northern and eastern hill streams during the pre-monsoon of April-May (Rasheed, 2008). However, all three rivers rise rapidly in June-July with the onset of the monsoon rains proper. The Brahmaputra normally reaches its peak level in July-August and the Ganges about a month later, in August-September (Brammer, 2004). Occasionally the Brahmaputra peaks in late August or September, coinciding with the Ganges peak; and the high Ganges flood sometimes extends to October (Brammer, 2004). The Meghna follows a similar pattern to the Brahmaputra, but high levels often extend into September due to the backing up of water above the confluence with the Ganges (Brammer, 1990).

Immerzeel (2008) predicted the strongest increase through climate change for the monsoon season. The combination of simultaneous discharge peaks of the tributaries, high run-off from the Meghalaya Hills, heavy rainfall in Bangladesh, and high groundwater tables will result in a very high peak discharge at Bahadurabad (Immerzeel, 2008). However, given likely increases in Himalayan glacier melting (IPCC, 2007b; Immerzeel et al., 2012), and local sea level rise as well, these expected continuations of current trends in climate and river discharge pose significant problems for Bangladesh's future environmental security.

Bangladesh faced severe floods in 1954, 1955, 1956, 1963, 1968, 1970, 1971, 1974, 1984, 1987, 1988, 1998, 2004 and 2007. During each flood, hundreds of people were killed, and damage to crops, small enterprises and infrastructure was as high as several billion US$, severely disrupting the national economy (Penning-Rowsell et al., 2012: s47). The reduction in potential GDP associated with major disaster has gradually become smaller as the national economy of the country has grown and become less dominated by agriculture (Penning-Rowsell et al., 2012: s47).

On the basis of adaptation and impact, most floodplain farmers define two types of flood: one is the 'normal flood' and the other is the 'abnormal flood' or 'damaging flood'(Paul, 1984, Brammer 1990, Rasid and Mallik, 1995) Normal flood or *barsha* (in Bengali) occurs due to monsoon rainfall, which farmers are well adapted to and build into their cropping practices (Brammer, 1990). Each year, approximately 20%-25% of the country experiences normal flooding (Chowdhury, 2000; Ahmed and Suphachalasai, 2014). The 'abnormal flood' or 'damaging flood', locally known as *bonna* (in Bengali), occurs due to the rising of water higher or more rapidly, which damages roads, railways and flood embankments, and submerges settlements and industrial sites (Brammer, 1990). The abnormal flood of 1988 caused damage of 1.2 billion US$, leaving 45 million homeless and killing 2000-6500 people (Ahmed and Suphachalasai, 2014). Table 5.7 shows the abnormal flood of 1987 caused massive crop damage (estimated at 1.5x 10^6 tonnes) (Bangladesh Agriculture Research Council, 1987, as noted by (Rasid and Mallik, 1995: 6)

Table 5.7: Impact of major flood in Bangladesh (sources: Ahmed and Suphachalasai, 2014)

Event	Impact
1954 floods	Affected 55% of the country
1974 flood	Moderately sever, over 2,000 deaths, affected 58% of the country, followed by famine with over 30,000 deaths
1984 flood	Inundated 52,520 square kilometres, estimated damage of $378 million
1987 floods	Inundated over 50,000 square kilometres, estimated damage of $1.0 billion, 2,055 deaths
1988 floods	Inundated 61% of country, estimated damage $1.2 billion, more than 45 million homeless, and 2000-6,500 deaths.

5.5.2 Tropical cyclone in Bangladesh

The Bay of Bengal is one of the most cyclone prone regions in the world, accounting for ~5.5% of all tropical storms (Ali, 1999). One count estimates that ~50% of all deaths from tropical cyclones have occurred in Bangladesh (Ali, 2003). About one tenth of the global total of tropical cyclone originates in the Bay of Bengal (ADB, 1994). Each year, an average of 16 tropical cyclone develop in the Bay of Bengal (Alexander, 1993) but not all move towards Bangladesh (Penning-Rowsell et al., 2012). Thus, some of these cyclones cross through an area of eastern India, while some move towards to Bangladesh and Myanmar (Alam, 2011). Even if a tropical cyclone hits Bangladesh, it does not affect the entire coastal area (Penning-Rowsell et al., 2011). Over a period of 100 years, 508 cyclones have affected the Bay of Bengal region, of which 17 percent made landfall in Bangladesh (MoEF, 2008). Out of 15 major cyclones since 1960, nine mainly struck the south-east coast, four mainly struck the south-west coast and two affected the central and eastern section of the coast Penning-Rowsell et al., 2011: 6). Hostorical records suggest that Bangladesh experiences one damaging cyclone every four and one-half years (Shamsuddoha and Chowdhury 2007; as noted by Paul and Dutt, 2010: 336).

5.5.3 River bank erosion

River bank erosion is a very common, but often imperceptible, event in Bangladesh. It is mainly related to monsoon flooding, but can also be associated with storm surges, and occurs in the wet season throughout the riverine part of the country. Due to the flat topography and convergence of the three mighty rivers of the Ganges, Brahmaputra and Meghna In every summer monsoon, heavy and prolonged rainfall in the summer monsoon, together with Himalayan glacier melting, causes these rivers to create large-scale flooding into adjacent flat regions of the country, and river bank erosion. Moreover, every year the Ganges and Brahmaputra transport huge amounts of sediment that interacts with hydrodynamic and morphological processes in the estuary leading to accretion in one place and erosion in another (Islam et al., 1999). Thus, erosion has been defined as the mechanism of detachment of sediment particles and other materials by the action of flow, wave, tidal fluctuations and other hydrological factors governing the flow condition of channel (Ahmed, 1989; Nath et al., 2013: 454).

The combined physical, social, economic and political effect of flooding and river bank erosion is significant. It has led to the destruction of houses, crops, agricultural lands, schools, markets and infrastructure. Due to river erosion, many people are displaced, or migrate to new places to take shelter. Every year of the order of 100 *upazilas*, or sub-districts, of Bangladesh are at risk of river bank erosion or flooding (Elahi, 1991). Every year 100 000 people become homeless due to river bank erosion alone in Bangladesh (RMMRU 2007). Recurrent displacements are common in the erosion-prone districts, and such multiple displacements hinder recovery and long-term rehabilitation (Hutton and Haque 2004). To aggravate the problems, the riverine areas of Bangladesh have been identified as among those most liable to famine (Currey, 1979; Lein, 2009) and are home to the poorest, most marginalized and vulnerable communities in the country (Lein, 2009).

Hutton and Haque (2004) carried out research on human vulnerability, dislocation and resettlement to identify and analyse the pattern of economic and social adaptation among river-bank erosion-induced displacement in Bangladesh. Some 238 displaced household units were randomly sampled and interviewed in the central city of Sirajganj. The findings of the research reveal that displacees experience substantial socio-economic impoverishment and marginalisation as a consequence of involuntary migration. Keya and Harun (2007) examined river bank erosion induced psychological stress on displaced women, and compared this to stress experienced by women who were not displaced. Haque (1988) and Zaman (1989) describe and explain the human adjustments to river bank erosion hazard in the Brahmaputra-Jamuna floodplain of Bangladesh. Haque (1988) found that community-level strategies were generally preventive, while individual-level measures were aimed at adaptation. Zaman (1989) suggests that a unified approach integrating perceptual and behavioural variables with socio-political and structural factors is essential to a holistic understanding of the problem of adjustment and such a perspective requires that respondents are viewed in context. Zaman (1991) also offers a socio-economic and political analysis of accretion land created from riverine sediments. He considered ownership of the new *char* system in rural contemporary Bangladesh and showed the relationship between the rural landlord and political power at the state level. He developed a critique of approaches that explain such local deployment of violence and power in term of isolation, marginality and weak state systems.

Though there are several papers on river bank erosion-related displacement for the upstream Jamuna River, no previous research had been carried out on the lower Meghna, one of the locations most at risk in the delta itself, as the river here is very dynamic due to the upstream junction of the three major rivers entering Bangladesh from India – the Ganges, Brahmaputra and Meghna. Thus, Mehendiganj *upazila*, which is situated in the Barisal district of Bangladesh, and is severely threatened by erosion from the lower Meghna, has been selected as the location of a case study into the human impact of river bank erosion in this dynamic region (Figure 5.5).

5.5.4. Sea level rise

Most Asian deltas are sinking as result of ground water extraction, floodplain engineering and trapping sediments by dam (IPCC, 2014a). Change in Bangladesh is also caused by subsidence due to tectonic activity or may be the result of crustal deformation under the weight of deltaic sediment (Syvitski et al., 2009 Stone, 2011; Syvitski et al., 2009; Stone, 2011; Hanebuth et al., 2013; Pethick and Orford, 2013). Estimates of the subsidence rate range from 8 to 18 mm a^{-1} by Syvitski (2009), 5 mm a^{-1} by Stanley and Haitt (2000) and 25 mm a^{-1} by Nicholls and Goodbred (2004). Many studies predict sea level rise in Bangladesh. The rate of mean sea level along the coast of Bangladesh has been rising at a rate ranging from 4-8 mm/year (Sing et al., 2001). Most of the country is less than 10 metres above sea level, and a part of the coastal area is below 1 metre and most vulnerable to sea level rise (figure 5.1). Thus, the country is very vulnerable to sea level rise. The World Bank (2000) projected sea level will rise 10 cm, 25cm and 1 m by 2020, 2050 and 2100 respectively, affecting 2%, 4% and 17.5% of the total land mass respectively of the country; the project also stated that if the sea level goes up 1 metre it will destroy the whole Sundarbans. IPCC (2007b) projected that sea level will rise 50 cm in the Bay of Bengal by 2100. However, this has been criticised for discounting recent observation of substantial ice losses from the Greenland and Antarctic ice sheets in its projections of future SLR, giving an estimate of an upper limit for ice sheet loss contributions to global SLR of 34 cm by 2100 (Mote et al., 2008; noted by Nishat et al., 2013: 8). Therefore, the SLR may fall within the range of 26 cm to 98 cm by 2100 for Bangladesh (Nishat et al., 2013).

"The direct and indirect consequence of sea level rise include salt water intrusion into surface and groundwater systems, drainage congestion and devastating effects on mangrove" (Poncelet, 2009: 7). About 2.8 million hectares of coastal soil already face salinization (Shamsuddoha and Chowdhury, 2007; Poncelet, 2009), due to heavy withdrawal of surface water and ground water irrigation and intrusion of sea water (Poncelet, 2009). When the flow of upstream water is reduced in the dry season, the saline water enters up to 240 kilometres inside the delta and reaches the Magura district (Shamsuddoha and Chowdhury, 2007).

5.9 Conclusion

The historical analysis of temperature and rainfall shows a statistically significant increasing trend in both rainfall and temperature since 1948 in many parts of the country. The annual rainfall and the average annual temperature show a statistically significant increasing trend since in 1948 at the rate of 3.8 mm yr^{-1} and 0.01^{o}C yr^{-1} respectively. There are also changes in the river discharges in the Ganges-Brahmaputra-Meghna River system dominating the country's hydrology. Most of the country's rivers have shown discharge increases over the last few decades; this is particularly notable on the main river system at Bahadurabad through which 60% of the discharge passes. However, the mean flow downstream at Harding Bridge shows statistically significant decreases in the dry season due to the construction of the Farakka dam in the 1970s. The frequency, and severity, of monsoon flooding has been increasing in recent decades, in line with the general increase in river flows. These changes increase the frequency of river bank erosion. This increase has been investigated for key areas in the river system and will be discussed in the next chapter.

Although very little past research on environmental change in Bangladesh has been considered, this research sets the scene for future analysis of physical environmental change in Bangladesh through an examination of recent climatic variability by exploring the temporal and spatial variation of mean temperature, rainfall, and river discharge combined. Shahid and Khairulmaini (2009) found annual rainfall has increased non-significantly at the rate of 4.9 mm yr^{-1} over a period of 35 years (1969-2003). He also identified three climatic zones: moist sub-humid, humid and wet by using De Martonne's aridity index and Thornthwaite's precipitation effectiveness index where statistically significant rainfall was observed only for the humid zone at the rate of 9.88 mm yr^{-1}. However, our study classified the country on the basis of physioclimatic conditions and examined the resulting regional variation of rainfall and temperature. Mirza et al. (1998) considered the whole basin area of the Ganges-Brahmaputra and the Meghna that covers Nepal, some parts of India and most parts of Bangladesh, where he subdivided the whole region into sixteen areas and analyzed annual trends of the individual area but this does not cover the southeast and some of the coastal and Islands area of Bangladesh that receive greater precipitation. However, he has shown that precipitation overall the basins of Bangladesh have been increasing over a period of 31 years (for the Meghna basin 29 years). Our study has confirmed his result as annual precipitation for many parts of the country has increased significantly (Table 5.4). Similarly, Immerzeel (2008) analyzed the historical trends in temperature and precipitation using a global 100 year monthly high resolution dataset for the Basin area of the Brahmaputra that was divided into the Tibetan plateau (TP), the Himalayan belt (HB) and the floodplains (FP) where the North-western zone of Bangladesh was considered as a part of the Brahmaputra basin. He found a temperature trend of 0.6 ^{o}C /century in the basin but the largest increase occurred in spring (pre-monsoon) in the flood plain (mostly Bangladesh) with 0.9 ^{o}C/century, but with a decreasing precipitation trend in summer in all three zones. In contrast, our study has shown most significant change in the other three seasons, with significantly increasing temperature in almost all other seasons and regions, and at rates significantly greater for the second half of the century than Immerzeel (2008) found over the century as a whole.

Various researchers have projected temperature (Karmakar and Shrestha, 2000; Immerzeel, 2008; Met-Office, 2011) and precipitation (Immerzeel, 2008; Met-Office, 2011) increases into the next century. Immerzeel (2008) also predicted the strongest increase for the monsoon season and the largest change to occur in the TP and the smallest change to occur in the flood plain that could lead to increased river discharge in the Brahmaputra that would increase the threat of flooding in Bangladesh. However, extreme discharge at Bahadurabad is due to a combination of processes and the upstream hydro-meteorological processes are not the only cause of flooding in Bangladesh (Immerzeel, 2008). The combination of simultaneous discharge peaks of the tributaries, high run-off from the Meghalaya Hills, heavy rainfall in Bangladesh, and high groundwater tables will result in a very high peak discharge at Bahadurabad (Immerzeel, 2008). Our research partially confirms this statement as I found that overall rainfall and river discharges are increasing in Bangladesh. However, given likely increases in Himalayan glacier melting (IPCC, 2007b; Immerzeel et al., 2011) and local sea level rise (Pethick and Orford, 2013; Brammer, 2014) as well, these expected continuations of current trends in climate and river discharge pose significant problems for Bangladesh's future environmental security. Next chapter will investigate environmental change impact on the coastal zone of Bangladesh.

Chapter 6

Environmental change impact on the coastal zone of Bangladesh

6.1 Introduction

In chapter 5, I have investigated recent hydro-meteorological environmental risk factors in Bangladesh. This chapter focuses on the coastal zone. Environmental change is a serious threat to the populated coastal community of Bangladesh. Change of relative sea level rise is a high risk for a low-lying delta area and its dense population. The coastal area, especially the delta section, has already experienced the multiple effects of cyclones, storm surges, coastal erosion, river bank erosion and salinity intrusion. Future sea level rise will further affect the region. Thus this chapter describes the sea level rise issue, and the frequency of cyclones, storm surges and erosion for the coastal zone of Bangladesh. The background information on river bank erosion has been described in chapter 5. In the current chapter the physical changes of lower Meghna in particular the rate and amount of erosion in Mehendiganj *upazila*, have been investigated using satellite images for a period of forty years.

6.2 Coastal zone of Bangladesh

Bangladesh has a 710 km long coast within the Bay of Bengal (Karim and Mimura, 2008). It is characterized by: (a) diverse physical features like *char*s, mudflats, beaches and tidal creeks; (b) dynamic hydraulic conditions with active interplay of fresh water and sea water; (c) rich diversity including the world's largest mangrove tract; (d) dense human settlements founded on farming and fishing, conditioned to a large extent in some areas by engineering interventions (Rasheed, 2008). The Bangladesh Coastal zone is covered by 19 districts, and makes up 32 % of the whole country (Shamsuddoha and Chowdhury, 2007). One third of the country is under tidal influences (Ali, 1996; as noted by Singh, 2002). Much of this region is at high risk from cyclones and storm surges, coastal erosion and sea level rise. This high risk area covers 20% of the total land of Bangladesh, with 30 million inhabitants. The high risk areas have been calculated from those districts that are exposed to the sea. This calculation was made by GIS. Population was counted from population census, 2011. The density of the population of this area is 900 people per square kilometre, which is around twenty times more than the global average.

The coastal region of Bangladesh can be divided into two hydrologically-different regions: a deltaic region and a non-deltaic section **(**Figure 3.2). The former can be sub-divided into two distinct zones: the western or tidal zone and the central GBM deltaic plain (Figure 3.2). The Western zone is characterized by tidal plains and rivers, criss-crossed by numerous channels and creeks, and mangrove swamp. Average rainfall is less than in the other zones, but coastal erosion is more of a problem here than in the eastern zone but less than the central deltaic zone. The world's largest mangrove forest (Sundarbans forest) is located in this area. The Central zone is characterized by extremely high sedimentation, monsoonal discharge and strong tides, waves and storm surges, plus the accretion and erosion of *Char* islands. The Eastern coastal zone has a strong tidal flow but has sandy beaches, a narrow strip of coastal plain, very low coastal erosion, high precipitation, and hilly areas. The world's longest sea beach is located in this zone.

6.3 Sea level rise

6.3.1 Temporal and spatial variation of mean tidal level

Tables 6.1 and 6.2 shows the seasonal average sea level variation and the trend of seasonal and regional sea level rise at four stations (chapter 3, figure 3.2). Due to the seasonal variation of local climatological variables and the dynamics of the hydrology and morphology of the delta, there are seasonal and regional variations of sea level. The water level tends to be highest in the summer monsoon and lowest in the winter, reflecting the changing density of the Bay of Bengal with river inflow. Similarly, the central, main deltaic, region has higher sea level each season compared to the west and east zones (Table 6.1).

My study found during the period of 1977 to 2008, along the coast of Bangladesh as a whole, the annual mean tidal level rose at a rate of ~6 mm yr^{-1} (99% statistical significance; table 6.2). This is high compared to the global rate of 1.7±0.3 mm yr^{-1} (Nicholls and Anny, 2010) and compared to the satellite altimeter trend measured over the whole Bay of Bengal during 1992-2012 [3.9± 0.4 mm yr^{-1} (Figure 6.1)]. Note that Sarker et al. (2012) claimed that the Bengal delta is not sinking at a very high rate. However, this assessment was based on three archaeological monuments located on the western coast of Bangladesh. Thus their claim could be true for the western coast but not for the central coast as a higher rate of sea level rise was found here for the central coast in all seasons. Similarly Mörner (2010) claimed that sea level in Sundarbans remained stable for the last 40-50 years.

My study found that the southwest region (my survey area) tidal level increasing rate is higher than the eastern part. The study of Pethick and Orford (2013) show even faster sea level rise in southwest region. Their study has shown relative mean water level at Hiron point increasing 7.9 mm yr^{-1} over the period of 1990-2011, whereas my study has shown tidal level is increasing 4.7 mm yr^{-1}. But the period covered by this station for my study is between 1977-2010. However, Mörner (2010) has suggested this gauge is in a very unstable position and so caution is required for linear trend analysis.

Singh (2002) found relative sea level rise in Cox's bazar, Char Changa and Hiron point of 7.8, 6 and 4 mm yr^{-1} over the period of 1977-1998. He suggests that due to subsidence the increasing trend in the east is higher, but sediment deposition occurs mainly in central parts of the coastal region station Char Changa and Khepupara. Though he found problems with the spatial variation in local sea level changes, he did not cite the cyclic changes that may prevent the application of trends, or the possible instabilities of the tide gauge stations (as noted by Mörner, 2010).

In the Ganges-Brahmaputra Meghna delta, river discharge is highly seasonal with 80% of discharge occurring during four months of the summer monsoon (Goodbred and Kuehl, 2000). However, the rate of the discharge in the Bangladesh part of the delta is changing (see chapter 5). In winter and pre-monsoon the river discharges at the one major station at Harding Bridge are significantly decreasing and in monsoon it is increasing (chapter 5, table 5.6). Thus, relative sea level rise in the deltaic region is likely to be higher due to land subsidence from the deposition of huge amounts of sediment during the monsoon each year. "The combined impact of land subsidence, eustatic sea level rise, tidal range amplification and a decrease in fresh water input results in an average rate of increase in ESLR in the Pussur Estuary of 14.1 mma^{-1} rising to 17.2 mma^{-1} in the densely populated Sundarbans" (Pethick and Orford, 2013). Thus an increase in relative mean sea level (RMSL) caused by subsidence may be cancelled by a decrease in fresh water flow, making assessment of the cause of change in RMSL difficult (Pethick and Orford, 2013: 241). Extraction of water due to the high agricultural activity could also lead to more subsidence, and so a further component of the increasing rate of sea level. Evidence suggests that the rate of the subsidence has also been increased by extraction of groundwater in both shallow and deep wells in Bengal delta (Ericson et al., 2006) and by plate-driven tectonic processes (Goodbred and Kuehl, 2000).

Table 6.1: Regional and seasonal mean sea level variation (m above datum)

Coastal Region	Station	Winter	Pre monsoon	Monsoon	Post monsoon	Annual
Western region	Hiron Point	1.55	1.69	2.10	1.92	1.83
Central part of coastal	Khepupara	1.96	2.17	2.60	2.31	2.29
	Char Changa	1.73	1.98	2.54	2.16	2.13
Eastern part of coastal	Cox’s Bazar	1.77	1.91	2.38	2.12	2.07

Table 6.2: Trend in mean sea level over 1977-2010, in mm yr^{-1}

Coastal region	Station	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual	Time period
Western	Hiron Point	6.40**	5.50	2.70*	5.70*	4.70**	1977-2010
Central	Khepupara	9.40**	10.80**	6.40*	9.97**	8.90**	1977-2008
	Char Changa	6.30*	8.30**	7.30**	5.93	7.10**	1977-2005
Eastern	Cox's Bazar	3.60	1.60	3.50	2.80	2.90	1977-2008
All stations	Seasonal average	6.50**	6.30**	5.00**	6.50**	6.00*	1977-2008

(*Significance at the level of 95%,** Significance at the level of 99%)

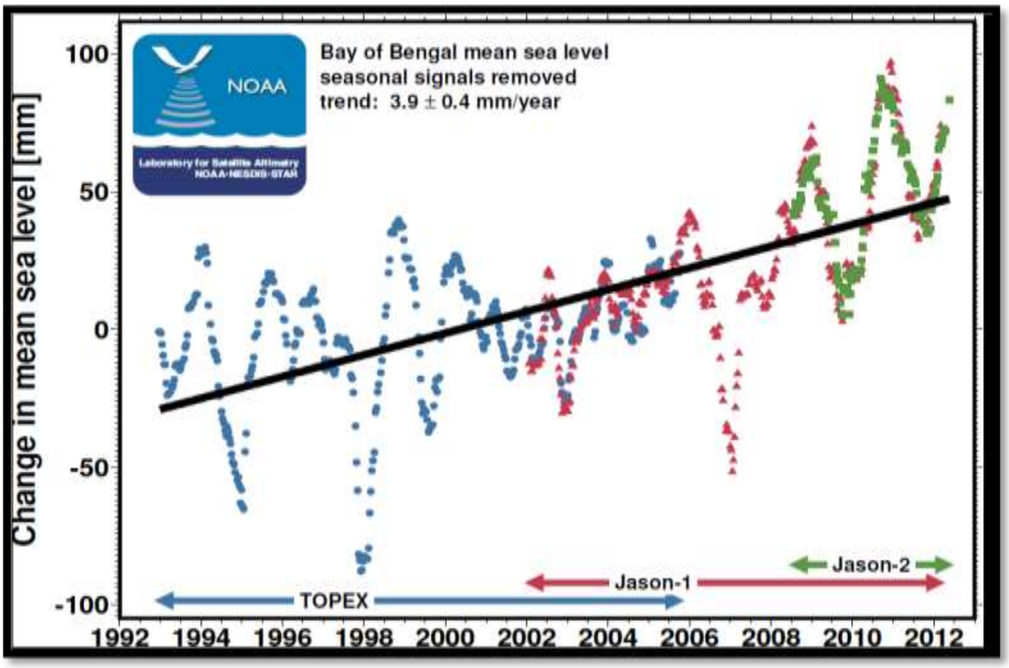

Figure 6.1: Altimetry sea level trend observed over 1992-2012 in the Bay of Bengal (source: http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/slr/slr_sla_bob_free_txj1j2_90.png)

6.3.3 Sea level rise and salinity intrusion in the study area

The Southwest region, my study area (Hiron Point), has a higher rate of mean sea level increase in the dry season than the wet season. This may lead to increased salinity as Bangladesh receives very little rainfall and river discharge in the dry season (winter and pre-monsoon); in particular the west part of the country receives less rainfall than the east (see chapter 5). The Harding Bridge station river discharge is 1687 m^3s^{-1} in pre-monsoon and 24122 m^3s^{-1} in monsoon (see chapter 5; section 5.4 table 5.5 and 5.6). Moreover, temperature is highest in pre-monsoon (see chapter 5). According to Mörner (2010: 237), the actual reason for rising salinity in south west coastal areas seems to be the dam in the Ganges, by that decreasing outflow, allows the salinity to rise away from the main outflow tributary. Wahid et al. (2007) agree that salinity is increasing due to the effects of the dam as they recorded a very strong decline in fresh water outflow after 1974 in the Siba and Passure rivers (as noted by Mörner, 2010). I have found a significant decreasing rate of river discharge at Harding bridge station (Ganges) due to the Farrake Dam. Details are described in chapter 5 section 5.5.2. Satellite images of Gorai river also provide evidence of the effect of the Farakka on the study area. It is noted that the Gorai is one of distributaries of the

Ganges, and is one of the main sources of water for southwest region (Mirza, 1998) The lower course of the river is named Madumati-Baleshwar (located in my study area). Evidence suggests that due to sea level rise, the salinity has increased in the Gorai-Madumoti river (Bhuiyan and Dutta, 2012). “Sea level rise of 59 cm produced a change of 0.9 ppt a distance of 80 km upstream of the river mouth corresponding to a climatic effect of 1.5 ppt per meter sea level rise” (Bhuiyan and Dutta, 2012: 219).

6.3.4 Potential area and people to be affected due to future sea level rise

Increasing sea level threatens the people of Bangladesh as 54% of the whole country is below 10 metres elevation and 78% of the delta in Bangladesh is below 5 metres elevation (similar procedure of calculation of the different scenario of the sea level has been applied to measure). However, it is hard to explore how much land and how many people will be affected in the near future because of the dynamic nature of the delta due to natural and human activity as the subsidence rate and coastal erosion are changeable. An assessment by the Department of Environment, Govt. of Bangladesh, predicted that future sea levels for Bangladesh will be 0.30-1.5 meter, and 0.3-0.5 meter by 2050 (Ali, 1996). IPCC 2^{nd} (World Bank, 2000) and IPCC 3^{rd} (Agarwal et al., 2003) reports projected that sea level will rise 30 and 50 centimetres by 2030 and 2050 respectively (Shamsuddoha and Chowdhury, 2007). Recently Brammer (2014: 61) mentioned, “If sea-level is currently rising at 1.3 mm/year, that is by only 13 mm (= 0.5 inch) in 10 years. Even if the rate is 3 mm/year, that is by only 30 mm (= 1.2 inches) in 10 years. But Bangladesh’s population of 150 million is currently growing at ca 2 million a year: i.e., it could grow by 20 million in the next 10 years. That will generate much greater pressure on the country’s land and water resources and its economy than will a slowly-rising sea-level.”

Here the potentially affected land and population of the coastal region of Bangladesh is roughly estimated using GIS methodology for different sea level rises (Figure 6.2[a-c]). If sea level raises by 50 centimetres, roughly 21693 km^2 (15%) area of Bangladesh would to be affected (Table 6.3) and the whole of Satkhira, Khulna and Bagerhat districts would be affected (Table 6.4). However, I use the current population to count the population of the district of the southwest region. It is noted that according to the census data from 2011, the percentage annual growth rate of Satkhira, Khulna and Bagerhat district are 0.62,-0.25 and -0.47 respectively, which means population could be unchanged. Migration could have an effect on changing the size of the population but still most people of the southwest region move to a nearby city (described in the next chapter). Thus I estimate that the population of my study area will not change significantly and therefore I used the 2011 population for predictions from the different scenarios.

Table 6.3: Potential area to be affected under different the scenarios of sea level rise. [* indicates inclusion of the upper Meghna]

Zone	Affected land	Sea level rise (m) in year		
		0.50 m	1 m	2 m
Western part of the Coastal zone	Land (km^2)	9424	10647	11729
Central part of the coastal zone	Land (km^2)	10799	14819*	18882*
Eastern part of the coastal zone	Land (km^2)	1470	1750	2224
Bangladesh	Land (km^2)	21693 (15%)	27216* (18%)	32835* (22 %)

Table 6.4: Potential area to be affected under different the scenarios of sea level rise in study area (Pop = population; M = million; HH = household)

South west region	District	50 centimetres			1 meter			2 meter		
		Area (km^2)	Pop M	HH	Area (km^2)	Pop M	HH	Area (km^2)	Pop M	HH
Survey district	Satkhira	3817	3	469890	3817	3	469890	3817	3	469890
	Khulna	4394	3	547347	4394	3	547347	4394	3	547347
	Bagherhat	3954	1	354223	3954	1	354223	3954	1	354223
Non survey district	Jessore	----	--	--	1173	1	241289	2607	2	536198
	Narail	--	--	--	485	0.36	81304	970	1	162607
Total South west region		12166	7	1.37	13824	8	1.7	15743	9	2.07

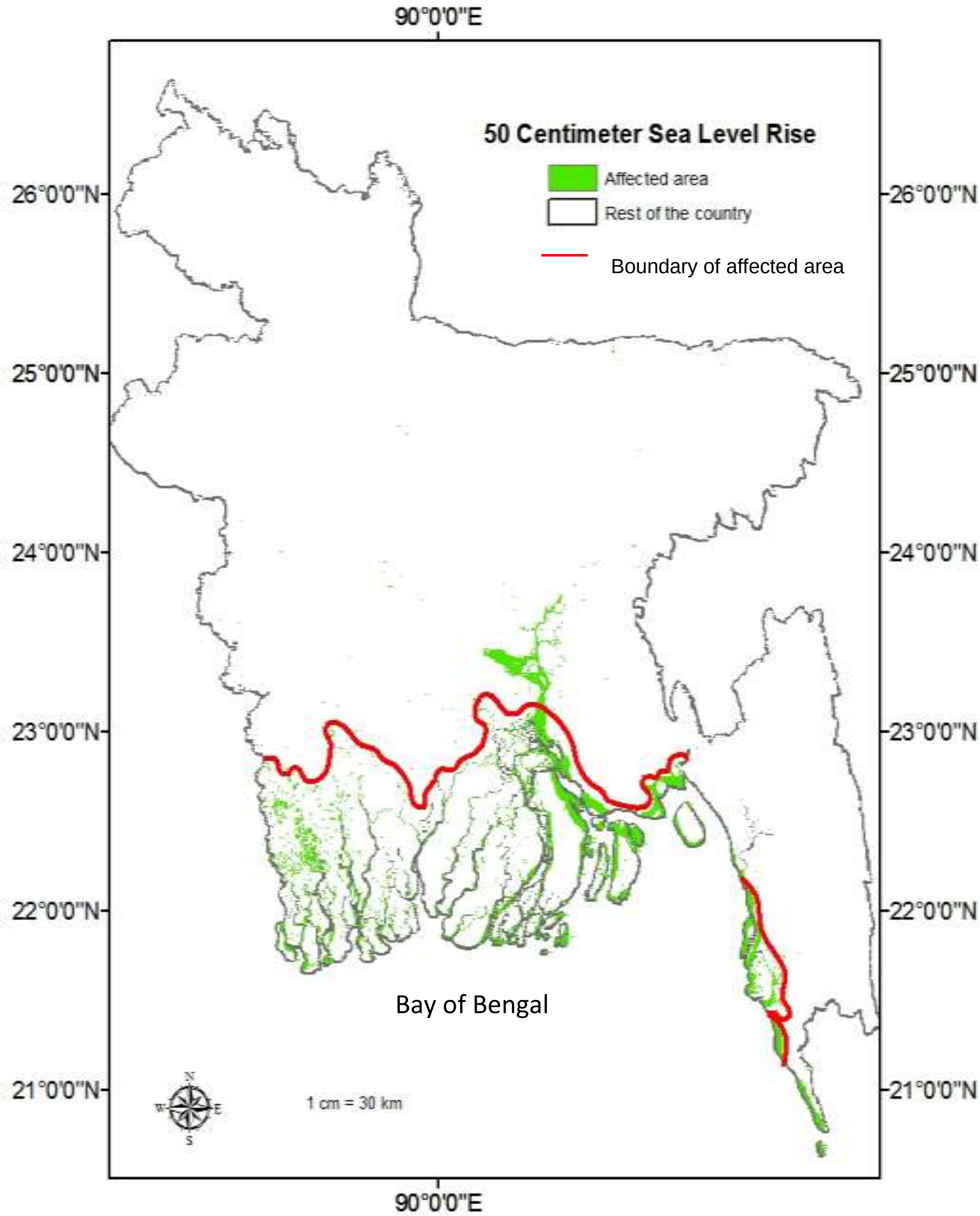

Figure 6.2(a): Affected areas for sea level rise of 50 cm. [the boundary line of the affected (and measured) area was not drawn in detail in the southern part. Salinity is also propagating further inland**.**

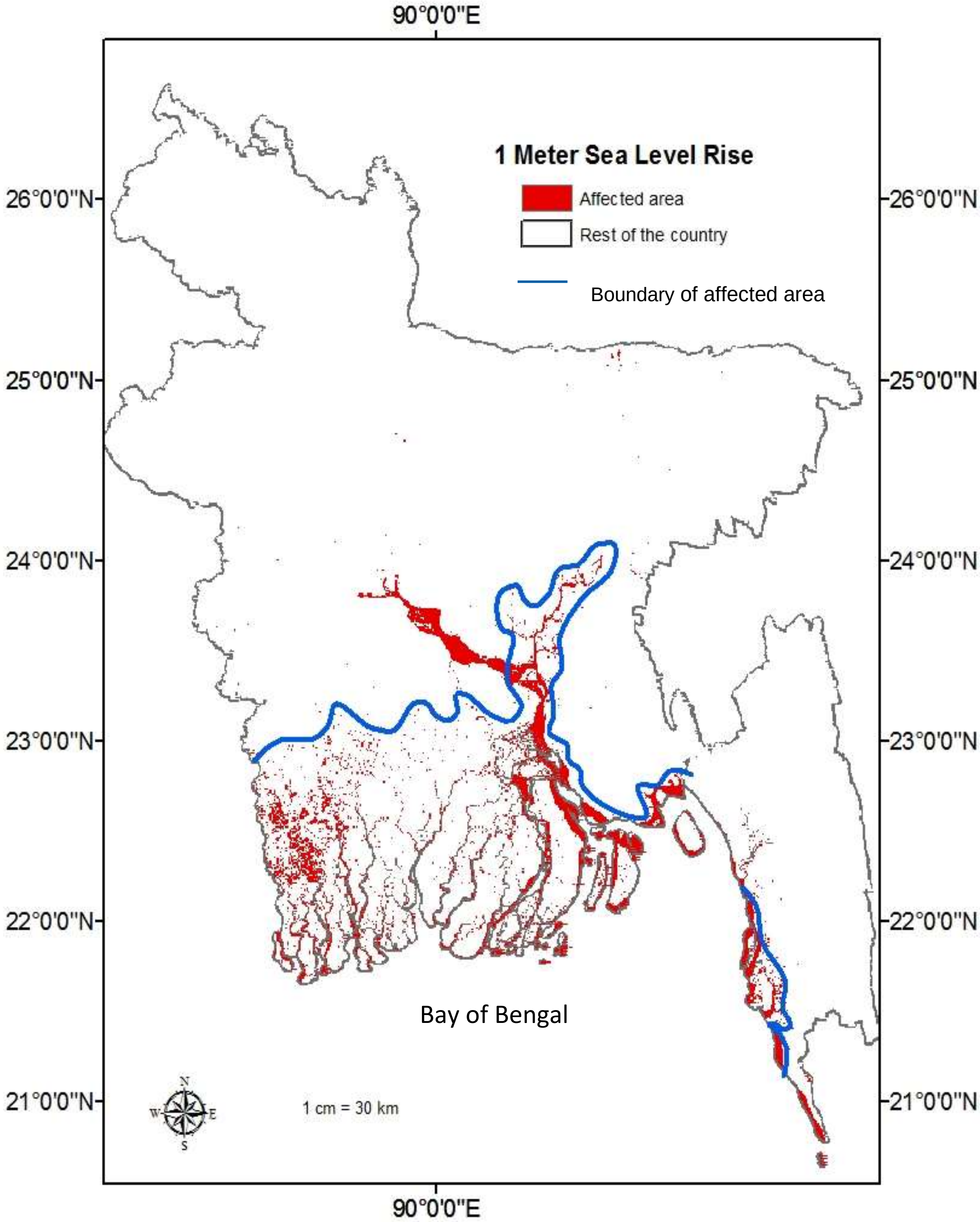

Figure 6.2(b): Affected areas for sea level rise of 1 m.

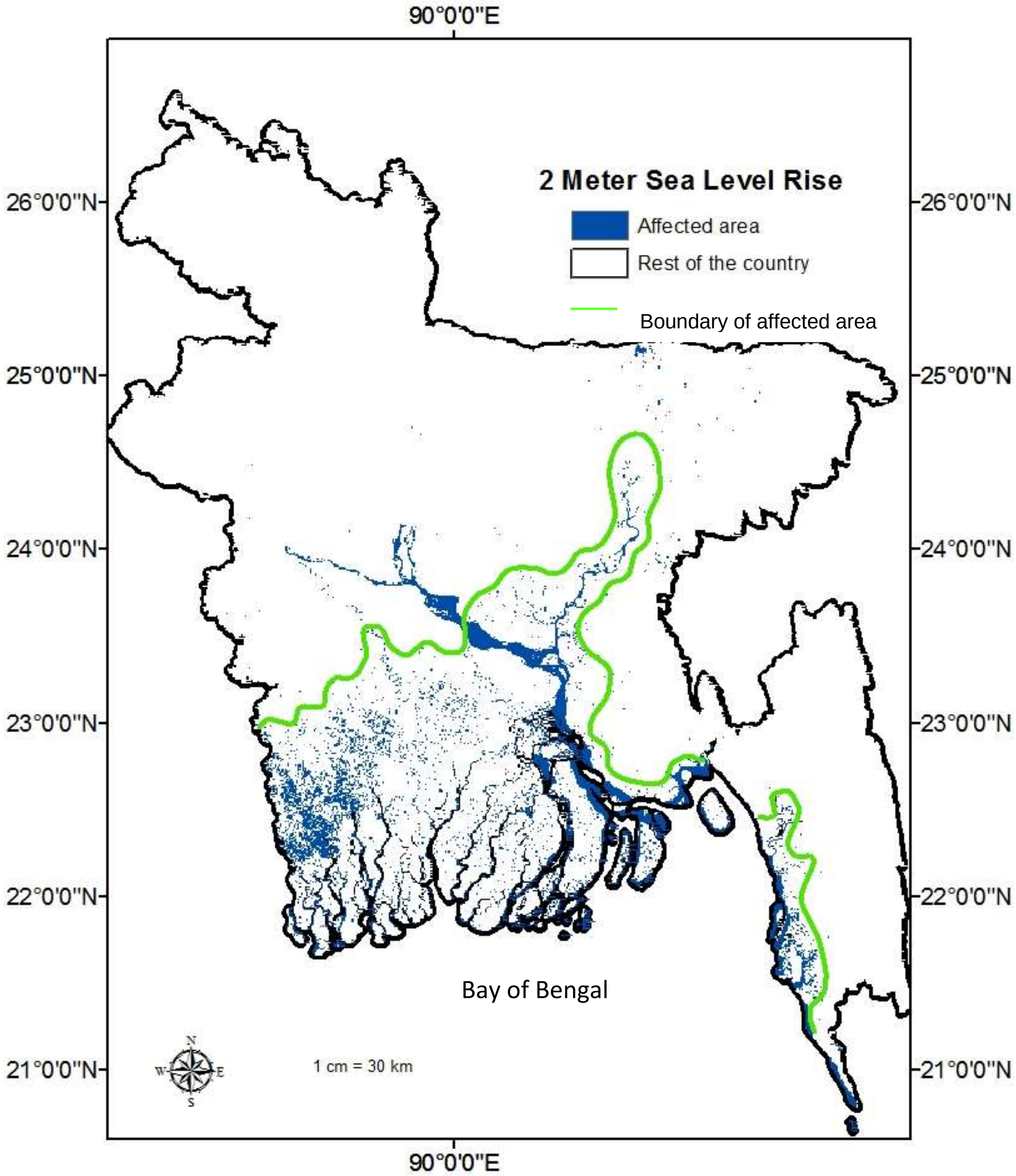

Figure 6.2(c): Affected areas for sea level rise of 2 m.

6.4 Cyclone and storm surges

The cyclones that form in the Bay of Bengal and cross the different coasts of India, Bangladesh and Burma can take a heavy toll in term of human lives, livestock, agricultural produce, property and houses. Cyclones in Bangladesh are often complex because of the recurving nature of the tropical cyclone path, the high astronomical tide in the Bay of Bengal, and the shallow, funnel shape of the northern tip of the Bay of

Bengal. This leads to the highest storm surge heights being in the coastal districts of Bangladesh.

6.4.1 Spatial and temporal distribution

I have analysed cyclone depressions which formed in the Bay of Bengal during 1974-2007. It was found that 245 cyclones occurred and these crossed different coasts around the Bay on 207 occasions during this period. Among these 43% (106 events) occurred in the post-monsoon season (Oct and Nov; figure 6.3).

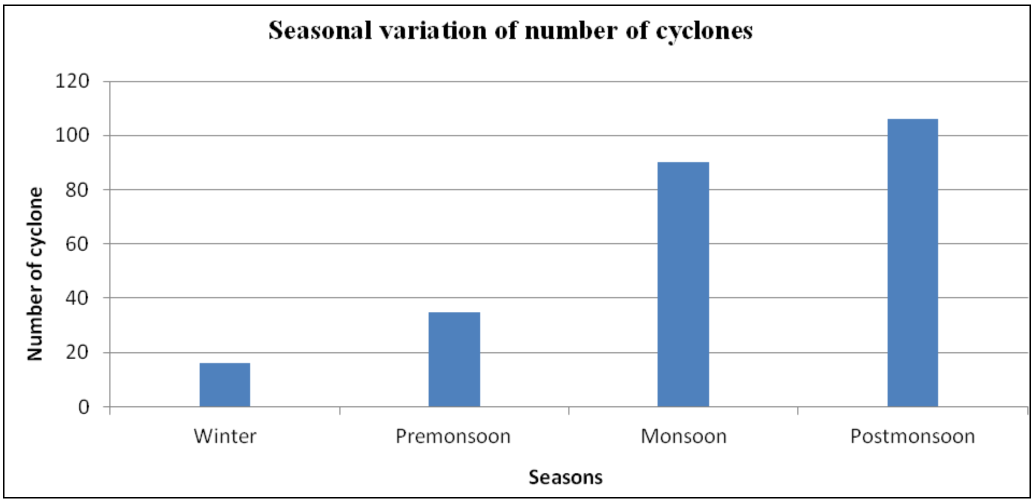

Figure 6.3: Seasonal variation of the total number of the cyclones that crossed the coast of India, Bangladesh and Burma over the period 1974- 2007.

Many studies, (Brammer, 1999 and 2004; Madsen and Jakobsen, 2004; Islam and Peterson, 2008; Paul and Dutt, 2010; Alam, 2011) confirm this finding. Islam and Peterson (2008) found 70% of the tropical cyclones hit Bangladesh in pre-monsoon and post-monsoon over the period of 127 years, as the average sea surface temperature in the Bay of Bengal and associated weather conditions are perfect for the formation of tropical cyclone in pre-monsoon and post monsoon (Islam and Peterson, 2008). Of those making landfall 66.2% (137 times) crossed the Indian Coast, 22.2% (46 times) Bangladesh and 9.2 % (19 times) the Burmese coast. It is also notable that thirty Severe Cyclones (maximum wind speed > 89 km hr^{-1}) formed in the Bay of Bengal during 1974-2007, of which eight crossed the Bangladesh coast. Overall, of the 46 depressions that crossed the Bangladesh coast roughly similar numbers crossed each section of the coast defined in chapter 3, figure 3.2.

Linear regression analysis was applied to investigate the temporal variation of cyclone and depression using R software. It was found that the annual frequency of cyclone and depression is significantly decreasing at the rate of 0.17 per year ($p<0.001$), with most of this decrease concentrated in the monsoon (not significant) and post-monsoon seasons (significant $p<0.001$) (Figure 6.4) (see appendix 8). Alam (2011) found similar result as he found an increasing trend over 117 years, while the last fifty years he found a decreasing trend. Singh et al. (2001) found that the trend of frequency of tropical cyclone over the period of 122 years (1877-1998) in North Indian Ocean enhanced in the month of November and May. He also found there has been a two-fold increase in the tropical cyclone frequency over the Bay of Bengal during November over the period of 122 years.

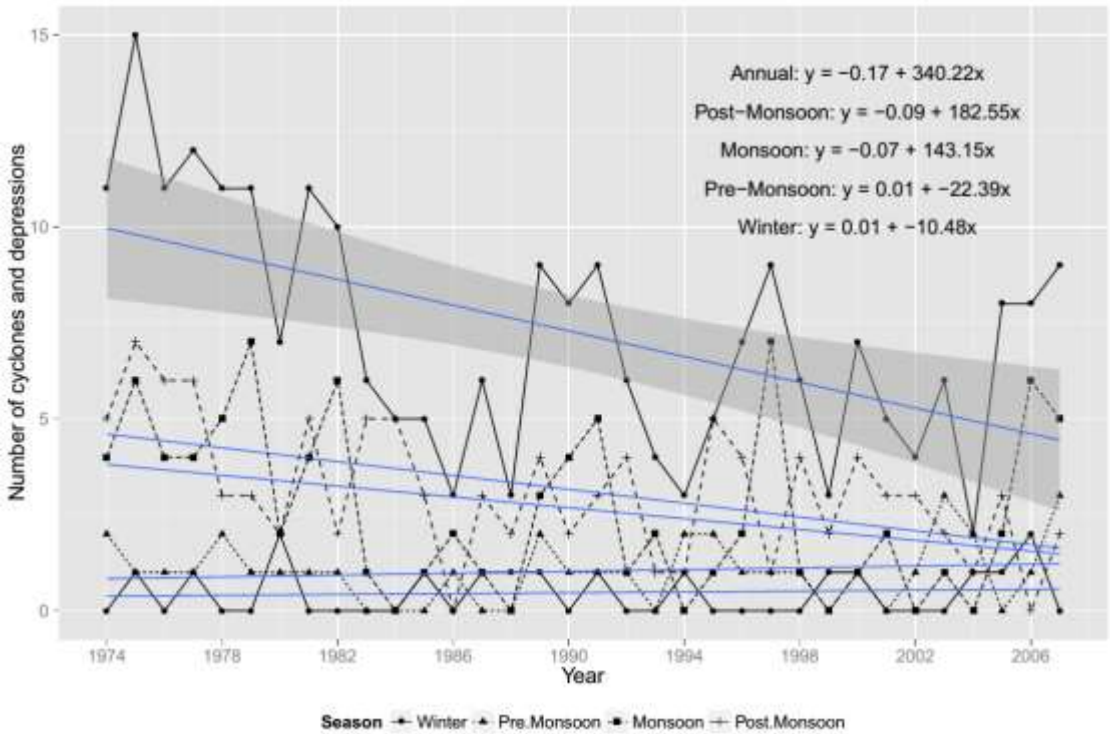

Figure 6.4: Seasonal and annual total number of cyclone and depression which formed in the Bay of Bengal over the period of 1974-2007.

In total, 19 cyclones hit in my study area (south west region) from 1891-2009 (record from BMD but adapted from Alam, 2011). These included 8 depressions, 6 cyclonic storms, 5 severe cyclonic storms (Figure 6.5). This data specifies that there were no cyclones after 1970 until 2000. After 2000, two super cyclones (Aila and Sidr) hit the area. Islam and Peterson (2008) found the southwest coastal area of Bangladesh (study area) has been hit the highest number of times (36) by tropical cyclones over the period of 127 years (1877-2003).

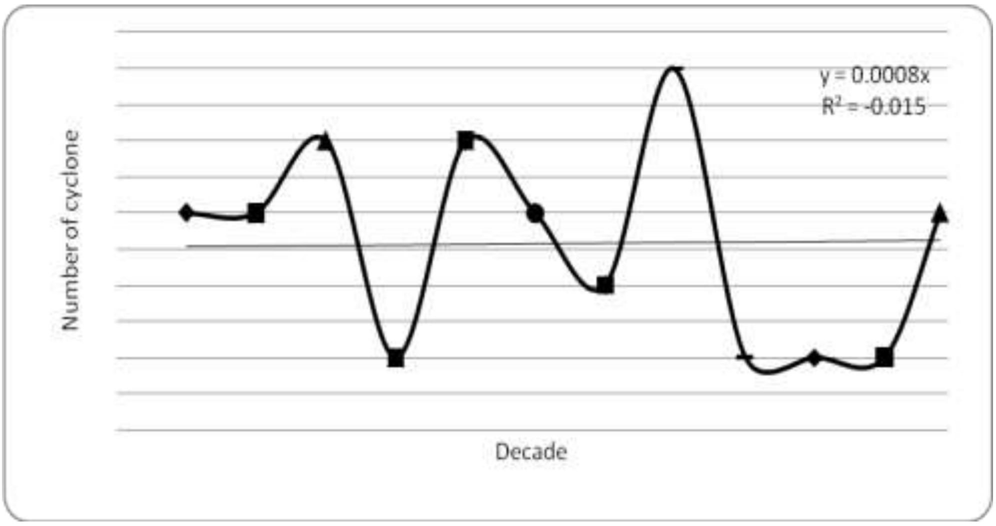

Figure 6.5: Trend of cyclones per decade from 1981-2009 in study area (Graph and calculation made by author, data adapted from Alam, 2011; original data sources BMD).

6.4.2 Storm surges of the study area:

Severe cyclone induced storm surges are relatively common in Bangladesh (Ali, 2004; Anwar Ali, 1999; Wisner, etal., 2004; Paul, 2009; Paul and Routray, 2103). The most severe cyclones hitting the coast of Bangladesh can generate a surge height as great as 10-15 m (Penning-Rowsell et al., 2011: 6). Karim and Mimura (2008) predicted if the storm surges reach 7.6 m, water would reach distances of 56 km and 62 km from the river Passur-Siba and Baleswar river respectively (two rivers located in my study area), flooding 1265 km^2 and 1441 km^2 area respectively.

Recently a storm surge inundation map has been created for all coastal regions by DMIC (Disaster Management Information Centre, Govt. of Bangladesh). I collected the map of my four rural sub-districts to understand the effect of the storm surges with distance. From this it is clear that Shyamnagar is the most affected area, even below 1 m height of storm surges. The effect on Sharankhola and Mehendiganj is moderate. The effect on Tala is lowest (see figure 6.6[a-d]).

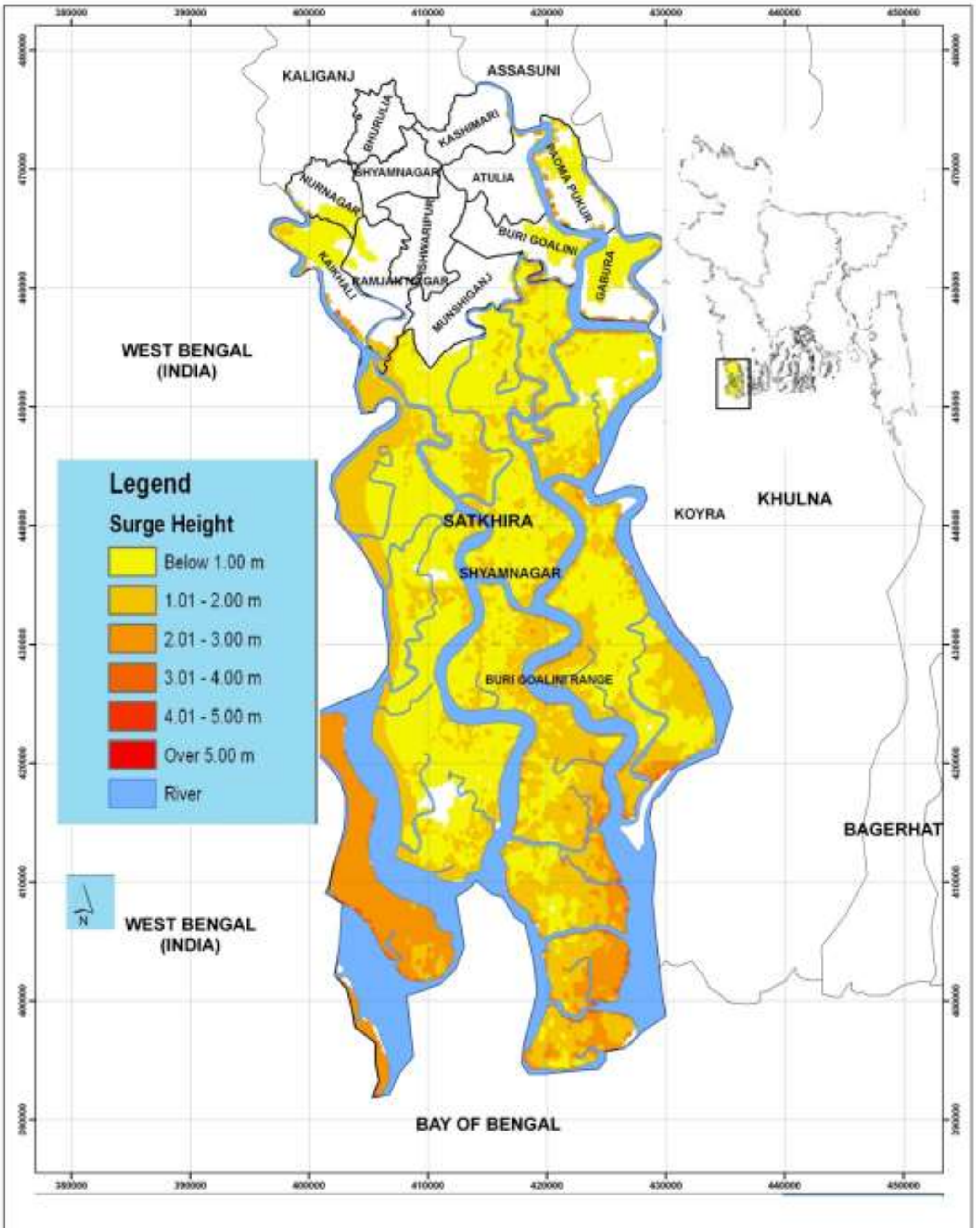

Figure 6.6(a): Estimated storm surge impact on Shyamnagar (see Gabura *union*) (sources: http://www.dmic.org.bd/inmap/)

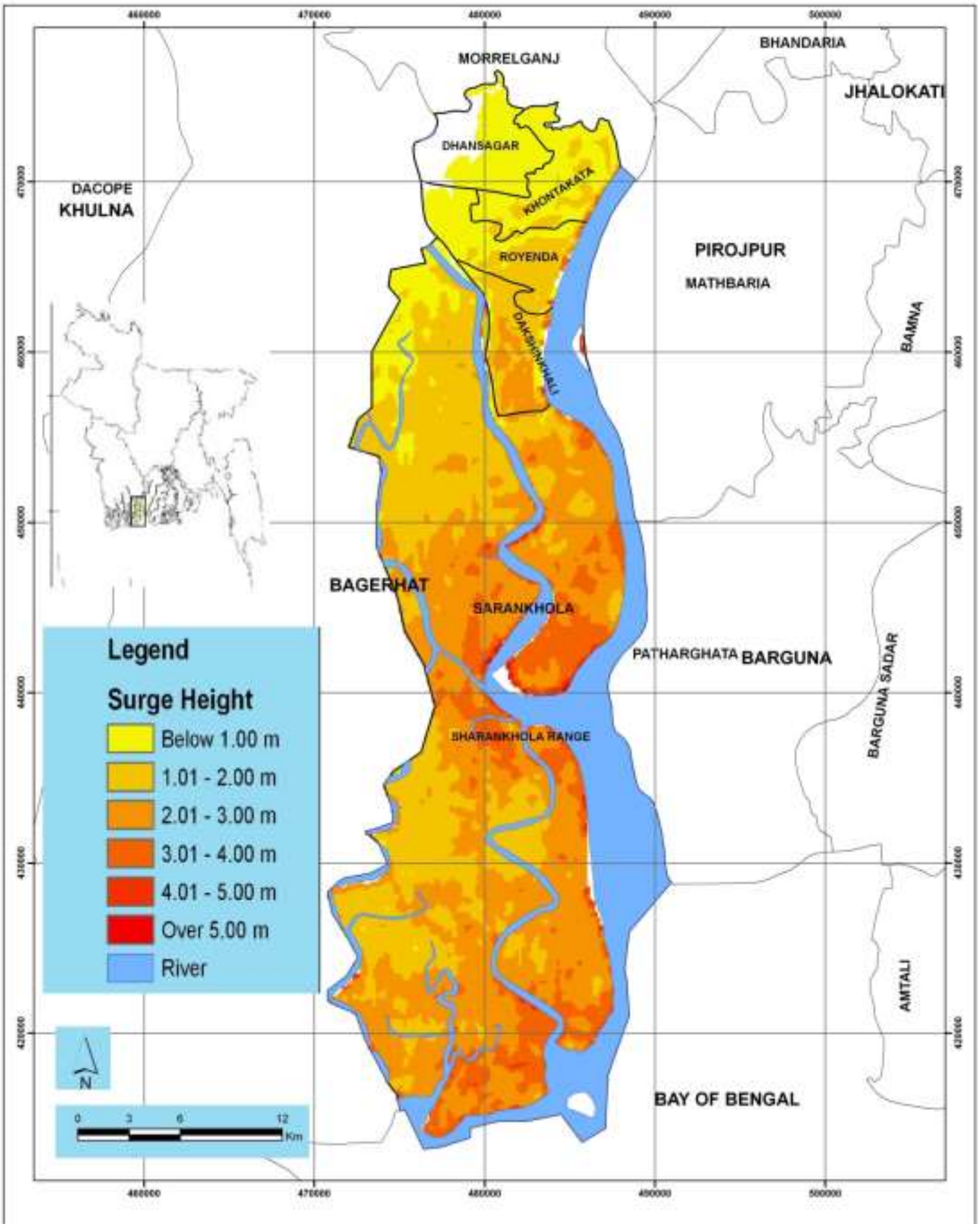

Figure 6.6(b): Estimated storm surge impact on Sharankhola (see Royenda *union*) (sources: http://www.dmic.org.bd/inmap/)

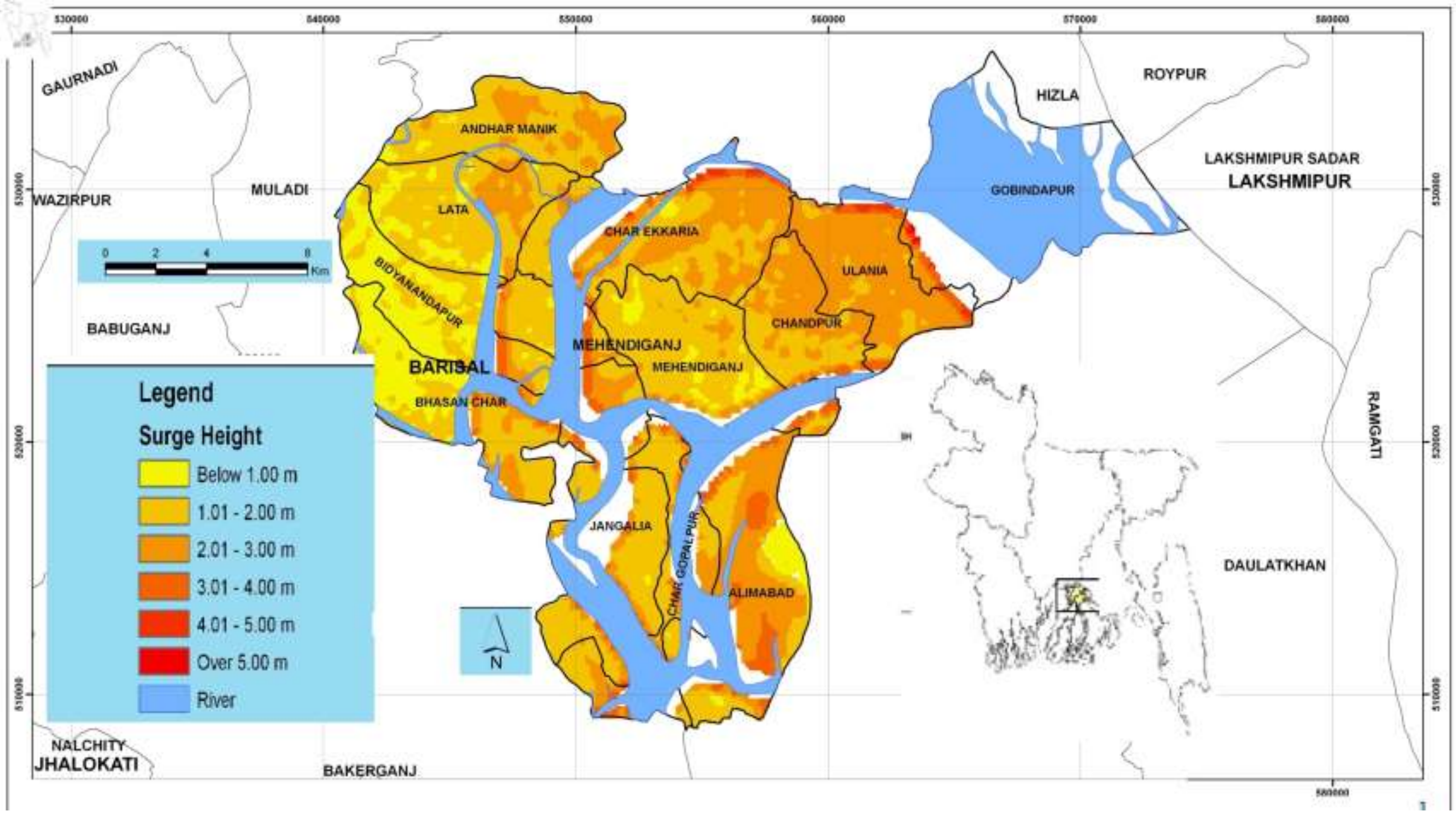

Figure 6.6(c): Estimated storm surge impact on Mehendiganj (see Ulania and Gobindapur *union*) (sources: http://www.dmic.org.bd/inmap/).

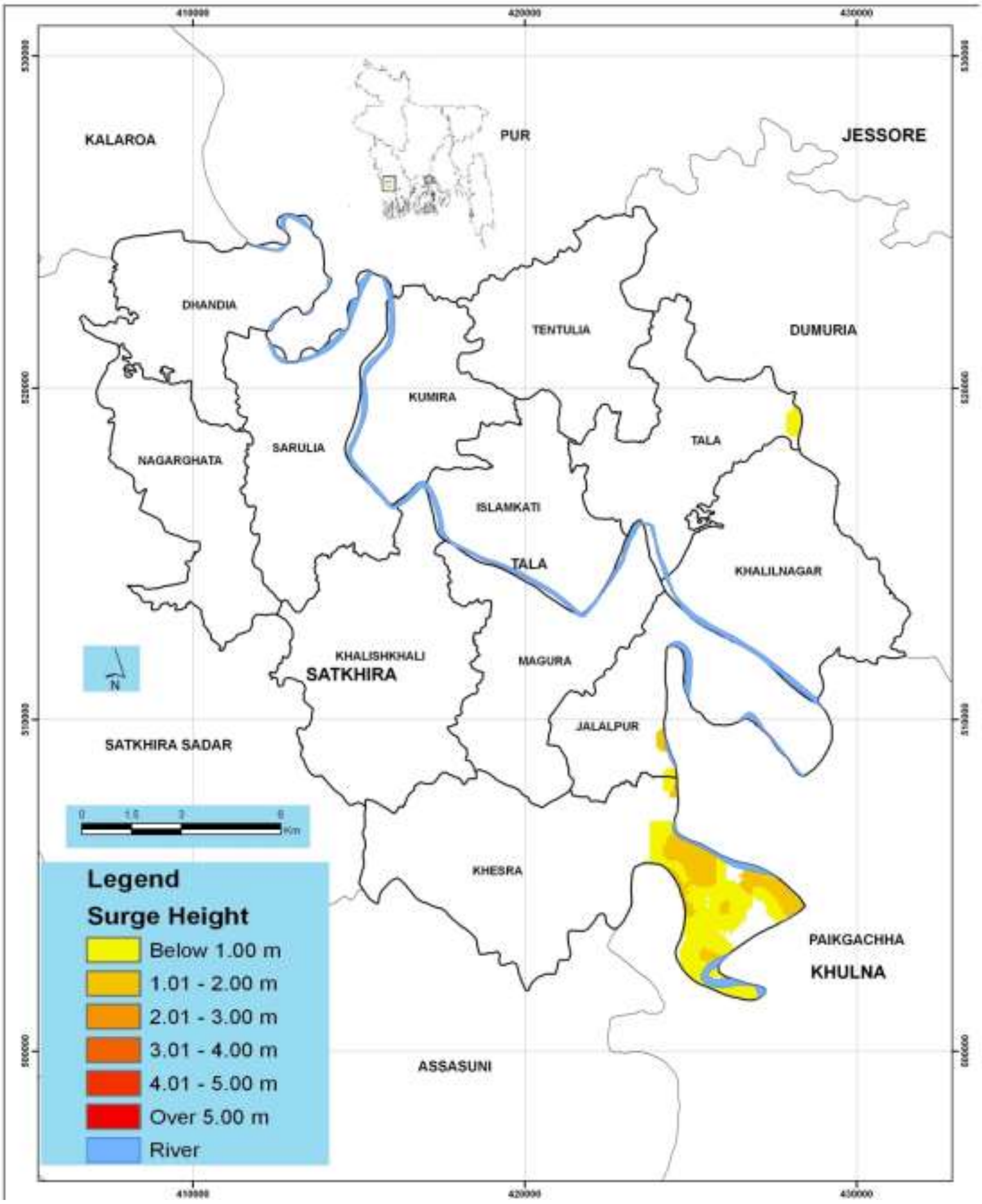

Figure 6.6(d): Estimated storm surge impact on Tala sub-district (see Jalalpur *union*) (sources: http://www.dmic.org.bd/inmap/).

6.4.3 Impact on south west region

Most of the cyclone damage is associated with storm surges. Apart from damage to property and human deaths, the cyclone-associated storm surges destroy agricultural land (especially paddy fields) by letting in saline water; the situation can be made much more severe when embankments are broken (see chapter 7). As most cyclones occur in the post-monsoon season (Figure 6.3) this is particularly serious for crop production. Because there is little chance of further heavy rainfall occurring to wash out salt from the soil, land may be left saline in the following dry season, making it impossible to grow dryland *rabi* crops (see the Bengali terms) on affected land (Brammer, 1999) and destroying transplanted *aman* (see the Bengali terms) in the coastal region. Thus, sea level rise also affect agricultural production and the Sundarbans forest by letting in saline water that will affect the livelihood of several million coastal people depending on the forest (Mallick et al., 2011). Moreover, "increased salinity will change the habitat pattern of the forest and may increase disease pressure for many species. It will affect livelihoods of several million coastal people dependent on forest. It also weaken protection of coastal people from cyclones as the mangrove swamps serves as natural barriers against strong winds and tidal surges" (Mallick et al., 2011: 632).

The increasing discharge during the summer monsoon has increased the frequency of river bank erosion, flood and silt deposition (see chapter 5, section 5.5.2, table 5.8 and figure 5.9). This situation leads to the deposition of sediment in the mouth of the Gorai-Madhumati River. This deposition blocks the river in the dry season and allows saline water to spread further inland in the dry season, while there are floods in the wet season. These floods are worsened by the need to open barrages created on the river (such as Farakka) to allow the outlet of flood water. As an example, southwestern Bangladesh faced flash floods in 2011 due to the release of excessive water from Farakka barrage in India during the monsoon. In August 2011, two months before the survey, three districts (Khulna, Satkhira and Jessor) of this region were severely flooded, affecting 26178 hectares of land, and 11741 metric tonnes of crops, resulting in economic losses of 210,92,00,800 BDT (Islam et al., 2011). A total of 68000 people were displaced to temporary shelters in school buildings and along roadsides (Oxfam, 2011).

6.5 River bank erosion in the delta

নদীর একুল ভাঙ্গে, অকুল গড়ে,

এইত নদীর খেলা

সকাল বেলার রাজা, আরে ভাই

ফকির সন্ধা বেলা |

Breaking this bank, building that

bank, this is the river's lark.

It makes the rich man of the morn

a destitute by dark.

-National poet of Bangladesh, Kazi Nazrul Islam; translated by Zaman (1989: 196).

The flow of the Ganges (Padhma in Bangladesh), Brahmaputra (Jamuna in Bangladesh), and Upper Meghna joins at Chandpur, some 30-40 km upstream from my study area (Figure 6.7). The combined flow of the Ganges-Brahmaputra Meghna from there to the sea is known as the lower Meghna; the planform of the combined river varies from straight to braided. In the wet season the Lower Meghna rises, leading to flooding and river bank erosion.

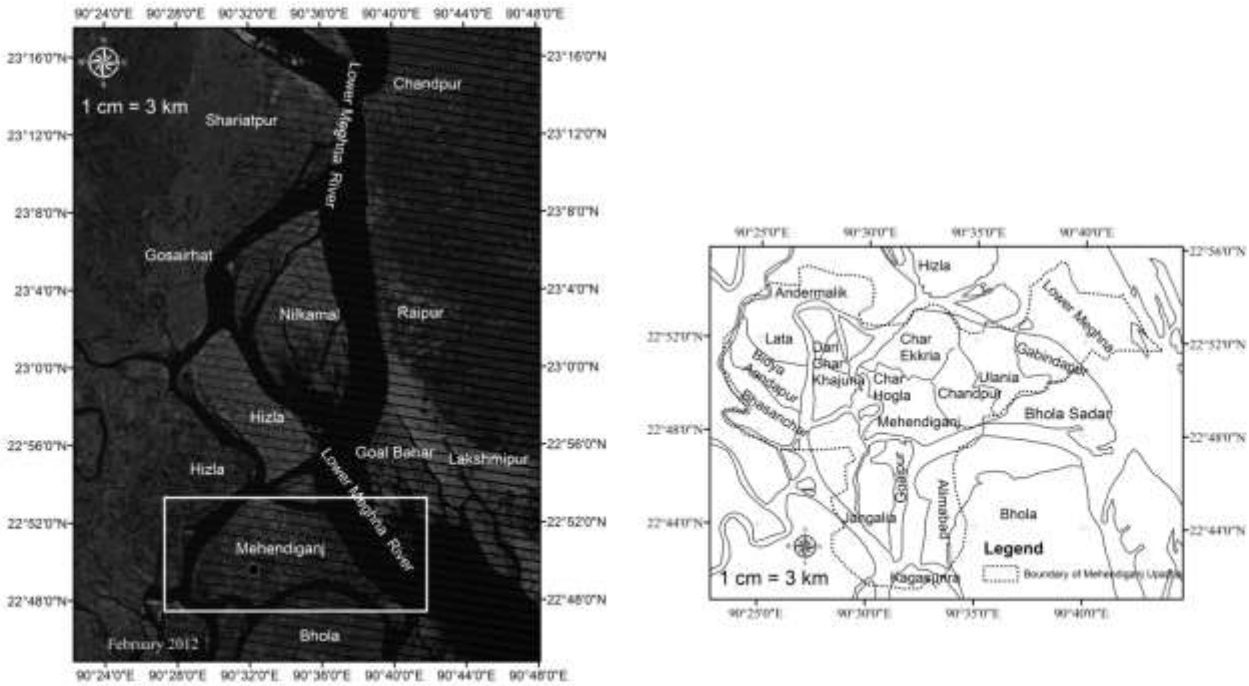

Figure 6.7: USGS Landsat image of the region of study (left) and a map of the *upazila* sub-divisions of Mehendiganj (right).

The lower Meghna has undergone significant physiographic change in the last four decades. The intensity of bank erosion varies widely from one reach to another as it depends on such characteristics as bank material, water level variations, near-bank flow velocities, planform of the river and the supply of water and sediment in the river (Sarker et al., 2003). From analysis of 2640 km^2 of the lower Meghna basin over the 24 years of 1988 to 2012, it has been found that 297 km^2 have been eroded. Mehendiganj alone lost 128 km^2 over the period 1972-2012 (Figure 6.8).

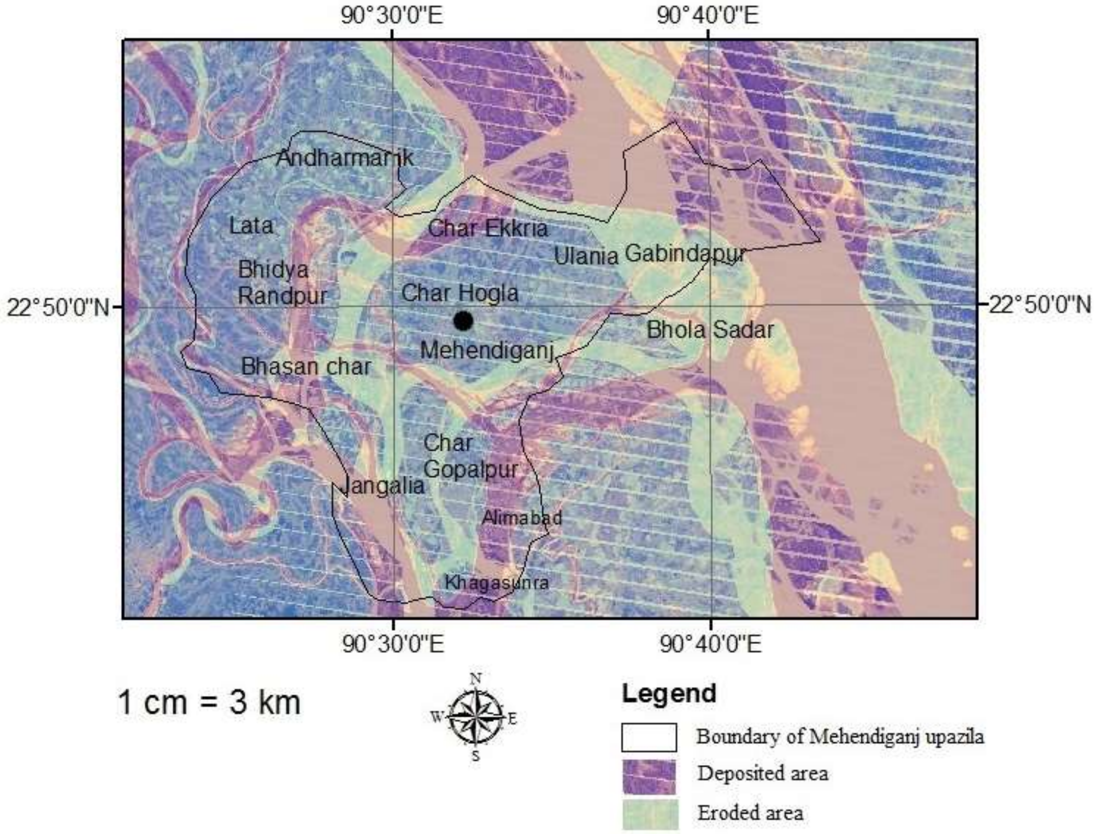

Figure 6.8: The erosion and deposition area of Mehendiganj over the period of 1972-2012, as shown by a superimposition of the 1972 and 2012.

However, 330 km^2 has been deposited as *char*s, or islands, or as a *char* joined with the mainland (Figures 6.9[a-c] and appendix, 9[a-c]). The mean erosion rate is 13.5 km^2 yr^{-1}, whereas the deposition rate is 15 km^2 yr^{-1}, but, as figures 6.9[a-c] and appendix 9[a-c] show, the erosion and deposition rates, and relative ratios, vary significantly over this period. The right bank of the lower Meghna is more susceptible than the left bank to erosion during this period (Figure 6.9[a-f]). A total of 234 km^2 was eroded from the right bank, whereas only 63 km^2 of the left bank was eroded.

During the 1970s the east channel was narrow and the west channel was the main channel, but the progressive formation of big medial bars or islands (part of Hizla *upazila*) (Figures 6.9a and appendix 9a) led the east channel to become more influential. Deposition continued in the west channel into the 1980s (Figure appendix 9b), leading to the main channel switching to the east (white circle in figure 6.9b); by 1988 the west channel was almost blocked. During the 1990s the river eroded its right bank (Figure 6.9c), causing formation of medial bars, and leading the lower Meghna to switch into a locally braided system.

Figure 6.9(a): Satellite images of the lower Meghna 1972. White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion (please ignore figure number in the image).

Figure 6.9(b): Satellite images of the lower Meghna 1988. White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion (please ignore figure number in the image).

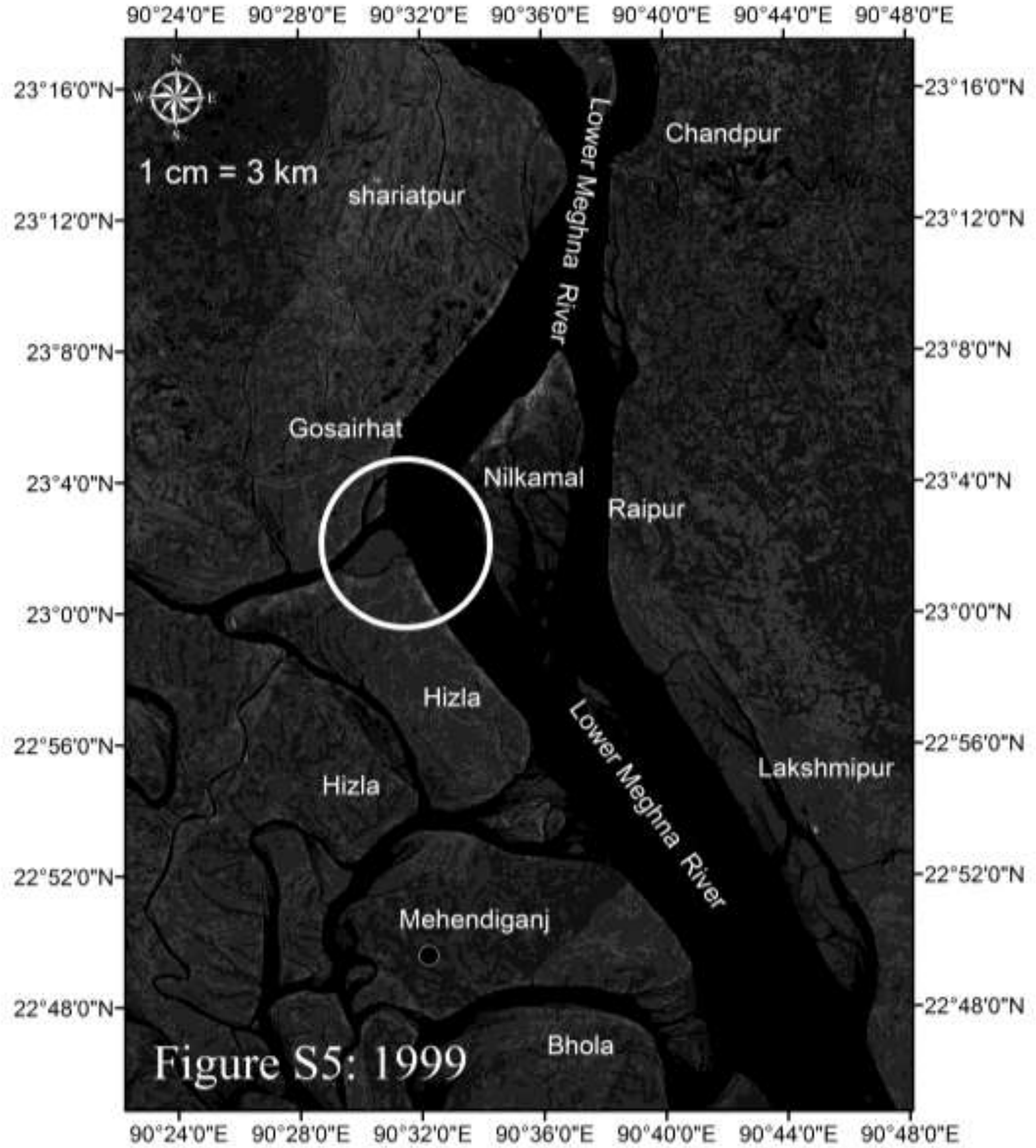

Figure 6.9(c): Satellite images of the lower Meghna 1999. White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion (please ignore figure number in the image).

Once a *char*, locally known as Nilkamal (Figure 6.7), appeared in Hizla *upazila* in Barisal district the channel divided into two (Figure 6.9c). The river was 6.7 km wide in 1988 but had increased to a width of 15.3 km by 1999, its rate of expansion then slowing so only another 1.2 km was added by 2012 (Figures 6.9[b-f]). This width increase was due to westward movement of the river, as this side was more dynamic. However, two very small *char* developed in 2003, one to the northwest of Nilkamal, and another opposite Hizla and Mehendiganj, which is now locally known as Goal Bahar *char* (Figure 6.9d, indicated by white dashed circles).

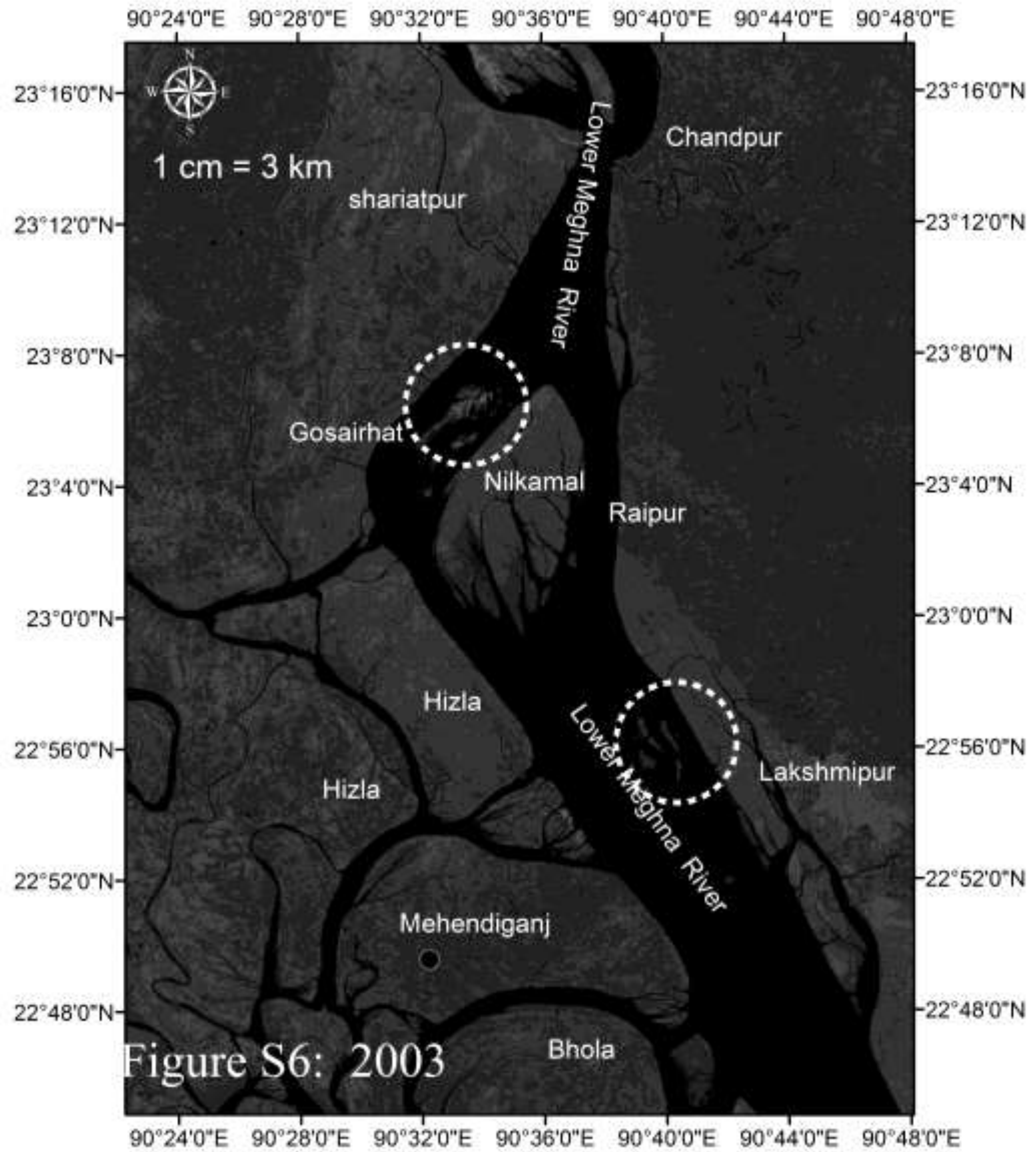

Figure 6.9(d): Satellite images of the lower Meghna 2003. White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion (please ignore figure number in the image).

By the end of the flood of 2004 these two *char* had grown substantially (Figure 6.9e). Due to the new *char* at Nilkamal, the width of the western channel of the Lower Meghna, between Nilkamal and Hizla *upazila*, has been narrowing since 2004 (Figure

6.9e). This situation seems to be repeating the landscape change of 1988 (Figure 6.9b), with Nilkamal replacing the previous role of Hizla.

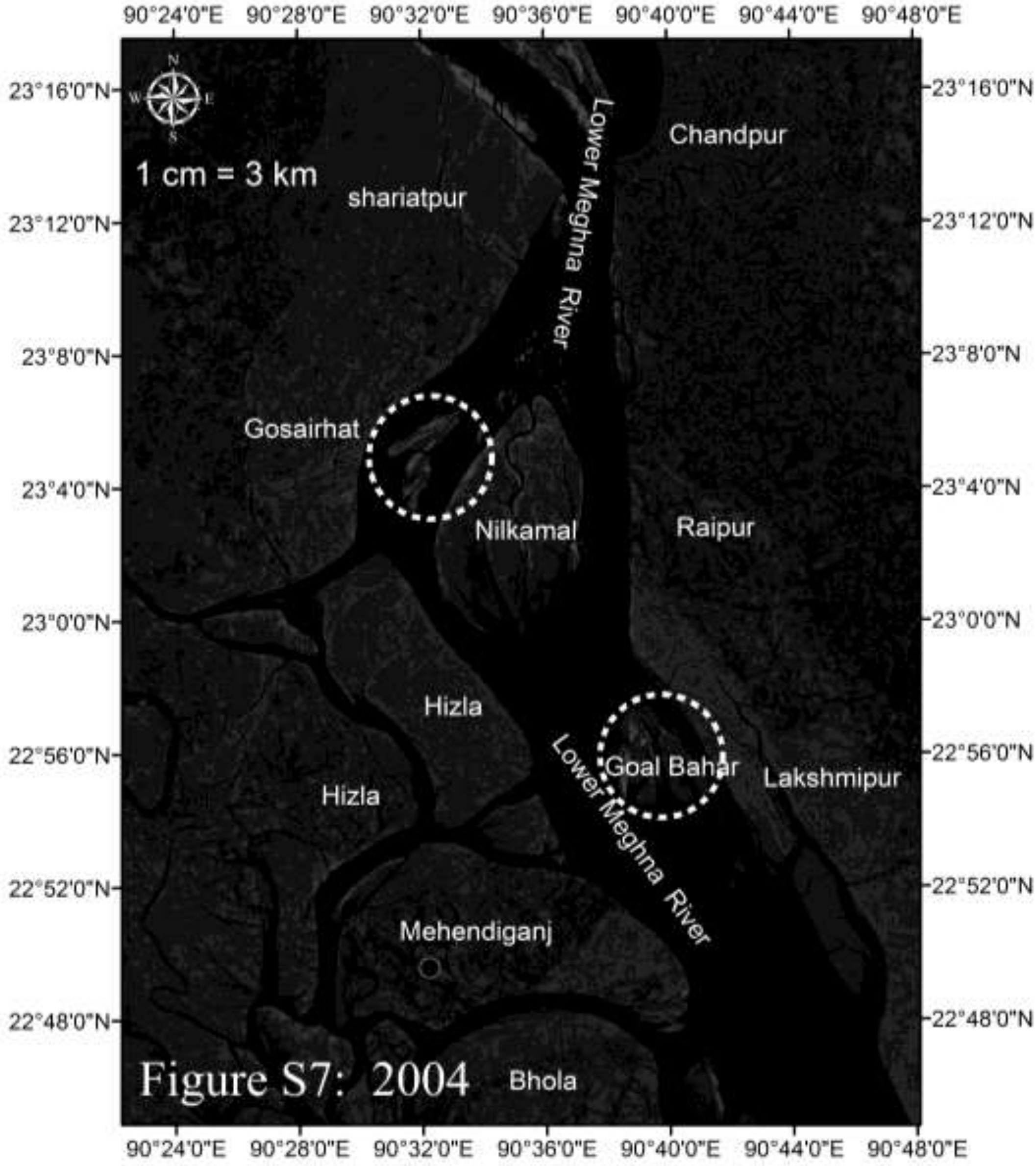

Figure 6.9(e): Satellite images of the lower Meghna 2004. White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion (please ignore figure number in the image).

A remarkably high rate of erosion has occurred over time, particularly at the western end of the island of Mehendiganj. The figures 6.9[a-e] and appendix 9[a-c] suggest, and local people have confirmed, that the intensity of erosion here has increased since

2004. Formation of the bars opposite the Nilkamal and Goal Bahar *char*s (Figure 6.9 e, indicated by white dashed) played a significant role in this increase in the intensity of the erosion of Mehendiganj, as these bars led the east channel flow to impact on the eastern part of Mehendiganj more effectively (Figure 6.9f). Moreover, the size of the Goal Bahar *Char* is increasing; in 2004 the size of the bar (Figure 6.9e, indicated by white dashed colour) was 16 km^2 whereas in 2012 it was 47 km^2 (Figure 6.9f). This could re-direct the flow once more and so threaten what remains of Mehendiganj.

There has also been major change to the landscape to the immediate north of Mehendiganj, to the island of Hizla *upazila*. In 1980 this divided the Lower Meghna into two, with a channel of 7 km width to the east and 2.5 km to the west. Subsequently the western channel essentially closed (Figure 6.9b, indicated by white circle). The increased flow in the eastern channel began eroding significant parts of Hizla *upazila* (Figure 6.9[a-c] and appendix 9[a and b]). The area of this island was 180 km^2 in 1980, decreasing to 114 km^2 in 1988, 80 km^2 in 2004 and 75 km^2 in 2012.

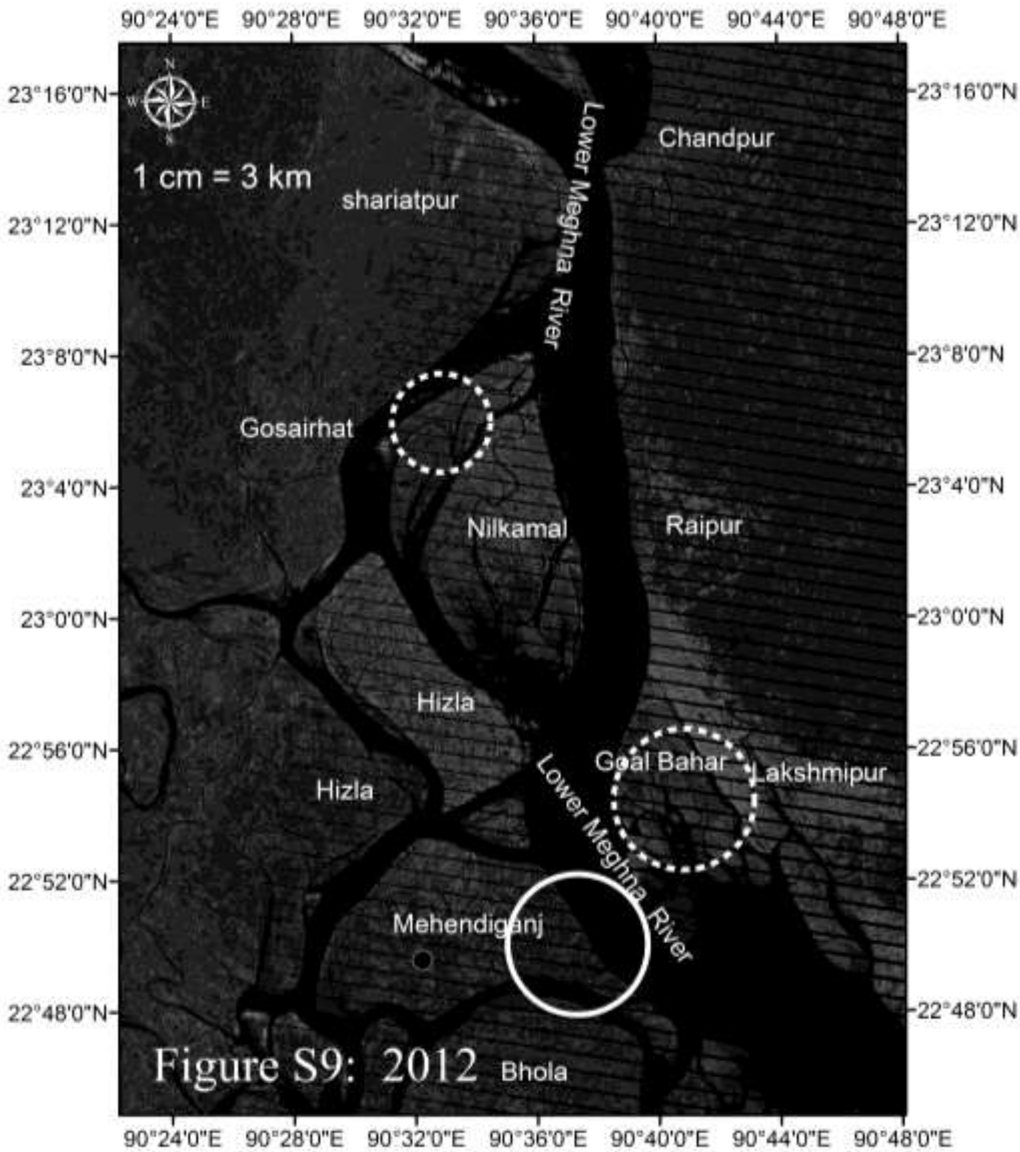

Figure 6.9(f): Satellite images of the lower Meghna 2012. White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion (please ignore figure number in the image).

It has been shown that the river channel is highly dynamic and current developments shown in the figures suggest that the channel may well straighten in the future, leading to dramatic erosion of the eastern part of Nilkamal island. Currently, however, the eastern part of Mehendiganj is eroding rapidly in the flow of the main channel, at a rate of ~3.2 km^2yr^{-1} (Table 6.5). However, any such remedial measures are likely to have only short-term effects. The rate of the erosion for the different periods is summarised in Table 6.5 and the rate of movement of the main channel in Table 6.6.

It has been shown that the river channel is highly dynamic and current developments shown in (Figures 6.9[a-e] and appendix 9[a-c]) suggest that the channel may well straighten in the future, leading to dramatic erosion of the eastern part of Nilkamal island

Table 6.5: Bank erosion of Mehendiganj in the lower Meghna over the period of 1972-2012

Period	Area of erosion (km^2)	Rate of the erosion (km^2yr^{-1})
1972-1988	31	1.94
1988-1999	32	2.91
1999-2003	8	2.00
2003-2012	57	6.33
1972-2012	128	3.20

Table 6.6: Shifting of the Lower Meghna to the west at the Mehendiganj over the period of 1972-2012.

Period	Shifting of the river (km)	Rate of the Shifting (myr^{-1})
1972-1988	1	63
1988-1999	1.8	164
1999-2003	0.24	60
2003-2012	3.56	396
1972-2012	6.6	165

6.6 Conclusion

Due to several factors it is very difficult to measure and predict how much the sea level is rising in the delta part of Bangladesh particularly in the southwest. However, the result of my study of the South west region of Bangladesh indicates that this region will face serious consequences even though sea level rise is stable, because the salinity is increasing and likely cyclone storm surge effects on the coastal area. River bank erosion is also another serious threat to the riverine region of the delta. It is also important to assess the socio-economic effect of environmental change on the delta. Thus, the next chapter will describe this and highlight the vulnerability of the study area.

Chapter 7

Social vulnerability of the delta to natural disasters

7.1 Introduction

The impact of climate change on the coastal community of the delta has already been discussed in the previous chapter. This chapter addresses the impact of natural disasters on the social, economic, political, cultural and traditional characteristics of the delta, concentrating on those people who are at risk. This chapter compares the vulnerability of the four sub-districts.

The chapter also categorises environmental change as a source of stress and shocks and its relation to migration. Sudden-onset processes appear rapidly such as tropical cyclones, and flooding, but last for short time-periods ranging from hours to weeks and slow-onset process are those barely seen by society such coastal erosion, salinity intrusion and sea level rise (Cutter et al., 2009). However, as Walsham (2010) noted, there is some overlap between the two types of change, for example coastal and river bank erosion. Although many studies consider river bank erosion occurring as a sudden-onset event, my study considers river bank erosion as slow onset as my selected spot is being eroded almost every year.

Three of the four rural interview areas were found to face sudden climatic or environmental stresses. Sharankhola faced the tropical cyclone Sidr in 2007, Shyamnagar experienced tropical cyclone Aila in 2009, and Tala faced flash floods in 2011. Chapter 3, table 3.4, lists the various types of problems, and their severity, for the areas surveyed. On the other hand, the rural community of the Mehendiganj has faced gradual climatic stress as this place faces river bank erosion, with flooding every year (chapter 3, table 3.4). Shyamnagar *upazila* also faces gradual stress as saline water is increasing in this area, but they cope with stress as they have changed their cultivable land to shrimp farming. Following tropical cyclone Aila in 2009, some *union*s of this *upazila* are also facing coastal flooding. The condition of the Gabura *union* of Shyamnagar *upazila* is very serious now. Every year, during the rainy season most parts of this *union* are being flooded due to tidal inflow.

7.2 Social vulnerability of sudden environmental shocks

In this section I will examine the socio-economic impacts on the delta's population due to the sudden environmental shocks discussed above. This will be done by examining sequentially the impact on vulnerable groups, infrastructure, health, income, agriculture and food. The section will close with some more social-oriented consequences of sudden shocks.

7.2.1 Most vulnerable groups

Demographic factors including gender and age are seen as important factors for vulnerability (Paul, 2010; Penning-Rowsell et al., 2012).Women, children, older people and disabled people are the most affected by natural disasters. The traditional clothes of women, such as the *sharee*, do not allow ease of movement and present entanglement risks during cyclones and storm surges. Furthermore, their reluctance to evacuate and maternal instinct to rescue their children mean women are particularly at risk (Alam and Collins, 2010). Bike driver, Anwar Hossain, of Sharankhola *upazila* said, "I saw 100 to 150 dead bodies after the cyclone. Most of them were women and children but some were aged men. Some dead women I saw had their clothes snagged on branches of trees, straw and waste" (Interview, November 2011). A number of studies (CARE, 1991; CARITAS, 1991; Haque and Blair, 1992; Ohiduzzaman, 1993; and Alam and Collins, 2010) note that women and children are most vulnerable. In particular, younger women are the most vulnerable group (IOM, 2009). For an example, tropical cyclone Gorky killed five times as many women as men in 1991 in Bangladesh (IOM, 2009). Another study carried out by BBS in 1991 found that people aged between 15-49 were able to save themselves, while the women, elderly people and children could not and died in greater numbers (Shamsuddoha and Chowdhury, 2007). This is because, many also leave their homes at the eleventh hour of the cyclone, fearing theft of their household possessions or in the case of women, because they are afraid to move without (or without the permission of) their husbands if the latter are absent (Brammer, 2004: 138).

This group, especially women, also suffer after taking shelter in temporary makeshift tents. There is a distinct lack of privacy. Those people who took shelter in the schools at Tala suffered as five or six families took shelter in one small room, and a huge number of people had to use one toilet. Selim Ahmed reported "Due to lack of fresh clean water in the temporary makeshift tent at Gabura and Munshiganj, women in particular suffer a lot to keep them clean" (Interview, November, 2011). Alam et al. (2008) found that many women fear to go to shelters due to lack of privacy, especially pregnant women who are unwilling to share space with or nurse in front of strangers.

Another consequence of natural disasters is that women-headed households are more likely to live in poverty (Bianchi and Sapin, 1996; Cutter et al., 2009). There is wage discrimination between men and women. After a natural disaster this discrimination is even more noticeable as there is then a job crisis and women are perceived as not being able to manage a job as well as a man. Selim Ahmed, a boatman, said, "a man's pay from agricultural labour, or labour in shrimp farms is 170-200 BDT (£1.30 to £1.60) a day whereas women receive 150-170 BDT (£1.10-£1.25) in Gabura *union* for the same job. Women have less energy than men, thus a shrimp farm owner will pay less money to a woman labourer."(Interview, November, 2011). Thus, female headed household earn less money and face financial crisis. Therefore, vulnerability is highly differentiated by gender (Osbahr et al., 2008).

Another group not normally considered is the dead. According to Muslim custom dead bodies need to buried as soon as possible. But due to either storm surges or flash floods, it can be difficult to find higher land. As one respondent put it, "After Aila I was in Gabura *union*, where I saw 5 dead children of one family. There was no unflooded land at Gabura for their burial, so they had to be taken to near the *upazila* office to be buried in higher land" (Selim Ahmed, November, 2011). Another participant, when asked about the severity of the flood, said, "the area submerged was so huge that it was difficult to find higher land. If anybody died we had no alternative to burial of the dead body in the river" (Abu Mia, November 2011).

Since women and older men face difficulties in gaining employment, they face even greater difficulty in a post-disaster period. Women are unable to make the decisions about migrating for work without gaining the permission of the male head of the household (Kartiki, 2011). Even during the disaster they cannot independently take the decision of going to the cyclone shelter (Alam and Collins, 2010). Moreover, women need security at their destinations. Due to prevailing cultural norms, many women do not wish to accept slum conditions in city. However, many women are forced to accept the insecurities associated with precarious urban life when they are left by their husbands in rural areas. This study found many single women who were forced to move to slums in Dhaka (see next chapter).They are one of the most vulnerable migrant groups in city. Evidence suggests that female-headed households move due to social causes as they are persecuted and driven away by their husband or in-laws (Ahsan, 1997). Many respondents acknowledged that after Aila many men left their wives, and in some case their older parents. According to the 2011 census, the percentage of female headed households are greater in Shyamnagar than other sub-districts. I found one respondent in Sharankhola whose husband left her due to poverty. Older people do not have much energy to work, which contributes to a fear of moving. One participant from Gabura commented: “I have been working as a day labour such a long time. When I was young I used to work hard as a day labour. Now I am 60, do not get energy to work. It is hard for me now. That’s why I did not migrate and try to do easy job here” (Musa Mia, Oct 2014).

7.2.2 The impact on housing and infrastructure

Location and pattern of settlement is one of the most important factors for determining vulnerability to tropical cyclone of the coastal community of Bangladesh (Alam and Collins, 2010). From the interviews, it was clear that most of the houses are poorly made. They are typically straw-walled, mud-walled or bamboo-walled, with bamboo poles and sometimes concrete-poles supporting *goalpatha* (leaves of Nypa tree) or tin sheets as a roof with a muddy plinth as flooring (Figure 7.1a). Some of the extremely poor could not even afford to build with these materials but simply covered their house with some polyethylene (Figure 7.1b). These traditional houses are very vulnerable to tropical cyclones and floods as they could easily collapse and be washed away. Roughly 90% of houses in the areas visited were found to be vulnerable. My study revealed that extremely poor respondents live near the river, income is low and houses are made with very low quality materials (Figure 7.1b). This is partially confirmed in a study by Alam and Collins (2010), who found that settlements closer to the coast are more susceptible to cyclonic wind and storm surges due to houses being made with poor quality materials.

It has been found that most of the transportation infrastructure is vulnerable to tropical cyclones and floods as roads are often mud, unpaved or cobbled. These were also often found to be damaged. The coastal embankment is also used as a road. Following tropical cyclone Sidr damage to the transport infrastructure such as inland water transport, roads, and bridge culverts was estimated at 115 million US$ (GoB, 2008).

Due to a breakdown of communication systems, many victims could not reach cyclone shelter. This damage to infrastructure compounded problems after the disaster (Mallick et al., 2011) as 100% of respondents said food price had increased due to fractured communication channels and damage to agricultural production (see section food insecurity). Households who lived further away from the main road, had experienced delays in accessing emergency aid (Akter and Mallick, 2013). Moreover, collapsed trees also made a barrier for relief distribution. Talking about this issue an respondent said: “After Sidr a huge number of the trees had collapsed onto the street, which made a barrier and prevented aid workers from reaching us. Thus, we had to remove these trees from the street.”(Anwar Hossain, from Sharankhola, November, 2011). Mallick et al. (2011) found 38% of respondents did not receive relief due to wrecked embankment water-logged situations and broken communication. “The front-liner or those who resides near the market places collected more relief good and helps” (Mallick et al., 2011: 645).

Community buildings and education centres were also damaged after the cyclones. Cyclone Aila destroyed 445 education facilities and partially damaged 4,588 across all affected districts, impacting approximately 50,000 children. School furniture and teaching materials were reported to be badly affected in all affected districts (UN, 2010). The embankment had not been effectively mended after Aila. This made 47,000 households homeless (Mahmud and Prowse, 2012). One respondent Noor Hossain said, “before Aila we were never scared as they [local government] would manage to mend the road and damage, but after Aila, due to the high tide embankment being broken in lots of places, it is difficult to rebuild the embankment. Thus every year this [flooding] becomes a hazard for the people of Gabura.” (Interview, Oct 2014). Another respondent Salim Ahmed said, “the situation for the people of the Gabura *union* is very pathetic, as it is an island and it is surrounded by the river. People, who took shelter on the embankment due to Aila, are fearful that they might have to face a cyclone again.” The maintenance of the embankment was a major concern for the people of the southwest region (Kartiki, 2011). Recent evidence suggest that 94% of respondents reported problems poor work quality, misuse and mishandling of resources and tendering with the reconstruction process of the embankment (Mahmud and Prowse, 2012). This effect led to many people moving to a city temporarily. Many of them try to settle elsewhere instead of returning

(Kartiki, 2011). One respondent, Zakir Hossain from Sharankhola said, “we need a strong embankment. We can accept to stay without food couple of days, but we do not want embankment will be broken. If embankment is broken, it is great disaster for us” (Interview, November 2011).

Figure 7.1a: Typical rural houses

Figure 7.1b: Typical housing of extremely poor (located at the bank of the river, highly vulnerable)

7.2.3 Impacts on health and water security

“Water scarcity, projected to increase worldwide even without climate change, is also intricately linked to disaster risks and food insecurity. In addition, water scarcity is compounded by poor water quality, which exposes communities to major water and food-borne threats affecting public health and livelihoods" (FAO, 2013: 5). Natural disasters can create a huge threat to the health of vulnerable people. The flood water is polluted by the dumping of domestic waste, animal excrement, dead cattle, dead fish, floating garbage and overflow of latrines leading to the outbreak of water-borne diseases in the affected region (ACAPS, 2011). After tropical cyclone Aila, 210,000 household latrines were fully or partially damaged in the affected area of Khulna and Satkhira districts (UN, 2010). It was found in the interviews that during storm surges and floods the water and sanitation system completely broke down. During the flood in Tala and after tropical cyclone Aila in Shyamnagar, diarrhoea and skin diseases increased. One responder said "we do not get fresh water for bathing and washing hands before eating; this leads to an increase in water-borne diseases". Due to saline water intrusion in Gabura *union* skin disease has increased. Shamim Ahmed, a school teacher aged 35, said, "saline water is very harmful for skin. The skin turns dark and creates itching because of having to use saline water for bathing and washing hands and face." (Shamim Ahmed, November, 2011). Nayeb, a hotel boy [waiter] in Khulna city, [migrant from Shyamnagar] said, "…our most vital trouble is fresh and clean water" (Nayeb, November 2011). After tropical cyclone Aila, NGOs had been supplying drinking water in this region for 7-8 months. However, it was not sufficient for a large number of affected people. People, especially women, had to collect the water from a long distance away, sometimes involving a journey by boat, and had to wait in a long queue. Selim Ahmed, boat man, said, "we have a drinking water problem. Sometimes we use the whole day for collecting water." (Interview, November, 2011). A shortage of water is also threatening agriculture production, which supports many livelihoods in coastal communities. This often results in a substantial decline in labour productivity and an increase in poverty (Schmidhuber and Tubiello, 2007). Due to salinity in soil and ground water, these marginalised people are affected much more intensely by a fall in their income, combined with decreased agricultural production and food security, which can lead to out migration in order to search for work in cities (see section 7.6).

7.2.4 Food insecurity

Natural hazards and food insecurity are directly interconnected (FAO, 2013). Evidence suggests that environmental change affects outcomes for the four main elements of food security – food availability, food accessibility, food utilization and food system stability – in various direct and indirect ways (FAO, 2008). Drought, flooding and sea level rise already having immediate impact on food distribution infrastructure, incidence of food emergencies, livelihood assets and human health in both rural and urban areas (FAO, 2008). Environmental change affects food production directly through changes in agro-ecological conditions and indirectly by affecting the growth and distribution of people's income (Schmidhuber and Tubiello, 2007). Food represents a large share of farmers' incomes and the budget of poor consumers; large price changes have a significant effect on real incomes (IFAD et al., 2011). Moreover, the poorest of the poor buy more food than they produce (IFAD et al., 2011). This study found that approximately ~85% of the rural coastal community produce their food from their own production of rice, vegetables, fish etc. Due to the cessation of agricultural production following a natural disaster, the supply of food dropped dramatically, leading to an increase in the price of food. This affects the poor members of the community most seriously. A large number of the people interviewed were unable to purchase food to meet their needs during the disaster and hunger following a natural disaster was common, particularly for the extremely poor, who were already vulnerable. Moreover, due to there being no jobs available and people's income having dropped, the poor cannot afford to buy the higher priced food. This socio-economic effect may last for some time beyond the disaster itself, depending on the nature of the disaster and location. In order to survive in the short term, many of those who are extreme poor must rely on selling what assets remain or their livestock at a reduced rate, or have to take out loans from moneylenders at high interest. This leads them to become poorer, exacerbating their situation and leading to difficulty in remaining or temporary displacement to a local centre. The study found that displaced households especially from the Gabura *union* and the Munshiganj *union* of the Shyamnagar *upazila* faced these issues severely after tropical cyclone Aila. For example, after the cyclone the price of rice, lentils and oil increased dramatically. Abdur Gaffar said, "before Aila one kg rice, dall [lentils] and oil were 20, 80 and 70 BDT [respectively]. After Aila the price increased dramatically to 30, 120 and 110 BDT [respectively]." These issues continued to affect people, even three years after the disaster as high levels of salinity in the area following storm surges meant that villagers could not grow paddy in their farms (Martin et al., 2014).

Impact of food production does not exclusively impact on a local scale but also at a national scale as poor transportation systems will affect the food supply. During the natural disaster, due to damage to infrastructure these crises are exacerbated. Herrmann and Svarin (2009), further support the idea, highlighting how Bangladesh suffers food shortages as a result of natural hazards (see also chapter 2, section 2.7). However, the increasing frequency of environmental events, which contributes to the weak development of the agricultural sector and recurrent threat to food security, is one of the key reasons for increased migration from affected areas to urban areas (Herrmann and Svarin, 2009).

7.2.5 Response to advance warning

Ignorance of the approach of a cyclone enhances social vulnerability to natural disasters. Additionally, people do not always believe the prediction, even if they are aware of it, because predictions are not always accurate. Though a cyclone can be detected by monitoring several days before it strikes, the development and track of a cyclone is difficult to predict – it may either dissipate over the Bay of Bengal or move towards land (Brammer, 1999). Sometimes a cyclone may not develop, other times it may increase or weaken or change path and speed in unpredictable ways making it difficult for meteorological Department to predict accurately. This sometimes result in what appears to be false alarm (Brammer, 1999). As an example more recently, tropical cyclone Mahsen hit southern Bangladesh and quickly weakened. Thus, many people will doubt predictions in the future (Haque, 1997; Shamsuddoha and Chowdhury, 2007). Another example, before the 1970 cyclone Bhola there was another cyclone a couple of months before which did not hit powerfully, thus people thought tropical cyclone Bhola might not affect them that much.

My study found 67% of the interviewed people in Sharankhola received the warning. Most of the respondent did not believe it. Abdul Hamid from Sharankhola said, "I did not believe the cyclone Sidr would affect us so powerfully". Asma Akther, assistant primary teacher in Sharankhola, said, "It was raining heavily before cyclone Sidr. I did not believe that the disaster would be like it was, though we heard the signal.

However, there was no electricity to hear further news on the TV". However, people are more aware now than before.

This study is consistent with Paul and Dutt (2010). They found that though 73% of respondents in the Sidr affected area (Bagerhat, Barguna, Piriojpur and Patuakhali) had received warning, of this 32% did not believe the warning and 6.4% complained that they are incompletely informed as they were not given information on wind speed, wind direction, possible surge~~s~~ height and duration, landfall time and location and the extent of damage expected. They also reported various reasons for not following the evacuation order as cyclone Sidr approached Bangladesh; out of 172 respondents, 20% (34), did not realize the danger, 16% (27) did not have time, 15% (25) have no past experience, 15% (25), fear of burglary, 12% (20) felt safe at home and 15% (25) had a false sense of security. Thus, the key variables influencing a decision to evacuate include the presence of a warning system, the credibility of warning messages, the perceived personal risk presented by the hazard and the logistics of the evacuation itself (Perry, 1979; Penning-Rowsell et al., 2012: S49).

The people of the Gabura, Shyamnagar were not alerted in a timely fashion about tropical cyclone Aila by BMD though they understand the signal (Mallick et al., 2011). My study found that almost two-thirds of the respondents (60%) in Gabura did not receive any warning before tropical cyclone Aila.

Talking about the matter a respondent said: "I did not receive any cyclone warning. Thus, I was not prepared. Within 10 minutes the water rose five feet. My family members and I had to swim to reach a roof of a building to take shelter." (Moinuddin, Oct 2014). The current findings seem to be consistent with Mahmud and Prowse (2012) who found only 38% of households received warning. This is in contrast with a study by Mallick et al. (2011) on Shyamnagar who found that 87% of respondents received the news (Table 7.1). The focus of Mahmud and Prowse's (2012) research was to explore the difference between poor and non-poor. They found non poor respondents received cyclone warnings more than the poor. While the current the research also looks at the differences between poor and non-poor group, it also examines reasons why certain people, particularly the poor, cannot go to cyclone shelters, and its relation to displacement that can eventually to lead migration.

Table 7.1: Comparison of different published studies with the current study with regards to receiving cyclone warnings and being unable to reach cyclone centres

Authors	Region	Received warning message (%)	Did not go to a cyclone shelter (%)
Mahmud and Prowse (2012)	One sub-district of Khulna	38%	90%
Mallick et al. (2011)	Shyamnagar	87%	71%
The current research	Shyamnagar	40%	76%
	Tala	80	--
	Sharankhola	67	--

In response to the question concerning taking shelter in a cyclone centre the current study found that almost two-third of the respondents (71%) did not go to a shelter (Table 7.1). This outcome matched with Mallick et al. (2011) as they found a very similar result for Shyamnagar, with 76% of respondents being unable to reach a safer place due to the speed of water intrusion and also because the roads were inundated immediately. Even though many respondents receive the warning they did not get time to take preparation as the embankment was broken and water entered and escalated within half an hour. In terms of responding to warnings and not reaching or going to shelter, the present study identified a number of reasons. These are 1) they did not receive warning; 2) they did not believe the warning; 3) they got less time to go to the shelter; 4) the cyclone shelter was far away; 5) it was crowded; 6) they chose wait and see to take decision; 7) there were insufficient shelter centres; 8) they were waiting for the decision of male-head (Alam and Collins, 2010) 9) they were concerned for livestock (Alam and Collins, 2010) 10) they were afraid of burglary (Haque, 1995). Karim a respondent from Gabura said, “due to high number of people took shelter. We did not get any space in the shelter. Thus we took shelter on the roof of a local mosque”. Distance was one of the important barriers to attending a cyclone shelter (Mallick et al., 2011). Many respondents in my study area could not take shelter as there were no shelters near their house. For example, one respondent from Gabura said, “as cyclone shelter was far and Water was rising, immediately we decide to take shelter on the roof of a local mosque” (Abdul Halim, Oct 2014). Another respondent from Royndee *union* stated: “we could not took shelter due to no shelter centre being available near my house.” (Suleman, November, 2011). This study found that extremely poor respondents living near the river faced most difficulty in reaching a cyclone shelter (see chapter 9, 9.2 sections). Thus, some of the respondents even took shelter in big trees or on the roof of their thatched homes. Thus, the big trees became life-saving shelter for many people and domestic animals (Alam and Collins, 2010) and even wild animals like snakes. Bike driver Anwar Hossain said, “snake and human took shelter in a same tree” (Interview, November, 2011). The co-existence of humans, animals and wild species, such as snakes, has been observed in cyclone shelters, houses and large trees during cyclone surges by Alam and Collins (2010). School teacher Asma said, “snake and human took shelter in coconut tree. Snake did not bite”. Monirul from Sharankhola said, “due to fear of death many household who are located in low-land (near river) displaced to further inland or migrated to nearby town.” (Interview, November, 2011).

7.2.6 Relief problems

After tropical cyclone Aila and Sidr a huge amount of humanitarian relief was given by NGOs and the Government to the affected region but responders claimed that this relief was not distributed fairly. *Union* chairmen and members (equivalent of a local councillor), or influential local political leaders play a significant role in aid distribution, and many people perceived that this led to mismanagement and corruption. Thus, after tropical cyclone Aila and Sidr a lot of money was allocated for the repair of roads and the embankments. Almost all of the respondents (95%) in Sharankhola reported about relief mis-distribution. This is consistent with Mahmud and Prowse (2012). These authors found ninety nine percent of households reported corruption. They also reveal that this practice is at a greater level post-disaster (eg food aid, and public work schemes) than pre-disaster (cyclone warning and disaster preparedness training). A group of poor people at the Royndee *union*, Sharankhola said “After Aila we received very little money. Aid was not fairly distributed, though a vast amount of aid was provided here. Even the chairman and local members stole money from the construction budget for the road, or repair of the road and embankment. Thus, they are getting richer and we are getting poorer." It was also perceived that local political leaders tend to provide the relief to their alliance or supporters, as they will support them, and influence the people to cast their vote for them, in the next election. Jalal Uddin, said, "after Aila, the Government and non-government organizations provided a huge amount of aid in Gabura but we did not get enough money; 80% of the money was grabbed by local political leaders, and they give priority to their supporters rather than poor people."

Due to insufficient relief, it was hard for many of them to survive. Thus food and livelihood insecurity influenced them to migrate to a nearby city. Kartiki (2011) confirmed this as she also found that those who received insufficient relief to address their long-term concerns over employment and stability, also migrated (Kartiki, 2011). With regards to the social oriented consequences of sudden environmental shocks, it has been shown that such incidents lead to varying patterns of migration, based on the diverse impacts such shocks have on vulnerable groups, infrastructure, health, income, agriculture and food, responses of advanced warning systems and relief distribution. It is also interesting to discuss the migration in relation to the social vulnerability of gradual environmental stress. Slow-onset events are described in the next section.

7.3 Social vulnerability of gradual environmental stress

The negative effect of slow onset environmental events such as drought, riverbank erosion, salinity intrusion, and sea level rise are already affecting the rural community of the delta of Bangladesh. Here I will discuss the socio-economic impact of river bank erosion on Mehendiganj, Barisal. This type of disaster does not take lives but it destroys houses and agricultural land, and negatively impacts on livelihoods.

Mehendiganj has ~55 000 households spread over thirteen *union*s and a total area of 418.96 km² including 2.36 km² river area (BBS, 2012). The population of this *upazila* was 304 364 in 2001(BBS, 2010b) and 301 046 in 2011 (BBS, 2012), giving an annual rate of decline of -0.11 % (see table 7.2). This contrasts with the contemporaneous population growth rate in Bangladesh of 1.37%. This negative growth rate is because people are migrating from Mehendiganj. Ten out of the thirteen *union*s of Mehendiganj are threatened by bank erosion. Those *union*s seriously at risk are Gobindapur, Ulania, Jagalia, Darirchar-Khajuria, Bashanchar and Andermalik (see chapter 6, figure 6.7).

Table 7.2: The population of four coastal rural affected areas (calculations are by the author; data sources: BBS census 2001 and 2011)

Rural study area	Population and annual growth rate	2011	2001	CAGR - NAGR
Shyamnagar	Population	318254	304364	-1.23
	Annual growth rate	0.14	1.7	
Tala	Population	299820	294400	-1.19
	Annual growth rate	0.18	0.59	
Sharankhola	Population	119084	114083	
	Annual growth rate	0.42	0.56	-0.95
Mehendiganj	Population	301046	304364	
	Annual growth rate	-0.11	0.42	-1.48

National annual growth rate 1.37

CAGR = Current annual growth rate

NAGR = national annual growth rate

Figure 7.2: The remaining part of Gobindapur is waiting to be engulfed by the river[I wrote this legend in 2013, but this spot no longer exists as of 2014]

As I have seen above, the bank erosion around this island has been faster in recent decades, which has led to a significant numbers of people becoming landless and homeless. Using census data, I estimate that during the last two decades (1991-2011) roughly 100 000 people and 18 000 households have been displaced (calculation has been added in the appendix 10). These people have either migrated to less-affected areas of Mehendiganj or out of the *upazila* to major cities such as Dhaka and Barisal. Some places in this *upazila* have been eroded and damaged so fast that people have not been able to save their resources. One group of respondents said: “we saw some victims who could not shift their stuff [furniture, housing material such as roof, wall and pole] due to the fast erosion. You see a miserable view in the rainy season as some affected people prepare to move, some take steps to shift their stuff and some cut trees. Look at these two coconut trees (Figure 7.3), they did not get enough time to cut them.’’ (Interview, November 2011). These trees would have been useful for making poles for houses in a new place. Figure 7.3 indicates this area eroded in the most recent wet season.

Figure 7.3: Gobindapur (picture taken in November 2011)

7.3.1 Displacement within the *upazila* from Gobindapur *union* to Ulania *union*

It has already been mentioned in chapter 6 (Figure 6.9) how much of Gobindapur has disappeared. In 1972 it contained thirteen villages. Out of these thirteen villages only one fifth of one village remains, as of 2012, and this is again under serious threat. According to the census of 2001, the population of Gobindapur was 28, 956 (BBS 2010b) whereas according to the census of 2011 it was only 8, 158 (BBS 2012). This means that over a decade more than 20,000 people were displaced either to the neighbouring *union* of Ulania (Figure 6.8), further inland or forced to migrate to a large city like Dhaka. Overall, 97% of the population of this *union* has lost their land since 1972 (calculation shown in appendix 10). Many of these people are likely to have moved a relatively short distance to Ulania *union*. According to the census of 2001 the population of the Ulania *union* was 37,426, made up of 6,804 households (BBS, 2010b), whereas according the census of 2011 the population and households increased dramatically to 51,077 and 11,200 respectively (BBS, 2012).

On being displaced, many landless people built make-shift houses on the roadside, near the local lord's (or *zamindar's*) pond, on the government's open spaces or took shelter or built houses on others' open land. In addition, the local community helps each other. One land owner Jamsed Hossain said, "I have some spare land in Ulania. I provided shelter to twenty displaced families. Some of them are my relatives. … We local people try to help these victims as much as we can'' (Interview, November 2011). Due to displaced population, Ulania has become very crowded. According to the census of 2001, the population density was 1,517 per km^2 whereas according to 2011, it had risen to 2,070 per km^2 to become one of the most densely populated rural communities. Previously, some people in the Ulania *union* had a house with a big garden. But these gardens are disappearing as people are moving here and building houses, or even two-storied buildings, in these gardens. Harun-ur Rasid, a retired army staff officer, said "Landless people have taken shelter in this *union*. Thus, the environment of this *union* has become crowded, just like a crowded town. Vulnerable people of five *union*s are moving here. They took shelter on other's land and in the old *zamindar's* building. Nine people live in a house; just imagine how crowded it is" (Interview, November, 2011).

There are several reasons displaced people have for moving to Ulania *union*. There are schools, banks and NGO offices situated in this area. The second largest market of Mehendiganj is also situated in Ulania. Local jobs are therefore available. Moreover, the Meghna River is near here, so they can be involved in agricultural and fishing activity. Furthermore, land prices are cheaper in Ulania than in the central part of Mehendiganj (e.g. Patarhat), which is not threatened by river bank erosion. Thus, in 2011, an area of 1 *katha* [720 square feet; ~ 67 m^2] at Patarhat cost two lakh BDT [~£1,600] whereas it was thirty thousand BDT [~£250] in Ulania. Thus, an area of 1 *katha* [720 square feet; ~ 67 m^2] at Patarhat costs two lakh BDT [~£1600] whereas it is thirty thousand BDT [~£250] in Ulania. House rent is also higher in Patarhat; the rent of a 2 bedroom flat in Mehendiganj town is 5,000 BDT [~£50] per month which is nearly same as in Barisal or Khulna city. Even some middle class people prefer to buy land in Ulania as prices are cheaper. Thus, poorer people have strong incentives to migrate to Ulania.

A group of teachers at the Ulania Secondary Girls High School said, "if vulnerable people move to town they need shelter and a job first. One earning person can assist ten members of his family here, but it is quite impossible in a city. In Dhaka nobody will give land to build houses but here people will do so. That means people are getting at least shelter, which is not possible in the city. Moreover, they need a job in a city. Thus, in spite of having lots of problems, some people do not like to move. And also, some people are waiting to get back their land from *char*. Thus, most prefer to stay here. [Nevertheless], lots of landless people have migrated to Dhaka." (Interview, November 2011). However, Ulania *union* itself is under serious threat from erosion.

The edge of Ulania village is only 50 m away from the river and will be the next area to be eroded. Impacts in Ulania can already be seen. For example, the numbers of school students are decreasing significantly. Harun-ur Rasid, a retired army staff officer, said, “this *union* is highly threatened by riverbank erosion. There were three *union*s Gobindapur, Dolkhola, and Uttar Shahabajpur that have been engulfed by the Meghna. Little of Gobindapur is left (chapter 6, figure 6.9), and Ulania *union* is at the waterfront now and will be the fourth *union* to disappear soon. We are losing land and assets, everything, and that is leading people to become beggars.” (Interview, 2011).

7.3.2 Impact on Infrastructure and education

Over the last two decades in Gobindapur, a large number of schools and colleges, madrasas, mosques and temples, ponds, roads, business establishments, hats (village markets that open one or two specific days like a Sunday market in the UK), agricultural land and betel nut groves were lost to bank erosion. One of the colleges lost was the hundred year old Uttar Shahabajpur George Institute, built by the local Hindu *zamindar* (feudal local landlord) in 1911. Moreover, many more educational institutes are seriously at threat of destruction in Ulania now. This is particularly important in this area as Mehendiganj is educationally rich. It has an average literacy rate of 70% whereas the national average is 46.5% (BBS, 2010b), so the loss of these institutions threatens to damage the economic and social structure of local society. An *upazila* Education officer Sikder Hossain from Mehendiganj said, “in 2009 Mehendiganj achieved second place in the national primary school examination in Bangladesh”. Impacts in Ulania can already be seen, with numbers of students decreasing significantly. Altab Hossain, Head Master of Ulania Secondary Girl’s School, said, “this school is now seriously at threat as it is only 300 feet [100 m] away from the river. The number of students attending was 900 in 1998 and 750 in 2006, but now only 650 students are studying here. Due to river bank erosion the number of students is declining. [already,] in the rainy season this school is flooded under three / four feet [1 m] water.’’ (Interview. November, 2011).

7.3.3 Land conflict

It has already been mentioned in chapter 6 that 297 square kilometres have been eroded during the last twenty years by the lower Meghna, whereas 330 square kilometres has been deposited as a *char* island and along the mainland. Both erosion and accretion have negative social impact on poor people, who typically are the most affected. I have seen some of the consequences of riverbank erosion in earlier chapter. New *char*s appear also, however, but are not immediately suitable for settling as the land is not stable, and there are very poor communications with the mainland. If people move there they have to depend on the mainland's markets, educational institutes, health facilities and other services. Moreover, the elevation of a typical *char* is only marginally above river level so this land is prone to flooding during the summer monsoon (Figure 7.4). However, these *char* lands give hope to the poor landless people. Kashem, one victim of riverbank erosion said, "I [have been displaced] three times. I do not have enough money to buy land for building a house. Thus, I rent a house in Ulania. We are hoping that we may build our house on *char*" (Interview, November, 2011). Nevertheless, it is hard for the displaced to get back their land in this way, due to the complex laws concerning newly emerged land.

Local power dynamics play a significant role in the gaining of control over the newly emerged *char* land, and in many cases clashes between two groups have occurred. Nevertheless, one respondent Monwar said, "there are land conflicts over occupying *char* between two groups. But sometimes they compromise to avoid violence and allow the victims of river bank erosion [to regain land]" (Interview, November 2011).

Local landowners gain control over newly emerging land through outright occupation, secured by deploying poor farmers dependent upon them for employment and access to land (Lein, 2009). The dynamics of establishing control over the newly emerged *char* land in most cases results in arguments between groups, with typically an augmentation of power by large land owners (Hutton and Haque 2004). Zaman (1987) reported forty cases relating to land conflict violence over *char* land over a period of five years (1978-1982), while a total of 733 (over five years) people died during clashes for control over the accreted land (Sarker et al., 2003). Kayes Chowdhury, an upper class respondent said, "there are land conflicts in the villages especially regarding occupation of *char*. Influential people grabbed the paddy land of weak people in *char* and take all the paddy during the harvest time. This type of conflict still exists in some parts of greater Barisal Division. Politically influential people grabbed the *char*. They could give some land to poor people but they do not do that. They grabbed all available land. Those who lost their land due to riverbank erosion, they do not get any; political leaders and influential people occupied the new land. They use poor people to plant paddy land but at harvest time they do not care for them; sometimes they do not even give anything to poor people. The influential people have good connections with officers of the land authority" (Interview, November 2011).

Figure 7.4: A *char* in the Meghna channel in the dry season (November 2011).

7.4 Socio-economic movement

With the sudden onset of natural disaster, most people will be affected but economic effects may last for some time: Anwar Hossain from Sharankhola said, "after tropical cyclone Sidr saline water was logged for seven months but we could not grow any crops for two years due to salinity of the soil" (Interview, November 2011). From the interviews I found that social status declined due to sudden environmental disasters, with notable downward transitions from middle class to poor and poor to extremely poor. However the degree of this downward social mobility varies from place to place. Thus, two years after tropical cyclone Sidr people of the Royndee *union* had returned to normal life but those of the Gabura and some other *union*s of the Shyamnagar *upazila* were not. Tropical cyclone Aila had an even bigger impact, with all middle and lower class people dropping to extreme poverty in the short term. Two years after the cyclone, 50% of the middle class had returned to their original status, but 50% remain in a low socio-economic position. Selim Ahmed said, "those whose financial condition was originally better, but lost everything; they could not get any help from humanitarian organizations. Even to take shelter on the roadside after Aila they felt indignity. They became poor silently. But I believe they will able to get back [their dignity] if they can start their *ghe*r farm again." (Interview, November 2011). A similar sentiment was indicated by the study of Mallick et al. (2011: 643), “the Middle class family neither can seek relief nor can engage[d] themselves with day labour activities due to their social status and psychological barrier and it contributing to increase their vulnerability, but most often it remains unnoticed.”

The situation is a bit different for the slowly evolving environmental problems of Mehendiganj. Most of the displacees have lost their land more than once. Though rich people can move to the city, or a safe region, middle and lower class people normally cannot buy land in the city, as it is too expensive. After losing their original house they again buy land near the river as it is cheaper. However, their new house and land again comes under threat. After a couple of times of losing their land they tend to become landless and even have to take shelter in makeshift tents beside the road. Abdul Malek, a victim of riverbank erosion, said, “my house was near Goalpur School. We had good earnings before, but now I am facing financial problems as I have lost my house and land four times. I have become extremely poor. I work now at Ulania market as a labourer. I earn only 50 to 100 BDT per day [less than £1 per day]. I have a miserable life here. We took shelter with Fakir Bari [a land owner] temporarily. In the wet monsoon these houses are flooded under 3 to 4 feet of water [~1 m]. Like me, at least twenty families took shelter here. Most of us have faced loss of our homes at least four times. Some of us are fisherman. Thus, those have to stay near the river to work. I might [eventually] go and try to cope with a new place [like Dhaka, rather than stay here].’’ (Interview, November 2011).

Figure 7.5: Abdul Malek, who lost everything due to riverbank erosion. [during the fieldwork, these houses were situated within 50 m distance from the river that is a

high risk area to flooding and river bank erosion. To cope with flooding they use traditional knowledge to build houses, illustrated in the picture. Houses have been made on raised bamboo stilts. However, these houses do not exist anymore (in 2014) due to river bank erosion.]

7.5 The impact of environmental change on the rural community's culture and tradition

The interview surveys have revealed a range of ways in which either sudden or sustained environmental change impacts on the traditional way in which local communities function, or on things they value. I have encountered some of these already in this chapter but here I will explore a range of these in more detail, from traditional practices and beliefs, to the impact on cultural history.

7.5.1 Impact on religious practice

The Sundarbans -dweller is a traditional community, with a largely Hindu origin. The Hindu community of the Sundarbans join a 200 year-old pilgrimage, called *Rash Mela*, every year on *'Rash Purnima'* [the full moon] on Dublar *char*, an island on the coast in the middle of the delta. There is a temple in the heart of the island. Huge numbers of people gather on the island during the five day festival; it has also become a significant tourist attraction. However, due to the impact of tropical cyclone Aila, the festival did not occur in 2009 (Muhmud, 2009). From the perspective of longer-term environmental change, this island is at great threat from sea level rise as it is the most southerly island of the delta, and exposed to the Bay of Bengal.

7.5.2 The threat to historical buildings

A traditional *zamindar* building and mosque are situated beside the Uliana market (Figure 7.6). During the last three hundred years the *zamindars* of Ulania of Mehendiganj built ~ 100 magnificent architectural buildings over an area of sixty acres (0.24 $km^{2)}$. Many landless people have taken shelter in these old buildings and beside the pond around them. The traditional market, their places of work and the opportunity to take shelter around the *zamindars'* buildings play a significant role in attracting vulnerable people to Ulania. But this market and these magnificent buildings are now under threat from the Meghna river, as they are only 1 km from the river. Thus, people of this area are very anxious about this hazard. Local people said, "if the government of Bangladesh do not take any initiative, we will lose this traditional market and magnificent buildings built by the *zamindars*".

Figure 7.6: The hundred and fifty year old mosque at Uliana which was built by a feudal local landlord (*zamindar*), and is now under threat from the river (November, 2011)

7.6 Environmental change and its impact on livelihoods

The most severe consequences of environmental change are expected to have large impacts on the food security and livelihoods of nature-oriented residents in vulnerable rural societies (FAO, 2013). Agriculture, forestry and fisheries are all particularly sensitive to environmental change. Their production processes are likely to be affected by environmental change (FAO, 2008). For example, increased rainfall might be beneficial for agriculture due to increased water availability; at the same time it could be harmful to agriculture due to soil erosion and leaching (Ericksen et al., 1997). The performance of the agricultural sector has a key direct impact on important macro-economic objectives, such as employment generation, poverty alleviation, human resource development and food security (Selvaraju et al., 2006). The socio-economic effects of environmental change therefore arise from interactions between climate and society and these in turn affect both natural and managed environments (Ericksen et al., 1997). Livelihoods in coastal rural communities are diverse, complex, irregular and seasonal. Analysis of the interviews found that the most important livelihoods are agriculture, fishing and forestry. These are the key to food security as well as livelihood security. However, their importance varies from place to place. So 75% of households of the Jalalpur *union* of the Tala *upazila* depend on agriculture, whereas 80% of households of the Gabura and Munshiganj *union*s of the Shyamnagar *upazila*, and 40% of the Royndee *union* of the Sharankhola *upazila*, depend on fish farming in the *gher* and fishing in the forest. In what follows, I will examine these key activities in turn.

There are a range of livelihoods in the Mehendiganj *upazila* but they are dominated by rural activities: agriculture, agricultural labourer, wage labourer and fishing. Most poor people earn their living through agriculture. To give an example of the problems, a large area of betel nut plantation was lost through river bank erosion in the rainy season of 2007. Thus, a range of different livelihoods, especially in agriculture, are seriously at risk from bank erosion. One group of respondents said, “we do not like to move. We live on agriculture. We grow crops and vegetables and sell these to the local market. Some of us are fishermen: we live close to the river though we are victims of river bank erosion.” (Interview, November 2011). Marginal farmers who cultivate small land-holdings as an owner, tenant or share cropper, and landless people who work as hired labour are the most vulnerable to natural disaster. For example, of the respondents of the Jalalpur *union* of the Tala *upazila*, 70% were found to be marginal farmers or day labourers. This group experienced miserable conditions during the flash flood of August 2011, as 5990 hectares of cropland were seriously damaged (Christian aid et al., 2011). These marginal farmers also face increase of vulnerability due to small size farm, low technology, low capitalization and diverse non-climatic stressors but at the same time the coping factor such as diversification of livelihood could aid to decrease vulnerability (Morton, 2007) (see the section 7.6.1). After tropical cyclone Aila and Sidr all types of farmer were affected, whether small- or large-scale. One assistant teacher in Kanadia Primary School, Tala, said, “flood destroyed my 15 *bigha* (14,400 square feet) of paddy land. I do a job in the school, that’s why it was possible to survive. But most of the farmers suffered a lot” (Shaha, November 2011).

Livestock and poultry provide one of the most important and common sources of income for those living in rural communities. Livestock are particularly essential to enhance the adaptive capacity of impoverished marginal households (Thornton et al., 2015). The reduction in livestock production may have an effect on the food security and incomes of smallholders (Calvosa, 2009). Cattle, buffalo, goat, chicken and duck are the principal livestock farmed. Meat from these animals has high demand in Bangladesh. Thus, most marginal and landless farmers, and some middle class households, earn money through selling produce from these animals to support their family. Many of them reported that that selling livestock, milk cows, poultry and eggs are one of the most profitable non-farm activities (Antwi-Agyei et al., 2014) but at the same time during the disaster period many households forced to sell livestock at low rate due to lack of livelihood and food security. Moreover, Tropical Cyclone Aila had a significant impact on the decline of livestock due to the decrease in food for livestock.

Livestock are integrally linked to crop production in the affected areas. This is often known as integrated mixed farming. "Crops and residues are used to feed livestock, and manure is a crucial source of nutrient for growth or as fuel in crop-livestock system" (Thornton et al., 2011: 3). One respondent, Shamim Ahmed, said, "after Aila, farming of cattle and goat has declined remarkably in the Gabura and Munshiganj *union*. Due to salinity intrusion, grass and paddy are not growing here anymore, and these are the main food of the livestock. Therefore, the number of domestic animals is decreasing. Thus, due to less availability of these, we are not able to buy milk, as the milk price is very high because it has to be brought from outside of this *union*. That impacts on babies as they need it for nutrition."

Women are active in this practice by caring for domestic animals, chickens and ducks. Traditionally, the rural community of Bangladesh depends heavily on home-made food, overwhelmingly cooked by women. They also make fuel from cow dung and crop residues for cooking (Figure 7.7). Therefore, firewood and cow dung are the most important sources of fuel for cooking as there is rarely gas available in rural areas. One household spends 800 BDT (£6) per month to buy firewood. However, following a natural disaster there is a lack of suitable firewood. This contributes to people facing starvation after a natural disaster. Cow dung is also used for making fertilizer for crops and food for fishing. Farmers use the livestock for ploughing. They are also used for freight transport in the rural community. Thus, the weakening of the crop-livestock farming system leads to a decrease in livestock that would in turn decline food security and livelihood security. This is one of the reason that pushed people to moved city for jobs in the informal sector from Shyamnagar *upazila*.

Figure 7.7: Cow dung being dried for fuel (picture taken November, 2011)

Sundarbans Forest is major source of income for the rural communities of southwest Bangladesh, especially for our survey areas of Sharankhola and Shyamnagar *upazila*s. It provides fish, crabs, fuel, honey, fodder, wood, construction material such as *goalpatha* (nypa leaf/mangrove plam), timber (Zohora, 2011) and straw. These forest products have also been used to support the recovery following natural hazards by earning money as well as delivering economic support for agricultural activities and rural livelihood more broadly (Dixon et al., 2014: 193). Those who live closest to the forest are the poorest and it is their only sources of income (Akter and Mallick, 2013). A large number of people depend on the forest as they have fewer employment opportunities than those who live further inland (Akter and Mallick, 2013). Quantitative data revealed that 40% of the households of Gabura and Munshiganj *union*s of Shyamnagar *upazila* (who are mainly landless) collect prawn larvae, crabs and go fishing in the inter-tidal waters of the Sundarbans. Selim Ahmed said, “a huge number of people go to the forest to cut *goalpatha* with the permission of the forest authority. They collect this leaf for three months a year [winter] and sell it in the local market. It costs about 5000 BDT [£45] to make a *goalpatha* roof of a typical house” (Shamim Ahmed, November, 2011). After tropical cyclone Aila, due to the increase of unemployment and consequent drop of earnings relying on fish farming and agriculture, the local communities’ dependency on the Sundarbans forest for fishing and prawn larvae collection has increased, increasing the number of fishermen using the forest. For many in this community, fishing practices in the forest remains the only way to earn enough money for survival. However, during the collection of tiger prawn larvae other fish larvae are killed. Thus, respondents reported that many species have disappeared from the Sundarbans, or have decreased in number. However, overfishing and the depletion of stock of fish not only causes negative ecological consequences, but also reduces fish production, which further leads to negative social and economic consequences (FAO, 2014). In long run, this may lead to deceased livelihood opportunities and food security in future.

Coastal lands have also been comprehensively shifted to shrimp farming industries since the 1980s, primarily in response to high levels of salinity (Agrawala et al., 2003) (see the figure 7.8). This has proved to be one of the most popular livelihood options for people living in coastal communities because of its ability to generate high economic returns (Kartiki, 2011) (see also the section 7.6.1). Respondents reported that shrimp farming encouraged farmers to allow saline water to enter their farm. This caused severe damage to the forest cover and damaged the embankment. The reduction of forests in water logged shrimp areas also increased pressures in other parts of the Sundarbans forest for fuel wood and timber, enhancing the rate of forest depletion (Agrawala et al., 2003). This reduced access of the mangrove forest and increase the insecurity of livelihoods (see also Orchard et al., 2013). However, there are social conflicts between local people and rich shrimp farmers (Azam, 2011). Due to their economic and political power, many richer farmers buy land from poorer small farmer forcefully and convert the land to shrimp farm. Due to low incomes, limited access to resources, lack of power, insecure land-use rights and insecure livelihood, many poor farmers are encouraged to migrate to urban areas.

Figure 7.8: This cultivable land is converted to shrimp farming (picture taken during the interview at Jalalpur *union*, Tala; November, 2011)

7.6.1 Diversification of traditional livelihoods

The impact of climate change on traditional livelihoods for the coastal community of Bangladesh is an under-researched topic. Though it is important to maintain the incomes of affected people, to cope with the new environment they may not be able to maintain their traditional livelihood. This idea was carried out using qualitative assessment. As I have seen, even displaced people may find it hard to gain employment in new places. Consequently, they change jobs into the informal sector. This particular group tends to be poor or extremely poor. Some respondents from Mehendiganj said, "lots of people change their livelihood to cope with new environments. Some landless people used to work as agricultural workers, fishermen and shopkeepers but they moved to the city and are now involved in the informal sector as rickshaw pullers, building workers, waiters, street vendors, beggars etc." The number of fishermen in this region is increasing as this *upazila* is surrounded by the river, while other professions, like agricultural activity, are at threat due to riverbank erosion. Sulaiman Hossain, lecturer of Paterhat RC College, Paterhat, Mehendiganj said, "fishermen live near the river. They do not like to move to the city though they face this hazard [displacement] again and again. One reason is they need money to settle in a city and another is they do not like to leave their family, relatives and friends. Landless poor people who used to live on agriculture are changing their occupation to fishing. The number of building workers is decreasing in vulnerable areas as the higher class [who have the money] do not like to build new houses there, as regions like Ulania might disappear in the near future. People from this profession [construction] either move to the city or change their profession to fishing." Though the river continues to engulf the land, most fishermen do not wish to move. They live near the river, even though they face eventual displacement.

On the other hand, due to increases in salinity, agricultural productivity has been seriously affected in the coastal rural communities of Satkhira, Khulna and Bagerhat. Thus, these communities are changing their land use from agriculture farming to shrimp farming. This change from paddy cultivation to shrimp farm cultivation is encouraged by the high prices that can be obtained from shrimps in the market. This even extends to international demand. Zakir Hossain, Assistant teacher said, "the shrimp farmer earns more money than an agricultural farmer. The price of two kg of shrimp is 1,000 BDT (£8) which is worth of forty kg rice." (Interview, November, 2011). However, large-scale shrimp farmers are rich and live in the city. They take most of the profit and pay low wages to the day labourers. Moreover, local employment generally decreases as a result of this move to shrimp farming, as to maintain a shrimp farm needs less labour than an agriculture farm. Jalal Uddin said, “before shrimp farming started in this region 24 people used to work on an acre of land [4046 m^2, local equivalent - 3 *bigha*]. From these three *bigha* we used to produce 1.8 metric ton or 25 bags of rice, which gained us 25,000 BDT [£200] [in total]. However, from the same land we can earn 45,000 BDT [£400] from the shrimp farm and we only need two farmers to work in the farm for the whole year.’’ (Interview, November, 2011). In addition, shrimp farming is a very seasonal activity and for half of the year it offers little employment. Due to this reduction in labour intensity, agricultural labourers are left jobless by the shrimp farms and many people migrate to city in search for new income as a coping mechanism (Faist and Schade, 2013). My study showed that due to this process many people seasonally migrate to Dhaka, Satkhira, Khulna or Barisal. After tropical cyclone Aila this seasonal migration increased in this region. Jalal uddin and Malek Hossain said, “we left for six months and earned thirty to fifty thousand BDT [£250-400]. The rest of the year we engaged in shrimp farming or fishing in the forest. Every year roughly 20 thousand people from Shyamnagar *upazila*, [now] move as seasonal migrants to Dhaka and Barisal, to work in the brick field” (Interview, November, 2011).

Immediately after Aila, almost all respondents lost their jobs. Though there were no jobs available, some work was offered by local government and NGOs to repair the road and embankment. Thus, many farmers and fishermen shifted their livelihood to day labour (Mallick et al., 2011). Due to water logging, some respondents who were old or did not find jobs relied on fishing to survive. Many households who were not able to secure income from locally organised rehabilitation works were forced to migrate (Mallick and Vogt, 2013). Mallick and Vogt (2013) found 35% respondents were displaced due to loss of livelihood. Many household sell off productive assets or migrate for work (Akter and Mallick, 2013). My study confirmed these findings as I found respondents’ family members moved temporarily. This study also found that some seasonal migration has increased due to the unavailability of livelihoods, particularly after tropical cyclone Aila.

7.7 Assessing vulnerability, sensitivity and adaptive capacity with the migration of interview area.

The concept of vulnerability to environmental change, adaptive capacity and the migration process was defined in chapter 2, section 2.5. In section 2.6, I describe the factors that influence vulnerability, as well as a set of commonly used composite proxy indicators, which were used to quantify vulnerability in this current study (see also section 2.7). The method used to create vulnerability index (VI) was described in chapter 3, section 3.5. The VI compared the various four coastal rural sub-districts' vulnerability to adaptive capacity, sensitivity and exposure and differential vulnerability. From this data, one can compare contributing factor scores for adaptive capacity, sensitivity and exposure in each region through using through using 'vulnerability triangles' (see figure 7.9).

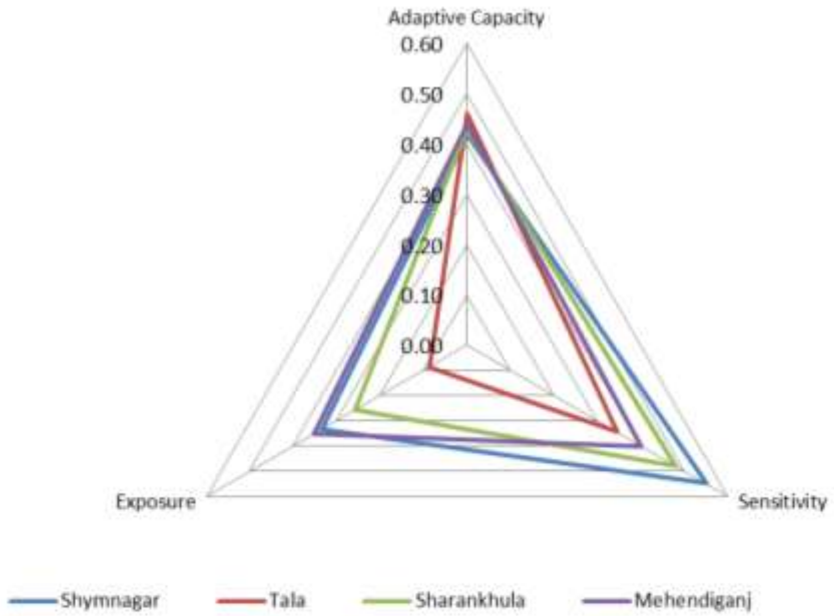

Figure 7.9: Vulnerability triangle diagram for four rural sub-districts. The scale of the diagram ranges from 0 (less vulnerable) at the centre of the web, increasing to 0.6 (more vulnerable) at the outside edge in 0.1 unit increment.

The vulnerability score is highest in Shyamnagar, meaning this sub-district is highly sensitive to environmental change (Table 7.3). As described earlier, this sub-district is particularly exposed to salinity intrusion. The second most vulnerable sub-district is Mehendiganj. It is highly exposed to river bank erosion, and the research found a high number of respondents had experienced this phenomenon.The majority of those displaced were found to not move far, because of a combination of factors relating to the social and economic advantages of re-establishing themselves locally. However, many respondents were found to have been displaced multiple times, which increases the probability that they will eventually be forced further afield, most likely to urban areas as environmental refugees. This happened on average 3.5 times per victim. While all four rural survey sub-districts have experienced substantial environmental events, exposure is highest in Mehendiganj (0.53) and Shyamnagar (0.33) (Table 7.3). In general, Tala is a safer place. The effect of Aila on Tala was small. Exposure to environmental change is greater in Sharankhola (0.26) than Tala (0.09) (Table 7.3). Although Sharankhola is much closer to the sea, elevation from sea level is on average nine meters, according to respondents, salinity level has not changed much. Most respondents said the salinity level of this sub-district has remained almost the same. The variability in monthly mean temperature and rainfall has been found higher in Sharankhola (0.69 and 29 respectively) and Mehendiganj (0.48 and 29 respectively) than Shyamnagar and Tala.

Table 7.3: Overall vulnerability score and ranking.

Sub-district	Adaptive capacity	Sensitivity	Exposure	Vulnerability	Ranking
Shyamnagar	0.42	0.53	0.33	0.49	1
Tala	0.46	0.34	0.09	0.33	4
Sharankhola	0.43	0.48	0.26	0.43	3
Mehendiganj	0.44	0.40	0.35	0.44	2

Shyamnagarwas the district with the highest sensitivity to climate change, with an overall score of 0.53 (Table 7.3, figure 7.9). The sub-district Tala, showed lowest sensitivity to climate change, with a score of 0.34 (Table 7.3 and figure 7.9). As such, this study suggests that demographically, socially, physically, economically and politically Shyamnagar is more sensitive than other sub-districts (see the spider diagram 7.10).

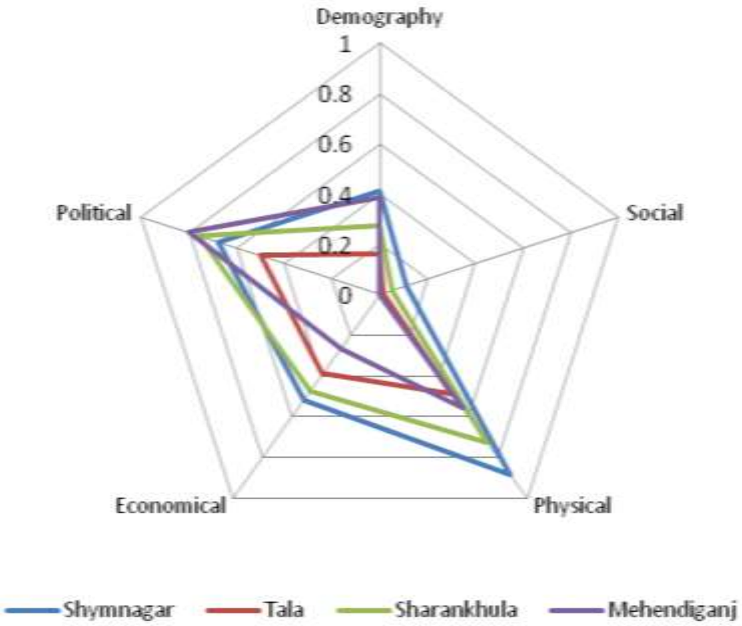

Figure 7.10: Sensitivity on the basis of five drivers. The scale of the diagram ranges from 0 (less sensitivity) at the centre of the web, increasing to 0.1 (more sensitivity).

Findings of the study indicated that Shyamnagar and Mehendiganj are more densely populated than others areas (Table 7.4 and 7.5). The erosion of land could be a key reason (see the section 7.3). According to census data from 2011, the Gabura *union* of this sub-district has a higher population density (1,137 per square km), a higher percentage of female population, and a higher number of female headed households (widow/divorced/separated) than other sub-districts (Table 7.4 and 7.5). This is particularly significant as evidence has highlighted that women, children, older people and female headed households are the most vulnerable groups to environmental change. These groups are either forced to stay or forced to move (as described in section 7.2.1). Shyamnagar received the higher score in these indictors (Table 7.5). Tala is less densely populated (991 per square km) and has fewer female headed households. Therefore, this sub-district is less demographically sensitive to environmental change.

Table 7.4: All indictor values for four rural sub-districts.

Index	Dimension	Driver	Indicators	Unit	A	B	C	D	Max	Min
VI	AC	Demographic	Population between 15 and 59 years of age (a)	%	58	61	53	51	100	0
			Employed women	%	0	3	2	2	100	0
			Number of seasonal and temporary migrants	%	26	6	14	4	100	0
		Social	Household with social network	%	81	76	67	67	100	0
			Household with social support	%	71	83	37	86	100	0
			Literacy rate (a)	%	36	51	60	52	100	0
			People using traditional knowledge from elder and neighbour	%	20	16	23	23	100	0
		Physical	House of ownership		86	96	91	64	100	0
			Household with access to information before the disaster	%	43	41	55	57	100	0
		Economic	Credit access without interest	%	4	14	22	30	100	0
			Remittance from migrant member	%	22	2	9	24	100	0
			Daily wages	Count	160	210	210	220	230	80
	S	Demographic	Density of population (a)	Count	1137	991	1060	1130	1137	991
			Female population (a)	%	51	50	51	50	100	0

Index	Dimension	Driver	Indicators	Unit	A	B	C	D	Max	Min
			Disabled population (a)	%	2	2	2	2	100	0
			Widowed/divorced/separated female (a)	%	13	12	10	8	100	0
		Social	Household reporting water conflict	%	11	2	5	0	100	0
		Physical	Vulnerable household	%	96	89	91	90	100	0
			Household without access to water	%	89	5	49	9	100	0
			Household without electricity connection	%	81	52	78	69	100	0
		Economic	People reporting high interest credit	%	76	49	70	40	100	0
			Unemployed male	%	11	9	9	4	100	0
			In poverty	%	5	25	33	23	100	0
			Household forced to sell asset during and post disaster period	%	15	0	5	0	100	0
			Household not able to buy food due to price increase in post- disaster	%	78	67	81	23	100	0
			Income coming from natural resources	%	89	83	86	68	100	0
		Political	People reporting about relief mis-distribution	%	80	33	95	90	100	0
			People reporting land conflict (*char*-occupied)	%	55	67	56	70	100	0
	E	Environmental	Number of cyclones and storm surges,	Count	4	2	2	3	4	2

Index	Dimension	Driver	Indicators	Unit	A	B	C	D	Max	Min
			floods, river bank erosion in last 10 years							
			Household not receiving cyclone warning	%	60	20	33		100	0
			People reporting increasing salinity	%	100	2	5		100	0
			Elevation from sea level (b)	1/(elevation+1) cm	0	0	0	0	1	0
			Mean standard deviation of mean monthly temperature (c)	Degree Celsius	0	0	1	0	1	0
			Mean standard deviation of mean monthly rainfall (c)	Millimetre	26	26	29	36	48	26

a) BBS = Bangladesh Bureau of Statistics; b) GMET = Global Multi-Resolution Terrain Elevation; c) BMD = Bangladesh Meteorological Department.

A = Shyamnagar, B = Tala, C = Sharankhola and D = Mehendiganj

AC = Adaptive capacity, S = Sensitivity and E = Exposure.

Max = maximum and Min = minimum.

Table 7.5: All indictor scores for four rural sub-districts.

Index	Dimension	Driver	Indicators	Unit	A	B	C	D
VI	AC	Demographic	Population between 15 and 59 years of age (a)	%	0.58	0.61	0.53	0.51
			Employed women	%	0	0.03	0.02	0.02
			Number of seasonal and temporary migrants	%	0.26	0.06	0.14	0.04
		Social	Household with social network	%	0.81	0.76	0.67	0.67
			Household with social support	%	0.71	0.83	0.37	0.86
			Literacy rate (a)	%	0.36	0.51	0.6	0.52
			People using traditional knowledge from elder and neighbour	%	0.2	0.16	0.23	0.23
		Physical	House of ownership	%	0.86	0.96	0.91	0.64
			Household with access to information before the disaster	%	0.43	0.41	0.55	0.57
		Economic	Credit access without interest	%	0.04	0.14	0.22	0.3
			Remittance from migrant member	%	0.22	0.02	0.09	0.02

Index	Dimension	Driver	Indicators	Unit	A	B	C	D
			Daily wages	count	0.53	0.87	0.87	0.93
	S	Demographic	Density of population (a)	Count	1	0	0.47	0.95
			Female population (a)	%	0.51	0.5	0.51	0.5
			Disabled population (a)	%	0.02	0.02	0.02	0.02
			Widowed/divorced/separated female (a)	%	0.13	0.12	0.1	0.08
		Social	Household reporting water conflict	%	0.11	0.02	0.05	0
		Physical	Vulnerable household	%	0.96	0.89	0.91	0.9
			Household without access to water	%	0.89	0.05	0.49	0.09
			Household without electricity connection	%	0.81	0.52	0.78	0.69
		Economic	People reporting high interest credit	%	0.76	0.49	0.7	0.4
			Unemployed male	%	0.11	0.09	0.09	0.04
			In poverty	%	0.05	0.25	0.33	0.23

Index	Dimension	Driver	Indicators	Unit	A	B	C	D
			Household forced to sell asset during and post disaster period	%	0.15	0	0.05	0
			Household not able to buy food due to price increase in post- disaster	%	0.78	0.67	0.81	0.23
			Income coming from natural resources	%	0.89	0.83	0.86	0.68
		Political	People reporting about relief mis-distribution	%	0.8	0.33	0.95	0.9
			People reporting land conflict (*char*-occupied)	%	0.55	0.67	0.56	0.7
	E	Environmental	Number of cyclones and storm surges, floods, river bank erosion in last 10 years	Count	1	0	0	0.5
			Household not receiving cyclone warning	%	0.6	0.2	0.33	
			People reporting increasing salinity	%	1	0.02	0.05	
			Elevation from sea level (b)	1/(Elevation+1) cm	0.21	0.12	0.05	0.1
			Mean standard deviation of mean monthly temperature (c)	Degree Celsius	0.19	0.19	1	0.34
			Mean standard deviation of mean monthly rainfall (c)	Millimetre	0	0	0.16	0.47

a) BBS = Bangladesh Bureau of Statistics; b) GMET = Global Multi-Resolution Terrain Elevation; c) BMD = Bangladesh Meteorological Department.

A = Shyamnagar, B = Tala, C = Sharankhola and D = Mehendiganj

AC = Adaptive capacity, S = Sensitivity and E = Exposure.

Based on economical factor, Shyamnagar is highly sensitive due to a high number of people living in poverty, a high unemployment rate, and higher interest rate of credit access (Table 7.4 and 7.5). During the post-disaster period 78% respondents in Shyamnagar faced difficulty meeting basic needs. However, conversely, due to less poverty and a lower unemployment rate, Mehendiganj was found to be the least sensitive region with the exception of Mehendiganj, income for about 90% of households in these districts comes from natural resources (directly and indirectly). Dependency on natural resources for income leads people to become more susceptible and vulnerability to environmental change. A large number of people from Shyamnagar and Sharankhola highly depend on Sundarbans forest. During more extreme conditions, forest-dependent households are seriously affected, particularly through a disruption to livelihoods, and this can lead them to migrate in order to search for work (Ahsan and Warner, 2014).

Based on social factors, Tala and Mehendiganj show lower levels of sensitivity. This is because a high number of households have access to safe water in Mehendiganj, and as such there are few conflicts over water in this sub-district (Table 7.4 and 7.5). Conversely, conflicts over water are highest in Shyamnagar. Almost all respondents acknowledged problems with drinking water due to salinity. The study found that on average people from Gabura (Shyamnagar) travelled 1.2 km to collect drinking water every day. Furthermore, it was mostly women and girls who are responsible for collecting drinking water. After tropical cyclone Aila, repairs on the embankment at Shyamnagar took more than two years to complete, resulting in the area becoming water logged. As such, women and girls had to use boats or sometimes walk in polluted salt water in order to collect drinking water (Mallick, Rahaman, and Vogt, 2011). Many school age girls are engaged in household water collection instead of going to school (Mallick et al., 2011) (see also section 7.2). Many water sources have long queues and this can sometimes result in arguments and conflicts. Although there are some conflict over water collection in Shyamnagar, Mehendiganj showed highest land conflict. This may be due to *char* land (see section 7.3.3).

With regards to political aspects, Mehendiganj and Sharankhola are more sensitive than other areas. The poor distribution of relief and aid is one of the most important political factors for environmentally affected areas, largely a product of mismanagement and corruption by local political leaders (details described in section

7.2.6). This aid is supposed to support affected people to recover, which can also indirectly affect migration decisions. However, in Sharankhola, 95% of respondents reported relief mis-distribution. While conversely, few respondents talked of aid mis-distribution in Tala.

The quality of house as a physical vulnerability factor has been described in section 2.7. Almost all houses in these four sub-districts are vulnerable to environmental change in some form. Very high numbers of households have access to safe water and electricity connection in Tala. High numbers (78% and 81%) of households do not have an electricity connection in Sharankhola and Shyamnagar (Table 7.4). As these two sub-districts are exposed to the sea and highly sensitive to tropical cyclones, electricity connection is an important factor in accessing information before a disaster strikes. Moreover, these two regions have little access to safe water. Thus, on the aspect of physical factors, these two regions are highly sensitive to environmental change.

Considering adaptive capacity dimensions, the study found that Shyamnagar had the lowest adaptive capacity (Table 7.3). This is the result of less social support, lower levels of literacy, borrowing money with high interest, and very low daily wages, despite the sub districts having a high rate of out-migration, with the remaining population receiving remittances (Table 7.4 and 7.5). Although Sharankhola has a higher literacy rate, with the people also commonly making use of more traditional knowledge and a higher number house ownership, this sub-district was also found to have the least adaptive capacity due to low levels of social networks and a comparatively less economically active population (Table 7.4 and 7.5). On the other hand, the adaptive capacity of Tala shows a highest score with 0.46 (Table 7.3). This is a result of high house ownership, social networks and a higher economically active population, higher numbers of employed women and comparatively higher daily wages (Table 7.4 and 7.5). Similar explanations could be appropriate for Mehendiganj although this sub-district shows a low proportion of house ownership (Table 7.4 and 7.5). Almost all sub-districts have a level of out-migration, resulting in households being supported by remittances. Thus, migration, and remittances from migrant members, plays a significant role in increasing adaptive capacity. During the survey with migrant households and migrant members, it has been found that many households have improved due to remittances. This research found 78% of migrant families in Shyamnagar have improved circumstances as a result of these remittances. Those who have not improved have at least earned some money to survive. These sub-districts also have a higher working population (15-59 ages). This group is very active for temporary and seasonal migration that contributes to reduced poverty and increased adaptive capacity, which also encourages other people to move. The study found the highest seasonal and temporary migration was in Shyamnagar, with Sharankhola having similar, but slightly lower levels. Similar explanations could also be applied for Sharankhola as well. The present study found very few seasonal and temporary migrations from Tala and Mehendiganj, though there was some permanent migration. Sharankhola has a similar effect of seasonal and temporary migration.

Overall, the most vulnerable and exposed sub-district to climate change is Shyamnagar. The results suggest that both permanent and non-permanent migration processes have a close relation to vulnerability and non-permanent migration has a close link to adaptive capacity. The study found that the sub districts of Shyamnagar and Mehendiganj may be more vulnerable in terms of sensitivity and exposure and less adaptive capacity, whilst Mehendiganj is more vulnerable in terms of exposure to hazards than other sub-districts. These two vulnerable regions also have shown higher number of migrants, from Mehendiganj as permanent migration whilst from Shyamnagar as non-permanent migration. Therefore, migration is a significant approach for reducing vulnerability to environmental change by increasing adaptive capacity. Thus, policy makers, in particular adaptation planners, may need to consider the case for the defending economically important rural areas, as well as revisiting the role of migration (Heltberg and Bonch-Osmolovskiy, 2010).

7.8 Environmental change vs migration

A significant result of this study is that environmental drivers could be a primary reason for migration due to river bank erosion. Local displacement due to river bank erosion or tropical cyclone had a direct effect on migration. There was a statistically significant ($p<0.001$) relationship between environmental change and migration, and the data provides sufficient evidence to conclude that migration is driven by environmental drivers (see the method in the section 3.7). Table 7.6 shows the distinction between migration from low and highly environmental change impacted areas. It clearly has been identified that households with more experience of, or that more affected by environmental change have experienced more migration than those who are less or unaffected by environmental changes.

Table 7.6: Distinction between migration from low and highly environmental change impacted areas

Sub-district	Migration from low environmentally impacted areas	Migration from highly environmentally impacted areas
Shyamnagar (N=27)	14%	33%
Tala (N=65)	3%	3%
Sharankhola (N=43)	7%	23%
Mehendiganj (N=47)	2%	64%
Total (N=182)	5%	28%

In addition, this study clearly observed and calculated from the satellite images that the study area has been eroded over time, which has led to a displaced population. Although I conducted interviews in this area in 2011, I have frequently communicated with some of the respondents in all of the rural survey areas (e.g 2012, 2013, 2014 and even 2015). This has helped me to analyse that environmental change has a continued effect on migration. The population displacement from Mehendiganj continues, as river bank erosion has occurred almost every year. Fakir-bari (Figures. 7.2, 7.3 and 7.5) did not exist anymore in 2014, meaning that more than 17 poor households have become displaced households within 0.2 km (see chapter 9, figure 9.2) and were forced again to move. Tala and Sharankhola have not faced any environmental events since my survey. The situation is very different in Gabura *union*, Shyamnagar, where people are still facing problems as salinity is increasing. The increases of salinity threaten their livelihoods. Thus migration continues from this sub-district, particularly seasonal migration. On, 23 Feb 2015, while I am writing this section, Shyamnagar faces river erosion and some households have been locally displaced. Moreover, during the third week of March in 2015, 200 feet area of embankment broke leading to water entering this sub-district. The water level rose up to the plinth of houses. Although people have not moved, their livelihoods have been affected.

7.9 Conclusion

I have seen that migration or displacement is one of the coping mechanisms vulnerable people have to deal with environmental stress. Slow-onset disasters lead to permanent migration (Boano et al., 2008) and sudden events lead to (at least) short-term displacement (Raleigh et al., 2008). My study has nevertheless, shown varying responses to sudden natural disaster. After the flash flood in 2011, even though a large number of people were displaced temporarily, after three months most had returned to their home. In contrast, following tropical cyclone Aila, people of the Shyamnagar district were displaced temporarily to the local embankment, building temporary make-shift tents. Many people could not go back to their house, and a significant proportion of these moved to cities such as Khulna and Dhaka. In the case of tropical cyclone Sidr, people from Sharankhola were mostly displaced to a cyclone centre or other safe places. However, in the aftermath of the cyclone, many extremely poor people built new houses with the help of NGOs.

The VI compared the various regions' vulnerability to adaptive capacity, sensitivity and exposure and differential vulnerability. From the comparison of the four rural sub-districts, my research found Shyamnagar is the most exposed to environmental change, highly sensitive and having less adaptive capacity. Comparatively, Mehendiganj and Sharankhola are less sensitive than Shyamnagar but more than Tala.The results suggest that both permanent and non-permanent migration processes have a close relation to vulnerability and non-permanent migration has a close link to adaptive capacity. The study found that the sub districts of Shyamnagar and Mehendiganj may be more vulnerable in terms of sensitivity and exposure and less adaptive capacity, whilst Mehendiganj is more vulnerable in terms of exposure to hazards than other sub-districts. These two vulnerable regions also have shown higher number of migrants, from Mehendiganj as permanent migration whilst from Shyamnagar as non-permanent migration. There are some migrations from Sharankhola but very few migrants households were found in Tala.

In the next chapter I will explore the fate of migrants further, firstly to the local centres of Khulna and Barisal, and then to the larger cities further afield – Dhaka and Comilla.

Chapter 8

A study of migrants to urban areas from Bangladesh's rural delta

8.1 Introduction

All migration entails a relation or a two-way dynamic between those who migrate and the societies/communities that receive them. Therefore, in this thesis it was necessary to engage not just with potential migrants from environmentally-threatened coastal areas (chapter 7), but also with their potential hosts and those former rural inhabitants who had already migrated. This chapter is divided into two interview studies related to the geographic proximity of the urban centre to the migrants' origin: firstly, I studied two divisional headquarters in the delta, Khulna and Barisal; and secondly investigated migration to two urban districts in the central region of the country, the megacity Dhaka, and Comilla. This chapter will focus on the vulnerability of the migrants and the impact of societal crises on existing urban population. Vulnerability will also be compared between Dhaka and Comilla city.

8.2 Short distance migration to divisional headquarters in the delta

As I demonstrated in chapter 7, the two coastal divisions of Barisal and Khulna, are already experiencing climate change-induced migration. Khulna city and Barisal are two important potential places where people from the coastal regions could migrate to in the initial stage of displacement. The precarious situation of the coastal rural communities affected by natural disasters has resulted in increased migration to urban centres, with long-term implications for the displaced families (UN, 2010). After tropical cyclone Aila, 100,000 people migrated to Khulna city but it is not known how many people subsequently returned to their homes. Nevertheless, despite the various factors leading to migration to Khulna from the surrounding Division, by the 2011 census the population had decreased to 60,444, compared to a population in 2001 of 237,897. While there have been quality issues within the shrimp processing industry (SAFE, 2012), and the March timing of the census coincided with the arrival of seasonal and temporary workers, it is likely that onward migration to the central area of the country has become important in recent years. The impact of this will be demonstrated later in this chapter. Firstly however, this chapter will give a view of the immigrants' situation in Khulna as seen through the interviews that were conducted.

Figure 8.1: Interviewing Nayeb (a hotel boy or waiter) in a restaurant in Khulna city (Interview, November 2011)

One lower class respondent named Nayeb aged 28 (Figure 8.1), moved to Khulna city from Shyamnagar, Satkhira (see figure 5.1 for location), and is now working as a waiter in a restaurant. He stated, "after tropical cyclone Aila, our land was waterlogged by saline water for two years. Due to this saline water, our land is not suitable for growing crops and vegetable plants. If we could grow vegetable plants over the whole year, my family would survive. Thus, I migrated here but my family is still in Shyamnagar. Now I am supporting my family through this job in Khulna. The spread of saline water [back home] is increasing, agricultural production of this region is still going down, with the effect that the local people are becoming poorer. [however,] there are lots of people who migrated that do not have anything to do, [yet] they cannot return to their former state. In spite having lots of problems they would like to stay here." Thus, as a coping mechanism, some people seasonally and temporarily migrate to Dhaka, Khulna or Barisal to become either shrimp processing factory-workers, labourers or rickshaw pullers.

Despite the population changes mentioned above, the perception amongst Khulna inhabitants is that people from south-western Bangladesh do not like to move to Dhaka, due to job competition and the cost of living being much higher. Another, middle class, respondent said "house rents in Dhaka and Chittagong are much higher than in Khulna. My family can stay in a one room house very cheaply in Khulna, whereas my relative, who lives in Chittagong, pays double what I do in rent. Thus, if I need to move I will move to Jessore or Satkhira [within the division], or I will stay in Khulna as the opportunities [in such places] are much more than in other cities and the travel costs and house rents are less”. It was also found that richer people were not keen on moving to Dhaka or Chittagong as they had found Khulna an attractive place to live. Moreover, they feel Dhaka is crowded, noisy and polluted and not comfortable for living. Anwarul Huq (non-poor), a local respondent said that “I would not like to move to Dhaka, as Dhaka is overcrowded and expensive. The rent of a two bedroom flat in Khulna [city] is 4000-6000 BDT [£37 to £50] per month, whereas in Dhaka it is [£100 to £400].’’ Land prices are also less in Khulna city than in Dhaka and Comilla. For example, he stated that the price of one *katha* [720 ft^2] is 20-30 lack BDT, which is five times less than in Comilla city. There are job opportunities in Khulna city in both the formal and informal sectors. Due to the job opportunities the city has fewer beggars than other cities; in addition the number of beggars is decreasing according to some respondents, though the slums have increased in size.

Barisal division is under threat from cyclones, coastal erosion, flooding, and river bank erosion. Of these threats river bank erosion is currently the most serious. In Barisal eleven people were interviewed (Table 3.2). Of these, three individuals migrated from Mehendiganj *upazila* to Barisal city. Five respondents migrated from Patuakhali district and 3 from Barguna, both of which are vulnerable to cyclone flooding and sea level rise. All of the respondents bar one experienced the impact of cyclones or river bank erosion. Thirty percent of the respondents live in Barisal as temporary migrants.

Though the population of Barisal division and Barisal district as a whole are decreasing, it is increasing in Barisal city. According to the 2011 census the population of Barisal district is 2.32 million, compared to 2.35 million in 2001. However, the population in Barisal city was 190,000 in 2001, and had grown to 320,000 by 2011. This decline in the district’s population, but increase in the city’s population is likely to be due to migration caused by river bank erosion. Evidence for this is demonstrated in the previous chapter. Note that there is a distinct difference between the long-term impacts of cyclones compared to river bank erosion: victims of river bank erosion are forced to move and they cannot return, but after cyclone affected people are able to return if they have sufficient resources.

Migration to Barisal caused by river bank erosion is not new. However, this study has revealed that this problem has increased during recent decades. One upper class migrant respondent said, “my grandfather moved to Barisal city in 1949 due to river bank erosion in Hizla *upazila*, Barisal. Now people are migrating from Mehendiganj. Some people have had this problem four or five times. If anybody faces this type of problem so often, they definitely will have lost everything. If your house is burnt down something will be left, but if you face river bank erosion nothing will remain. If you go to Mehendiganj you will see people’s social status is going down due to river bank erosion, and they are moving to Barisal, Dhaka and Chittagong. Due to such migration the slums are increasing in Barisal city.” Those from higher social classes and those who are richer also tend to buy land in Barisal and Dhaka in case they are displaced. This tends to cause house prices to rise. Jibon Chowdhury said, “monthly rent for a one bedroom house is currently 6500 BDT (£50) and the land price in the central part of the city is 2 to 2.5 million BDT *khata* (720 ft^2, £17-20,000) on average in Barisal city”. However, this is much less than in Dhaka or Comilla; the rent for the same house in Dhaka and Comilla is double that in Barisal, whereas the land price in Dhaka is ten times more, and Comilla six times more, than in Barisal.

A large number of people also move as seasonal migrants or temporary migrants when agriculture activities are not available at home, or their *char* land is temporarily flooded during the wet season between June and August. However, Barisal is not an industrial area. People who are forced to migrate to Barisal work as day labourers or rickshaw pullers, or other informal sector jobs. If they are unable to get a job, they may move on to Dhaka or Chittagong as a second potential migrant destination to find employment. For example, women are going to Dhaka to work in the garments sector. Monir Hossain said, “lower and middle class people from Barisal division are moving to Dhaka, Savar, Gajipur and Narayanganj (in the centre of Bangladesh) as garment workers. That’s why it is hard to get a maid servant in Barisal.” It is notable that people from Barisal tend to be well educated, thus people from the middle and upper class of Barisal obtain respectable jobs when they migrate to the larger cities. In contrast, people from lower classes have to take jobs such as building workers, garment workers, industry workers or other informal sector work in Dhaka, Saver, Gajipur, Naryanganj or Chittagong. As large numbers of people from Barisal have already migrated to the central part of the country this can promote further migration because of family connections. Kabir a lower class respondent said, “ I migrated from Amtali *upazila*, Barguna district to Barisal city two months ago to get a job. Amtali is very vulnerable to cyclones, coastal erosion and salinity intrusion. I got a job on a steamers as a general assistant. I do not intend to stay permanently in Barisal. My family is in Amtali. However, if I and my relatives experience problems in Amtali due to sea level rise we might move to Dhaka as I have relatives there” (Interview, November).

8.3 Long distance migration to the central region of the country

The current study has shown that every day, on average, 1300 people move to Dhaka. This calculation was based on census data from 2001 and 2011 and the difference has been converted to a daily rate (However, birth rate and death rate has not been counted). Forty percent of the urban population of Bangladesh live in Dhaka (Walsham, 2010). This study found most of the poor migrants coming to the city (Dhaka and Comilla) are from the Northwest region, particularly Rangpur, Dinajpur, Kurigram, Lalmonirhat, Gaibandha and Nilphamari (Figure 8.2). Some of them moved on a temporary or seasonal basis, but this led many to eventually settle in these cities. They came due to seasonal famine, river bank erosion, flood and drought (Figure 8.2). Due to river bank erosion, a vast number of people from the districts in the centre of the country such as Jamalpur, Sherpur, Sirajganj (Jamuna river), Shariatpur (Padma-Meghna) and Barisal (Lower Meghna) moved to Dhaka (figure 7.4).The study also found that due to tropical cyclone Aila many people moved to Khulna, Dhaka and Chittagong city from the south-west region of the country (Figure 8.2).

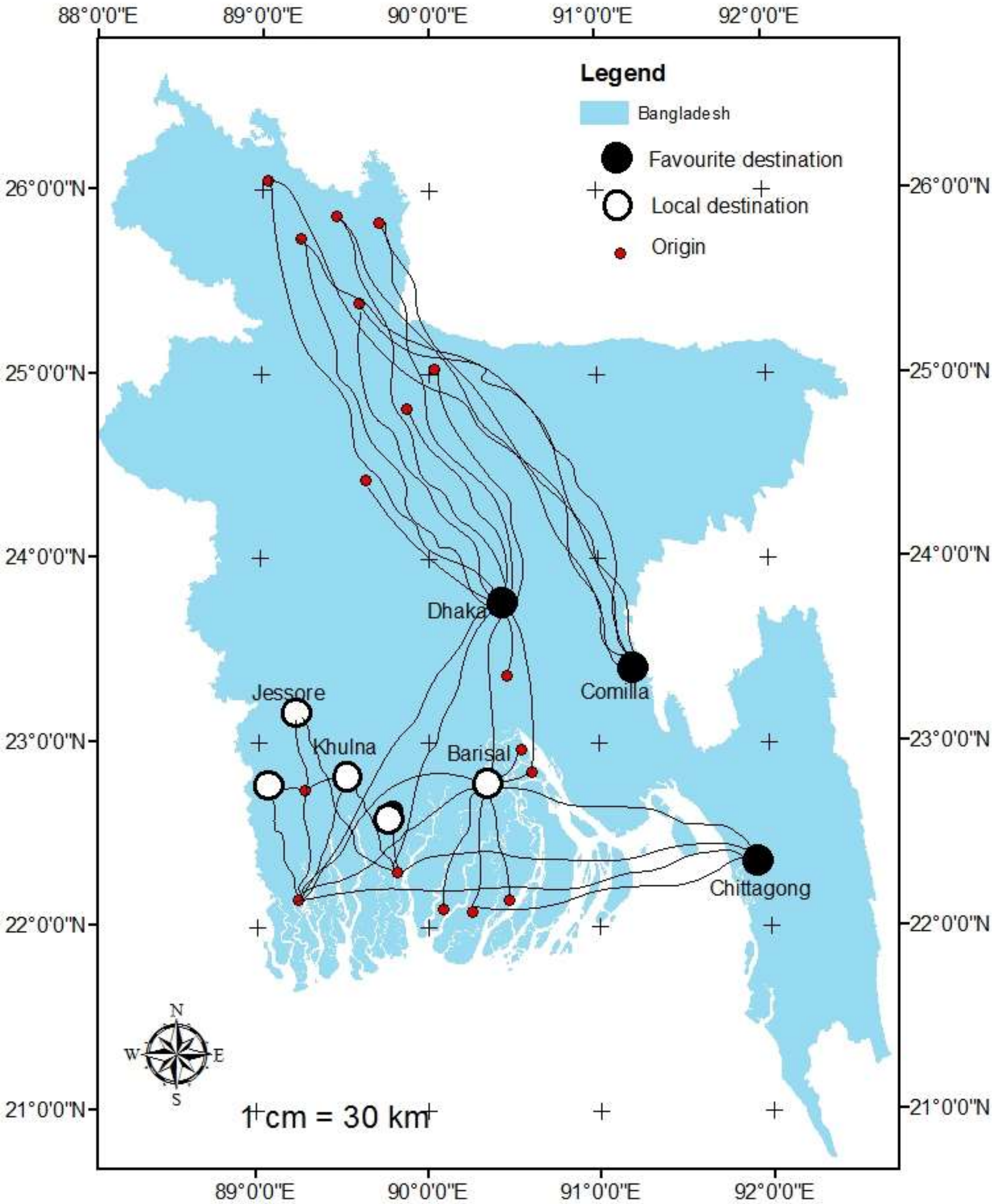

Figure 8.2: Local and favourite destinations of migrants (map has been made from interview and questionnaire survey result in 2011 and 2010)

Of the 13 migrant rickshaw pullers interviewed in Dhaka, 65% came from Rangpur, Kurigram, Jamalpur, Sherpur and Shariatpur (non-coastal areas), mostly as a result of river bank erosion and poverty, while 35% came from Shatkhira, Khulna and other coastal areas. Many of them moved because of the impact of tropical cyclone Aila, coastal flooding and coastal erosion (see the appendix 11[a and b]). Most of the 40 migrant housemaids who were interviewed in both new and old slums came from

Jamalpur, Sherpur and Shariatpur because of river bank erosion. However, 20% of these individuals came from coastal areas as a result of tropical cyclone Aila and Sidr. Thus, as well as migration due to riverbank erosion, a significant proportion of migrants moved to Dhaka after tropical cylone Aila and Sidr. Sirajul Islam (26), a rickshaw puller living in the slum at Madartek, said, "I moved to Dhaka from Shyamnagar Shatkhira (southwest region). Due to tropical cyclone Aila we lost our house and everything in it. The affected people did not receive enough relief at the time due to diversion of aid by local political or influential leaders, although the government sent enough aid initially. Due to tropical cyclone Aila, at least 20-25 people moved to the small slum where I live". Three upper class people who moved to Dhaka from Mehendiganj due to riverbank erosion were interviewed. They now work in a bank. One said, "most of the area of Mehendiganj *upazila* had already eroded by 2005. Due to this riverbank erosion, affected people moved further inland, built their house near the riverbank, or moved to Barisal or Dhaka. A huge number of lower and middle class people from this *upazila* moved to Shanir Akhra (the expanded eastern part of Dhaka)".Another upper class respondent, who had lost his house in 1985, said, "my family moved to Dhaka, and my uncle moved to Khulna permanently, after losing our house to river erosion. Most of the extremely poor people who lose their homes in this fashion move to slums in Dhaka, or build new houses on embankment areas in the affected region. Many of them moved to Dhaka and became garment workers, or building labourers."

Like in Dhaka, this study revealed that the seasonal or temporary migration to Comilla from famine-prone areas of the northwest of Bangladesh is considerable. Approximately 40% of the migrant respondents had moved to the city temporarily. The people of the north-west depend on agriculture for their livelihood. However, due to environmental changes, they can't grow crops like rice as before. So their agricultural production is no longer sufficient for them to survive. By the pre-monsoon, food is scarce and many choose to move to different cities in Bangladesh. Generally, they used to move as seasonal agriculture workers, but now they are becoming rickshaw pullers seasonally. These short-term migrations lead many to eventually settle in the city. In Comilla especially, economic activity and employment opportunities are increasing; poor migrants from north-western Bangladesh consider Comilla as the 'Dubai of Bangladesh' as a number of people said during their interviews. They choose Comilla as they can easily get employment in the informal sector.

A group of migrant rickshaw pullers from the northwest region said, “we are poor; we came to Comilla to earn some money. But we fear to drive rickshaws during political violence and strikes. We live on agriculture work. We all have very small landholdings and the money we get from agriculture [and the fertilizer from government] cannot support our families. Some of us have agricultural land that was engulfed by the Teesta River.”

8.4 Vulnerability of the urban poor migrant

“Global environmental change and sustainability science increasingly recognize the need to address the consequences of changes taking place in the structure and function of the biosphere. These changes raise questions such as: Who and what are vulnerable to the multiple environmental changes underway, and where”? (Turner et al., 2003: 8074). My research attempts to answers these questions.

Most of the poor migrants who often lose their land, home and livelihood due to environmental effects move to Dhaka to find a place to live and work (Scheffran, 2012). “New migrants who have not yet built up capital are likely to move to such areas due to being located on affordable and vacant land” (Adger et al., 2012: 13). Due to overpopulation, weak infrastructure and low livelihoods the residents of marginal settlements are highly vulnerable to the consequences of environmental events (Braun and Aßheuer, 2011; Hardoy and Pandiella, 2009). In addition, the slum dwellers in Dhaka face extreme poverty due to lower earnings, with the majority living below the poverty line in terms of both calorie intake and the cost of basic needs (Hossain, 2006). “Most of these households are financially insecure, with on uncertain hold what they have accumulated, and little prospect of improving their economic circumstances. They live with the constant fear that their residential rights or place of the shelter may suddenly be taken away by the authorities or private landlords” (Rashid, 2000: 242). Middle and upper class (non-poor) people can cope with moving to Dhaka, because of their economic power, whereas for people from lower classes, it is very difficult, as they will need food, shelter, jobs and other facilities immediately upon arrival. The poor migrants choose to stay in the slum because the cost of living is cheaper there. Due to a lack of housing space poor migrants are forced to settle on marginal land (Braun and Aßheuer, 2011).

8.4.1 Components of vulnerability of the urban poor in cities

Table 8.1 presents the five components of vulnerability that directly impact on poor households, in particular poor migrant households in cities. All these factors are related to socio-economic conditions (Braun and Aßheuer, 2011). Thus, different poor migrants have different adaptive capacity. Due to a weaker financial situation and being located in high risk areas, poor migrants face considerable difficulty in coping with external shocks such as extreme floods (Rashid, 2000; Wood, 1998). Exposure to flooding, physical vulnerability and livelihood are described in the next section. As shown in table 8.1, the poor migrants are more vulnerable than local poor or old migrants. I have considered an old migrant as a local who migrated at least two decades before. Poor migrants are more sensitive and have less adaptive capacity. It is thought that the poor are not able to pay for basic services (World Bank, 2011). The current study found that most slum-dwellers face financial difficulties, consistent with this view. Roughly 35% of their income was spent on rent and 65% spent on food. One participant commented, "I work as a house maid. My husband is a rickshaw-puller. He drives his rickshaw for only one shift a day as he is not physically strong enough to drive it two shifts. The money we both earn still makes it difficult to run the family, as food prices are very high, though we eat cheaper quality food." (Salma Akter, December 2010). Table 8.1 shows that 62% of the poor respondents (the extreme poor) face difficulty in buying food; while only 4% poor of (local or old migrant) respondents face difficulty in buying basic needs. None of the extreme poor migrants can save money. But some poor migrants who are seasonal and temporary migrants can save some money. This study found the average age of the group was 35 (Table 8.1). They rent rooms as a group and spend less on accommodation. Therefore, this group tends to have more adaptive capacity. The social component is strongly developed in slums in Dhaka (Braun and Aßheuer, 2011). Social support, social networks, social services and community-based organisations are determinants of adaptive capacity. Local or old migrants have a strong social network and more kinship ties than new migrants that increase their adaptive capacity. New and extremely poor migrants tend to stay in more risky areas (see later and table 8.1).

Table 8.1: Components of vulnerability for the urban poor in cites. Data sources: questionnaire surveys and interview data in 2010 in Dhaka; percentages for extreme poor, poor (migrant) and poor (local or old migrant) were calculated from the total number of poor respondents. The non-poor are also displayed here to demonstrate that they have more adaptive capacity than the poor

Component	Indicators	Poor				Non- poor	Adaptive capacity
		Extreme poor (migrant)	Poor (migrant)	Poor (local or old migrant)	Total	Local and migrant	
	Number of respondents	63% (61)	27% (26)	10% (10)	100% (97)	8	
Environmental	Exposure to flood and water logging	45% (44)	11% (11)	2% (2)	59% (57)	0% (0)	-
Demographic	Average age (year)	44	35	41	--	--	-
	Older respondents	10% (10)	2% (2)	1% (1)	13% (13)	--	-
	Female headed HH	5	0	1		0	-
Economic	Savings	0% (0)	17% (17)	4% (4)	22% (21)	75% (6)	+
	Average daily income	£2<	> £2	>£2		----	+

Component	Indicators	Poor				Non- poor	Adaptive capacity
		Extreme poor (migrant)	Poor (migrant)	Poor (local or old migrant)	Total	Local and migrant	
	Face difficulty buying basic needs	62% (61)	9% (9)	4% (4)	76% (74)	0% (0)	-
	Skilled	0% (0)	5% (5)	1% (1)	6% (6)	100% (8)	+
Social	Unhealthy/sickness	21% (20)	0% (0)	0% (0)	8% (8)	0% (0)	-
Physical	Vulnerable houses	Most vulnerable	Vulnerable	Vulnerable	---	Not vulnerable	-
	Access to water	0% (0)	2% (2)	8% (8)	10% (10)	100% (8)	+
	Access to electricity	9% (9)	25% (24)	10% (10)	34% (33)	100% (8)	+
	Access to gas	0% (0)	2% (2)	8% (8)	10% (10)	100% (8)	+
	Toilet facility	9% (9)	25% (24)	8% (8)	43% (42)	100% (8)	+

HH = Household

8.4.2 Livelihood of the poor migrants

Most of the poorer city dwellers are involved in low paid employment in an informal labour sector. Typically, such jobs include: rickshaw puller, house-maid, day labourer, van puller, construction worker, garment worker, factory worker, street vendor, small tea stall and grocery shop owner in the slums or in the road, and hawkers who buy recyclables and sell them on to factories. This study explored those jobs most commonly employing poor migrants, namely, rickshaw puller, house-maid, day labourer, van puller, construction worker, garments worker and beggar. The majority of the poor earn less than £2 a day (Table 8.1). Rickshaw pulling is the only occupation that is easy to enter into, as it doesn't require any formal training. Dhaka is known as the rickshaw capital of the world. My interviews showed that all 13 rickshaw pullers who were interviewed had migrated.

Due to their low incomes, often more than one person works in a household. Most of the interviewed house-maids' husbands engaged in low earning job such as rickshaw puller, construction worker or day labourer. Moreover, the husbands' jobs tended to be insecure. Mostafizur Rahman said, "I am a construction worker. I earn 300 BDT [£2.5] per day but I have a job only 15 to 20 days a month. Thus, my wife work as a house-maid and my daughter works in the garment industry to support the family." Those who do not get a job become street beggars. Twenty seven beggars were interviewed. Some of them were aged, and almost two-thirds of them were found to have physical disabilities (Table 8.1). The lack of a health service, poor and insufficient food, and living in a polluted environment can lead to them suffering from a range of diseases. As a result they cannot compete for a job. Even labour contractors do not employ them casually. One upper/middle class respondent from Goran said, "street beggars have increased as the slums on the street have increased." Nevertheless, in spite of having lots of problems, many migrant people are happy to live in Dhaka. One beggar said, "we lost everything due to riverbank erosion and moved to Dhaka; here at least I can get something by begging".

Figure 8.3: Livelihoods of poor people in Dhaka city. Interviewing a brick breaker (top), and plastics collector and Rickshaw-puller (bottom), in Khilgaon.

In Comilla, the most prominent jobs for such poor migrants were rickshaw puller, construction worker, day labourer and factory worker. A total of 27 migrant people were interviewed in the study, 48% (13) were rickshaw-pullers, 22% (6) construction workers and day labourers, and 18% (5) factory workers. Only one non-migrant was found amongst the 14 rickshaw pullers interviewed. Most (80%) of the migrants came from the northwest region because of seasonal famine or river bank erosion. One respondent said, “most rickshaw pullers come from north Bengal [Northwest region]. I have checked and the travel cost by rickshaw is the highest in this city compared to other cities. There are 80 thousand rickshaw pullers in this city. And roughly I can say that only 20% of [these] are local”.

While there are good opportunities for jobs in the informal sector for the less well-off, the addition of the pool of migrant workers has led to wage suppression. One local said, “if they [migrants] didn’t come locals would get a good salary like 500 BDT

(£4.20) per day. However, [migrants] work for 300 BDT (£2.50) per day now, which is not sufficient to [support a family]. Thus, poorer local people feel that they are not benefitting from the migration because their salary has decreased". One upper class respondent said, "most lower class migrant people moved to Comilla from the Northwest region especially Rangpur, Dinajpur, Kurigram. Some of them moved on a temporary basis. They came as seasonal workers in the agriculture sector. Another group were permanent migrants. To begin with, they started to work as rickshaw pullers, and then they changed their profession to another sector like building workers. It is very hard to find any local people who are employed as building workers now. Before, local lower class people used to work in labourer jobs and demanded more money. However, now employment opportunities are increasing in this city. That's why beggars have decreased. In the past, there was a big queue of beggars at my house especially on Friday [holiday], but now I do not see that."

As the city is expanding, high rise building is increasing and the number of real estate companies is increasing, leading to an increase in construction-related jobs. This theme of increased job opportunities was a recurring one in the interviews. One businessman said, "migrant people help us a lot. Before, it was hard to find a worker. Now it is very easy. Contractors are benefitted by people moving to this city. Before, local building workers used to charge 115 BDT to 120 BDT per square feet. But migrants do the same work for 105 BDT. Moreover they are very hard workers. A local building worker does not wish to work after 5 or 6 pm but migrant workers will work until 8 or 9 pm. In addition, [I know a] contractor who hired building workers [direct] from North Bengal and made one big temporary house for them where 20 to 50 people can live".

8.4.3 Vulnerability of the slum-dweller based on location and settlement pattern

Vulnerability to climate risk for the urban poor is in large part due to their location in slums and informal settlement, often where migrants first move (Adger et al., 2012). The challenge of accessing safe and reliable drinking water, proper sanitation facilities, and transport services to commute to and from work, health and education services can be enormous for slum-dwellers (World Bank, 2011). Thus, the present research revealed four different types of slum on the basis of size, social services, shelter availability and exposure to flooding. Of the respondents, 23% lived in the most desperate circumstances. This group mainly used polythene to make shelters beside the road (Figure 8.4). They had few belongings, and simply slept on the pavement. This group is at high risk from flooding and water logging. One respondent said, “we suffer extremely from flooding by rainwater during the rainy season; it is cold in winter and extremely hot on a hot day.” They do not have water, electricity, gas, toilets, health care or any facilities. They have to collect their water or sometimes they need to buy water. One responder said, “we use lamp post light to see at night.”

Figure 8.4: A slum on the road side in Banani

Another type of slum consists of *jupri* (32% of the poor respondents were found in this category). A *jupri* is a very small and temporary house, typically four feet by three feet, by four feet height (120x90x120 cm). They are mainly built with low quality material such as bamboo or polythene on vacant government land, beside roads, railway lines or banks of canals or lakes. As with the poorest slum dwellers, they also do not have any facilities or social services. One responder said, “we ask for water from rich families. If they are prepared to give us water we collect it, otherwise we come back without water.”

The third type of slum could be called an established slum, where migrants rent houses. These houses are slightly better quality than *jupri*, but this type of slum is very crowded (Figure 8.5). Due to the lack of land many slum-dwellers build suspended houses along the edge of canals, lakes or rivers. Of the poor responders, 35% were found in this category. This type of slum does have access to electricity, but not gas or water, although many houses obtain electricity and water through illegal connections.

They cook food using straw. Their toilet facilities are very rudimentary, and many people share a toilet. Whole families live in one tiny room, so there is no privacy.

Figure 8.5: Wapda Banani lake slum - an established slum

In one of these slums, Korail, the land is owned by PWD, BTCL, the Science and Information Communication Technology Ministry, and Gulshan thana. The population density of this slum is ~ 130000 [0.13 million] km^{-2}, and growing. Though these slums are unplanned, unstructured, unregulated and informal, many big slums have a social structure inside them. For instance, Korail contained ten mosques, two schools and a small market containing small shops such as tea stalls, grocery shops, barber shops, a small pharmacy, a firewood shop, a jewellery shop, shoe shops, fresh food shops, and even a restaurant. Assaduzzaman, chief Executive Engineer of DCC, said, “whatever they need in daily life, they have everything inside the slum.” Many slum-dwellers in this type of slum are provided with social services and utilities. NGOs provide toilets, health services and educational facilities. However, the slum community is always in fear of the government demolishing their houses, as these are often illegal.

Those slums that lie at the edge of rivers, canals or other low-lying places have problems with water logging and flooding in the rainy season due to poor sewage drainage. This is consistent with the findings of Jabeen et al. (2010). Though they are at risk of flooding, they are never given advanced warning of floods. These types of slums also have a significant fire risk as the congested housing made of wood or bamboo burns easily.

There is another kind of slum which is small and usually contains between 10 and 50 households. This type of slum is privately owned, and mostly situated in middle class areas. Occupants are financially better off than other slum-dwellers. They have electricity, gas, water and toilet facilities, but share most of these with other residents. These type of settlements are not at risk of flooding unless a big flood like that of 1998 occurs. Nasrin Akhter, a garment worker in Malibagh Chowdhury-Para, said,

"After tropical cyclone Sidr [5 years ago], I came from Awalipur, Patuakhali with my family to Dhaka. We have seven family members and rent two very small rooms. We pay 1500 BDT [£12.5] (2010 prices) per month. The space is not sufficient for our big family. Eighteen families in all live in this slum. We get electricity, gas, and water and toilet facilities. But we have to share the four toilets, one tube-well for drinking water, and an oven for cooking with these 18 households [100 people]. Sometimes, we have to stand in a long queue to collect water, which is sometimes not clean. Thus, we always boil the water. Sometimes water is not available when the pump does not work and we have to collect water from elsewhere. My mother then collects the water and it takes her 1 hour. Sharing this gas, water and toilet sometimes create aggressive behave between us."

8.4.4 Sensitivity of the poor migrant to flood and water logging

Slum-dwellers are increasingly exposed to the impact of flooding (World Bank, 2011). The current study has shown three types of slum dweller are the most vulnerable to flooding, due to the location of their settlement. Moreover inhabitants of these marginal settlements do not have sufficient drainage to avoid water logging. The World Bank (2011) claims only 10% of slum-dwellers in Dhaka have sufficient drainage to avoid water logging. Table 8.1 shows that 45% of the total poor respondents, who are mostly extremely poor migrants, stay in a high risk area. The study also found local or old migrants stay in less affected areas than poor migrants (Table 8.1). The findings of Braun and Aßheuer (2011) found that during a period of flooding many households suffered extreme hardship because they had no savings or food storage facilities. During a period of flooding, many slum dwellers are forced to move. Evidence suggests that some affected households move because they fear being bitten by snakes or rats; many are scared that their babies could fall and drown in the water or someone might be electrocuted because of the loose electrical lines littering the area (Ahmed, 1999; Rashid, 2000). Many households, however, do not move; they tend to survive floods by raising their *chowkis* (beds) and stoves with bricks and bamboo in an attempt to remain (Rashid, 2000). Many poor are unable to continue work due to not being able to reach their workplaces because of flooded roads (Braun and Aßheuer, 2011). Many poor are left unemployed for two or three months (Rashid, 2000). Moreover, during a period of flooding, all types of rotting garbage and human excreta mix with floodwater leading to water-borne diseases, such as cholera, diarrhoea, typhoid and skin disease, or mosquito vector diseases like dengue. Thus slum-dwellers are susceptible to water-borne diseases and are not able to obtain proper treatment due to their financial situations (World Bank, 2011).

8.5 Impact of migration on existing urban populations

Although I have described the vulnerability of poor migrants, this section considers the overall impact of environmental change on the urban population (poor and non-poor). I have also seen that the magnitude of the migration to urban centres from rural areas is significant. In section 8.4, I examined aspects of the lives of these migrants, but their presence will have impacts on the existing residents. I will now examine some of the both negative and positive impacts of migration on the social life of the city dweller.

8.5.1 Public utilities

Current research reveal that a key negative impact that migration has on Dhaka is the stress it adds to public utility services, such as supplying electricity, gas, and drinking water. Many respondents claimed that due to increase of population in Dhaka demand for public utilities is increasing. Exacerbating this, residential, commercial and industrial buildings are increasing while the supplies of electricity, water and gas to the city are not. For example, the electricity demand is 750-800 MW but the electricity supply department can only supply 700MW (RJUK, 2013). Thus, 50-100 MW has to be covered by load shedding in the different areas of Dhaka (RAJUK, 2013). The water demand of the city is 2.25 million cubic metres per day whereas Dhaka Water supply And Sewerage Authority (DWASA) is able to supply only 2.111 million cubic metres per day (Khan, 2013). This daily deficit is expected to rise to 2.451 million cubic metres per day by 2050 (Uddin, and Baten, 2011). Currently, 87% of the water supplied is from ground water sources, using 605 deep tube wells (Khan, 2013). Due to electricity load shedding the deficit in the water supply is made worse, as very few of the pumps are run by independent generators. Most respondents stated that in the hot season (pre-monsoon season) these services are the most stretched, as the demand for electricity is very high due to hot temperatures and greater use of air-conditioners, electric fans and fridges. Moreover, over this period the water level reduces to its lowest level in the annual cycle, due to increased evaporation and less rainfall. Respondents reported that the authorities are not able to meet the utility demands of people, leading to demonstrations and aggressive behaviour. 60% of respondents that claimed that they had participated in protests or observed demonstrations over the shortage of drinking water (Table 8.2). It is common for protesters to get wounded in clashes when police try to break them up. Hasan a middle class respondent said, "due to over population in Dhaka, demand of water, electricity and gas are increasing in Dhaka. City dweller faces huge load shedding every day at least three hours a day. In hot and dry season when temperature goes higher, suffering of load shedding increase even more. This makes everyday life worst. During this season demand for water also increase. This led many city dwellers to protest in the street. I have seen this on TV many times."

There are other consequences arising from the high demand for drinking water. DWASA is increasing the extraction of ground water and this is leading to a decrease in the local aquifer. Recently, the water level has been lowering, on average, by 2 metres per year (Shamsudduha et al., 2009). Monsoon season rainfall plays a vital role in recharging these aquifers. However, monsoon rainfall in the middle regions of the country is decreasing at a statistically significant rate of 4.07 mm/year (chapter 5, section 5.2.2, table 5.2). So, with population increasing and rainfall decreasing, the ratio of total extraction to recharge will decrease even further.

8.5.2 Traffic congestion

Another problem exposed by the interviews was the increase in traffic in the city. Traffic jams are common in Dhaka and these are made worse by occupation of the road and footpaths by street vendors, illegal parking, and numerous rickshaws. According to BRTA (2013), there are already 745,953 registered motor vehicles in the city. Moreover, due to migration the number of rickshaws is also increasing. A high number of rickshaws occupy the city's roads. Moreover, rickshaws are slow, so they block roads and create congestion (Mahboob and Elvira, 2012). Due to traffic congestion a kilometre ride in an auto-rickshaw can take more time than before. Mr Hanif (36) from Goran, Khilgaon said, "ten years (2002) back, it took 35 minutes to go to the university of Dhaka by rickshaw and the fare was 18 BDT (£0.15) whereas, due to traffic jams, now it takes more than one hour and the rickshaw fare has increased to 90 BDT (£0.80), nearly a six fold increase. I feel very uncomfortable spending time in the traffic, especially on a hot day." (Interview, October 2010). Due to overpopulation public transportation is not sufficient in the city, thus people often compete against each other to get on the bus (Figure 8.6). This can lead to aggressive behaviour between the passengers and bus driver, or even between passengers. Aggressive behaviour can also occur between drivers of the different types of vehicles that have to compete for the tiny amount of space available. Bilal Hossain (40), an auto rickshaw driver, said, "10 years back, when I was younger, I was aggressive. If anybody pushed my vehicle, immediately I used to say something but now I can tolerate this problem as it is common."

Figure 8.6: Heavy traffic and a crowded bus, with passengers standing in the door and inside

From the perspective of the local upper and middle classes the interviews found that there was only one real disadvantage of the increased migration to Comilla, namely the increase in traffic jams. This is in part because of the lack of investment in infrastructure to cope with the increased population; roads are very narrow and there are relatively few in the city. Due to the increase in population the number of vehicles are increasing, especially rickshaws and auto rickshaws.

8.5.3 Land prices

Dhaka is a city surrounded by a network of channels and four rivers. These physical features control the physical expansion of the city. Thus, the number of high-rise buildings is increasing and open spaces are being lost. One respondent Jamil said, “people have money, but there is no land to buy. The price of 1 *katha* (1 *katha* = 720 square feet) in Gulshan (a diplomatic area in Dhaka) is worth the equivalent of 1 acre in France” (Interview, November, 2010). Though this statement is not literally true, it expresses the popular impression of the increasing value of land in Dhaka. The prices of land and flats are also increasing; the price of a two bedroom flat was 20 lakh BDT (2 million) 10 years ago, now (2010) it is 60 *lakh* BDT (6 million BDT) in the Khilgaon area. Due to the rapid population increase, monthly house rents are also increasing all over Dhaka. 10 years ago, in the Khilgaon or Goran areas (which are middle class regions) a 1 bedroom flat cost 3500 BDT per month to rent but now (2010) the rent is 3 times higher, that is, more than 10000 BDT. So landlords are benefitting as most people (both migrant and resident) live in rented premises.

Comilla is not as watery a city as Dhaka, but the agricultural land that is mixed with the urban environment is being infilled due to population pressure. Due to competition land prices and house rents are increasing. However, the prices are much higher than those found in Khulna and Barisal City. One respondent said, "to rent a two bedroom flat (800 square feet) costs 8000 BDT [£75] a month in the centre of the city (as of 2010), but ten years ago the price was only 5000 BDT [£40]".

8.5.4 Disappearing canals

"Historically, Dhaka had an excellent drainage system comprising intricate river networks with numerous *khal*s (ephemeral water bodies) and canals that used to drain from its upper reaches during monsoon"(Ashraf, 2013: 76). It is clear to see the constricting effect of the canals and rivers within and around Dhaka, but they play a positive role as well, as they serve as a natural drainage outlet. However, these canals are a threat as they are progressively being filled, leading to water logging and the spread of disease. At least 17 *khals* have disappeared out of 40 (Dewan, 2013). In 1978 rivers, canals and wetlands occupied 52% of the Dhaka Metropolitan area, but by 2009 this had reduced to 21% (Habiba et al., 2011). An important canal is the Begun Bari canal. This canal serves as the natural drainage outlet of many important areas of Dhaka such as Gulshan (a diplomatic area) and the Tajgaon Industrial Area. This canal is connected with the Balu River. But the canal is at threat as this river is being filled in, and plots owned by one of the largest real estate companies in the country are rising there. One participant commented, "Balu *nodi* (Balu River) was once very big but now it looks like a small drain, as it is being filled up. Some real estate companies are also involved in infilling canals and other rivers to make more profit." (Raju, November 2010) Due to the rising price of land and rapid migration occupation of the canal and *khas jomi* (Government-owned land) is increasing. Thus, land-related conflicts are increasing.

8.6 Vulnerability and exposure and adaptive capacity of migrants in Dhaka city and Comilla

Tables 8.2 and 8.3 summarise the characteristics of Dhaka and Comilla, based on demographic, social, political and environmental factors. Figure 8.7 compares the vulnerability of these two cities. Similar contributing factors (adaptive capacity, sensitivity and exposure) of four rural areas (chapter 7, section 7.7) but different indicators have been applied to measure vulnerability. It has been found that the most vulnerable city for migrant workers is Dhaka.

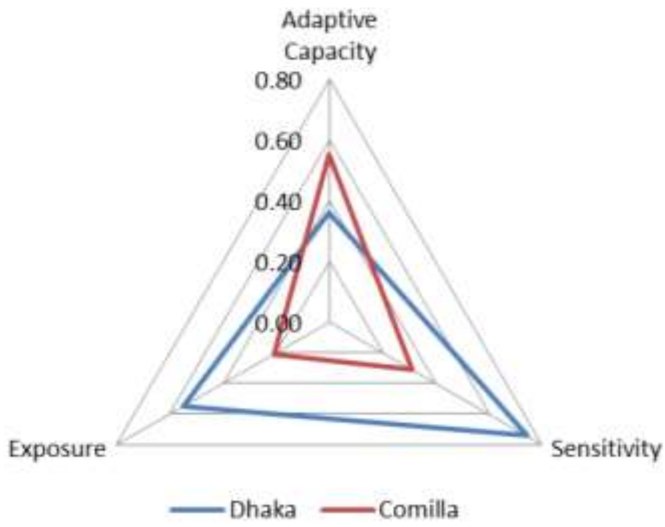

Figure 8.7: Vulnerability diagram for Dhaka and Comilla. The scale of the diagram ranges from 0 (less vulnerable) at the centre of the web, increasing to 0.8 (more vulnerable) at the outside edge in 0.1 unit increments.

The result shows Dhaka (0.55) is much more exposed to the impact of environmental change than Comilla (0.21). During the monsoon flood and water logging is very common in Dhaka, particularly for slum dwellers (Braun and Aßheuer, 2011). Dhaka has suffered nine floods in the last 55 years (Jabeen et al., 2010). These were in 1954, 1955, 1970, 1974, 1980, 1987, 1988, 1998 and 2004 (Alam and Rabbani, 2007). Among those, the floods in 1988, 1998 and 2004 were the most severe and damaging due to excessive rainfall and surrounding rivers overflowing (Alam and Rabbani, 2007). The flood in 1998 was the longest period of flooding in the history of Dhaka (Faisal et al., 2003). The excessive rainfall also caused water logging. Due to drainage congestion and inadequate pumping facilities, underground drains were silted up, worsening the problem (Faisal et al., 2003; Jabeen et al., 2010). Many parts of Dhaka stayed inundated for several days (Jabeen et al., 2010). Braun and Aßheuer (2011) found, on average a major flood hits their study area in Dhaka every four years, forcing them to take shelter in public schools, relative's houses or on elevated street or embankments (Braun and Aßheuer, 2011). I myself was a victim of the 1998 flood. My house was flooded for more than two months. Water reached my house and rose to a level of more than 2 feet. My family had to take shelter at our friend's and relative's houses. We used a small boat for travelling. Though I was not in Dhaka in 1988, I saw on the news that small boats were used in very busy and commercial areas (Motejheel). In terms of environmental impacts Comilla is a much safer place. As I am from Comilla city I have not faced any flooding there and did not hear from elders that Comilla suffered from flooding problems in the past. Moreover, no respondents from Comilla acknowledged that they faced any water logging or flooding (Table 8.2 and 8.3). It is notable that the average elevation above sea level in Comilla is much higher than Dhaka (Table 8.2 and 8.3).

It is very much clear from my research that Dhaka has less adaptive capacity for migrant populations in terms of demographic, social and economic support than Comilla city (Figure 8.8). At the same time, in terms of demographic, social, political and physical aspects, Comilla city is much less sensitive than Dhaka (Figure 8.9).

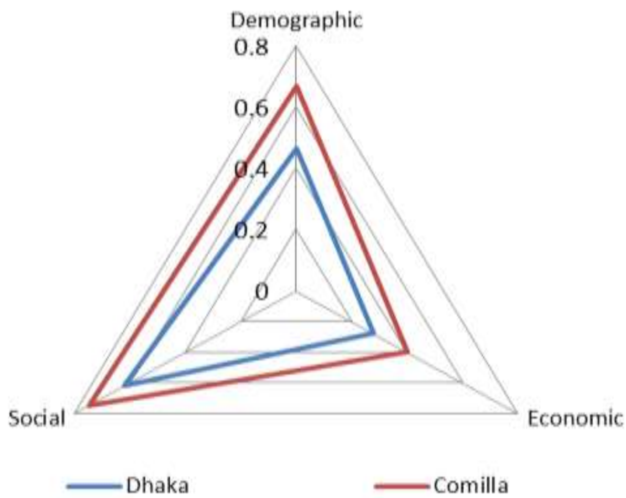

Figure 8.8: Adaptive capacity diagram for Dhaka and Comilla. The scale of the diagram ranges from 0 (less vulnerable) at the centre of the web, increasing to 0.8 (more vulnerable) at the outside edge in 0.1 unit increments.

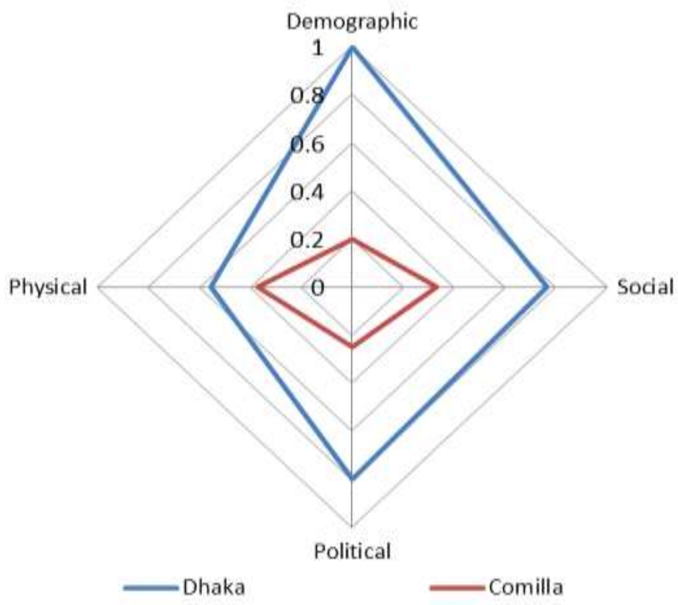

Figure 8.9: Sensitivity rectangular diagram for Dhaka and Comila The scale of the diagram ranges from 0 (less vulnerable) at the centre of the web, increasing to 1 (more vulnerable) at the outside edge in 0.1 unit increments.

Dhaka was also shown to very highly expose to natural disasters. In term of demographics, It was found that 100% of the interviewed migrants were aged between 15 and 60 in Comilla compared to 91% of Dhaka. This age group is more likely to be able to work hard and earn more money. The study also found that the highest levels of international migration in Bangladesh were from Comilla. In terms of economics, Dhaka showed higher daily wages (score 0.83) and skilled workers (score 0.05) compared to Comilla (score 0.67 and 0.03 respectively). Dhaka is a megacity and is seen by migrants as a city of opportunity. There are a high number of garments factories, industry, construction sites and other sectors which pull many skilled workers from all over the country. However, the job market in Dhaka is not increasing at the same rate as the population, so unemployment is increasing. Due to the pressure of migrants in the city, the price of food and other necessary commodities is going up. Unemployed people and poorer households find it very difficult to survive as the cost of living is relatively high (we have seen comparisons with other cities earlier in this chapter). For example, the monthly wage of a garment worker is less than US$26. Most of the garment factory workers in the Dhaka are not happy as they get lower wages than they need to survive. Therefore, the current study found that although migrant workers earn more money in Dhaka they do not save and send remittance (score 0.18) as much compared to Comilla (score 0.55).

In Comilla in particular, economic activity and employment opportunities are increasing; poor people from north-western Bangladesh consider Comilla to be the ‘Dubai of Bangladesh’, as a number of people said in their interviews. Despite the population increase, Comilla is seen as a city of opportunity because of its increasing employment opportunities. There is an EPZ, a large number of hospitals and private clinics, as well as a large number of shopping malls. There are also a large number of higher education institutes, including a public university, a public medical college, three private medical colleges, a teacher training college, a polytechnic institute and a cadet college. These opportunities also ultimately generate livelihoods for lower-class people, and so encourage migration, by increasing transportation, construction work, and small businesses.

On average poor migrants gained a job within four days of arrival (0.36) in Comilla compared to 19.5 days in Dhaka (0.04). In the survey it was found that migrant workers who had relatives and friends in the destinations they travelled to found jobs more easily than others. Comparatively, Comilla is not as well-known as Dhaka to many rural people. Thus, whoever migrates over long distances to Comilla uses social networks. Some migrant rickshaw-pullers found Comilla a better place than other cities. Some of them first moved to Dhaka, and then chose to move to Comilla. A rickshaw-puller, Salim said, “I first move to Dhaka. Within a couple days of arrival, I start rickshaw pulling. I do not feel good because Dhaka is big and has a high number of small and big roads. I do not know the roads very well. Once I forgot my address, [and] it took two days to find my home. Two nights I had to stay on the street. Then I decided to move to Comilla. I like Comilla as within a short time I was known about the city. It has less traffic jams than Dhaka. I even can save some money here.” Another respondent said, “I first moved to Dhaka and used to live in slum. The slum conditions were so dirty. The water was not safe for health. I feel unhealthy. Thus, I decided to move to Comilla. Comilla is better than Dhaka. The water is safe. I feel better now.”

Increases in the demand for water, electricity and gas, and increases in the price of food, house rent and other necessary basic needs, means that it is difficult to maintain the same quality of life for city-dwellers, especially for unemployed people and poorer households. The government of Bangladesh is unable to provide all the facilities needed by the city-dwellers due to its limited resources. Thus, demonstrations often occur in Dhaka, demanding water, electricity and an increase in wages. This can lead to violent conflict with the police. This study found that 70% (score 0.70) of the respondents in Dhaka reported or observed on television news this type of clash (Tables 8.2 and 8.3), while there were no similar demonstrations in Comilla.

Moreover, political conflict is common in Dhaka as it is the capital city of the country. There tends to be conflict as parties change power. This was demonstrated when there were clashes between the two major political parties in 1996, 2006 and 2013. When respondents were asked about the political crisis the majority in Dhaka commented that clashes are increasing (Table 8.2 and 8.3), while very few in Comilla found this.

Anti-social activities, especially drug and arms businesses, fighting and political clashes are common in slums in Dhaka. Poor and unemployed migrants can easily become involved with crime, such as burglary or murder; they can also be used by political leaders to cause unrest. One respondent said, "the drug businesses are controlled by the local politicians in power and with a change of ruling power this control will also be changed. This type of political leader has no ethical values; they could change their political party if the power change" (Alam, December, 2010). While I was interviewing in the Korail slum, I witnessed one of these clashes. Some rickshaw garage owners who are connected to a political party or local leaders force their rickshaw-pullers to attend processions, demonstrations, picketing or protests. They get some money from the garage owner in return, as he gets money from the local leader. One respondent said, "these types of problems are increasing in the capital. Moreover, unemployed people can be easily addicted to drugs that can lead to crime."

In contrast to the situation in Dhaka, the interviews showed that violence and conflict has decreased in the city of Comilla as employment opportunities have increased. One responder said, "crime has decreased in Comilla. Some 5-7 years ago, on any matter people became involved with conflict, even to the extent of murder as well. Crime has [now] decreased here because the availability of jobs has increased. The EPZ increased the job opportunities [even] more. The young generation is gaining jobs there". Another respondent stated "At this moment, I can say conflict is less here. Before, there was conflict of one village with another village, and one group with another group [This is now less.] But there are still conflicts over tenders for road and building construction. In this sort of conflict, intra-political and inter-political conflicts are involved". Nevertheless, one middle class respondent said that land conflict is increasing in Comilla as in Dhaka. Another upper class respondent said, "influential people are involved with land conflict. Powerful people occupy other's land and would like to be more powerful. They are so called 'land rovers'. I saw on TV that one real estate company illegally placed a signboard on another's land, to sell the land as [their own] plot. So these types of conflicts are increasing. People are becoming greedier for land as the price is increasing.'' However, this type of conflict is more likely to be between local people, not with migrants. One middle class respondent said, "migrant people would like to keep themselves away from any kind of conflict. They are simple and adaptable, hardworking and polite.'' In addition, some local people are also involved with drug-related crime, which is increasing according to some respondents. As Comilla is near the border with India various types of drugs can come from India illegally. So the number of addicts is increasing steadily. Apart from resource and political conflict, there are also land conflicts, which are increasing in both cities, but particularly in Dhaka (Table 8.2 and table 8.3).

While the vulnerable poor are moving to the cities, and the presence of slum-dwellers is leading to increased societal problems, they also play a significant role within the urban economy. Seventy percent of the workforce is employed in the informal sector, and the economy of Bangladesh's cities is highly dependent upon its poorer residents (Walsham, 2010). This study demonstrated that 78% of those interviewed are employed in the informal sector. Of these, 89% had migrated. In Comilla this figure was even higher with 86% engaged in the informal sector, of which 50% had migrated. Nevertheless, migration can also be useful in creating employment opportunities and reducing conflict, as was found in Comilla.

Table 8.2: All indictor values for Dhaka and Comilla cities

Dimension	Factor	Indicators	Dhaka	Comilla	Comments
Adaptive capacity	Demographic	Percentage of migrants aged between 15 and 60.	91%	100%	This was counted as the active population between 15 and 60.
		Percentage of migrant women employed in ready-made germents (RMG) sector.	1%	0%	This was counted for ready-made garments only. This figure is not a true count as garment workers were not available during the survey time (day time). However, I was able to talk to garment workers in Dhaka.
		Ranking of international migration (a).	3	1	This counted for the whole district rather than the city.
	Economic	Percentage of migrants who can save money for sending as remittance.	18%	55%	Most of the temporary and seaonal migrants tend to save money and send remittance to their familes.

Dimension	Factor	Indicators	Dhaka	Comilla	Comments
		Mean days taken to find job.	19.5 days	4 days	Calculation has been made only for poor migrants in 2010.
		Percentage of poor skilled migrants.	5%	3%	Calculation has been made only for poor migrants.
		Per days wages (BDT currency).	350	300	Calculation has been made only for poor migrants in 2010.
	Social	Percentage of migrants who moved using social networks.	95%	100%	Calculation has been made only for poor migrants.
		Percentage of migrants receiving social support	29%	50%	Calculation has been made only for poor migrants.
Sensitivity	Demographic	Population density (per	8229	1712	Considers the whole district.

Dimension	Factor	Indicators	Dhaka	Comilla	Comments
		square kilometer) (b).			
	Social	Participated in or observed demonstration for water demand.	60%	0%	The percentage of respondents that reported demonstrating or observed a demonstration. All non-poor people answered this but many poor people did not answer this question.
		Demand for wages increse (RMG sector).	70%	0%	The percentage of respondents that reported or observed a demonostration. Allall non-poor people answered this but many poor people did not answer this question).
		Percentage of people reported land conflict is incresaing.	100%	100%	Land conflict means land occupied illegally leads to even more problems with other residents. Some poor respondents did not know, but nobody said no. However, many of them face this crisis.

Dimension	Factor	Indicators	Dhaka	Comilla	Comments
	Political	Percentage of people reporting intra or inter political clashes are increasing.	80%	25%	This included those respondents who said clashes were increasing. Some of the respondents did not know. In Comilla the majority of respondents, in particular non-poor respondents, said political clashes were decreasing. But this figure is highly controversial as it depends on time. For example, during the election time this crisis increases throughout the country. My surveys took place in October 2010, when Bangladesh was politically stable.
	Physical	Vulnerable houses (poor migrants).	88%	70%	On the basis of observation or asking questions about the house quality.

Dimension	Factor	Indicators	Dhaka	Comilla	Comments
		No water access for poor migrants.	23%	4%	Counted only for poor migrants.
Exposure	Environment	Number of big floods in the last three decades (c).	3	0	In the last three decades three big floods have affected Dhaka (1988, 1998, 2004).
		Waterlogging effect for the last five years.	5 (Most years)	0 (No water logging)	Dhaka faced waterlogging problems in the wet season almost on an annual basis.
		Elevation above sea level (d).	8 cm	14 cm	Data was collected from GMTED 2010. Mean elevation was determined using GIS (average of forty data points for Dhaka and 20 data points for Comilla has been selected).
		Temperature (standard deviation from	0.53 °C	0.37 °C	Mean standard deviation of monthly average temperature. For Dhaka (1953-2010) and for

Dimension	Factor	Indicators	Dhaka	Comilla	Comments
		mean) (c).			Comilla (1948-2010).
		Rainfall (standard deviation from mean) (c).	32 mm	48 mm	Mean standard deviation of monthly average rainfall. For Dhaka (1953-2009) and for Comilla (1948-2009).

(a) This is the ranking of of international migration (for example largest international migration is from Comilla city); Data source: BMET (Bureau of Manpower Employment and training) record of 2004, 2005 and 2006.

(b) BBS (Bangladesh Bureau of Statistics) census 2011.

(c) (c) BMD (Bangladesh Meteorological Department) record.

(d) GMED (Global Multi-Resolution Terrain Elevation Data).

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Table 8.3: Indexed indicator, dimension and overall vulnerability of Dhaka and Comilla [see appendix 6(a) and (b) for process of calculation]

Indicators	Unit	Dhaka	Comilla	Maximum value	Minimum value	Score of Dhaka	Score of Comilla
Percentage of migrants aged between 15 and 60.	Percentage	91	100	100	0	0.91	1.00
Percentage of migrant women employed	Percentage	1	0	100	0	0.01	0.00
International migration	1/(1+rank)	0.25	0.5	0.5	0.02	0.48	1.00
Percentage of migrants who can save money for sending as remittance.	Percentage	18	55	100	0	0.18	0.55
Mean days taken to find job.	1/(1+days)	0.049	0.2	0.5	0.03	0.04	0.36
Percentage of poor skilled migrants	Percentage	5.3	3.03	100	0	0.05	0.03

Indicators	Unit	Dhaka	Comilla	Maximum value	Minimum value	Score of Dhaka	Score of Comilla
Per days wages (BDT currency)	Count	350	300	400	100	0.83	0.67
Percentage of migrants who moved using social networks	Percentage	95	100	100	0	0.95	1.00
Percentage of migrants receiving social support	Percentage	29	50	100	0	0.29	0.50
Population density (per square kilometer)	Count	8229	1712	8229	86	1.00	0.20
Participated in or observed demonstration for water demand.	Percentage	60	0	100	0	0.60	0.00
Demand for wages increse (RMG sector).	Percentage	70	0	100	0	0.70	0.00

Indicators	Unit	Dhaka	Comilla	Maximum value	Minimum value	Score of Dhaka	Score of Comilla
Percentage of people reporting land conflict is increasing	Percentage	100	100	100	0	1.00	1.00
Percentage of people reporting intra or inter political clashing is increasing	Percentage	80	25	100	0	0.80	0.25
Vulnerable houses (poor migrants)	Percentage	88	70	100	0	0.88	0.70
No water access for poor migrants	Percentage	23	4	100	0	0.23	0.04
Big floods occured in the last three decades	Count	3	0	3	0	1.00	0.00
Water logging in the last five years	Count	5	0	5	0	1.00	0.00
Elevation above sea level	1/(1+elevation)	0.11	0.06	1	0.027	0.09	0.03

Indicators	Unit	Dhaka	Comilla	Maximum value	Minimum value	Score of Dhaka	Score of Comilla
Temperature (standard deviation from mean)	°C	0.53	0.37	0.69	0.37	0.50	0.00
Rainfall (standard deviation from mean)	Millimetre	32	48	48	25.5	0.29	1
	Dhaka	Comilla					
Adaptive capacity	0.42	0.56					
Sensitivity	0.74	0.31					
Exposure	0.58	0.21					
Overall vulnerability score	0.63	0.32					

8.7 Conclusion

A range of experiences have emerged from the interviews in each city. Khulna faced short term displacement and seasonal migration, as rural areas of the Khulna district are prone to cyclones. People in these affected regions do not like to move unless they are forced to. Thus though they are temporarily displaced, for example after tropical cyclone Aila, they try to return to their home in the aftermath of the disaster. However, landless people from extremely vulnerable places like the Gabura *union* of Shyamnagar (Satkhira district) are directly migrating to larger cities like Dhaka, Chittagong, Jessore, Satkhira and even India (as it is close to the Indian Border). This suggests that people of the south-western region will likely be forced to migrate internally and externally in the near future if sea level rises by one metre or more.

Barisal city, in contrast, faces permanent migration due to river bank erosion. The city also faces seasonal migration during the rainy season as the *char* are flooded during the monsoon. Middle and upper class people of Barisal tend to be better educated. Thus, they can move all over the country, and especially to Dhaka, for jobs. Lower class people from Barisal also tend to move to big cities, especially to Dhaka, due to family and friend connections that allow them to more easily cope with the new environment and to engage in informal work.

There is no doubt; people from all social classes from all over the country are migrating to Dhaka city, although the scale of the migration varies from place to place. Migration to Dhaka is not a new phenomenon. Dhaka has experienced all types of migration - seasonal, temporary, or permanent - for a long time. In contrast, migration to Comilla is a new phenomenon. Seasonal and permanent migration has taken place only in the most recent decades. Migration to Comilla has led to opportunities rather than problems.

Khulna, Barisal and Dhaka all face problems with slums, whereas Comilla does not. Nevertheless, slum-dwellers can obtain a job in the informal sector quickly, although jobs are not secure and wages are low. Due to migration the competition for public services, and jobs, and the pressure on food prices and house rents are increasing in Dhaka, whereas these issues are perceived to be manageable in Khulna, Barisal, and to a lesser extent, in Comilla.

Historically, people of greater Barisal have experienced conflict in occupying the *char* land. Khulna is an industrial city, so conflicts here tend to be due to salary pressures. Political conflict is common in Dhaka as it is the capital city of the country, and there tends to be conflict as parties change power. Moreover, in Dhaka jobs are not increasing at a rate to match migration. Several respondents claimed that unemployed migrants are used by political leaders to cause unrest in the country. By contrast, in Comilla, job opportunities are increasing, even though more people are moving to the city. It is notable that beggars are decreasing in number due to these job opportunities and political conflict is perceived to be decreasing. The exception to this is drug-related crime, where Comilla's proximity to India allows the import of various illegal substances. Some influential people and political leaders are thought by the respondents to be involved with this type of business. Apart from political conflict, there are also land conflicts, which are increasing in all the cities, but particularly in Dhaka.

The findings of this research confirmed that poor migrants are the most vulnerable in the city. This group has less adaptive capacity than old migrants or poor local people, due to low level earning, limited access to resources and location and settlement pattern. Although this group has less adaptive capacity, they eventually increase their adaptive capacity by building social support, social services, networks and gaining skills. Poor migrants are exposed to floods due to their location and settlement pattern, while their socio-economic situation also makes them particularly sensitive to external shocks (Braun and Aßheuer, 2011). Thus, this research accounts for economic, demographic, social, political and physical factors in determining the vulnerability of migrants in Dhaka and Comilla. Taking all these factors together, it is clear that Comilla is less sensitive and has a higher adaptive capacity. Overall Comilla is less vulnerable than Dhaka. Thus, Comilla could be a suitable destination for poor migrants, in particular those who are environmentally affected in coastal rural areas.

Chapter 9

Evidence of environmental effect on migration.

9.1 Introduction

The previous two chapters analysed social vulnerability of the delta to natural disasters and considered the fate of resulting migrants to the city. The aim of this chapter is to address the evidence of environmental change on migration. I begin the chapter by illustrating and identifying the environmental effect on categorising the type of migration. The second part of the chapter then addresses the circumstances leading to a decision to move. The third part of the chapter addresses the major migration flows, different patterns of migration and their susceptibility to climate change.

9.2 Environmental effects on different groups of migration

The aim of the section is to define and identify who are motivated to migrate due to environmental factors. Although there are a number of definitions of those who are displaced and migrate due to environmental reasons (Renaud et al., 2011), my study focuses on four types including no-migration (see figure 2.7 in section 2.9 for a description of the types). Table 9.1 presents some of the main characteristics of the different groups of people in affected rural areas, discussed in this thesis

From table 9.1 it is clear that the poorest are the most vulnerable. This low income community has a lower level of coping capacity and has a higher level of vulnerability to environmental change. The current study found that the migration decision of the group A is highly sensitive to environmental change with the score of 25 (Table 9.2). This group may not have enough financial or social assets to move. The study found that although they are keen to move, they are unable to leave and are forced to stay in a high risk area (described in the section 9.3). A similar situation was found in New Orleans after Hurricane Katrina (Landry et al., 2007). In the present study it was found that this weak group relocates near the river, and so is at high risk of flooding and river bank erosion (see also chapter 7, figure 7.5 and chapter 9, figure 9.2 and 9.2). The Foresight report (2011) highlights this group as a 'hidden trapped population'.

Group B is less sensitive to climate change. This group is mostly from the middle class, and whilst still exposed to environmental change, have a more adaptive capacity. However, they do not like to move due to a range of reasons explained in decision to migrate section 9.3. Group C has less exposure again but are still moderately susceptible to climate change based on migration decision. This group has larger social networks that facilitate their migration decision more easily (Table 9.1). Group D is also found to be more sensitive to climate change. Like group C, this study found this group also has larger social networks. Although they have ability to stay, they are environmentally motivated to move to earn more money.

Table 9.1: The characteristics of different groups of people who are from rural affected areas. See chapter 2, section 2.9 and figure 2.7 for definitions of categories (three dub-districts, Shyamnagar, Sharankhola and Tala have been considered for the calculation)

Dimension	Variable	A	B	C	D	AC	Comments
	Respondents	60%	20%	14%	6%		
Environmental	Near the River ½ km	Most of them	Many of them	Very few of them	Many of them	-	This is a high risk zone. Respondents estimated to live within ½ km.
	Received cyclone warning	36%	55%	68%	65%	+	Percentage based on respondents in each group for example, 36% of group A, received a cyclone warning, or 22% of total respondents.
Demographic	Older respondents	8%	1%	0%	0%	-	% has been calculated from total population
	Female headed	6%	1%	0	0	-	% has been calculated from total

Dimension	Variable	A	B	C	D	AC	Comments
	HH						population
	Short distance Migration	10%	---	2%	0%	-	% has been calculated from total population
	Long distance migration	2%	---	5%	2%	+	% has been calculated from total population
Economical	Savings	None of them (0%)	Many of them	Many of them	Many of them	+	
	Average Household Income yearly	50000 (£400)	100000 (£850)+	100000 (£850)+	100000 (£850)+	+	Roughly calculated
	Face difficulty buying basic needs	100%	2%	1.5%	0%	-	
	Skilled	None of them	Many of	Many of	Many	+	

Dimension	Variable	A	B	C	D	AC	Comments
			them	them	of them		
Social	Unhealthy	9%	1%	0%	0	+	% has made from total population
	Social network	60%	87%	100%	100%	+	Percentage was made among same group.
Physical	Settlement pattern	***	**	*	**	_	Based on observation and answers to the questions

****Most vulnerable; ** Medium vulnerable; *Low vulnerable but there are some vulnerable house as well.

AC = Adaptive capacity.

HH = Household

Table 9.2: Climate sensitivity of different groups and its effect on migration decision of different groups (red = highly sensitive, yellow = medium sensitive and green = low sensitive; [sources: the method was developed from the PhD project of Schmidt-verkerk (2011). She modified from an original source, Fletcher (2005)]; see also appendix 12[a and b])

Group	Degree of climate sensitivity	Comments	Migration decision	Comments	score
A	Very high	Due to location, pattern of settlements, landless people and poverty; this group are highly sensitive to climate change.	Very High	This group would like to survive. They are forced to stay or forced to move.	25
B	High	This group has an adaptive capacity that reduced some sensitivity to this type of event.	Least	They do not like to move due a range of reason	4
C	Medium	Same as above	Medium	Migration is not influenced by environmental events.	9
D	High	Same as above	Very High	They are environmentally motivated to move.	20

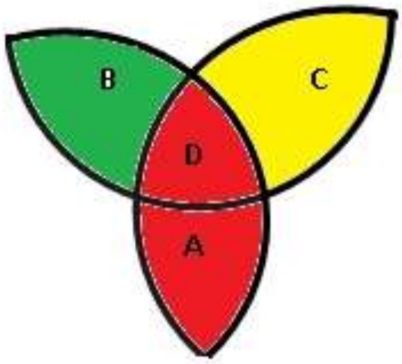

Figure 9.1: Various types of migration from rural vulnerable area (origin) based on most susceptible to climate change (red = highly sensitive, yellow = medium sensitive and green = low sensitive; see also appendix table 12[a and b]).

9.2.1 Environmental effects on distant mobility of poor people

Although it has been described in chapter 7 that poor vulnerable people tend to migrate less distance, here I have added a statistical test and considered the reasons for moving. A significant result of this study is that due to environmental change, poor people move short distances rather than a long distance (Figure 9.2). This result matches those observed in earlier studies, in which Zaman (1991) found nearly 88% of the survey of the households had remained within 2 miles of their earlier residence following the erosion of land and loss of homes. The study of Massey et al. (2010) also suggests that environmental change is more strongly related to short distance migration. Long-distance moves are generally related to financial assets (Henry et al., 2004) and social assets, in particular whether there is a pre-established migrant network (McLeman, 2011). This study confirms these findings, as people with less household income stayed in place, moved to a less distant place, or stayed near the river bank. There is a significant correlation (0.001 levels) between distance and household income (Table 9.2). As Black et al. (2008) also explain, those involved in short-distance, often cyclic or seasonal, migration and movement may be more strongly affected by climate change because the migrant is less able to make a sufficient livelihood at home, and thus is less able to resist impacts of climate change, such as droughts and floods.

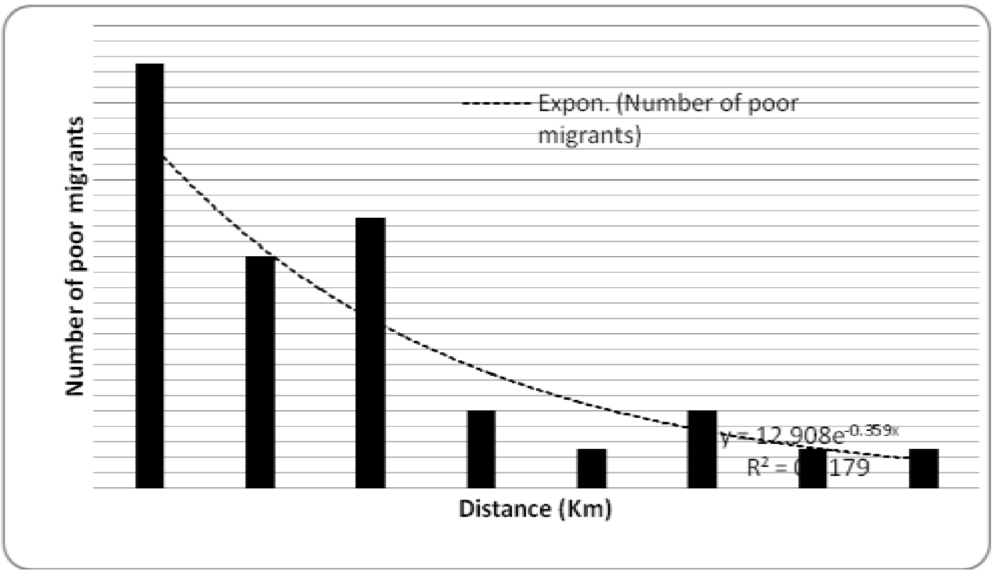

Figure 9.2: Poor population movement with distances (based on fieldwork in Mehendiganj)

[The research considers population migration induced by river bank erosion as forced migration if the victim moves permanently, even over a short distance. See chapter 2 and section 2.8 for a definition of the term migration and displacement as used in the thesis].

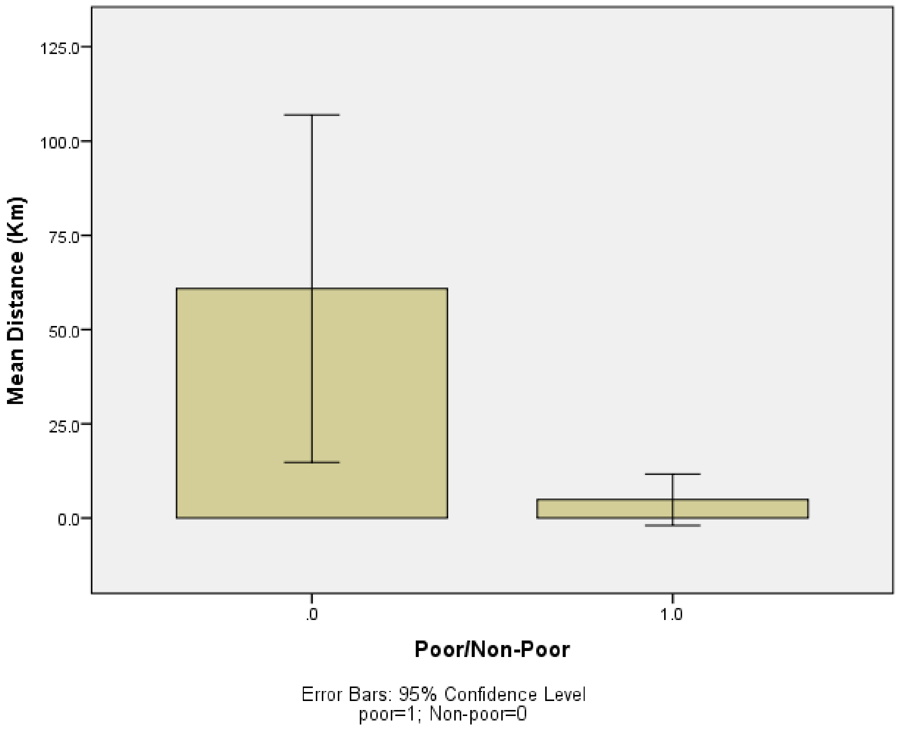

Figure 9.3: Poor vs non-poor displacement with distance (I have categorised the poor and non-poor using four determinants that describe in the section 3.4.4)

Table 9.3: Income distribution of displaced Households and their settlement pattern in Mehendiganj

Distance from the river (Km)	Monthly income of poor migrant respondents (BDT)	£	Settlement pattern
0.1	4000	33	Most vulnerable (see also chapter 7, figure 7.5)
0.2	4000	33	Most vulnerable
0.5	5000	42	Some are vulnerable (some house are made with brick built in the *zamindar* building)
1	5000	42	Vulnerable
5	6000	50	Not vulnerable
30	6000	50	-----
100	8000	67	------

Another important finding in this study was the significant positive correlation between poor people who live near the river and monthly household income (Table 9.3). This study further indicated that the cyclone shelter and the market are far from poor households (Table 9.4). The result of correlation between incomes and distances from river, cyclone shelter and market, of respondents is displayed in the table 9.5. This result echoes the findings of other studies, in which Akter and Mallick (2013) showed significant negative correlation between distance to cyclone shelter and monthly household income ($r=-0.15$, $p<0.05$). Similarly, Brouwer et al., 2007: 319) found a significant positive relation between the distance people live from the river

Meghna as an indicator of (collective) risk exposure and household income ($r=0.113$; $p<0.003$).

The calculation of household income was very difficult for the study area, particularly for poor households as their income is not fixed. Many poor respondents earn money only for 5/6 months. Many household incomes depend on more than one source. Many poor households take loans from moneylenders with high interest, before going to the forest and fishing for couple of months. Thus, I have calculated, roughly, annual household income rather than monthly household income. However, the result revealed that how much poor people (particularly group ‘A’) are vulnerable.

Table 9.4: Income distribution, distance from river, cyclone shelter and market and the settlement pattern of respondents (both displaced and non-displaced) in Sharankhola

Distance (Km) from river	Distance (km) from cyclone shelter (2014)	Distance (km) from cyclone shelter	Distance (km) from cyclone	Distance (km) from Market	Annual household income (BDT)	£	Settlement pattern
0.1	0.7	2.5	2.5	2	38000	315	Most vulnerable
0.3	0.5	2.5	2.5	1.8	45000	375	Most vulnerable
0.5	0.1	2	2	1.5	71000	590	Vulnerable
1	0.5	1.5	1.5	1	70000	580	Vulnerable
2	0.5	0.5	0.5	0.5	160000	1300	Very few better quality

Table 9.5: Correlations between income, distance from river, cyclone shelter and market of respondents

		Distance from river (Km)	Distance from cyclone shelter (Km)	Distance from market (Km)	Annual household income
Distance from river (Km)	Pearson Correlation	1	-.999**	-.978**	.964**
	Sig. (2-tailed)		.000	.004	.008
	N	5	5	5	5
Distance from cyclone shelter (Km)	Pearson Correlation	-.999**	1	.982**	-.961**
	Sig. (2-tailed)	.000		.003	.009
	N	5	5	5	5
Distance from market (Km)	Pearson Correlation	-.978**	.982**	1	-.909*
	Sig. (2-tailed)	.004	.003		.033
	N	5	5	5	5
Annual household income	Pearson Correlation	.964**	-.961**	-.909*	1
	Sig. (2-tailed)	.008	.009	.033	
	N	5	5	5	5

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

9.3 Decision of migration

The key drivers of migration and their effects on migration have been described in chapter 2 (section 2.3). However, the presence of migration drivers alone does not necessarily imply that migration will take place, as migration is the result of decision making processes (Black et al., 2011b).

In addition, the processes of migration related decision making are mediated by drivers of migration, intervening obstacles, facilitators, and their interrelations with each other (Kniveton et al., 2008) which are independent of environmental conditions. Possible exceptions to this include the extent to which attachment to place is influenced by local environmental characteristics (Black et al., 2011b) and also the nature of environmental events, such as being slow-onset or rapid-onset. These play an important role in the migration-decision making process. These two types of environmental processes affect population movement that is viewed as a continuum from entirely elective migration to entirely involuntary migration. In reality the situation is somewhere in between and very few decisions related to migration are entirely forced or elective (Hugo, 1996). In situations of slow onset environmental change this is likely to be more elective (Laczko, 2010) whilst rapid onset events constitute forced migration (Hugo, 1996). However, these flows are influenced through a variety of complex sets of facilitators and obstacles. The current research found that the Bangladeshi community's migration related decisions are mediated by informal non-monetary preparation such as financial assets, social support, social networks, livelihood diversification, perceived benefits and remittances through extended family networks to cope with loss after an environmental event (Kniveton et al., 2009). The section below illustrates how the migration decision making process is influenced by environmental change.

Environmental change may erode important assets which can make migration less likely in some cases and as such has important implications for poorer individuals who are unable to finance migration, while also being vulnerable to environmental change (Foresight, 2011). Therefore, lack of financial assets is one of the major barriers to the migration decision process. Many households who have money can move to distant places. Many of them sell their assets to send family members to these places. In the immediate aftermath of natural disasters, unemployment and increasing prices force many households to migrate. At the same times, due to a financial barrier poor households (group A) are forced to stay in the risk area; they only have the ability to move locally. The link to poverty, whether pre-existing or post-event, was clear in this study. In addition, changes to local natural resources were also important factors. Both rapid and slow environmental change caused societal stress leading to migration of the rural vulnerable community. This can arise in three forms: seasonal, permanent or temporary migration. However, these kinds of migration are linked to social status. Slow-onset events may provide more time with regards to decision making processes (Laczko and Aghazarm, 2009). It is a more planned migration. However, it is dependent on the nature of the event. For example, consider the case of a community's reaction to slowly developing river bank erosion. More affluent people of the affected regions can make preparations before the change occurs (discussed chapter 5, section 5.7). People from this class buy land in a city as a safety net, or even move earlier, while retaining a connection with their home area. In contrast, lower class people do not move unless they are forced to. They move at the last moment, when their houses and land are engulfed by the river. Middle class people cannot afford to buy land in distant cities, so they tend to buy land further inland, but in the general vicinity of their original homes. Thus both the poorest and the richest of people move to Dhaka or elsewhere as permanent migrants. However, higher class people live in the city with dignity, whereas poorer people become slum-dwellers.

Similarly slow intrusion of saline water has an impact on livelihood which contributes to poverty. In some cases, depending on financial resources and social networks this triggers migration as a strategy to diversify livelihood. On the other hand, those who remain in environmentally impacted areas try to adjust their livelihood strategies by switching their agricultural pattern (Martin, 2009) to shrimp farming. But not all farmers are able to take advantage of this opportunity. Many smallholder farmers face barriers to switching to shrimp cultivation due to expensive fertilizers and regular outbreaks of viral diseases (Kartiki, 2011). Thus, many of them are forced to lease their lands. Due to the loss of employment, they decide to migrate for their livelihood (Kartiki, 2011) (see the chapter section 7.7). Many environmentally impacted local farmers send household members to cities. Since impacted people see migration as a strategy to diversify their livelihood, the recruiters play a significant role in offering seasonal migration to those from southwest regions, especially Shyamnagar. Here agencies recruit a group through a team leader (a '*sharder*' in Bengali). The team leaders pay some money in advance to every member so that they can prepare for the journey. They buy all the basic needs before starting the journey (see the comments of Mohsin). Though they are away from their home and family, this journey does not need any financial investment.

Mohsin, a seasonal migrant from Shyamnagar said, "we are poor. There are not enough jobs due to salinity intrusion. Thus, I have started to go and work in brickfields in Dhaka, Chittagong, Barisal and even India. I do not have any choice where I will go. It depends on *sharder* (team leader), where he gets the contracts. Before starting the work, he gives us some money in advance. Before travelling I give the money to my family. I also buy basic necessary needs for my family for a couple of months as I was staying there five to six months. The money I get is not sufficient. But at least I can survive. I am a little better than before." (Interview, October 2014). This type of migration increased after tropical cyclone Aila. Environmentally impacted people also strongly use social networks that facilitate their migration decision as social networks assist them to gain jobs. Table 8.2 shows, 90% and 100% of migrant respondents moved to Dhaka and Comilla respectively with the aid of social networks. Migrant members not only send remittances but also act as a social network. They motivate and facilitate new migration. The current study found one seasonal migrant who used to migrate less frequently, but following tropical cyclone Aila he is going more regularly and also influencing friends and relatives to migrate like him. Thus after tropical cyclone Aila, seasonal migration as a group increased. Although many affected people migrate to cities either permanently or non-permanently most migrants still have a connection with their place of origin. Many of them have houses and even agricultural land in rural areas from where they came, even though they have settled in the city. In contrast, migration caused by river bank erosion is different for all classes of people as their land is engulfed by the river permanently requiring them to move.

In addition, due to the negative effect of environmental events on agriculture production, many vulnerable coastal people are pushed to take the decision to move to urban centres (Herrmann and Svarin, 2009) (see chapter 2, section 2.2). Moreover there are wage differences between rural and urban areas in Bangladesh (Table 9.6). During post-disaster this difference increases and more vulnerable areas offer less daily wages (Table 9.6). Thus, wage differences are one of the important factors that influence rural people to move to urban areas (Table 9.6). There is a strongly significant difference (the p-value of the test was $p=0.000<0.00$). The current study clearly found that due to these wage differences, some people are persuaded to move to Dhaka and Comilla. Another factor is that people diversified their livelihood from the agricultural sector to non-agriculture/ industrial sector. This is consistent with the Ravenstein model as he found flows of migration are dominated by rural-urban migration and the major direction of migration is from agricultural areas to centres of industry and commerce (see chapter 2, section 2.2).

Table 9.6: Wage differences between rural and urban

Rural/Urban	Sub-district/ district	Daily wages (BDT) for rural in 2011 and for urban in 2010.	Daily wages (BDT) in 2015
Rural	Mehendiganj	220	300
	Sharankhola	210	
	Tala	210	
	Shyamnagar	175	200
Average in rural		200	
Urban (2010)	Dhaka	350	500
	Comilla	300	450
Average in urban		325	475

Since the southwest region faces repeated environmental hazards leading to livelihood threat, loss or debt that influenced the decision to migrate (Warner, 2011). Many of them migrate to earn money to recover debt. Some household members in Shyamnagar borrow money with high interest rates from local moneylenders to make the journey. Thus accessing money with interest also causes poorer households to take the decision for a temporary move. This kind of act has increased in Sharankhola and Shyamnagar after tropical cyclone Sidr and Aila.

The current study illustrates that the Government response is very important to recover the situation. Due to a very quick response to the flood in Tala people recovered and all returned after the flood. Moreover, only 33% of respondents in Tala reported misappropriation of the relief distribution (chapter 7, table 7.3). This is consistent with the study of Paul (2005) which showed that following the 2004 tornado in Bangladesh, there was no migration due to availability of aid, effectiveness of distribution and the limited size of the affected area. But in the case of Shyamnagar and tropical cyclone Aila this was found to be different. After tropical cyclone Aila there were delayed responses to repairing the embankment due to the massive wreckage and also the involvement of local politics. Many households said it took more than two years to repair. In the meantime they faced tidal water intrusion twice a day. This directly affected their livelihoods and led to a drop in income. Although many people take the decision to move some people do not move, however. They involve themselves in ‘food for work’ or cash for work programmes provided by the government immediately after the natural disasters. Due to relief and different recovery schemes provided by the Government and NGOs, many households do not decide to move. Mahmud and Prowse (2012: 937-938) discuss short and long-term recovery intervention which brings immediate relief to affected households. Later rehabilitation interventions, such as grants for house rebuilding and embankments provide longer-term assistance. They also describe three categories of recovery scheme, such as “first emergency recovery relief (where households received BDT 3000-5000); second, medium-term relief intervention (where households received 20 kg of rice each month); and third a long-term social protection measure where households received cash/food in return for participating in public works. This activity reduced some labour competition and also reduced the push to move to the city to search for a job in the affected areas (Mahmud and Prowse, 2012). Thus, following sudden onset events migration into the affected area may increase, at least temporarily, as displaced people return along with relatives to assist them to recover, personnel come to work with agencies engaged in recovery, and new migrants come seeking work in the reconstruction process (Hugo, 2008; as noted by Barnett and Webber, 2010).

Population movement from environmentally impacted areas as result of the response of both slow or rapid onset environmental events illustrates varied arrangements of the migration continuum from; vulnerability to resilience (Laczko and Aghazarm, 2009). Moreover, vulnerability and capacity to adapt is further influenced by several indicators such as age, gender, skill, literacy background and may in turn to inform decisions related migration processes at the societal, household and individual level (Laczko and Aghazarm, 2009). The current study has observed that most seasonal and temporary migrants are young. This group is active and they are in demand in the labour market. Older people do not have much energy to work. That's why they feel fear to move. One respondent from Gabura commented: "I have been working as a day labourer such a long time. When I was young I used to work hard as a day labourer. Now I am 60, do not get energy to work. It is hard for me now. That's why I did not migrate and try to do easy job here" (Musa Mia, Oct 2014). This also accords with previous research of Afsar (2000) which showed two thirds of her total respondents of migrants were between 15-34 years old. The research on the USA Dust Bowl years of the 1930s, also found "it was not common to find elderly people or people physically unable to perform fieldwork among Oklahoman migrants to the southern San Joaquin" (McLeman and Smit, 2006: 44). As mentioned by Koerber (2006) following Hurricane Katrina younger people were more likely to migrate.

Gender is an important factor that limits migration ability (Schmidt-Verkerk, 2011). As mentioned in chapter 7 section 7.2, during the tropical cyclone, the decision to move for women in rural Bangladesh mostly depends on male-headed members because women cannot take the decision to move. Many male members save money in a migration destination and send it to their family members. However, a female headed household may take the decision to move. Recently, for example, many women from rural areas have moved to work in the ready-made garments sector. However, the current study clearly observed that after tropical cyclone Aila male members move temporarily and seasonally in the hunt for employment, leaving women behind. This agrees with Delaney and Sharder (2000) following Hurricane Mitch in Central America, and in environmental migration in Niger (as noted by Naik, 2009).

Skilled workers or educated people decide to move to the city for job purposes. The study found the poor are less skilled, and so less likely to move. Due to illiteracy they even fear buying land, as they think they may suffer fraud. Thus, environmentally impacted poor people households are more sensitive and fear to move. This is another reason that poor move short-distances or short durations during the post-disaster period.

Migration decisions can also depend on the perceived benefit of such action (Schmidt-verkerk, 2011). Many people in the middle classes (group B) do not want to move to the city (see chapter 9, section 9.2), as they are emotionally attached to their land, relatives, friends and their traditional culture (chapter 9, section 9.3). The alternative is to live in a city that is overcrowded, polluted and noisy, often with a number of societal problems. Moreover the city is expensive they fear not getting a decent job. Thus they do not like to move unless they are forced to. However, the social status of environmentally impacted people may decrease leading them to finally decide to move.

9.4 Population movement and the contrast between sudden and slow environmental change

Environmental change is encompassed of many different events -and different time scales (Warner et al., 2011). Sudden onset disasters like cyclones or flash floods lead to short-term population movement. This type of event leads to temporary displacement to a local regional destination. As an example, after the flash flood of 2011 a vast number of people were displaced, but stayed near their home (on unflooded land and embankments). Most of them returned after the flood. After tropical cyclone Aila in May 2009, huge numbers of people migrated to Khulna city temporarily. According to the ECHO partners' assessment (October 2009), after tropical cyclone Aila, approximately 40,000 people migrated from the Koyra *upazila* of Khulna district alone. Smaller, but still substantial, numbers came from other *upazilas*: around 30,000 from Paikgacha; 18,000 from Dacope; and 12,000 from Batiaghata. In total, around 100,000 people migrated to Khulna city after tropical cyclone Aila. It is not known how many people subsequently returned to their homes. However, many of these people were very poor, and it would have been difficult for them to afford to return and re-build their houses. Moreover, much agricultural land remained flooded for a long time after the cyclone. Displacement due to natural catastrophes, even just temporary displacement, can lead to longer term migration (Warner et al., 2009). Many households are permanently settled in the city. The Indian Ocean tsunami of 2004 and the 2005 Hurricane Katrina exemplify this (Warner et al., 2009). In the context of Bangladesh, it is difficult to estimate the number of people affected by either rapid-onset or slow-onset environmental change. On the other hand, river bank erosion is a more insidious and slow process, but can have a major impact. Every year due to river bank erosion, a high number of people migrate to the cities permanently in Bangladesh. I roughly estimated 97% people of Gabura *union*, Mehendiganj had migrated permanently due to river bank erosion as out of thirteen original villages only one third of one village remains. In contrast, slow onset events, such as river bank erosion and sea level rise, lead to more permanent relocations further inland or to the cities. Gradually, slow onset change will give environmental push factors an increasingly important position in the migration decisions (Warner, 2010).

9.5 Environmental sensitivity of different forms of migration

Environmental events, both sudden and slow onset, has an effect on livelihoods, food security, water availability, and infrastructure which all influence migration and population movement (CCEMA, 2010). This study shows that internal migration is highly sensitive to environmental change in Bangladesh (Table 9.7). Seasonal and temporary migration and locally-displaced, permanent migration are highly sensitive (Table 9.7). Section 9.2.1 describes the reasons for local displacement. Due to demand for financial and social resources, the poor are unable to undertake international and cross-border migration. These two types of migration are less sensitive to environmental change than internal migration. Moreover, International migration leads to increased internal migration. Evidence suggests that “remittances boost the local economy in places of international migrants’ origin, attracting internal migrants from elsewhere in the country” (Kniveton et al., 2013: 2). The Sylhet is an ideal example of this. The result of massive increase of economy supported by foreign remittance, particularly from the UK, pulls migrants into the district from elsewhere from the country (Marshall and Rahman, 2013) (see also chapter 4, section 4.4 and 4.5). Similar explanations could apply for the Comilla District (where interviews for this study were conducted). Chapter 4 shows Comilla to have the highest levels of international migration, and this study found a high number of internal migrations in the district. This confirms the findings of Marshall and Rahman(2013).

Political security is frequently cited as a driver of international migration (Black et al., 2011a) rather than domestic migration. Bangladesh has a long history of political migration (see chapter 1 and chapter 4). The country experienced conflict-induced migration during the partition time with India and Pakistan. Currently, however, there are no cross-border mass migrations (Walsham, 2010) (see also chapter section, 4.5). Migration in Bangladesh is dominated by internal migration, largely to the big cities like Dhaka and Chittagong. However, excessive internal movement may lead to migration to India or other countries and there is a higher risk of violent conflict with this since India is fencing the border. The border region with India also contains some of the areas of greatest environmental vulnerability (Walsham, 2010).

This study found some household members from Shyamnagar to seasonally migrate to the larger cities or even to India (based on recruiters' agency where they gained the contract). Thus, environmental events could encourage cross-border migration. In addition, as a result of pressure from an increasing population, and limited efforts to improve political stability, demands to increase disaster relief and urban services over-burden the governments' modest financial and institutional resources, an effect of cross-border and international migration (Black et al., 2008: 34).

Table 9.7: Different forms of migration and their susceptibility to environmental change.

Form of migration	Degree of climate sensitivity	Comments	Degree of relevance for migration decision	Comments	Score
Internal migration (seasonal and temporary)	Very high (5)	Due to effects on livelihoods	Very high (5)	This type of migration depends on social networks, accesses to recruiters and nature of contracts.	25
Internal migration (permanent local displacement)	Very high (5)	Due to river bank erosion	Very high (5)	Mostly poor, displaced locally (see 9.1 and 9.2)	25
Internal migration (permanent displacement in the city)	Very high (5)	Due to river bank erosion and tropical cyclone	High (4)	Many non-poor classes' households settled in the city. This group are motivated to move. Many landless and extreme poor also settle in slums due to river bank erosion.	20

Form of migration	Degree of climate sensitivity	Comments	Degree of relevance for migration decision	Comments	Score
Cross-border	Medium (3)	Due to environmental change existing flows could increase.	Medium (3)	In the past, Bangladesh has a long history of political migration with India. However, migration decision would depend on consequences saturation of cities (Black et al., 2011a: 47)	9
International migration	Medium (3)	Due to environmental change existing flows could increase.	Medium (3)	Migration decisions depend on consequences of saturation of cities (Black et al., 2011a: 47) and government policy. This also depends on financial assets.	9

9.6 Migration to be seen as an impact or as an adaptation strategy?

In response to climate change, migration has been seen as a failure of adaptation while others consider it as a process of adaptation (Renaud et al., 2011). The findings of this study are consistent with both. Rural people of Bangladesh are highly adaptable. The vulnerable community response to slow onset salinity intrusion or floods affecting an area is to switch agriculture patterns, such as changing from crop cultivation to shrimp farming or hydroponic agriculture. Although many groups are adaptable, many are not. Moreover, some of the vulnerable residents could not adapt their situation due to the intensity of disasters, as well as the repetition of natural disasters. Many of the residents are forced to move due to their failure to adapt. However, at the same time many were unable to move. This was demonstrated this in chapter 7. This study found that many migrant families are much better off than non-migrant families because migrant remittances serve as an important source of income for many households. According to this view, migration could potentially help slow the process of environmental degradation (IOM, 2009). Previous literature has suggested that remittances could serve the community in several ways, such as the direct impact of remittances on income distribution, poverty, alleviation and individual welfare, and their impact on employment, productivity and growth (OECD, 2006). Thus, migration could be one coping strategy for those whose livelihood is challenged by environmental events (Barnett and Adger, 2007). As mentioned in chapter 7, the link between the effects of salinity intrusion on livelihoods leads many people to move temporarily or seasonally, with their remittances contributing to improving the local economy. Remittances from migrant members can also stimulate agricultural investment in communities that lack agricultural, financial, or insurance markets as well as being used for investment in rural livelihoods (Leighton, 2009: 334).

9.7 Conclusion

The findings from this study make several contributions to the current literature. Firstly, it is clear that the poor in Bangladesh are the most vulnerable to environmental change. Thus, appropriate services and support for this group should be a priority in the emergency help phase. Secondly, the decision-making process about migration occurs at the local scale and is driven by a range of factors, including environmental change. However, economic impacts whether linked to such change or not, often play a significant role in the migration decision-making process. Thirdly, the study assesses the environmental sensitivity of different forms of migration.

Chapter 10

Conclusion

10.1 Introduction

This research has investigated the relationships between environmental variability, climate change and societal crisis in Bangladesh. The coastal areas, especially the delta section, face numerous ongoing threats from the multiple effects of cyclones, storm surges, coastal erosion, salinity intrusion, and even from the monthly spring tides which threaten poorly maintained embankments with breaching and flooding (Walsham, 2010). Future sea level rise will further affect the region. My study presents a new understanding of the role of environmental change in causing migration and its relation to societal consequences. The study focuses on the vulnerable poor in the delta who are less mobile, and also concentrates on the poor migrants who move to urban areas.

This chapter begins with a discussion of the general contribution of the thesis. Following this, the environmental changes and events in the coastal rural community and their role in population movement will be discussed. The main findings of the study will then be presented, before finishing the chapter with recommendation for future research.

10.2 Overall contribution of this thesis

10.2.1 Methodological contribution

To explore the environmental change of the country, the temporal variability of temperature, rainfall, and river discharge and long-term sea level across different regions have been examined (see chapter 6, section 6.3). The social impact of these environmental changes has been examined through over three hundred and fifty questionnaire surveys and interviews, both from the delta part of the country that is directly affected, and in the destination cities of internal migrants'. The human element of the research had been carried out through a combination of standardized, open-ended interviews, focus group and close-ended questionnaire surveys. The purpose of this was to determine the reaction of people in a number of situations: coping mechanisms of local people of the coastal region to both rapid and slow environmental change, and responses which included displacement and migration, whether temporary or permanent. Individuals, both migrant and local, in the destination regions were also surveyed. Different types of sampling methods were carried out for collecting data in both rural and urban areas. Most prominently, to avoid bias the study used a random sampling method to select the respondents in slums (see chapter 3; section 3.4.2).

The study constructed an index of vulnerability using a simple average score from factors including exposure, sensitivity and adaptive capacity (Heltberg and Bonch-osmolovskiy, 2010).

A model has been created to distinguish the various types of migrants which is influenced by the intensity of the environment change and its impact, and the subsequent vulnerability and capacity to adapt to such impact for each migrant grouping (see chapter 2, sections 2.9). These factors then influence to decisions of affected people to move or stay. A method developed by Schmidt-verkerk (2011) has been adapted to create a score for each of the different migration groupings, as well as for each type of migration.

10.2.2 Comparing the research with others' work

Although the attention paid to environmentally-induced migration in Bangladesh has increased in recent decades, in general, little research has been conducted on this topic in the past this is despite the fact that Bangladesh is densely populated and one of the most vulnerable countries to climate change in the world. There have been detailed investigations of changes to the physical environment (Ali, 1996; Ali, 1999; Mirza et al., 1998; Ericson et al., 2006; Wahid et al., 2007; Shamsuddoha and Chowdhury, 2007; Karim and Mimura, 2008; Bhuiyan and Dutta, 2012; Pethick and Orford, 2013; Brammer, 2014) social vulnerability to environmental change, (Brouwer et al., 2007; Alam and Collins, 2010; Mallick and Vogt, 2013; Rabbani et al., 2013; Ahsan and Warner, 2014) local population displacement as a result of natural hazards (Zaman, 1989; Zaman, 1991; Hutton and Haque, 2004; Kartiki, 2011; Mallick and Vogt, 2013) and internal migration, in particular rural to urban migration due to environmental pressure (Herrmann and Svarin, 2009; Marshall and Rahman, 2013). However, none of the research has investigated the relationship between climate change and migration in the context of vulnerability. Thus, the study also presents a new understanding of the role of environmental change in causing migration and its relation to it consequences for society. Therefore, the concepts of vulnerability to environmental change, adaptive capacity and the migration process have been applied. The study developed a Vulnerability Index (VI) to assess environmental change vulnerability in the four coastal rural sub-districts and the two cities in the central region. The VI compared the various regions' vulnerability to adaptive capacity, sensitivity and exposure, and differential vulnerability. Ahsan and Warner (2014) developed a Socio-economic Vulnerability Index (SeVI) using 26 indicators, however these differ to the ones used in this study. Moreover, some indicators like population density and percentages of the elderly and children were presented wrongly in the domain of adaptive capacity. These two indicators do not increase adaptive capacity. These should be in the domain of sensitivity. Their research completely ignored economic assets ability to increase one's adaptive capacity despite attempting to focus on social and economic aspect. Furthermore, this research failed to describe the effect of environmental change on migration.

The current study provides evidence that environmental change directly causes migration. Environmental change is more strongly related to short distance migration, while long-distance moves are generally affected by other drivers whilst environmental drivers are secondary or background drivers in this case. Work by Poncelet (2009) confirms this, however it does not describe the effects of long and short distance migration.

While there are few studies focusing on affected coastal areas, those studies that do fail to acknowledge the consequences of migrants in urban destinations. The current research considered this, comparing the societal situations in both a mega city context and a medium sized city context. Although there is some research on the vulnerability of the urban poor which highlights the major factors behind their sensitivity to floods and their ability to adapt to the related changes (Rashid, 2000; Jabeen et al., 2010; Braun and Aßheuer, 2011), none of this research investigates the vulnerability of poor migrants and the local poor. Although the current research focuses on poor vulnerable people, it also interviewed people from a range of social classes to provide a fuller picture of the fate of the migrants. Moreover, most of the previous studies overwhelmingly focus on Dhaka or other big cities, while no research has been carried out in cities such as Comilla. There is also no research that has calculated a vulnerability index for cities in Bangladesh, in order to compare vulnerability with Dhaka.

Although mega cities will play a significant role in absorbing future projected growth, the immediate future the majority of urban growth in developing countries will stay in small and medium-sized cities, a point that receives little media recognition or attention from other agencies (Bulkeley and Tuts, 2013; Cohen, 2006). Moreover, climate change will affect such cities just as severely as megacities, and; the capacity of smaller cities to respond will be more limited (Bulkeley and Tuts, 2013). The current research requires the attention of planners, particularly in developing countries that face environmental induced migration to medium sized cities because, unlike Dhaka, they suffer from fewer socio-economic disadvantages such as traffic congestion, crime, and unemployment and water access issues. As such, medium sized cities are easier to control and thus more manageable. Following from this, provided it is well managed and has a comprehensive policy on urbanization and planning, medium sized cities could be a more suitable destination for poor migrants; in particular those who are environmentally affected in coastal rural areas in Bangladesh, which at the same time would lessen the population burden and societal crisis in mega cities, such as Dhaka.

Finally, while there are several papers on river bank erosion-related displacement from the Jamuna river region, no previous research had been carried out on the lower Meghna, one of the locations most at risk in the delta. The river here is very dynamic due to the junction of the three major rivers entering Bangladesh from India – the Ganges, Brahmaputra and Meghna.

10.3 Climate change, climatic variability and environmental events in the coastal rural community

Much of the population of Bangladesh has experienced multiple natural disasters due to increasing environmental variability (see chapter 7). As a result of decreasing river discharge in the non-monsoon period, and increasing discharge during the summer monsoon at Harding Bridge station (chapter 5, section 5.4.1), the frequency of river bank erosion, flooding and deposition has increased. With regards to the area studies in this research, the eastern part of Mehendiganj has been eroding rapidly in the flow of the main channel, at a rate of ~3.2 $km^2 yr^{-1}$ between 1972 and 2012 (chapter 6, section 6.5).

10.4 The role of environmental change in population movement in Bangladesh

Environmental change is seen here as fast or slow in timescale. For the former, tropical cyclones are the clearest example. Tropical cyclone Aila and Sidr had the largest impacts of the past few years, leading to affected people being displaced to shelters or regional centres. Tropical cyclone Aila had the largest impact, with all middle and lower class people experiencing extreme levels of poverty in the short term. Thus many people, particularly those from Gabura *union* (south-western Bangladesh) could not return home due to poverty, as it would have been difficult for them to afford to return and re-build their houses. Moreover, much agricultural land remained flooded for a long time after the cyclone hit, leading to a drop in earnings. This situation persuaded many of the extremely poor residents to settle in slums in cities, whether as a seasonal, temporary or permanent migrant. Flash floods (e.g. in 2011) on the other hand have a more limited, but still non-negligible, impact. For example, the people of Tala were displaced in the short term to local destinations in 2011, but most returned home in due course. River bank erosion is a more insidious and slow process, but can also have a major impact. As a consequence, twelve of the original thirteen villages of the *union* of Gobindapur in the district of Mehendiganj have disappeared over the period of forty years, meaning their residents have had to migrate further inland or to more distant cities. Overall, during the last two decades in this region roughly 100 000 people and 18 000 households have been displaced (see the appendix 9). The majority of those displaced were found to have not moved far, because of a combination of factors relating to the social and economic advantages of re-establishing themselves locally. However, many respondents were found to have been displaced multiple times, which increases the probability that they will be forced further afield, most likely to urban areas, as environmental migrants.

These environmental changes, along with the influence of a combination of social, political, economic and cultural variables lead affected individuals to take a decision either to move or to struggle and stay. Therefore, this research also identified who are environmental migrants and who are likely to be environmental migrants in the future.

In the recent decades, many people have been forced to migrate to Dhaka, Chittagong or other cites due to drought, river bank erosion, cyclones or coastal erosion. This can sometimes lead to increased societal stress in the destination city.

To survive in the city poor people tend to work in the informal sector. As the cost of living in the city is relatively high, and due to low wages in this informal sector, most family members, including children, are engaged in work to earn money to support their family. Thus, children of these poor families tend to work rather than going to school. As a result poor families that have been forced to migrate remain poor, despite their move to the city.

10.5 Key findings

10.5.1 Environmental drivers can be recognised as a primary cause of migration in Bangladesh

Although many previous studies have stated that environmental drivers cannot be isolated from other migration drivers, this study found that environmental drivers could be a primary reason for migration due to river bank erosion. Local displacement due to river bank erosion or tropical cyclones had a direct effect on migration. The characteristics of different groups determined how vulnerable they were to these environmental issues. There was a statistically significant ($p<0.001$) relationship between environmental change and migration, and the data provides sufficient evidence to conclude that migration is driven by environmental drivers (chapter 7, section 7.8). Moreover, river bank erosion in Mehendiganj is highly dynamic. It has been found that the right bank of the lower Meghna was more susceptible than the left bank to erosion during the last 40 years. A remarkably high rate of erosion has occurred over time, particularly at the western end of the island of Mehendiganj. Local people have confirmed findings from satellite measurements showing that the intensity of erosion here has increased since 2004. The effect of the physical changes on both locally displaced and non-displaced households and their capacity to adapt to major life changes has been assessed. Erosion mostly affects small landowners, although large landowners can also be negatively affected However, its impact is generally severest among the landless and impoverished farmers who have the least capacity to recover from natural hazards (Hutton and Haque 2004). My study has found that many of those subject to river bank erosion have lost their land more than once. Some of these people suffer multiple displacements, become landless and struggle to remain in the local area, even if they wish to do so. The situation is very different in Gabura *union*, Shyamnagar, where people are still facing problems as salinity is increasing. The increases in salinity threaten their livelihood. Thus, migration continues from this sub-district, particularly seasonal migration (chapter 7, section 7.6.1).

In section 7.3, the analysis of census data showed that most of the coastal study areas experienced weaker annual population growth rates compared to the national average; Mehendiganj even shows negative annual growth. This demonstrates the experienced of out-migration in this region, which I ascribe to environmental change. This out migration was found to be higher in Mehendiganj and Shyamnagar than other sub-districts.

10.5.2 To what extent do people move short distances or long distances? Who moves and why?

This study confirmed that environmental change is more strongly linked to short distance migration. Long-distance moves are generally undertaken for financial (Henry et al., 2004) and social reasons, in particular where there is a pre-established migrant network (McLeman, 2011). For example, 90% and 100% of migrant respondents moved to Dhaka and Comilla respectively with the aid of social networks. Poor households are exposed to natural hazards due to their location and settlement pattern. The study found that there was a significant positive correlation between the distance at which respondents lived from the river and monthly household income (chapter 9, section 9.2). This study further indicated that cyclone shelter and market are far from poor household and most vulnerable settlements were found in high risk areas, far from cyclone shelters or markets. These results are consistent with the findings of previous studies (Brouwer et al., 2007; Akter and Mallick, 2013).

10.5.3 Why do some people migrate while others stay put though they face similar environmental problems?

The present study confirms previous findings and contributes additional evidence that suggests locally displaced and internal migrants are highly sensitive to environmental change in Bangladesh. The poor are the most vulnerable, because this group is forced to stay in high risk areas, due to several factors: 1) lack of economic affordability to be able to move to an urban area; 2) the hope of regaining land through *char* formation in the future (Hutton and Haque, 2004: 3) the emotional attachment of the rural people to their land, relatives, friends and their traditional culture; 4) a desire to continue traditional employment such as agriculture and fishing; 5) cheapness of land and cost of living; and 6) a desire not to move to slum conditions in urban areas. However, some are eventually forced to move further afield to these conditions in major cities such as Dhaka, Khulna, Barisal or Chittagong.

10.5.4 How do environmental drivers interact with other effects to create different forms of migration or influence the individual decision-making process during migration?

This study makes a clear distinction in migration decisions between those who were forced to stay, forced to move, or who moved voluntarily. Lack of financial and social assets is one of the major barriers in migration decision making. Changes to local natural resources were also an important factor, while both rapid and slow environmental changes cause societal stress. Migration of the vulnerable rural community can arise in three forms: seasonal, permanent or temporary migration. However, these types of migration are linked to social status. Middle class people cannot afford to buy land in a distant city, so they tend to buy land further inland, but in the general vicinity of their original homes. Thus both the poorest and the richest of people move to Dhaka or elsewhere as permanent migrants. However, higher class people live in the city with dignity, whereas poorer people become slum-dwellers. In line with findings from Schmidt-Verkerk (2011), the current study found recruiters are an important factor that plays a significant role in offering seasonal migration from southwest regions. Wage differences between rural and urban areas, in particular in the agricultural sector and industrial sector, is one of the important factors that influences the decisions of rural people to move to urban areas. This is consistent with the Ravenstein model (chapter 2, section 2.2).

The current study illustrated that the Government response is very important in recovering the situation post-disaster. A delayed response may directly lead to a drop in the affected people’s income. Thus, reduced income may be the most important factor that influences a migration decision (Perch-Nielsen et al., 2008). Although many people take the decision to move some people do not. They involve themselves in ‘food for work’ or ‘cash for work’ programmes provided by the government immediately after the natural disasters. Due to relief and different recovery schemes provided by the Government and NGOs, many households do not decide to move.

Age, gender and the skills of the individual also affect the migration decision-making process. Migration decisions can also depend on the perceived benefit of such action (Schmidt-verkerk, 2011). Many people in the middle classes (Group B) do not want to move to the city (see chapter 9, section 9.2), as they are emotionally attached to their land, relatives, friends and their traditional culture (chapter 9, section 9.3). The alternative is to live in a city that is overcrowded, polluted and noisy, often with a number of societal problems. Thus they do not like to move unless they are forced to.

10.5.5 Is migration the result of vulnerability or does it reduce vulnerability by increasing adaptive capacity?

Vulnerability indices for four affected rural *upazila*s including Shyamnagar, Mehendiganj, Tala and Sharankhola (chapter 7, section 7.8) and two urban areas Dhaka and Comilla (chapter 8, section 8.6) have been considered in this research. Although all four rural sub-districts experience substantial environmental events, exposure is highest in Mehendiganj and Shyamnagar. Mehendiganj is at high risk of river bank erosion, while Shyamnagar is affected by frequent natural disasters such as tropical cyclone and salinity intrusion. The average elevation above mean sea level in Shyamnagar is three metres, leaving it at risk of tidal surges and salinity intrusion. In this aspect Tala is located in a safer place. Shyamnagar illustrated the highest levels of sensitivity, while the sub-district of Tala showed the lowest level of sensitivity, due to rapid government response and less relief mis-distribution in this sub-district. Comparatively, Mehendiganj and Sharankhola are less sensitive than Shyamnagar but more than Tala. This study found that the highest level of seasonal and temporary migrations were from Shyamnagar. These temporary migrants were found in both short and long distances. Migration and remittance from migrant members plays a significant role in increasing adaptive capacity. However, the vulnerability score was highest in Shyamnagar in both scenarios, indicating that this sub-district is highly sensitivity to climate change (Table 7.3). The second most vulnerable sub-district was Mehendiganj. Although the majority of affected households displaced were found to not move far, because of a combination of factors relating to the social and economic advantages of re-establishing themselves locally, the present study found very few seasonal and temporary migrations from Tala and Mehendiganj, though there was some permanent migration. Overall, the most vulnerable and exposed sub-district to climate change was Shyamnagar. From the previous discussion, it is possible now to say that migration is the result of vulnerability. At the same time it reduces vulnerability via non-permanent migration (temporary and seasonal), as non-permanent migrants send remittance that increases a household's adaptive capacity (Figure 10.1).

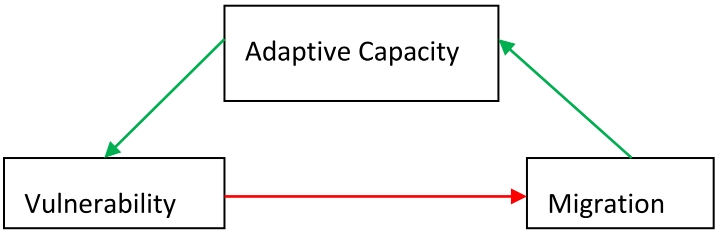

Figure 10.1: Migration is the result of vulnerability, and migration itself reduces vulnerability by increasing adaptive capacity (red indicates negative impact and green colour indicates positive impact).

10.5.6 What are the effects of migration on destination cities? What societal issues do rural migrants face in the city?

A range of experiences have emerged from the interviews in each city. Khulna faced short term displacements and seasonal migrations, as rural areas of the Khulna district are prone to cyclones. Barisal city, in contrast, faced permanent migration due to river bank erosion. The city also faced seasonal migration during the rainy season as the *char* are flooded during the monsoon. Lower class people from Barisal tend to move to big cities, especially to Dhaka, due to family and friend connections that allowed them to cope more easily with the new environment. Dhaka has experienced all types of migration - seasonal, temporary, and permanent for a long time. In contrast, migration to Comilla is a relatively new phenomenon. Seasonal and permanent migration has taken place only in the most recent decades. Due to migration the competition for public services, jobs, and the pressure on food prices house rents are increasing in Dhaka, whereas these issues are perceived to be manageable in Khulna, Barisal, and to a lesser extent, in Comilla.

Historically, people of the Barisal division have experience of conflict in occupying the *char* land. Khulna is an industrial city, so conflicts here tend to be due to salary pressures. Political conflict is common in Dhaka as it is the capital city of the country, and there tends to be conflict as parties change power. Moreover, in Dhaka job numbers are not increasing at a rate to match migration. By contrast, in Comilla, job opportunities are increasing, even though people are moving to the city. It is notable that beggars are decreasing in number here due to these job opportunities, and political conflict is perceived to be decreasing. As well as from political conflicts, there are also land conflicts, which are increasing in all the cities but particularly in Dhaka.

The findings of this research confirmed that poor migrants are the most vulnerable to floods and external shocks due to limited adaptive capacity, low level earning, limited access to resources, and their locations and settlement pattern. Comilla is less vulnerable overall than Dhaka; it is less sensitive and has higher adaptive capacity. It could therefore be a suitable destination for poor migrants.

10.6 The potential future for climate migrants in Bangladesh

Environmentally induced migration is an important environmental, social and political challenge within Bangladesh. At the moment people are largely migrating internally. Due to the rapid growth of the population, large cities, especially Dhaka, are facing severe social, economic and environmental problems. Thus internal migration may become less attractive in time. In the near future the displaced may try to cross the border into India, particularly from the southwest region of Bangladesh. The people of the south-western border districts of Bangladesh share a common culture with people in neighbouring India (Siddiqui and Sikder, 2009). This could encourage people to move to a neighbouring country as a safer region if extreme environmental change occurred in the future. There is, however, a high risk of violent conflict in this instance, as India is fencing the border to stop illegal migration from Bangladesh already (see also chapter 4, section 4.5). Another destination for internal migration could be the Chittagong hill tract of south-eastern Bangladesh as this region is free from flooding. But here there are possibilities of ethnic conflict being exacerbated, as the Bengali migrants clash with the residents of the receiving areas along socioeconomic, ethnic, religious, and national lines (Reuveny, 2007). This conflict and political instability may affect the internal security of the country. There is also the risk that international security will be affected by regional destabilisation around Bangladesh's borders (Ansorg and Thomas, 2008).

10.7 Recommendations and future research

Both national and local government institutions have a vital role to play, as do other stakeholders such as NGOs, civil society and development partners (Walsham, 2010). Two important recommendations are – 1) minimizing forced migration and protecting the displaced 2) supporting planned and well-managed migration as adaptation which will seek to maximize the benefits of human mobility by expanding the benefits which can pass from those who migrate back to those individuals remaining in the region of environmental vulnerability (Walsham, 2010). This type of planned migration can reduce the chance of later humanitarian emergencies and displacement (Foresight, 2011). "Reduced options for migration, combined with incomes threatened by environmental change, mean that people are likely to migrate in illegal, irregular, unsafe exploited or unplanned ways. People are also likely to find themselves migrating to areas of high environmental risk, such as low-lying urban areas in mega-deltas or slum in water-insecure expanding cities" (Foresight, 2011: 13).

As it was found in Dhaka, jobs are not increasing at a rate to match migration, increasing societal crisis; and due to increased environmental risk, these processes could exacerbate cities' current adaptation deficit (Adam et al., 2012). While voluntary migration plays a significant role in enhancing the adaptive capacity of origin areas, over time voluntary population flows will adjust the balance between rural and urban areas in the context of adaptation opportunity. One can envisage a tipping point which migrant inflows to urban areas become unsustainable or even detrimental to these destination areas, particularly without planning. Thus, there will be a threshold that if crossed would mean that migration no longer is effective as an adaptive option for both receiving and source areas. However, the current thesis does not say where the threshold point is. Future research may address the point. Thus a suitable policy for domestic migration is to identify the threshold point of migration from vulnerable areas to inform sustainable progress. At the same time, it requires the attention of planners so that the poor migrants may choose a suitable city and receive maximum benefit. Some of the recommendations are given below.

10.7.1 Assistance from institutions

- Although cyclone and disaster preparedness training programs exist in cyclone prone areas, the study of Mahmud and Prowse (2012) found that only 14 percent and 20 percent of households respectively attended training before and after tropical cyclone Aila. People should be encouraged to attend training at least twice a year, before or at the beginning of the post-monsoon and pre-monsoon seasons, as these two periods are sensitive to cyclones. This can help reduce unplanned and forced migration.

- Awareness at the community level is essential to promote and adapt to both sudden and slow onset changes using coping experience, knowledge and local wisdom. In this research, I found many respondents used local wisdom passed down from elders and neighbours. However, this local wisdom was not used by all affected people, as different people used different forms of knowledge and practices one community could benefit others and vice versa. Thus, it is essential to gather all types of knowledge into one frame. NGOs and the Government should come forward to compile all individual local wisdom from coastal communities in a frame and disseminate this to these communities in order to increase adaptive capacity.

- It is essential to create a government level strategy plan for the aftermath of sudden onset events, such as tropical cyclones or floods, so that vulnerable communities can recover as soon as possible. In contrast, a rural development and adaptation policy is required to adapt to slow onset events such as providing saline-tolerant crops and plantations, or flood water tolerant crops.
- Policy makers need to pay extra attention to the extreme poor. It is essential to give assistance to group A (chapter 9, section 9.2) in rural areas during or even after cyclones. They should be given training on how to cope with the situation.

- The Bangladesh Red Crescent society provides a number of training schemes to volunteers under the Cyclone Preparedness Program (CPP) to rescue affected people. This programme also implements public awareness activities.

But the CPP does not cover the reasons why many people cannot take shelter, why people do not respond to warnings and how to encourage people to go to shelters. Thus, in terms of responding to warnings and not reaching or going to shelters, the present study identified ten reasons (see the chapter 7, section 7.2.5). Based on these reasons the CPP or any local NGO can provide some training and encourage those communities who are prone to tropical cyclones. They can include these with their existing activities or update their activities to include some of the following; distributing leaflets, booklets at the household level, posters, publicity campaigning, cyclone drills and demonstrations, staging drama and film and video shows programmes in affected area. At the same time, early warning systems, increasing the provision of cyclone shelters and evacuation plans should be improved by the Government.

- Affected rural areas and local migration destinations also need to be improved so that migration further afield can be minimized. The government may facilitate the role of migration as an adaptation strategy to environmental change (Walsham, 2010). For example, this could involve building up non-permanent migration such as seasonal, temporary and circular migration schemes for the environmentally vulnerable and strengthen the developmental benefit of such migration for affected rural communities (Walsham, 2010).

- Despite the continuing and widespread impact of riverine hazards in Bangladesh, a comprehensive public policy strategy on river-bank erosion management, prevention and migration issues has yet to be developed (Hutton and Haque, 2004; Chowdhury, 2000; Haque, 1994). However, a joint Bangladesh-German project has been instigated to protect riverbanks at a cost estimated to be US$ 2.5M per km (German Embassy Dhaka, 2014). If this proceeds it will help to reduce the impact of a major environmental problem in Bangladesh.

- Poor vulnerable people who move in search of a job often risk low wages, insecure working environments and inadequate housing services and infrastructure (SCMR, 2013). If supported properly, this form of migration could be beneficial for these people (SCMR, 2013). For example, in considering migrating to the city, potential migrants can be provided with knowledge about destinations and possible local solutions. They should be given the training and skills to build a more secure livelihood. Small scale technology for this group is needed to protect their infrastructure. In this respect, household, community and national level strategies could reduce the vulnerability of affected areas.

- Unlike Dhaka, due to fewer socio-economic disadvantages such as traffic congestion, crime, unemployment and water access issues, medium sized city Comilla is easier to control and thus more manageable. Following from this, provided it is well managed and has a comprehensive policy on urbanization and planning, medium sized cities could be a more suitable destination for poor migrants; in particular those who are environmentally affected in coastal rural areas in Bangladesh, which at the same time would lessen the population burden and societal crisis in mega cities, such as Dhaka. Therefore, medium sized cities require the attention of planners, particularly in developing countries that face environmental induced migration.

10.7.2 Document of migration

Although currently records of international migration and internal migration are not available in Bangladesh (explained in chapter 3, section 3.6), I recommend recording four different forms of migration in future censuses: permanent, temporary, seasonal and return migration. This documentation should be at *union* level rather than sub-district level, because the current study found that many poor households are displaced locally within the sub-district.

10.7.3 Future research

- Migration process is not homogeneous, and different forms of migration should be considered when linked to land use change (Bell et al., 2010). Although currently records of different forms of migration, especially domestic migration are not available in Bangladesh (explained in chapter 3, section 3.6), I recommend recording four different forms of migration in future censuses: permanent, temporary, seasonal and return migration. This documentation should be at *union* level rather than sub-district level, because the current study found that many poor households are displaced locally within the sub-district. This record could be useful for researchers and policy makers to understand and analyse vulnerability and environmentally induced migration as well as creating a vulnerability index. One reason for this is that growing migration from rural to urban areas can be a sign of weak rural resilience and a lower coping capacity, and thus higher vulnerability (Vincent, 2004). On the other hand, different forms of migration have insightful impacts on increasing adaptive capacity. For example, permanent migration could reduce competition for resources, temporary and seasonal migration could be useful for increasing adaptive capacity and return migration could be useful since they bring technology, skills and knowledge. Meanwhile, return migration will increase resource competition. This record could be helpful to create *union* level vulnerability index (VI) after every census. The new VI could then be compared with the baseline VI. This difference could be useful for policy makers to know the current condition at the local level. Moreover, with the help of census data and using qualitative methods together could be useful to understand and analyse environmentally induced migration at the local level. This record could also be used to create a vulnerability index at *union* level between migrant and non-migrant households. However, there should be some limitations as household vulnerability is more dynamic.

- Research into establishing a social vulnerability index for the whole coastal region of the country is needed, in order to identity the vulnerable communities for both rapid environmental change and slow-onset events. Forming a vulnerability index for all coastal sub-districts, and maintaining it over time, could be very effective. The result could be displayed using GIS.

- Poverty plays a significant role in forcing victims to move. However, the relationship between economic and environmental migrants is complex and largely depends on resource availability, in combination with their socio-economic and environmental context. Though it has been discussed in this thesis, more research is needed to examine poverty and its relation to environmental change in Bangladesh. In figure 10.2, I propose the following model to illustrate the nexus of environmental change-migration and poverty. Since the current research found difficulties with regard to selecting variables. From this model environmental change could be the independent variable, and its effect on migration as a dependent variable. In this case, poverty driven migration could be the control variable.

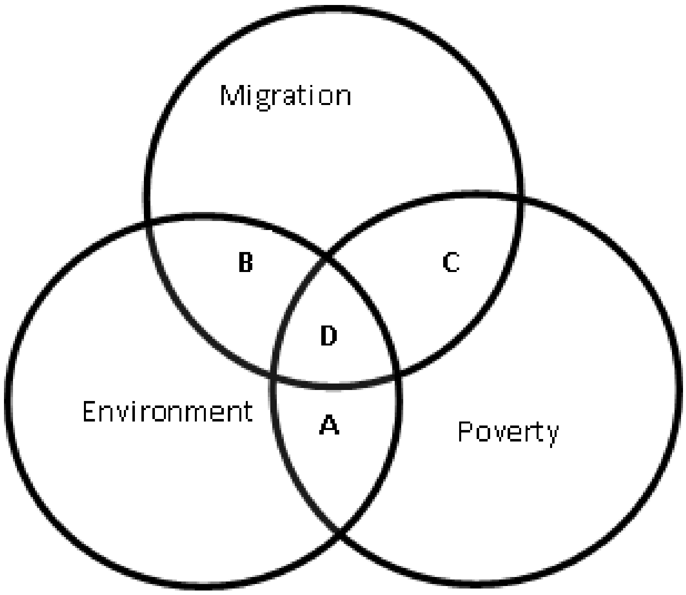

Figure 10.2: Various types of migration from rural vulnerable areas (origin)

A: Those forced not to migrate

B: Environmentally motivated migration

C: Poverty induced traditional rural-urban migration

D: Environmentally forced migration

This model will aid categorisation of migration pattern and processes, and the role of environmentally motivated migration in poverty reduction that will build resilience of impacted areas and increase adaptive capacity. In this regard using following model would be useful (Figure 10.3).

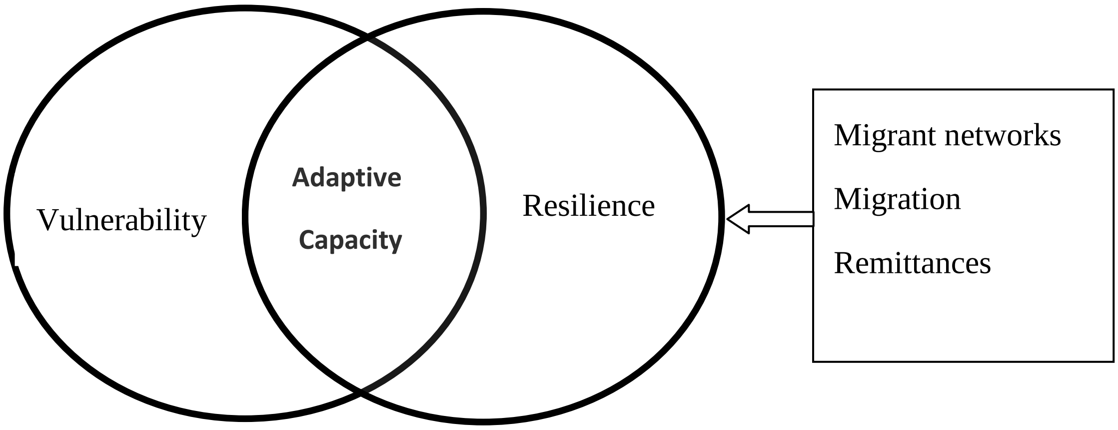

Figure 10.3: Environmental induced migration in resilience building

Although the study focuses on migration as a result of vulnerability to environmental change, it also contributes to discussions on the contribution of migration to reduce vulnerability. This is empirically substantiated by using the coping experiences of some respondents and an innovative vulnerability index. The study does not, however, discuss how vulnerable people spent remittance money on their needs, or how remittance finances contribute to local economies. Future research should, therefore, concentrate on investigating this impact on local migration. This could be helpful in considering a poverty reduction policy and building resilience. Thus, my future research will focus on migration process and its role in building resilience in the context of environmental change.

10.8 Final word

“If our house burnt, then the land will still be there but if it is engulfed by the river the land will just disappear. Nothing will be left.” This statement from an respondent shows the vulnerability of the riverine community of Bangladesh. The present study attempts a holistic approach to understanding this community. Returning to the hypothesis posed at the beginning of this study, poor people migrate short distances (locally) rather than long distances. Environmental change is more strongly related to short distance migration. Long-distance moves are generally affected by other drivers while environmental drivers are secondary or background drivers in this case. Migration is the result of vulnerability, while it also reduces vulnerability by building adaptive capacity. Positive and negative effects of migration to cities have been explored. The findings of the study have a number of important implications for future practices. Overall, I hope that the findings of this research will encourage future researchers from social science, economics, political science, and environmental science to work to integrate climate and social-environmental change, and the response of the Bangladeshi community to it through internal and external migration.

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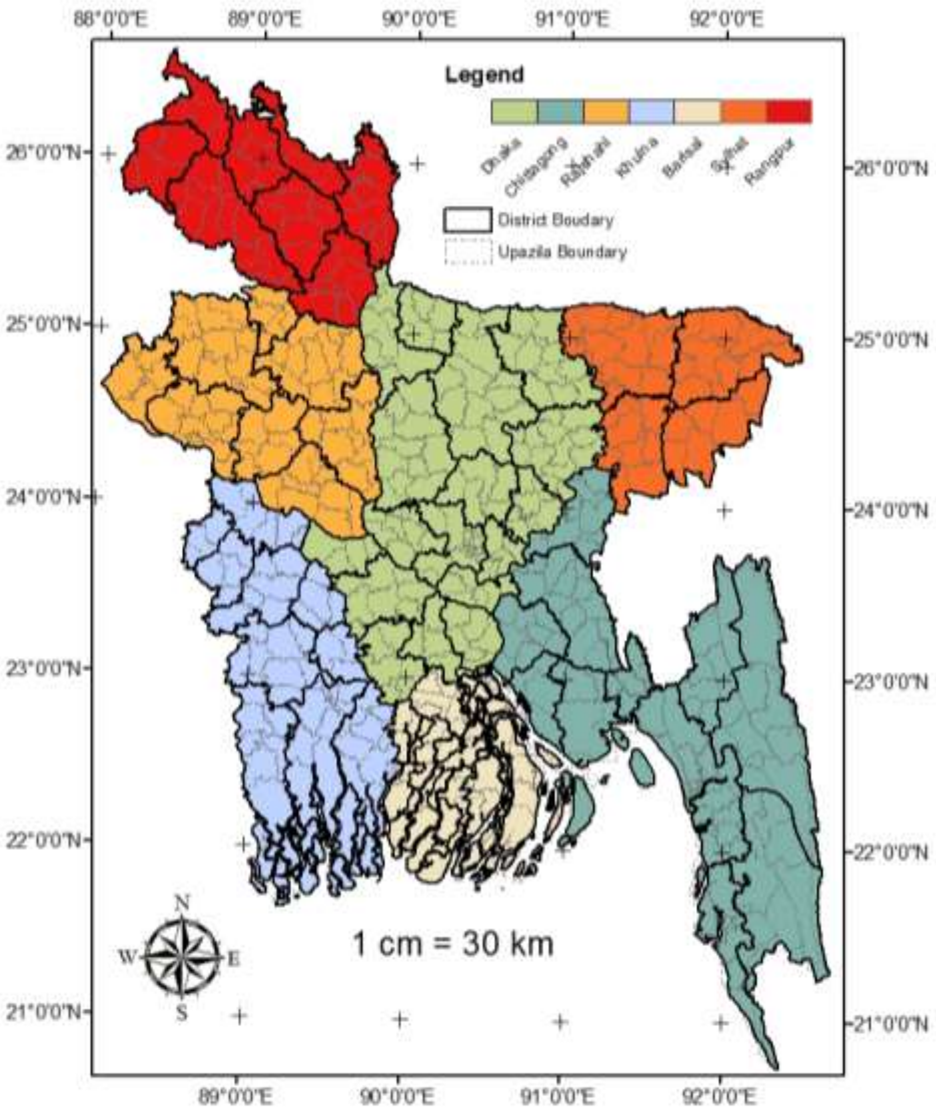
12. Appendix

Appendix 1: Administrative division of Bangladesh

Bangladesh is divided into seven administrative divisions. Each Division is further subdivided into districts. There are sixty-four districts in Bangladesh, and again each district is subdivided into *Upazila* or Thana and each *upazila* is again subdivided into *Union*s. Each *union* consists of several villages.

In this study the intermediate-sized administrative area of an *upazila* has been considered, to show the impacts on an extended community about the size of the hinterland of a typical market town, rather than focusing on individual villages alone



Appendix 2: Regional divisions

Bangladesh is split into seven regions determined by the physiography of the country and its response to the general climatic patterns discussed below.

1. Northwest Region: This is located near the foothills of the Himalayas and is part of the contiguous plain of west Bengal; the Gangetic plain lies to its west. It is relatively dry, with the shortest duration of the summer monsoon, the fewest rain days and the least amount of seasonal rainfall.
2. Northeast Region: This is located near the foothills of the Meghalaya Plateau, which adds an orographic effect to the monsoon rainfall.
3. Western central: This region is the hottest and driest region of Bangladesh, consisting of the Barind Tract, and the Atrai and Ganges flood plains.
4. Middle Zone: This is the central part of the country and consists of low-lying parts of the flood plains of the Ganges, Atrai, Brahmaputra-Jamuna, Old Brahmaputra, and Meghna rivers. High temperature and heavy monsoon rainfall is characteristic of the zone.
5. Southeast Region: This is located near the Bay of Bengal. The zone is the entry and exit point of the Bay of Bengal Branch of the South Asian Monsoon (Spate and Learmonth, 1984; Ahmed and Karmaker, 1993; as noted by Ahmed and Kim, 2003). The only extensive hill area in Bangladesh lies in this region, bordering Burma on the southeast. It is relatively wet, with the longest duration of the summer monsoon. High humidity, heavy rainfall and small temperature variation between day and night are characteristics of the region.
6. Southwest Region: This forms part of the Ganges delta and contains the Sundarbans forest. It is relatively dry and the lowest seasonal rainfall for the country is a characteristic of this region.
7. Coastal central and Island: This is within the Meghna estuary. It is relatively wet, and has the longest duration of the summer monsoon. It has a similar climate to the southeast region.

Appendix 3: Classification of cyclones

Table: Classification of cyclones (sources: BMD)

Classification	Pressure Drop (mb)	Max wind speed (km/hour)
Depression (D)	2-4	40-51
Deep Depression (DD)	4-6	52-61
Cyclonic storm (CS)	6-12	62-88
Severe Cyclonic storm (SCS)	12-21	89-117
Severe Cyclonic storm with a core of Hurricane winds	≥21	118

Appendix 4: Questionnaire

Common profile for all types of respondents

Name:

District/*Upazila/ Union*/Village (Address):

- Sex:
- Age:
- Occupation:
- Family size
- Religion:
- Social status: Lower class/middle class/upper class/above or below poverty
- Land/ Landless:
- House: owner/rented/homeless
- Income/wages

Common question for all types of respondents

- Could you tell about your house quality? (or observe myself)
- Are you satisfied with your income? Can you save any money?
- What about your employment status? Do you have any employed/unemployed or self-employed family members? (sources of income, job found after arrival in city, skilled/non-skilled)
- Can you afford to buy food and other necessary things?
- Do you have any access to financial services (loan with interest/ without interest)
- Do you get social support?

- Do you have services like electricity/water/gas? If yes, do you face any problems? If not how do you manage?
- Are there any problems in your current places? Have you faced any environmental problem like salinity intrusion, river bank erosion, cyclone, flood (rural); flood and water logging (urban) (e.g: recent decade).
- Have you faced or observed conflict in your life? What types (eg: political)
- Is there a conflict of resources for crop land/water/ shelter/ job/land occupied
- Is crime and violence increasing? What types and why?

Migrant

- Why did you move here? How did you come (example, social network)? (Types of migration- permanently/temporary/seasonal migration)
- Did you face any environmental problems that influenced you taking the decision to move? What types of environmental problem did you faced?
- Do you know anybody who moved like you? why? how? have any of your family members/relatives/neighbours/friends moved due to environmental events?
- What types of migration (permanently/temporary/seasonal)?
- Do you send remittance to support your family? How often?
- Are you planning to move from your current place? Why are you planning further moving?

Community who receives migrants (Non Migrant)

- How is your experiencing migrant people? Where are they coming from?
- Are there any differences in attitude towards different regions?
- Are you experiencing/facing any problem living with migrants? What types of problems?

- Are you benefitting from migrants? How? If not, why and how?

<u>Who might move (Did not Move)</u>

- Do you face any environmental problems in this area?
- Are you planning to move because of environmental problems? If yes, where would you like to move? Why? (What types, temporary, seasonal or permanently?) If not, why do you not plan to migrate?
- Did you move before? If yes, why and when? Or do you know anybody who moved? If yes, why and when? What is the reason?
- Have any of your family members/relatives/neighbours/friends moved due to environmental problems? Or any other problems? (What types, temporary, seasonal or permanently?)? Do you have anybody elsewhere to use as social a network for moving?
- Where did they move? Why did they choose the place? Are they facing any problem in their new places?
- Do your family members send remittances? How often? How do your family use this money? Have your family improved their living conditions? If yes, how much?
- Do you get social support, especially during disasters? (NGO, GO and community) Did you use local knowledge/local wisdom for support during the disaster);
- Have you faced any relief mis-distribution?)
- Have you received cyclone warning access? Have you believed the cyclone warning?
- Could you afford to buy food and other necessary things during the disaster? How did you survive (e.g: selling assets).

Appendix 5(a-d): Environmental event impact on four rural study areas

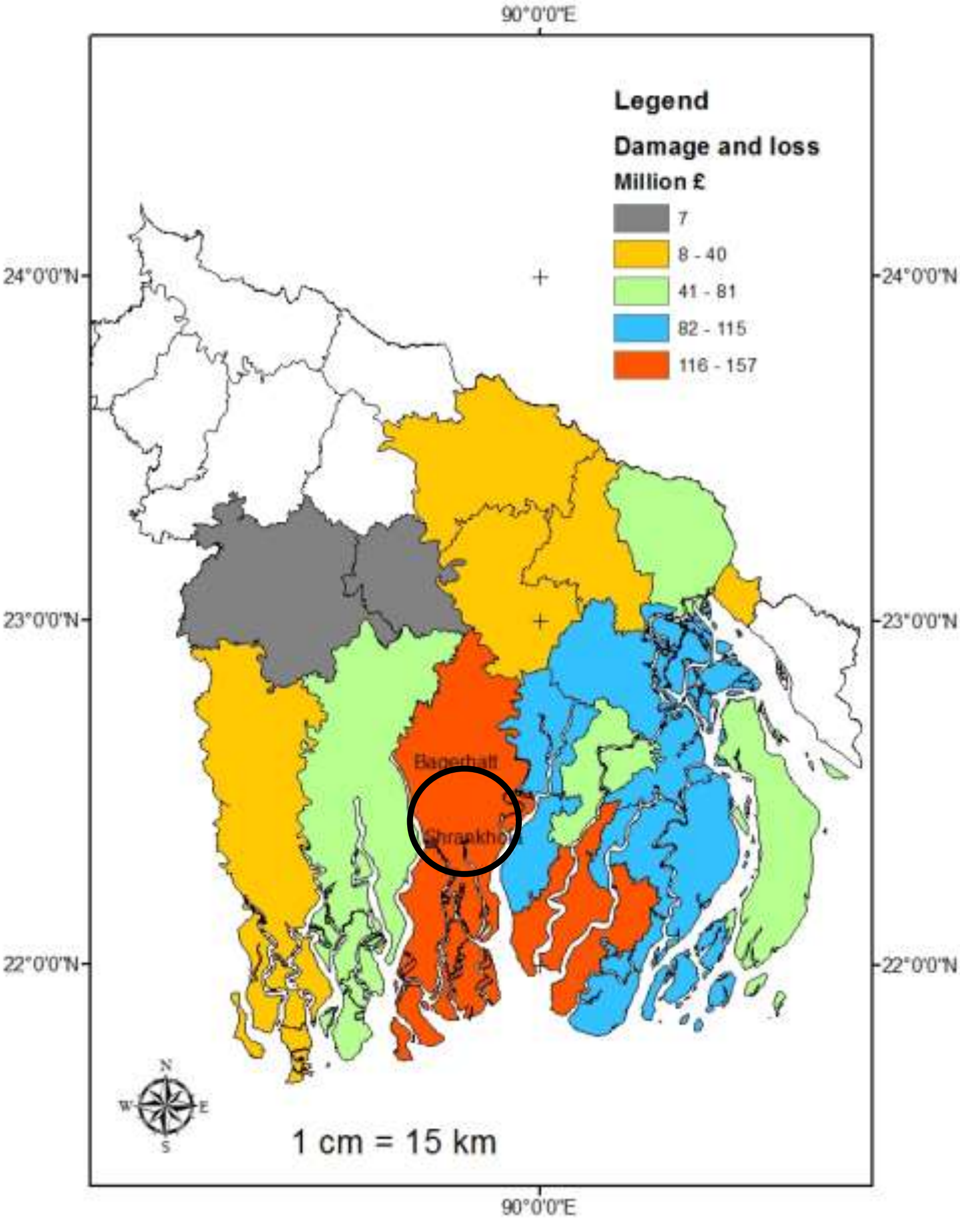


Figure 5(a): Damage and loss by district, following tropical cyclone Sidr 2007 (black circle shows the study area) [Map was created from the data sources from the joint team of Bangladesh Government, EC and World Bank, 2008].

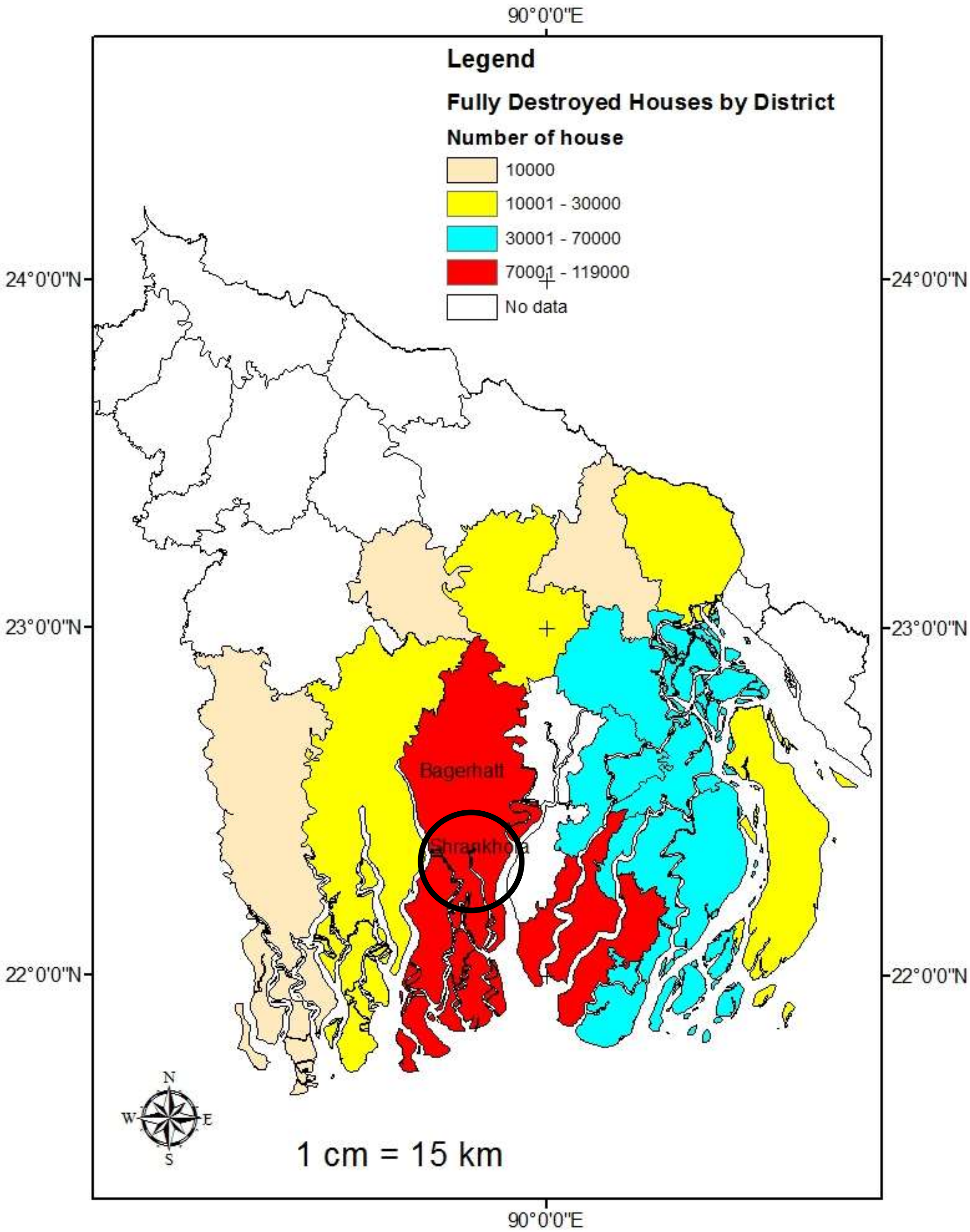


Figure 5(b): Number of houses destroyed by district, following tropical cyclone Sidr 2007 (black circle shows the study area) [map was created from data sources Bangladesh Government, EC and World Bank, 2008].

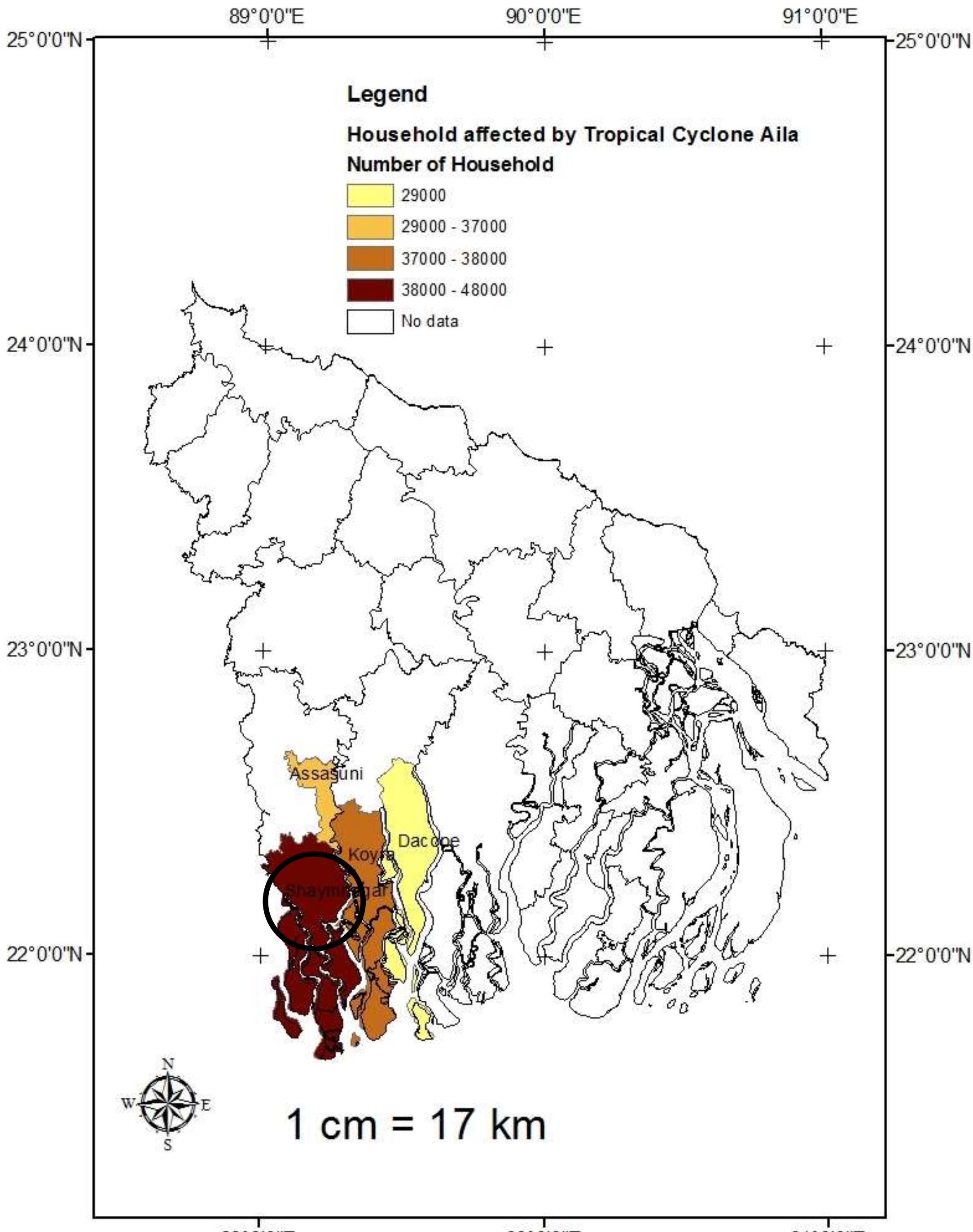


Figure 5(c): Number of Household affected by sub-district, following tropical cyclone Aila 2009 (black circle shows the study area) [map was created from the data sources UN, (2010)]

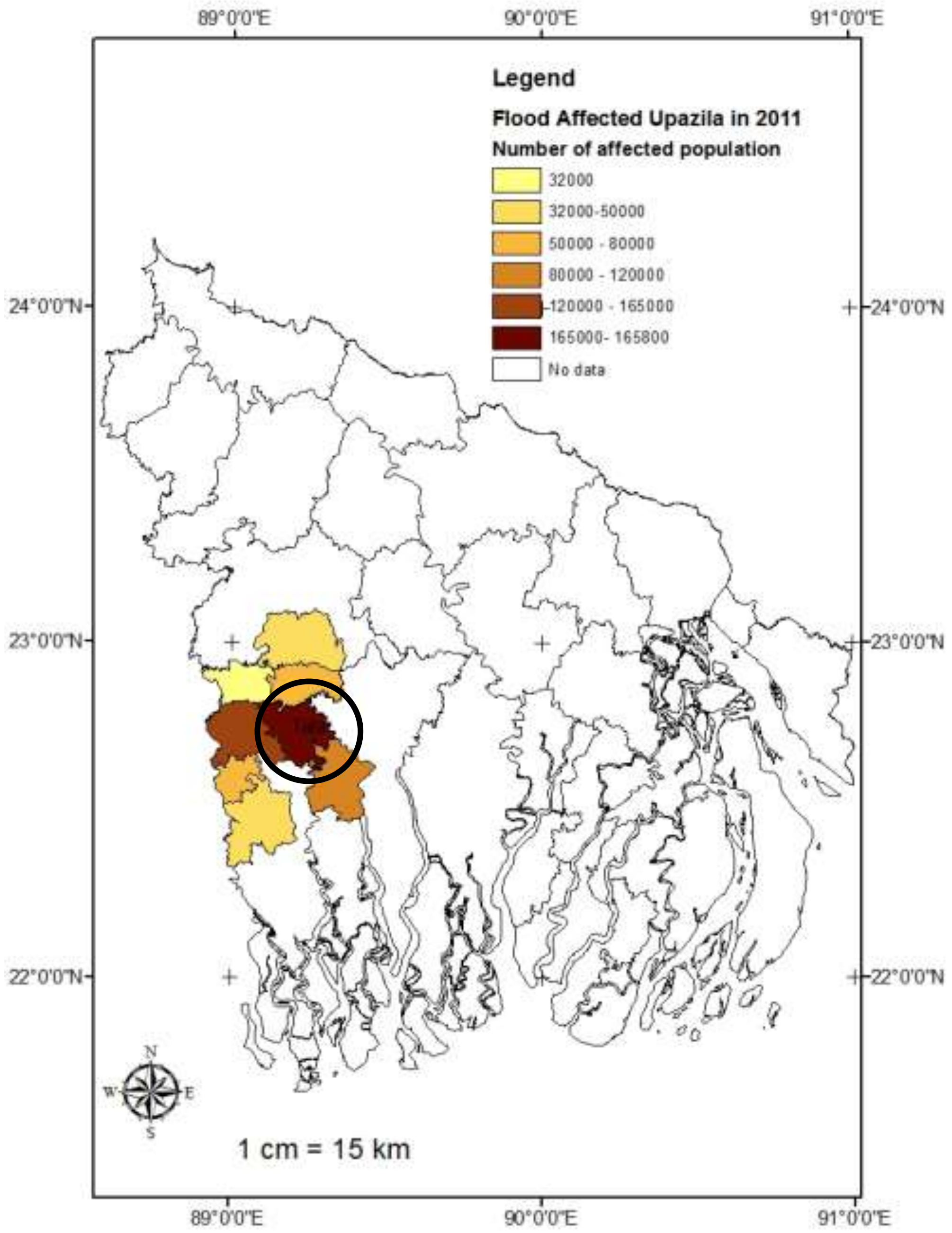


Figure 5(d): Number of people affected, by sub-district, after flash flood (black circle shows the study area) (data source: ACAPS, 2011).

Appendix 6(a): Calculation of vulnerability index.

	Dimension	Driver		Indicators
VI =E+S(1-AC)	AC = (Demographic+ Social+ Physical+ Economic)/4	Demographic = (A1+A2+A3)/3	A1	Population between 15 and 59 years of age (a)
			A2	Employed women
			A3	Number of seasonal and temporary migrants
		Social = (A4+A5+A6+A7)/4	A4	Household with social network
			A5	Household with social support
			A6	Literacy rate (a)
			A7	People using traditional knowledge from elder and neighbour
		Physical = (A8+A9)/2	A8	House of ownership
			A9	Household with access to information before the disaster

	Dimension	Driver		Indicators
		Economic = (A9+A10+A11)/3	A9	Credit access without interest
			A10	Remittance from migrant family
			A11	Daily wages
	S	Demographic		Density of population (a)
				Female population (a)
				Disabled population (a)
				Widowed/divorced/separated female (a)
		Social		Household reporting water conflict
		Physical		Vulnerable household
				Household without access to water
				Household without electricity connection

	Dimension	Driver	Indicators
		Economic	People reporting high interest credit
			Unemployed male
			In poverty
			Household forced to sell asset during and post disaster period
			Household not able to buy food due to price increase in post-disaster
			Income coming from natural resources
		Political	People reporting about relief mis-distribution
			People reporting land conflict (*char*-occupied)
	E	Environmental	Number of cyclones and storm surges, floods, river bank erosion in last 10 years
			Household not receiving cyclone warning

	Dimension	Driver	Indicators
			People reporting increasing salinity
			Elevation from sea level (b)
			Mean standard deviation of mean monthly temperature (c)
			Mean standard deviation of mean monthly rainfall (c)

(a) BBS = Bangladesh Bureau of Statistics (b) GMET = Global Multi-Resolution Terrain Elevation (c) BBD = Bangladesh Meteorological Department.

Similarly, repeat for sensitivity and exposure (please see also appendix 6b)

Appendix 6(b): Calculating vulnerability Index for Dhaka (Technique adapted from Hahn et al., 2009).

Indicators	Indicator values for Dhaka	Max indicator values for Dhaka	Min indicator values for Dhaka	Index value for Dhaka	Demographic driver values for Dhaka
Percentage of the migrant whose age between 15 and 59 (D_1)	91.00	100.00	0.00	0.91	0.47
Percentage of the Employed migrant women D_2	1.00	100.00	0.00	0.01	
International migration, D_3	0.25	0.50	0.02	0.48	

Step 1 (repeat for all indicators): $Index_{D_1\,(Dhaka)} = \frac{91-0}{100-0} = 0.91$

Step 2 (repeat for all drivers):

$$Index_{Demgraphic\,(Dhaka)} = \frac{D_{1\,Dhaka} + D_{2\,Dhaka} + D_{3\,Dhaka}}{3} = \frac{0.91 + 0.01 + 0.48}{3} = 0.47$$

Step 3 (repeat for all for Dimensions): (Adaptive capacity, sensitivity and exposure)

$$Index_{AC\,(Dhaka)} = \frac{(0.47)(3) + (0.28)(4) + (0.62)(2)}{3 + 4 + 2} = 0.42$$

Step 4 (repeat for all study area's overall vulnerability):

$$Index_{Vulnerability\,(Dhaka)} = \frac{S + E + (1 - AC)}{3} = \frac{0.74 + 0.58 + (1 - 0.42)}{3} = 0.63$$

AC = Adaptive capacity; S =sensitivity; E= Exposure

Appendix 7(a): Research ethics application form.

The University Of Sheffield.

University Research Ethics Application Form for Staff and PGRs

This form has been approved by the University Research Ethics Committee (UREC)

Date:	October 2010
Name of applicant:	Mohammad Shohrab Hossain Sarker
Research project title:	**Environmental change and its impact on migration in Bangladesh**

Complete this form if you are a **member of staff or a postgraduate research student** who plans to undertake a research project which requires ethics approval via the University Ethics Review Procedure. [x]

or

Complete this form if you plan to submit a **'generic' research ethics application (i.e. an application** that will cover several sufficiently similar research projects). Information on the 'generic' route is at: www.sheffield.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/review-procedure/generic-research-projects [ ]

If you are an undergraduate or a postgraduate-taught student, this is the wrong form.

PLEASE NOTE THAT YOUR DEPARTMENT MAY USE A VARIATION OF THIS FORM: PLEASE CHECK WITH THE ETHICS ADMINISTRATOR IN YOUR DEPARTMENT

This form should be accompanied, where appropriate, by all Information Sheets/Covering Letters/Written Scripts which you propose to use to inform the prospective participants about the proposed research, and/or by a Consent Form where you need to use one.

Further guidance on how to apply is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/review-procedure

Guidance on the possible routes for obtaining ethics approval (i.e. on the University Ethics Review Procedure, the NHS procedure and the Social Care Research Ethics Committee, and the Alternative procedure) is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/ethics-approval

Once you have completed this research ethics application form in full, and other documents where appropriate, check that your name, the title of your research project and the date is contained in the footer of each page and email it to the Ethics Administrator of your academic department. Please note that the original signed and dated version of 'Part B' of the application form should also be provided to the Ethics Administrator in hard copy. Ethics Administrators are listed at:
www.shef.ac.uk/polopoly_fs/1.99105!/file/Ethics-Administrators.pdf

I confirm that I have read the current version of the University of Sheffield 'Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue', as shown on the University's research ethics website at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy [x]

* If you have marked boxes marked * then you also need to obtain confirmation that appropriate University insurance is in place. The procedure for doing so is entirely by email. Please send an email addressed to insurance@shef.ac.uk and request a copy of the 'Clinical Trial Insurance Application Form'.

It is recommended that you familiarise yourself with the University's Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue before completing the following questions. Please note that if you provide sufficient information about the research (what you intend to do, how it will be carried out and how you intend to minimise any risks), this will help the ethics reviewers to make an informed judgement quickly without having to ask for further details.

A5. Briefly summarise:

i. The project's aims and objectives:
(this must be in language comprehensible to a lay person)

The overarching goal of the study is to provide a comprehensive understanding of the role of environmental change in causing migration and its relation to societal consequences.

ii. The project's methodology:
(this must be in language comprehensible to a lay person)

The research carried out through a standardized, open-ended interview (face to face interview) and some focus group interviews and questionnaire survey to determine the reaction of the three categories of people: firstly, those who might be displaced and be forced to migrate; secondly, migrant people who have already migrated to the central part of the country as a destination due to job availability, food security and other resources; thirdly, the communities that receive them.

A6. What is the potential for physical and/or psychological harm/distress to participants?

There are safety issues in slums and also in Shymnager *Upazila* (a sub-district in southwest region).

A7. Does your research raise any issues of personal safety for you or other researchers involved in the project? (especially if taking place outside working hours or off University premises)

Yes.

If yes, explain how these issues will be managed.

All work in the field has been conducted in full compliance with the University's Ethics and Risk regulations. However, there are some suggestions for future researchers studying similar topics.

1. Inform the local administration before going to selected sub-districts.
2. Involvement of the local NGO would be beneficial.

A8. How will the potential participants in the project be:

i. Identified?

I identified the areas I wanted to study because they were the most vulnerable to environmental change. People from these areas were also more likely to move to central regions.

ii. Approached?

Different types of sampling methods were carried out for collecting data in both rural and urban areas. Both probability and non-probability sampling methods were chosen in collecting survey data such as individual or household interviews and focus group interviews. Cluster random probability sampling method was chosen for both rural areas and slum areas in the city. Non-probability sampling methods such as snowballing, purposive and convenience methods were chosen in urban areas

A12. Will the research involve the production of recorded media such as audio and/or video recordings?

YES [x] NO [ ]

A12.1. This question is only applicable if you are planning to produce recorded media:

How will you ensure that there is a clear agreement with participants as to how these recorded media may be stored, used and (if appropriate) destroyed?

The taping of interviews and the photographing of participants will only be done with the agreement of the relevant parties.

Guidance on a range of ethical issues, including safety and well-being, consent and anonymity, confidentiality and data protection are available at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/policy-notes

University Research Ethics Application Form - Part B - The Signed Declaration

Title of Research Project:

Environmental change and its impact on migration in Bangladesh

I confirm my responsibility to deliver the research project in accordance with the University of Sheffield's policies and procedures, which include the University's *'Financial Regulations'*, *'Good Research Practice Standards'* and the *'Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue'* (Ethics Policy) and, where externally funded, with the terms and conditions of the research funder.

In signing this research ethics application form I am also confirming that:

- The form is accurate to the best of my knowledge and belief.
- The project will abide by the University's Ethics Policy.
- There is no potential material interest that may, or may appear to, impair the independence and objectivity of researchers conducting this project.
- Subject to the research being approved, I undertake to adhere to the project protocol without unagreed deviation and to comply with any conditions set out in the letter from the University ethics reviewers notifying me of this.
- I undertake to inform the ethics reviewers of significant changes to the protocol (by contacting my academic department's Ethics Administrator in the first instance).
- I am aware of my responsibility to be up to date and comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data, including the need to register when necessary with the appropriate Data Protection Officer (within the University the Data Protection Officer is based in CiCS).
- I understand that the project, including research records and data, may be subject to inspection for audit purposes, if required in future.
- I understand that personal data about me as a researcher in this form will be held by those involved in the ethics review procedure (e.g. the Ethics Administrator and/or ethics reviewers) and that this will be managed according to Data Protection Act principles.
- If this is an application for a 'generic' project, all the individual projects that fit under the generic project are compatible with this application.
- **I understand that this project cannot be submitted for ethics approval in more than one department, and that if I wish to appeal against the decision made, this must be done through the original department.**

Name of the Principal Investigator (or the name of the Supervisor if this is a postgraduate researcher project):

Professor Grant Bigg

If this is a postgraduate researcher project, insert the student's name here:

Mohammad Shohrab Hossain Sarker

Signature of Principal Investigator (or the Supervisor):

Date: 18 May 2015

Email the completed application form and provide a signed, hard copy of 'Part B' to the Ethics Administrator (also enclose, if relevant, other documents).

Appendix 7(b): Letter from Supervisor.

The University Of Sheffield.

Department Of Geography.

Head of Department
Professor Grant Bigg

Department of Geography
The University of Sheffield
Winter Street
SHEFFIELD
S10 2TN

Telephone: +44 (0) 114 222 7905
Secretary: +44 (0) 114 222 3601
Fax: +44 (0) 114 279 7912
Email: grant.bigg@sheffield.ac.uk

5 May 2011

To whom it may concern

Mr. Mohammad Shohrab Hossain Sarker, my PhD student, has been awarded a postgraduate fieldwork award to carry out field surveys in Bangladesh as an important part of his research work. This will take several weeks, from late August through September 2011.

Should you need further information about Mr.Sarker, please do not hesitate to contact me.

Yours faithfully,

Professor Grant R. Bigg

Appendix 8: Tropical cyclone regression model results.

```
> summary(model_annual)

Call:
lm(formula = Freq ~ Year, data = cyclones_annual)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.9587 -2.3361  0.7124  1.8283  5.2009 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 340.22307   93.68271   3.632 0.000973 ***
Year         -0.16730    0.04706  -3.555 0.001200 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.692 on 32 degrees of freedom
Multiple R-squared:  0.2831,	Adjusted R-squared:  0.2607 
F-statistic: 12.64 on 1 and 32 DF,  p-value: 0.0012


> summary(model_premonsoon)

Call:
lm(formula = Freq ~ Year, data = cyclones[cyclones$Season == 
    "Pre.Monsoon", ])

Residuals:
     Min       1Q   Median       3Q      Max 
-1.20000 -0.75882 -0.02941  0.15000  1.82353 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -22.38824   29.18866  -0.767    0.449
Year          0.01176    0.01466   0.802    0.428

Residual standard error: 0.8389 on 32 degrees of freedom
Multiple R-squared:  0.01972,	Adjusted R-squared:  -0.01092 
F-statistic: 0.6437 on 1 and 32 DF,  p-value: 0.4283


> summary(model_monsoon)

Call:
lm(formula = Freq ~ Year, data = cyclones[cyclones$Season == 
    "Monsoon", ])

Residuals:
    Min      1Q  Median      3Q     Max 
-3.1059 -1.6559 -0.3647  1.1588  4.8118 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)  
(Intercept) 143.15294   74.69440   1.917   0.0643 .
Year         -0.07059    0.03752  -1.881   0.0691 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.147 on 32 degrees of freedom
Multiple R-squared:  0.09957,	Adjusted R-squared:  0.07143 
F-statistic: 3.539 on 1 and 32 DF,  p-value: 0.06908
```

```
> summary(model_postmonsoon)

Call:
lm(formula = Freq ~ Year, data = cyclones[cyclones$Season ==
    "Post.Monsoon", ])

Residuals:
    Min      1Q  Median      3Q     Max
-3.5233 -1.2240  0.1895  1.2021  2.4851

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 182.55157   52.53217   3.475  0.00149 **
Year         -0.09015    0.02639  -3.416  0.00175 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.51 on 32 degrees of freedom
Multiple R-squared:  0.2672,	Adjusted R-squared:  0.2443
F-statistic: 11.67 on 1 and 32 DF,  p-value: 0.001748


> summary(model_winter)

Call:
lm(formula = Freq ~ Year, data = cyclones[cyclones$Season ==
    "Winter", ])

Residuals:
    Min      1Q  Median      3Q     Max
-0.5613 -0.4830 -0.4046  0.5225  1.5872

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -10.47792   21.63542  -0.484    0.631
Year          0.00550    0.01087   0.506    0.616

Residual standard error: 0.6218 on 32 degrees of freedom
Multiple R-squared:  0.007939,	Adjusted R-squared:  -0.02306
F-statistic: 0.2561 on 1 and 32 DF,  p-value: 0.6163

> sink()
```

Appendix 9: Satellite images of the lower Meghna.

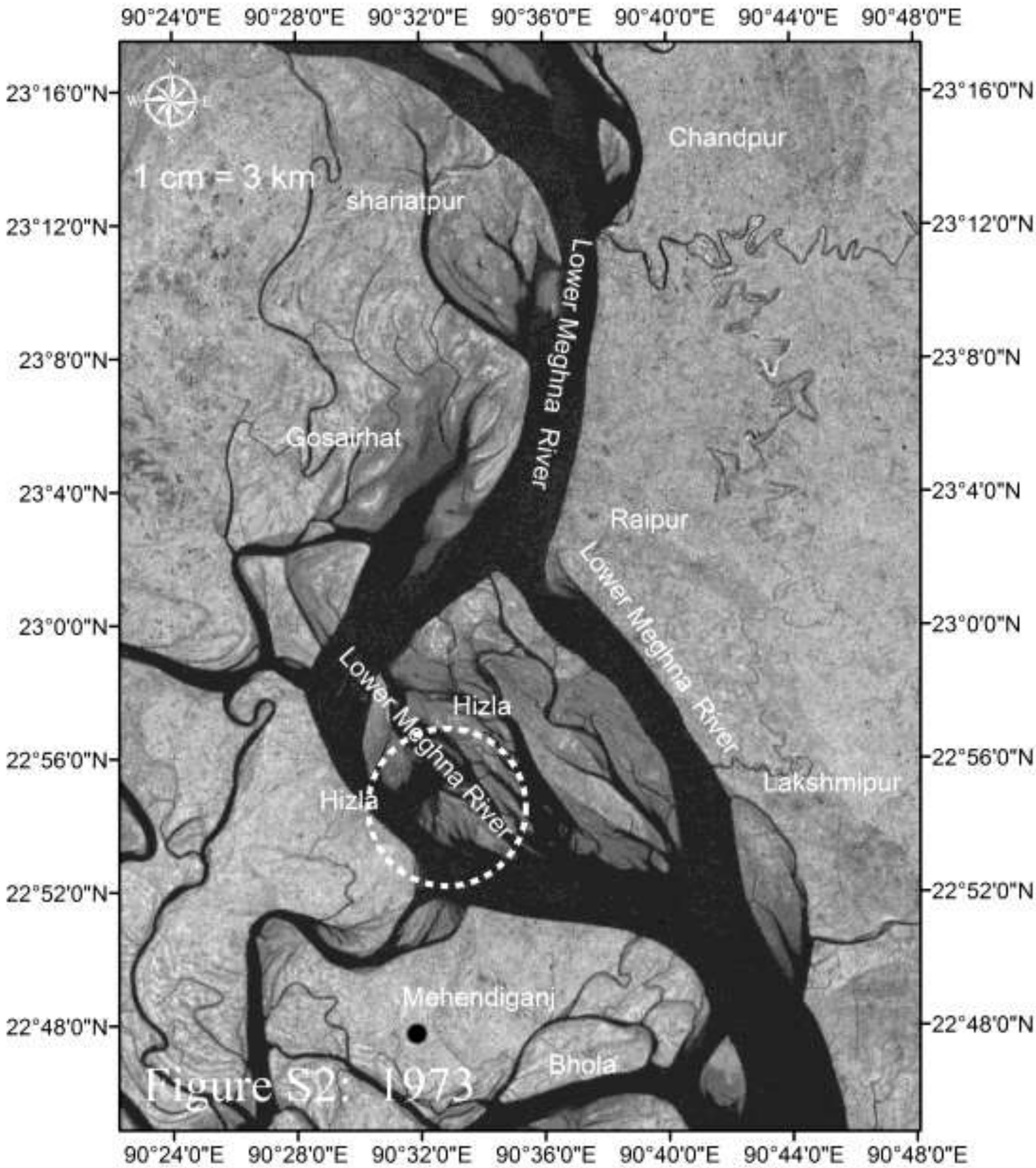


Figure 9(a): Satellite images of the lower Meghna in 1973 (please ignore figure number in the image). White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion.

Figure 9(b): Satellite images of the lower Meghna in 1980 (please ignore figure number in the image).White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion.

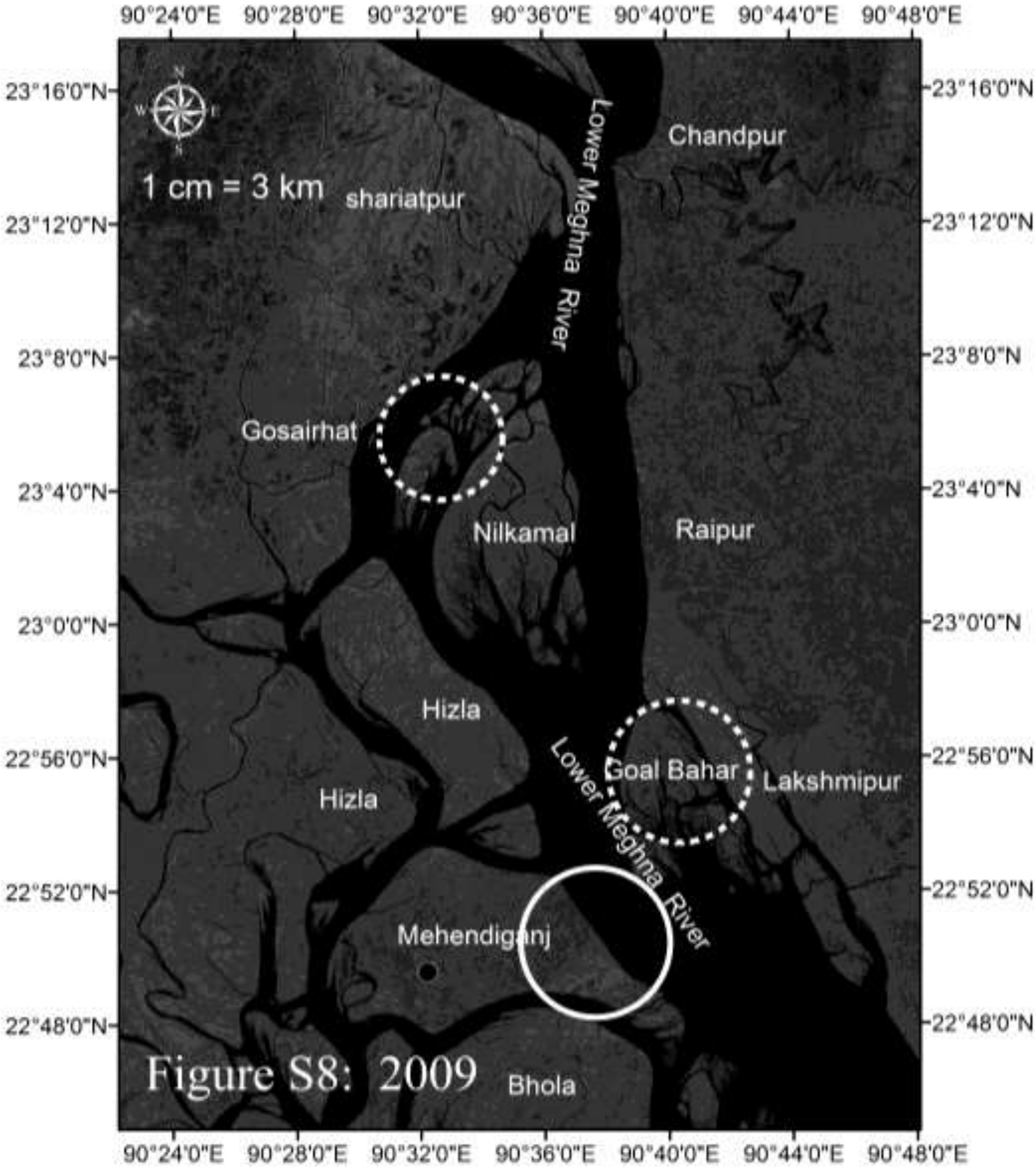


Figure 9(c): Satellite images of the lower Meghna in 2009 (please ignore figure number in the image). White circles show regions of erosion while white dashed circles show regions of accretion. See text for detailed discussion.

Appendix 10: Calculation of displaced population from Gobindapur *union*.

Area of Mehendiganj (km^2)	HH	Pop	Pop per square Km	HH per square Km
418	58,719	304,364	728	140.48
Total eroded area (km^2)	Total displaced pop (128*Pop per square kilometre)		Total displaced HH (128*HH per square kilometre)	
128	93202		17981	

HH = Household; Pop = Population

Appendix 11 (a): Population movement to Dhaka due to different factors

Origin	Environmental factor		Social	Economic factor	
	Forced migration (Permanent displacement)	Find new job following environmental disaster		To improve life chances	To escape poverty and find a job
Coastal	6	7	3	3	14
Non-coastal	20	3	2	3	34
Total	26	10	5	6	48
% of Total migrants	28%	10%	5%	6%	51%

Note: Few non-poor class people were selectively chosen using snowball methods.

Appendix 11(b): Population movement to Comilla due to different factors.

Origin	Environmental factor		Social	Economic factor	
	Forced migration (Permanent displacement)	Find new job following environmental disaster		To improve life chances	To escape poverty and find a job
Coastal	0	0	0	2	2
Non-Coastal	0	2	0	1	20
Total	0	2	0	3	22
% of Total migrants	0%	7.4%	0%	11%	81%

Note: Few non-poor class people were selectively chosen using snowball methods.

Appendix 12(a): Matrix measuring the effect of climate change on migration (source: Schmidt-verkerk, 2011: 215).

Degree of Climate sensitivity (score 1-5)	**5**	**10**	**15**	**20**	**25**
	4	**8**	**12**	**16**	**20**
	3	**6**	**9**	**12**	**15**
	2	**4**	**6**	**8**	**10**
	1	**2**	**3**	**4**	**5**
	Degree of relevance for migration decision (score 1-5)				

Appendix 12(b): Scores for the degree of climate sensitivity and relevance decisions (source: Schmidt-verkerk, 2011: 216).

	Degree of Climate sensitivity	**Degree of relevance for migration decision**
1 (very low)	Effect very unlikely, negligible.	Almost nothing to do with migration decisions, negligible.
2 (low)	Small effect possible, yet non-climate factors stronger.	Small effect on migration decisions possible, yet other factors more important.
3 (medium)	Some changes to existing situation possible but no large ones, other factors might be stronger.	Some effect on migration decision, yet not a determining arguments.
4 (high)	Substantial effect, changes of existing situation likely.	Strong effect on migration decisions.
5 (very high)	Very substantial effect, changes of existing situation almost certain.	Major factor in migration decision, determining argument.