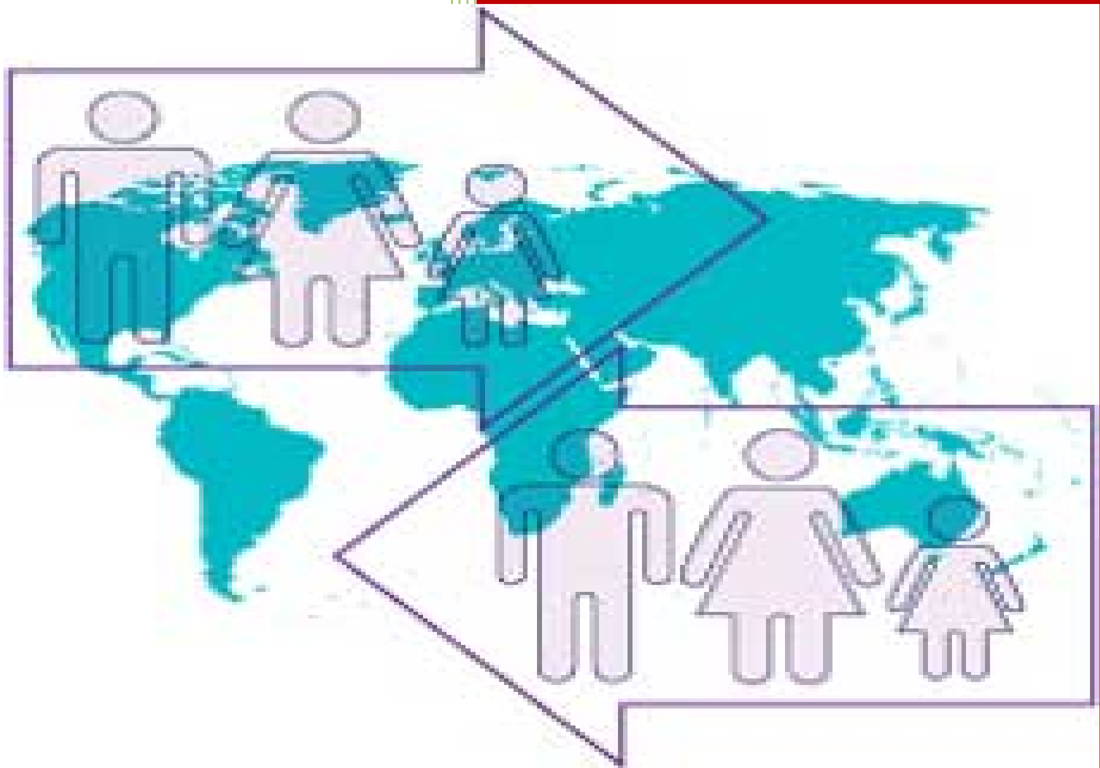
Accounting Climate Induced Displacement in Bangladesh: An exploratory GIS based study



Accounting Climate Induced Migration in Bangladesh: An Exploratory GIS Based Study
November 2011

> ***This is a 'Working Draft' and is meant to raise discussion and seek comments. Please do not quote.***

Acknowledgement
The report is an output of the programme titled **Regenerative Agriculture and Sustainable Livelihood for Vulnerable Ecosystems (RESOLVE)** supported from a grant of **Oxfam Novib**. The programme is implemented by Gana Unnayan Kendra (GUK), Gono Kalyan Sangstha (GKS) and Shariatpur Development Society (SDS) with the technical assistance of Unnayan Onneshan (UO).

The report has been prepared by **Tanjinul Hoque Mollah, Mohammed Abdul Baten & Rashed Al Mahmud Titumir**. Authors are also grateful to **Shahriar Kabir** and **Lubna Seal** for editing the report.

Acknowledgement goes to respondents of various Government and Autonomous Institutions, and respondents of the three different areas who helped a lot providing their valuable opinion and information regarding riverbank erosion, drought and sea level rise.

For orders and request, please contact:

Unnayan Onneshan - The Innovators
16/2, Indira Road, Farmgate
Dhaka-1215, Bangladesh
Tell: + (880-2) 8158274, 9110636
Fax: + (880-2) 8159135
E-mail: info@unnayan.org
Web: www.unnayan.org

EXECUTIVE SUMMARY

This paper aims at estimating the number of climate induced migrants in Bangladesh with specific reference to riverbank erosion, drought and sea level rise. The study has used Kazipur upazila of Sirajganj for riverbank erosion, which is already identified as the most erosion prone area in Bangladesh; Sundarganj upazila of Gaibandha for drought and Gosairhat upazila for anticipated sea level rise as reference points to draw an overall migration scenario for Bangladesh. Human migration is largely resulted from risk perception. Both the observed and anticipatory risk influences people to migrate. People affected by river bank erosion and cyclone immediately migrate for safe shelter and later permanently for survival, are examples of observed risk. While people migrate based on the perception that in future there would be worse condition that could hamper lives and livelihood; drought and sea level rise are two such factors that affect slowly and most of the time people migrate to avert future risk. In this paper we have considered both observed risk such as river bank erosion and anticipatory risk such as drought and sea level rise as causal factors of migration.

Using GIS and Remote Sensing technology, the study overlapped existing maps with maps of 70s and tried to estimate number of displaced people in relation to land area coverage under different climatic impacts such as river bank erosion, drought and sea level rise.

In addition, this paper contains mapping and analyzing primary data and secondary information. Modern technological tools have been used for mapping, modeling and data analysis. Satellite navigation data have been developed and linked with large scale cadastral (CS in the 1910s) and Revisional (RS in the 1970s) survey maps afterwards for detailed and long term understanding of displacement and migration. Satellite navigation data has been used for accumulating both the primary and secondary data. Mouza sheets have been scanned and digitized and later projected at BTM parameters. The generated GIS maps have been overlapped on sub-metre accurate Google Earth imagery of 2010 to the said areas that were eroded, inundated and have a serious water scarcity. BTM projected Google imagery on the CS and RS mouza maps at plot level has helped to identify and to plot the trend and spatial pattern of displacement and migration under different and variety of contexts.

The adverse effect of rise of sea level, drought and riverbank erosion compels the population to migrate from one place to another. In the Kazipur upazila of Sirajganj district, 21,961 people were migrated which is 9.35 percent of the total population in recent years. The rigorous effect of riverbank erosion in Bangladesh there are 1, 29,853 people are displaced yearly. Permanent migration occurred within the neighbors and primarily it happened in a short distance because of the lack of earning source and social bonding.

Geographical location, lack of irrigation facilities and the shifting of temperature are the causes for increasingly dry and lose of moisture at northern part of Bangladesh and drought occurred during the month of March to May and October as a result. Drought was being calculated by the using modern technological tools such as GIS and remote sensing as well as the analysis of the NDVI. The late rate of seasonal or temporal migration is 1988 which is 10 percent of the total population in the Sundarganj upazila of Gaibandha district. In the context of Bangladesh, the rate of temporary or seasonal migration is about 5, 98,450 people in 2011.

Global warming causes sea level to rise by thermal expansion of the ocean waters and the melting of land-based ice, generating a range of impacts. According to the IPCC Projections, B1[1]scenario is predicting that the Gosairhat Upazila of Shariatpur district is out of the risk from the tidal penetration and B2 scenario is likely to be beyond the threat of tidal penetration of land area of Gosairhat. A2 and A1F1 scenario penetrates the 39.43 percent and 67.52 percent of the land area of Gosairhat Upazila. Permanent migration occurred according to A2 and A1F1 scenario. The number of displaced people in A2 and A1F1 scenario is 55,226 and 94,518. They are 39.49 percent and 67.48 percent of the total population displaced within 21st century according to A2 and A1F1 scenario. In the perspective of Bangladesh, there are approximately 31 million people likely to be migrated permanently from the southern part of Bangladesh within 21st century.

Above all, the integration approach was also a unique outcome through this research work which has helped finally to develop database on displacement having all sorts of graphical and scientific evidences. If any further work to be initiated, these imageries and coordinates will help to depict a clear picture of displacement.

[1] B1 scenario: The scenario has been predicted for year 2100 against the best estimated temperature increase of 1.8°C (the likely range is 1.1-2.9) compared to the year 1980-1999 (the upper end of the sea level rise has been counted),and the emission at 600 ppm.

[2]B2 scenario: The scenario has been predicted for the year 2100 against the best estimated temperature increase of 2.4°C (the likely range is 1.4-3.8) compared to the year 1980-1999 (the upper end of the sea level rise has been counted) and the emission at 800 ppm.

[3]A2 scenario: The projection of global average sea level rise at the end of the century has been projected against the best estimated temperature (3.4° C) increase, the likely range is 2.0-5.4, compared to the year 1980-1999 (the upper end of the sea level rise has been counted), the scenario is estimated against the emission 1250 ppm.

[4]A1FI scenario: The scenario has been projected against the emission 1550 ppm and the best estimated temperature 4° C compared to the year 1980-1990 where the likely range of temperature is 2.4°C-6.4°C.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.1 INTRODUCTION

Migration phenomenon occupies a significant part of human history that started since the dawn of civilization in search of food, shelter or improving living condition. However, either forced or otherwise, human migration is the most significant consequence of climate change of today and coming decades (Steiner, 2008). Environmental degradation and climate change could potentially result in large scale population migration where the world is presently ill-equipped to prevent or address in an effective manner. Moreover, increased migration in itself may contribute to further degradation and vulnerability, even when migration represents a coping mechanism and survival strategy (Morton *et al.* 2008). Intergovernmental Panel on Climate Change (IPCC) also identified human migration as the greatest single impact of climate change where millions of people may be displaced by shoreline erosion, coastal flooding and agricultural disruption (IPCC, 1990).

The growing scientific evidence on climate induced migration has largely forced policy makers to start discussing and finding a solution to this problem. However, the complexity of defining 'climate migrant or environmental migrants' as well as the difficulty of predicting its scale has in some respects worked against building awareness and momentum for practical action (Morton *et al.*, 2008). Many terms and concepts such as environmental or climate change migrants, environmentally induced or forced migration, ecological or environmental refugee or climate change refugee, and environmental displacement are used in literature. However, there is no generally agreed definition on environmental displacement to pinpoint the issue (Warner and Ehrhart, 2009). Apparently, environmental migrants or climate migrants are understood to be those individuals, communities and societies who choose, or are forced, to migrate as a result of damaging environmental and climatic factors. This broad and diverse group ranges from people forced to flee disasters such as flooding to impoverished farmers abandoning degraded land and migrating to urban centers in search of alternative livelihoods (Morton *et al.*,2008).

Both the climatic and non-climatic drivers are contributing to growing mass of migrants worldwide. In case of climate drivers, *climate processes* such as sea-level rise, salinization of agricultural land, desertification and growing water scarcity, and *climate events* such as flooding, storms etc are forcing human to migrate. But non-climate drivers, such as government policy, population growth and community-level resilience to natural disaster, are also important (McLeman *cited in* Brown, 2008a). However, the speed of migration and number of migrated people depend on severity of the disasters and social and economic strength of addressing the disasters of the respective areas.

Bangladesh is one of the most disaster prone countries of the world. Despite progress in economy the country has been struggling to maintain the growth due to recurring natural disasters. Whenever the country hits the headlines of the world press and the other media, some natural or man-made calamities occupy the centre of attention, playing havoc with human lives, crops, cattle raising, poultry, fishery, houses, roads, forests and many other types of property and economic infrastructure. In this paper, we shall focus on the climate induced migration in Bangladesh, who has been uprooted from their homes by due to natural disasters floods, salinization, droughts and river erosions where a combination of economic, social, institutional and political factors catalyzes the process.

Migration occurs both temporarily and permanently. Temporary migration as an adaptive response to climate stress is already apparent in many areas. But the picture is nuanced; the ability to migrate is a function of mobility and resources (both financial and social).
In other words, the people most vulnerable to climate change are not necessarily the ones most likely to migrate (Brown, 2008). On the other hand permanent migration occurs when the people lose all other alternatives to survive in one area; for instance loss of land and settlements due to tidal surge and river erosions. Almost every year, a significant number of populations is displaced or forced to migrate both temporarily and permanently, due to natural calamities in Bangladesh. Approximately 500,000 people were displaced when the Bhola Island was permanently inundated by the floods of 2005. In addition, recent occurrences of major cyclones like Sidr, 2007, and Aila, 2009, may be an indication of more frequent and severe climatic catastrophes. But, there is still a lack of awareness among the public about climate change and also, little consensus among the concerned bodies about the existence and the types of environmental effects of climate change and the numbers of environmental displacements.

Human migration is largely resulted from risk perception. Both the observed and anticipatory risk influences people to migrate. People affected by river bank erosion and cyclone immediately migrate for safe shelter and later permanently for survival, are examples of observed risk. While people migrate based on the perception that in future there would be worse condition that could hamper lives and livelihood; drought and sea level rise are two such factors that affect slowly and most of the time people migrate to avert future risk. In this paper we have considered both observed risk such as river bank erosion and anticipatory risk such as drought and sea level rise as causal factors of migration.

1.2 THEORETICAL DISCOURSE VERSUS REALITY

Despite strong scientific evidence of climate change, the consequences of climate change on human population distribution or migration is unpredictable and unclear. Establishing a liner and causative relationship between anthropogenic climate change and migration has been difficult to date due to its association with other social, economic and political factors. Different terms and concepts such as environmental migration, climate change-induced migration, ecological or environmental refugees, climate change migrants and environmentally-induced forced migrants are found using by researchers, policy makers and practitioners. The main difficulty of defining climate induced migration is arising from lack of clear methodology of isolating environmental factors from other drivers of migration. Another problem arises from identifying forced versus voluntary migration (Dun and Gemenne, 2008). In response to the growing debate on defining environmental migrants, International Organizations for Migration (IOM) proposes the following definition, "Environmental Migrants are persons or group of persons, who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living condition, are obliged to leave their habitual homes or chose to do so, either temporarily or permanently, and who move either within their country or abroad"

,

While finding a solution to this climate induced migration another debate is going on whether this group of population needs special protection or existing legal frameworks are sufficient to provide for their protection (Kirsch-Wood et al. 2008). Some are defining those displaced people as climate refugee and advocating for the expansion of the definition of a refugee in the 1951 Refugee Convention in order to include them; others call for the adoption of new instruments to provide them with protection similar to that provided for refugees. However, other group of people is skeptical about the notion of 'environmental or climate refugee' and their refugee like protection by arguing that such ideas serve only to confuse the traditional concept of a refugee and play into the hands of those – governments – who wish to classify all as economic migrants and thereby avoid their obligation to provide refugee protection (Stavropoulou, 2008). Another problem of categorization of those environmentally displaced people as Refugee is that it largely relies on crossing an internationally recognized boarder, but most of the displaced people stay within their own country's territory is 'Internally Displaced Person' (IDP) (Brown, 2008b).

Whatever the status of consensus on defining climate induced displaced populations, the number of displaced people is increasing in geometric order due to increased frequency of natural disasters. Various analysts have tried to put numbers on past and future climate migrants. Jodi Jacobson in 1988 estimated up to 10 million 'Environmental Refugees' and warned that due to climate change the number of environmental refugee would be six times higher than political refugee at the end of 21st century. On the other hand, Myers (1997) estimated that there would be 200 million climate migrants by 2050 which was 25 million in mid-1990s. However, the current climate change trend is signaling for a worse future than anticipated. Within last five years, hundreds of thousands people were displaced only in South and South-East Asia by natural disasters namely Cyclone Sidr and Aila in Bangladesh, Nargis in Myanmar, flood in Pakistan and Thailand which indicates the overwhelming vulnerability of these countries to the climate change. To see the increasing trend of displacement Myers reviewed his previous figure and warned that the number of environmentally displaced people could reach as high as 250 million (Myers, 2005).

It is clear that climate change will contribute both to increased temporary displacement and longer term migration. An accurate definition of this displacement category is, therefore, essential in order to relocate or resettle those displaced people. Moreover, a clear definition could help in designing and implementing appropriate institutional frameworks in humanitarian response programme (Bronen, 2008).

1.3 AIM AND OBJECTIVES

The research aims to quantify internal migrants forced by factors derived from climate change and its associated hazards. To fulfill the aim of the research the following specific objectives have been set up. Those are:

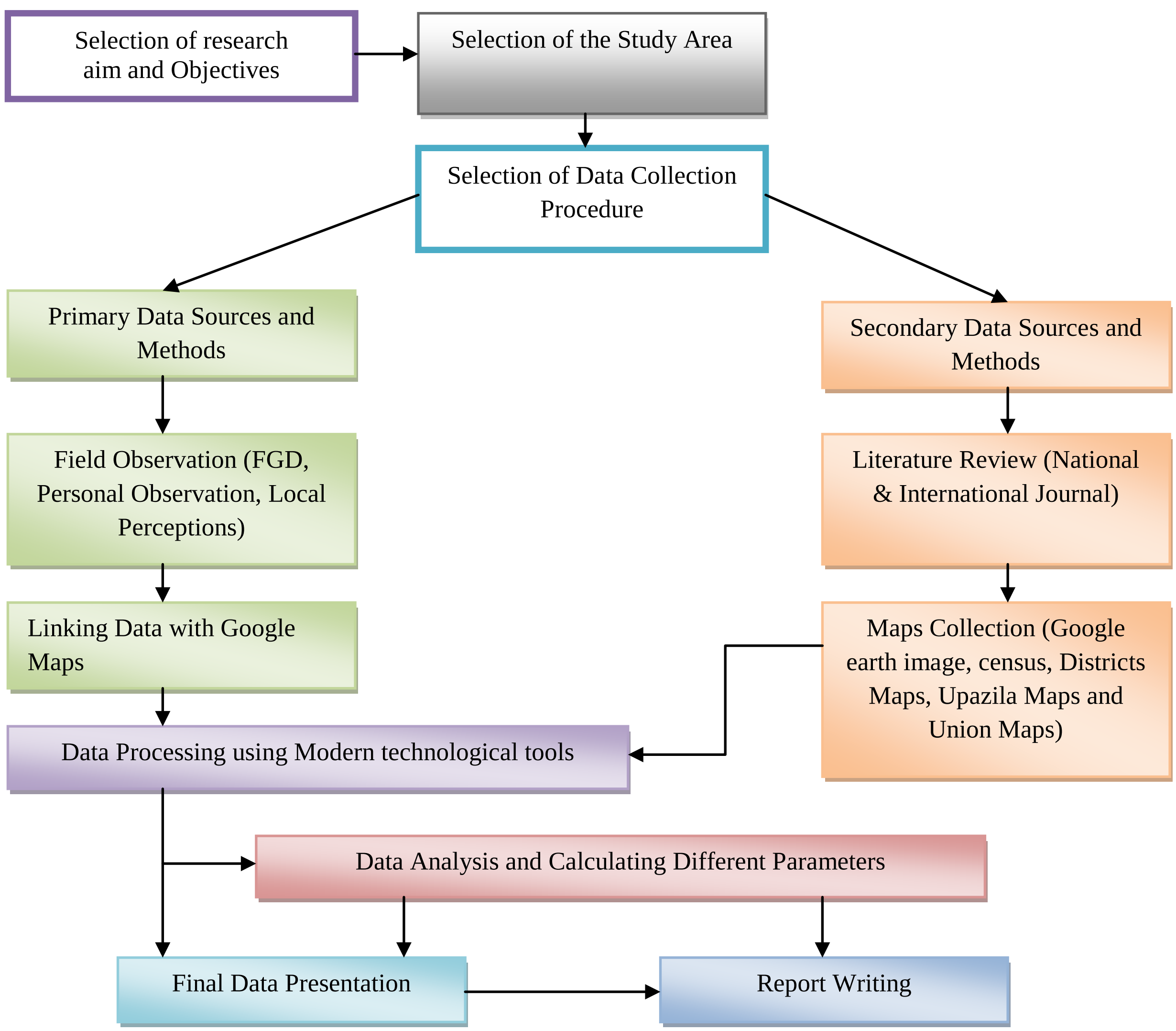
1. Knowing what type of migration occur due to climate change with the support of local people perception
2. Identifying and calculating the entire penetrated area due to sea level rise and relation to the migration
3. Problem identification within the areas and counting the rate of migration
4. Mapping and analyzing the current situation on the basis of rate of migration

2.1 DATA AND METHODS

The study used primary data and secondary source to meet up the objectives of the study. The study mainly depends upon primary data which has been done through FGD, key informants interview, case study and personal observation.

Secondary data such as Google earth image, census, Districts Maps, Upazila Maps and Union Maps were used for detailed analysis of the migration and displacement. The secondary data and literature helps to identify the each vulnerable area such as drought, riverbank erosion and sea level rise in the different regions of Bangladesh. The method of data collection has been given bellow:

Figure 2.1: Data and Methods



2.1.1 Selection of the Study Area

Three study areas have been selected for the research. These areas are mainly exposed to riverbank erosion, drought and sea level rise.

2.1.1.1 Riverbank erosion in Kazipur Upazila of Sirajganj District

Kazipur Upazila is located between 24°38'30" and 24°64'17" north latitudes and between 89°39'00" and 89°65'00" east longitudes. Total area of the Kazipur Upazila is 368.63 sq km and it is delimited by Dhunat, Sariakandi and Sarishabari Upazilas and the Jamuna River on the north, Sirajganj Sadar Upazila on the south, Sarishabari Upazila and the Jamuna River on the east, Dhunat Upazila on the west. There are several inhabitation including Mallickpara, Dhulaura, Maijbari, Manik Patal, Kazipur, Meghai, Tarakandi, Tengalahata are regularly getting extinct by riverbank erosion. Jamuna-Bhramaputra Flood Protection Dam built in the 1960 on the west side of the Jamuna could help much neither in defy river erosion nor in controlling flood.

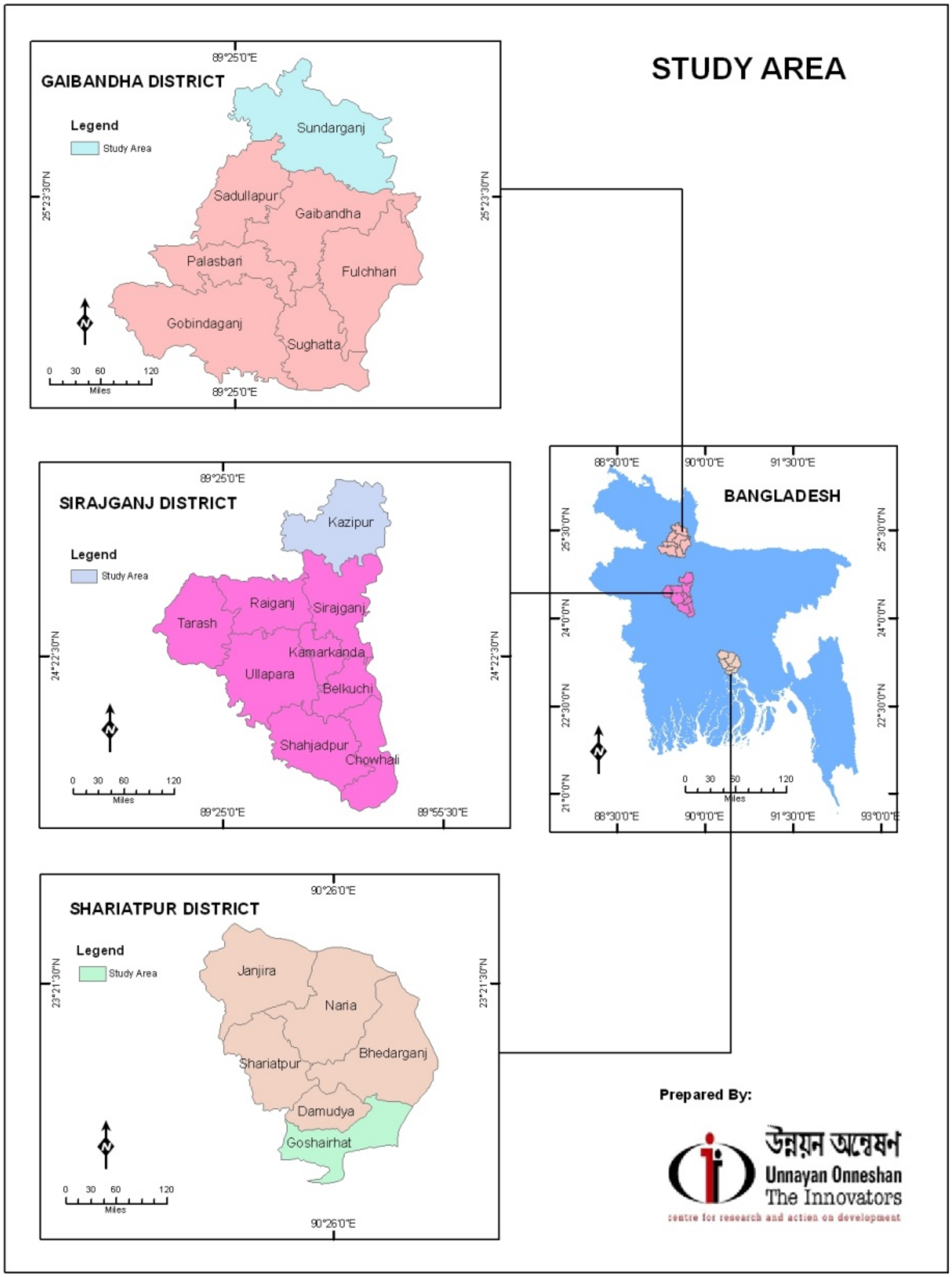
2.1.1.2 Drought in Sundarganj Upazila of Gaibandha District

Sundarganj Upazila is situated between 25°22'00" and 25°38'00" north latitudes and between 89°22'00" and 89°42'00" east longitudes. Sundarganj Upazila with an area of 426.52 sq km is delimited by Pirgacha Upazila and Chilmari Upazilas on the north, Gaibandha Sadar and Sadullapur Upazilas on the south. Main rivers are Tista, Bhramaputra and Ghaghat.

2.1.1.3 Sea level rise due to climate change in the Gosairhat Upazila of Shariatpur District

Gosairhat upazila is to be found between 23°05' and 23°10' north latitudes and between 90°20' and 90°34' east longitudes. Meghna River flows in the eastern part of the Gosairhat Upazila. Total area of this Upazila is 177.86 square kilometers along with last integrated Kuchaipatty union. It is surrounded by Damudya Upazila and Bhedarganj Upazila on the north, by Haimchar Upazila of Chandpur District on the east, by Muladi Upazila and Hizla Upazila of Barisal District on the south, and on the west by Shariatpur Sadar Upazila and Kalkini Upazila of Madaripur District. Main rivers are Meghna, Jayanti and Dharmaganj.

Figure 2.2: Study Area



2.1.2 Focus Group Discussion (FGD)

The FGD is qualitative approach and one of the key parts of data collection. The FGD comprised with men and women, age from 20 to 70 years, dominated by subsistence farmer, small land holders and share cropper. The size of the focus group was twelve people, an ideal size according to American Statistical Association (1997). Focus group helps to gather a wide range of information in a relatively short time. Unlike, one to one interview, focus group generate data through sharing and comparing their ideas and point of views with the other group member and the answer is not restricted only what they think rather it compromises why they think.

2.1.3 Google Images

Google earth image is used for:

- Detailed Data collection
- Physical land feature identifications
- Drought prone area identification
- Drought prone area monitoring and compare with other seasons
- Sea level rise identification
- River bank erosion identification and compare with different period of time
- Meta data development on different aspects
- Satellite navigation data development on sea level rise, river bank erosion and drought prone area

2.1.4 Mouza Maps

Mouza sheets are used for:

- Identification of In-situ and Ex-situ migration.
- Plot to plot detailed survey
- Eroded area calculation and identification
- Drought prone area identification and calculation

2.1.5 Aster Satellite Image

Aster satellite image is used for:

- Evaluating, Identifying and comparing the river bank erosion and drought within different period of time.
- Land and water bodies separation

2.1.6 Tools Descriptions

GIS software is used for detailed data analysis and some of the software is shown in below:

Table 2.1: GIS Software for data preparation and Analysis

SL. No	Software	Used for
1.	ArcGIS 9.3	Digitized Google Image, Spatial Analysis, Statistical Analysis, Database Management and Map Generating
2.	ArcView 3.3	Geoprocessing and Geocorrection
3.	ArcInfo 7.2.1	Topology Building Projection Transformation

2.1.6.1 GPS (Global positioning system)

The Global Positioning System (GPS) is an escalating technology, which provides unequal correctness and litheness of positioning for navigation, Surveying and GIS data capture.GPS is needed for detailed primary data collection and metadata development. Site specific data collection and spatial references of individual sites have been developed by the supporting of GPS. GPS helps this research to Geoprocessing and Geocorrection the relevant mouza maps and verify it in the field level. Collecting the GCP (Ground control point) and overlapped on the different remote sensing imagery for detailed understanding of the riverbank erosion, drought and sea level rise by using modern technology. Satellite navigation data development and current situation analysis depends on the GPS data.

2.1.7 Methods of Accounting

There are some methods for counting the number of people exposed to the sea level rise, riverbank erosion and drought. The following equation expresses the people displaced due to sea level rise and riverbank erosion.

$$\sum \text{Displaced population} = \{(\sum \text{Population}/\text{Area}) * \sum \text{eroded area}\}$$

Temporary or seasonal migration occurs from the drought prone areas and the following equation helps to count the number of migrants.

$$\sum \text{Migration} = [\{(\sum \text{Population/ Area})^* \sum \text{eroded area}\}/5]$$

2.1.7.1 NDVI calculation for the drought prone Areas

Drought has been calculated using Landsat TM images with 30m resolution. NDVI value was determined for each image using the following Equation of the Landsat TM spectral bands.

$$\text{NDVI} = (\text{band 4- band 3}) / (\text{band4+ band 3})$$

The anomaly of NDVI has been calculated for a specific year using the mean, maximum value of the total durations e.g. 2000-2007 based on the following equation

$$\text{Anomaly NDVI i} = (\text{NDVI max i} - \text{mean NDVI max})/ (\text{mean NDVI max})^*100$$

Where, anomaly NDVI i is NDVI anomaly in i^{th} year, NDVI max is maximum NDVI and mean NDVI max is the average of maximum NDVI during the period of study.

Table 2.2: Agricultural drought risk classification using NDVI anomalies

Percent of NDVI	Anomalies Class
0% to -10%	Slight drought
-10% to -20%	Moderately drought
-20% to -30%	Severe drought
above -30%	Very Severe drought

2.1.8 Limitation of the Research

There are some limitations in the research work. Some of limitations are as follows:

- ✓ Mouza data of some vulnerable areas are not clearly identified
- ✓ Data on migration are not available in the local offices
- ✓ Land features identification problem for lack of sufficient time
- ✓ Lack of data in terms of recent census at community level

3.1 RIVERBANK EROSION AND DISPLACEMENT FROM THE KAZIPUR UPAZILA OF SIRAJGANJ DISTRICT

Riverbank erosion is a devastating hazard in Bangladesh that permanently displaces and impoverishes many people. The flood plain of the Jamuna River covers most of the northern portion of Bangladesh. The local channels of the forceful Jamuna River have intermittently and impulsively wandered across the landscape, eroding their banks, destroying everything in their paths and accreting land elsewhere. River Bank erosion is common place both there and on other floodplain of the country. Abnormal flooding and rapid riverbank shifts seriously disrupt human settlement and activities. This study demonstrates the magnitude of the riverbank erosion by examining its occurrences in an area of the Jamuna river floodplain and determining number of population displaced.

Rivers are dynamic systems as they are continuously changing their way. In its natural process, erosion and accretion is normal. However, sometimes erosion exceeds accretion and cause havoc in lives and livelihoods, mainly the poor community become the worst victim. Riverbank erosion occurs both naturally and through human intervention. The natural process of riverbank erosion can produce favorable outcomes such as the formation of productive floodplains and alluvial terraces. Even stable rivers may have some amount of erosion; however, unstable rivers and the erosion that take place beyond normal range on either bank is a serious concern.

Kazipur Upazila is facing extensive riverbank erosion and consequent environmentally forced migration. Displacement due to river bank erosion in Kazipur Upazila of Sirajganj district is at increasing trend over the years that cause both in-situ and ex-situ migration . In case of in-situ migration, a significant amount of displaced people are forced to live in embankments.

Erosion mainly depends on land slope where convex slope is more prone to erosion than the concave slope. The studied area seems to have convex slope that is subject to widespread erosion (3.1). Being located at the upstream of Jamuna River, Kazipur faces high velocity of the wave action which destroys the slope of the land.

Figure 3.1: Recent scenario of Eroded area, In-Situ and Ex-Situ Migration

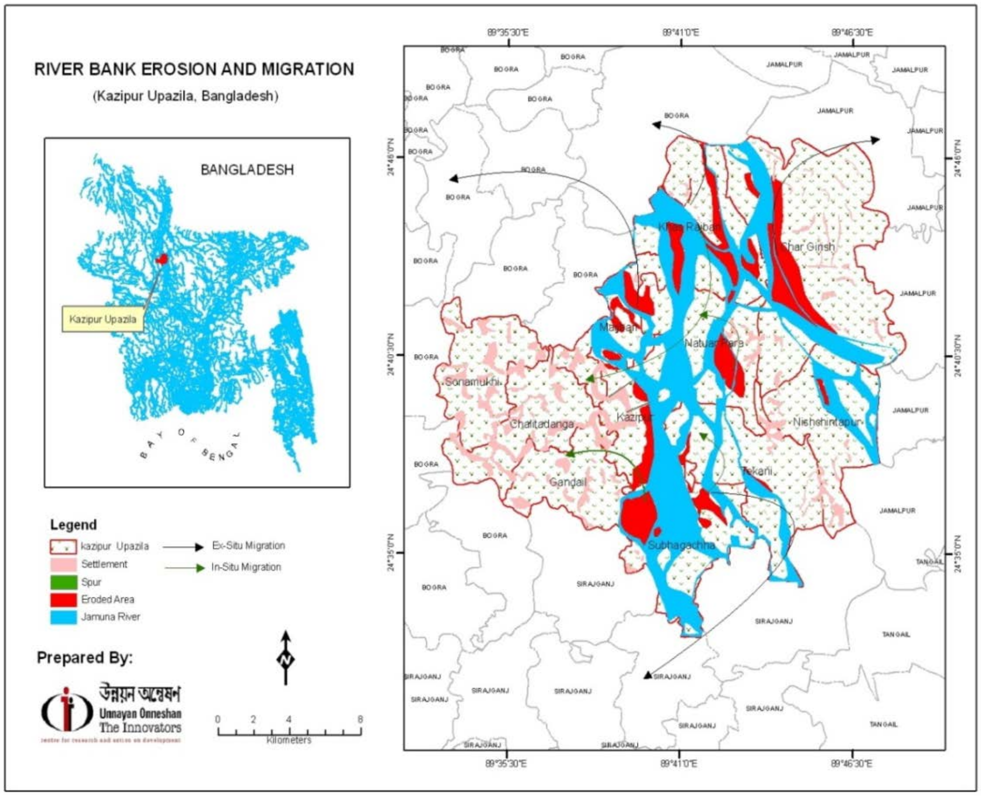


Table 3.1: Land features of Kazipur Upazila, Sirajganj

	Area in Hectares	Area in sq km	Total Area in sq km	Percentage (%)
Settlement	2720	27.20	368.12	7.39
Agricultural Land	22708	227.08		61.69
River	7941	79.41		21.57
Eroded area	3443	34.43		9.35
			Total =	**100**

Source: Field survey, 2011

The eroded area is 34.43 Sq in the recent year. According to the local people perception, if there is no construction of embankment surroundings the vulnerable areas it will be submerged within one or two years.

In the above table it is clearly understood that river bank erosion is one of the major causes for migration. The rate of riverbank erosion is high in the Khas Rajbari Union, Meghai and Maijbari Union. In the recent year, 34.43 sq km area was eroded and its percentage was 9.35%.

Table 3.2: Migration due to riverbank erosion (percentage)

Total Population	**Population Density**	**Migrated Population**	**Percentage (%)**
2,34,804	637	21,961	9.35

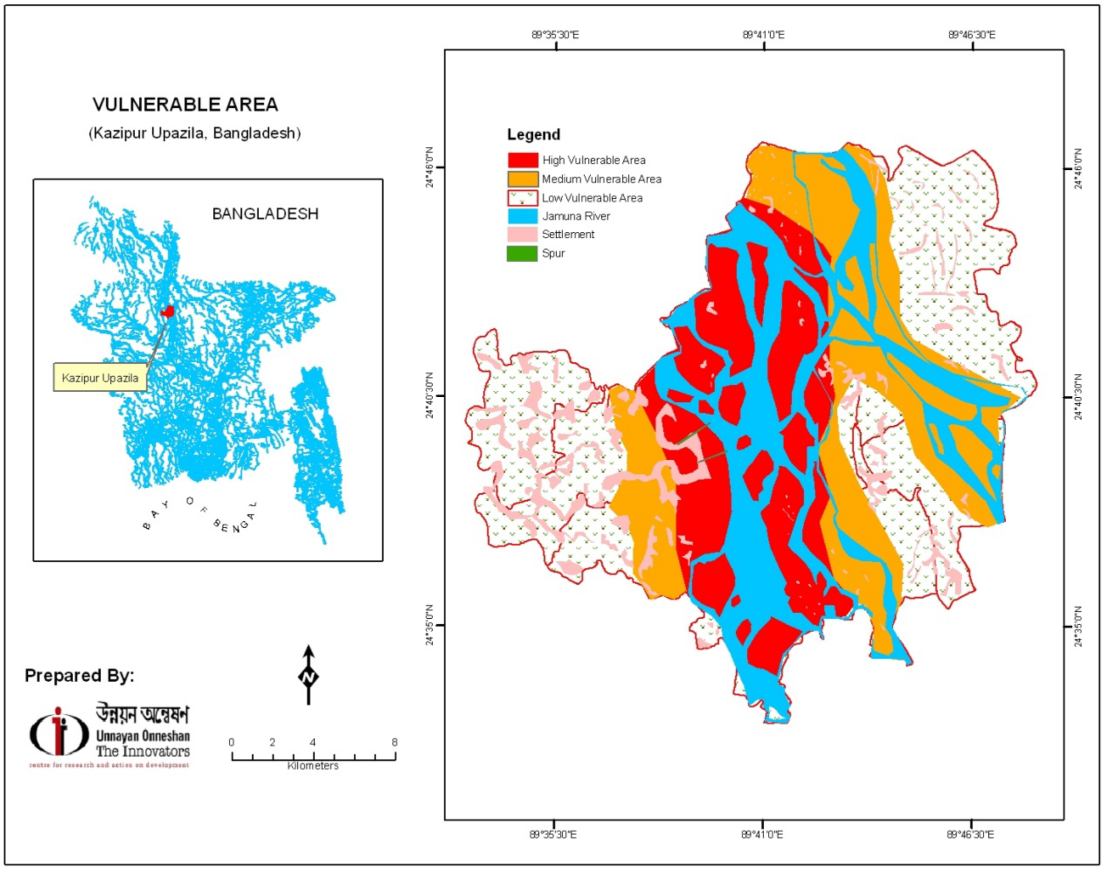
Source: Field survey, 2011

In-situ migration is more than ex-situ migration because of continuous erosion and deposition of char land in natural processes. As a result, the local people of the char land area have migrated to nearer char land which was newly created. Due to river bank erosion, the rate of forced migration is estimated as 9.35% in 2011 which corresponds to 21,961 people.

3.2 FUTURE SCENARIO

Natural disaster such as flood usually characterized by a rapid onset, and its destructive impact are function of the number of vulnerable people in the region rather than the severity of the disaster. Poor people in the Kazipur Upazila are the most affected because they are the most vulnerable. Recent flooding in the Kazipur Upazila forced numbers of people to be displaced from their origin.

Figure 3.2: Vulnerability map of the Kazipur Upazila



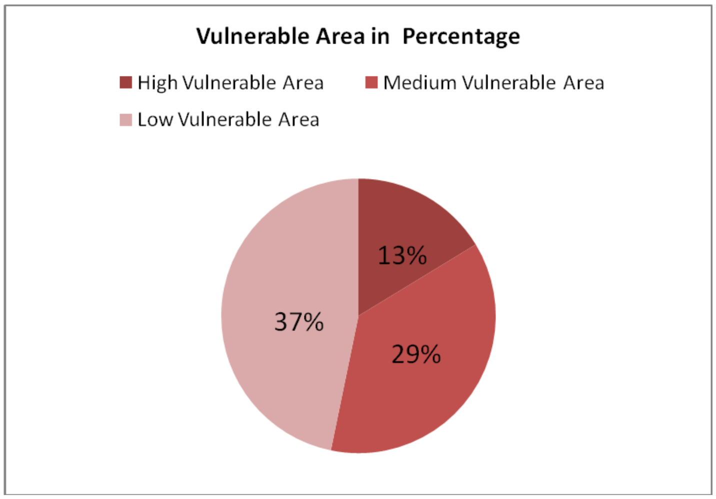
If riverbank erosion continues in the Kazipur Upazila the rate of migration will increase gradually. Total Kazipur Upazila is divided into three major categories according to the vulnerability. The first one is highly vulnerable area which consists 47.01 Sq km; the second one is medium vulnerable area which consists 106.56 Sq km and the last one is low vulnerable area which consists 134.93 Sq km of the total land mass of the Kazipur Upazila. Upward areas are more prone to erosion than downward areas because in the upward areas the velocity of the wave is high.

Table 3.3: Vulnerable areas (%)

	Area in Hectares	Area in Sq km	Total Area in Sq km	Percentage (%)
High Vulnerable Area	4701	47.01	368.12	12.77
Medium Vulnerable Area	10656	106.56		28.95
Low Vulnerable Area	13493	134.93		36.65

Source: Field survey, 2011

Figure 3.3: Vulnerable area shown in a pie chart



The pie chart shows the approximate vulnerable area of the Kazipur Upazila in Sirajganj district.

Table 3.4: Migrated population in future of the Kazipur Upazila

Total Population	Population Density	Future Migrated Population	Percentage (%)
234804	637	29,945	12.75

Source: Field survey, 2011

Total population of the Kazipur Upazila is 2,34,804 and if it remains fixed in future the rate of forced migration due to riverbank erosion is 12.75%. In the char land permanent migration varies occasionally because of continuous formation of char land. Lesser amount of the population migrates because of education.

Key Findings:

- Kazipur Upazila of Sirajganj district is one of the most vulnerable areas and exposed to riverbank erosion. Yearly thousand of population migrates at a short distance. The most vulnerable areas are Khas Rajbari Union, Meghai and Maijbari Union.
- During 2011, 34.43 sq km area has been eroded and it was 9.35% of the total land area of the Kazipur upazila. In future, the eroded area will be increased because of unplanned structure and lack of planning. 47.01 Sq km area will be highly vulnerable to riverbank erosion in recent future.
- Already 21,961 populations displaced which is 9.35% of the total population. Next year it is likely to be 12.375% of the total population.

4.1 DROUGHT AND MIGRATION IN THE SUNDARGANJ UPAZILA OF GAIBANDHA DISTRICT

The total land area of Sundarganj upazila is 410.83 sq km. The main rivers of the Sundarganj Upazila are Tista, Bhramaputra and Ghaghat. Drought mainly occurs in the Sundarganj Upazila due to lack of rain water over a long period of time. Rain does not occur timely. If rain occurred it is not enough for the ground to absorb. Plants and animals require water to stay alive. So if there is not enough water they die from dryness and lack of moisture. Around 27.56% of the total land of Sundarganj upazila experiences drought. Temporary migration occurs because of drought. According to the local people's perception, yearly 10-15 percent of the people migrate within the surroundings at a short period of time. Geographical location is one of the major causes for occurring drought in Sundarganj Upazila. Droughts tend to occur between March to May and in October as the weather is hot and water quickly evaporates. Droughts can last for years in most extreme cases in the Sundarganj Upazila. These types of droughts affect outback properties and can demolish crops and livestock.

Figure 4.1: Drought and Seasonal Migration in Sundarganj Upazila

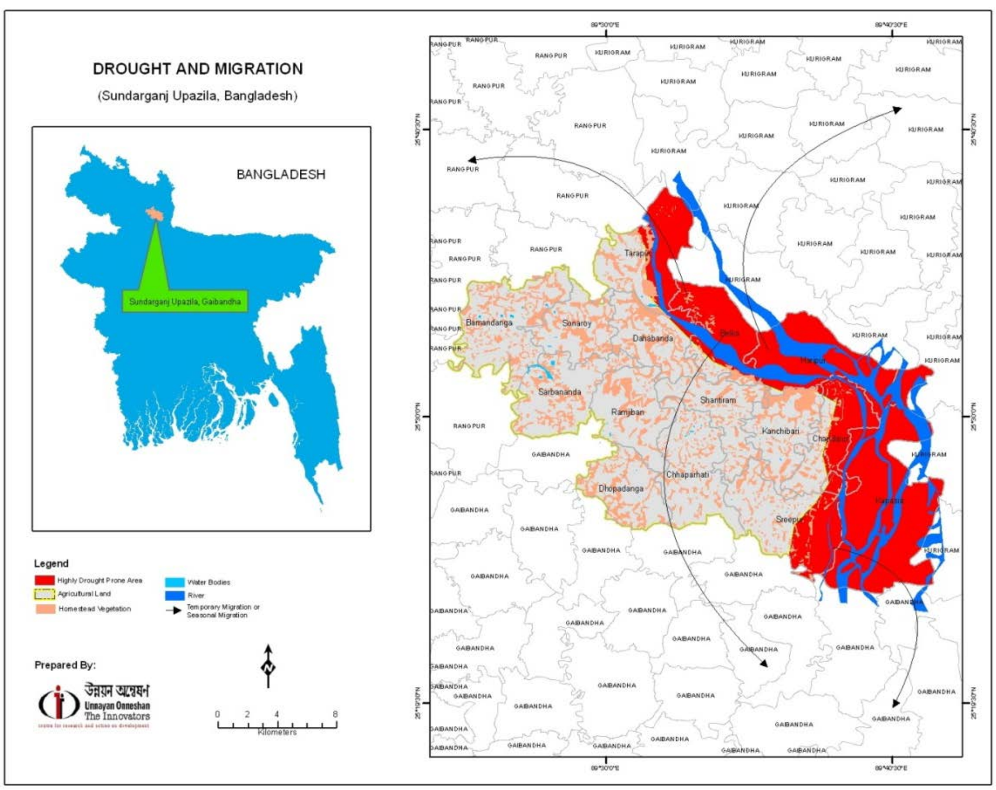


Table 4.1: Land features showing different parameters

	Area in Hectares	Area in sq km	Total Area in sq km	Percentage (%)
Settlement	6790	67.90	410.83	16.53
Agricultural Land	29838	298.38		72.63
River	4455	44.55		10.84
			Total	100
Total Drought Prone Area In recent year				
Drought Prone Area	11323	113.23	410.83	27.56

Source: Field survey, 2011

According to Geographical location drought are common natural disaster in the Sundarganj Upazila and causes migration seasonally or temporary. Permanent migration usually does not occur as they are traditionally been coping with these hazards from long time. Tista Barrage is one of the major causes for water scarcity that creates drought in the Sundarganj Upazila during the month of March to May and October. Because of Tista Barrage water does not flow throughout the season and therefore, Tista River became a seasonal channel to the Kapasia, Chandipur, Belka, Haripur and Tarapur union.

Drought is one of the major problems for the farmers to cultivate their land. Lack of irrigation option and raising temperature reduce the crop production in the Sundarganj Upazila. In the above diagram land use has been shown in different parameters, where 73% of total land is occupied for agriculture activity and will degrade gradually and become productive.

Table 4.2: Percentage of Migration in a year

Total Population	Population Density	Total Population in Drought prone area	Number of household in the Drought prone area	Seasonal Migrated Population	Percentage (%)
360676	877.92	99406	19881	1988	10

Source: Field survey, 2011

Around10% of total people migrates temporarily to increase their income during the period of drought. Mainly head of the household migrates only for two to three months. Migration mainly occurs in the neighboring areas. They migrate to Bogra district and a smaller number migrate to the Dhaka district.

4.2FUTURE PROJECTION

Drought prone area in Sundarganj Upazila is increasing gradually and the rate of seasonal migration or temporary migration also increasing. Total drought prone area has been divided into four categories in terms of vulnerability. First one is high drought prone area; second one is medium drought prone area; third one is low drought prone area and last one is very low drought prone area.

Figure 4.2: Future projection of the drought prone areas

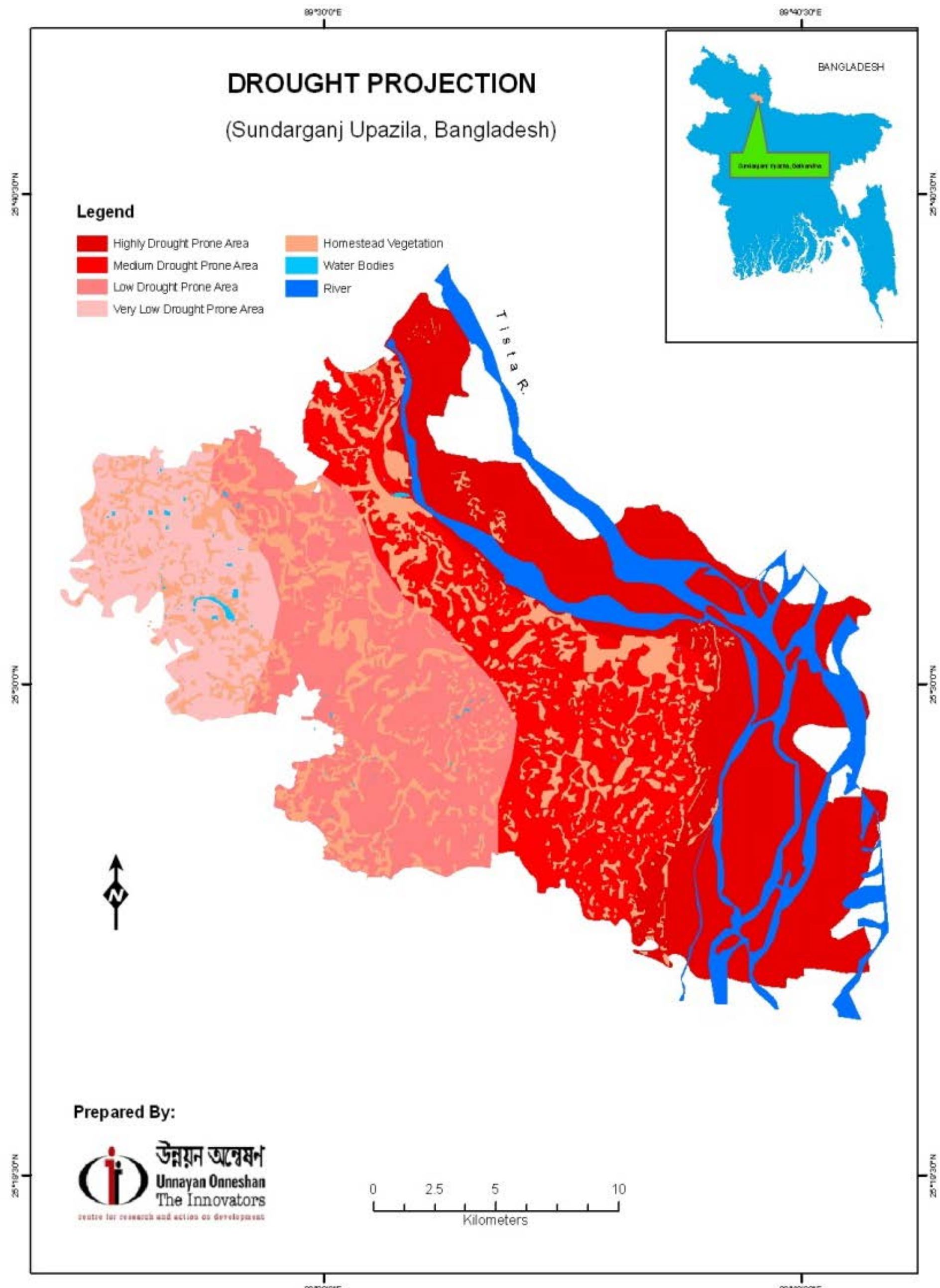


Table 4.3: Categories of Drought Prone Area

	Area in Hectares	Area in Sq km	Total Area in Sq km	Percentage (%)
Highly Drought Prone Area	11323	113.23	410.83	27.56
Medium Drought Prone Area	10209	102.09		24.85
Low Drought Prone Area	10120	101.20		24.63
Very Low Drought Prone Area	4976	49.76		12.11
River	4455	44.55		10.84

Source: Field survey, 2011

The above table shows the areas which will be more vulnerable due to drought and rate of drought prone area gradually increasing because of climate variables. Here, highly drought prone area is 113.23 Sq km. Lack of irrigation and no rainfalls are the major causes which make this area dry and unfertile. Continuous moisture stress and dry environment increase the drought prone area and which will cover around 215 Sq km.

Table 4.4: The rate of temporary or seasonal migration

Total Population	Population Density	Total Population in Drought prone area	Number of household in the Drought prone area	Seasonal Migrated Population	Percentage (%)
360676	877.92	189033.73	37806.74	7561	20

Source: Field survey, 2011

Total population of the Sundarganj Upazila is 360676 and the density of the population is 877.92 per sq km. If population of the Sundarganj Upazila remains constant in future, the seasonal or temporal migrated population will be 20% of the total population in drought prone areas.

Key Findings:

- Drought is one of the major causes of temporal or seasonal migration in the Sundarganj upazila of Gaibandha district. People migrate seasonally because of increasing income for a certain period of time.
- Current drought prone area is 113.23 Sq km and yearly rate of seasonal or temporal migration is 1988 which is 10% of the total population in the Sundarganj upazila.
- In future, the rate of migration will be increased because of lack of irrigation facilities and changing temperature. There is approximately 215 Sq km area will be brought under drought and the seasonal migrated population will be 7561 which is 20% of the total population in the Sundarganj Upazila of Gaibandha district.

5.1 SEA LEVEL RISE DUE TO CLIMATE CHANGE IN THE GOSAIRHAT UPAZILA OF SHARIATPUR DISTRICT

Global sea level has been rising since late 1700s, according to tide gauges measurements that began in Amsterdam in 1700, in Liverpool, In England 1768 and in Stockholm, Sweden 1774. These gauges proposed that the rise has been accelerating at 0.01mm/yr^2, and if the conditions that led to this acceleration continue, it is estimated that sea level will rise by 1.1 ft (0.34 m) by 2100 (Jevrejeva *et al.*, 2008). At a minimum, sea level rise during the 21st century is estimated to be equal that of the 20th century, about seven inches (0.6 feet, 0.18 m). This is the lower bound given by the IPCC in its 2007 assessment, which projected sea level rise of 0.6 - 1.9 ft (0.18 - 0.59 m) by 2100.

Sea level rise is one of the major causes of migration. The penetrated area due to rise of sea level in the Gosairhat Upazila according to the IPCC scenario during 21^{st} century is 120.10 Sq km. The current landuse of the Gosairhat upazila is shown below:

Figure 5.1: Landuse of Gosairhat Upazila

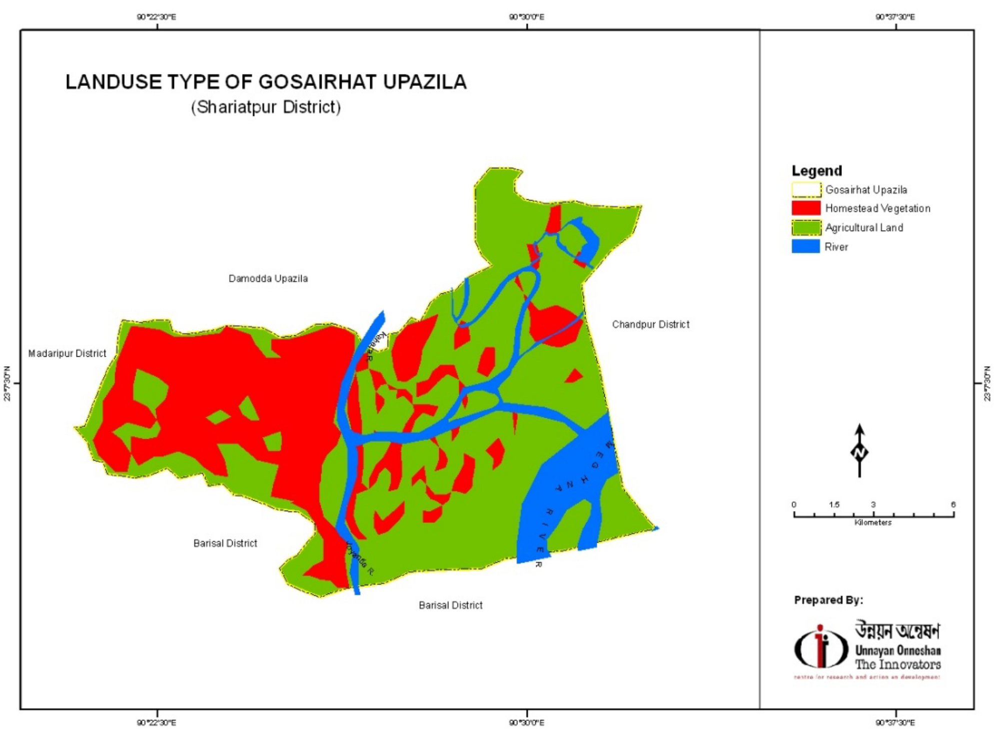


Table 5.1: Landuse of Gosairhat Upazila

	Area in Hectares	Area in Sq km	Total Area in Sq km	Percentage (%)
Homestead Vegetation	5527	55.27	177.86	31.07
Agricultural Land	10261	102.61		57.69
River	1998	19.98		11.24
			Total	100

Source: Field survey, 2011

The table shows that land used for agricultural purpose is more than land used for other purposes. The total agricultural land in the gosairhat upazila is 102.61 Sq km which reflects that most of the population of this area mainly depends on primary economic activities. Unexpected flooding in the recent years in Gosairhat Upazila has damaged the agricultural crops.

Figure 5.2: Land type of Gosairhat Upazila

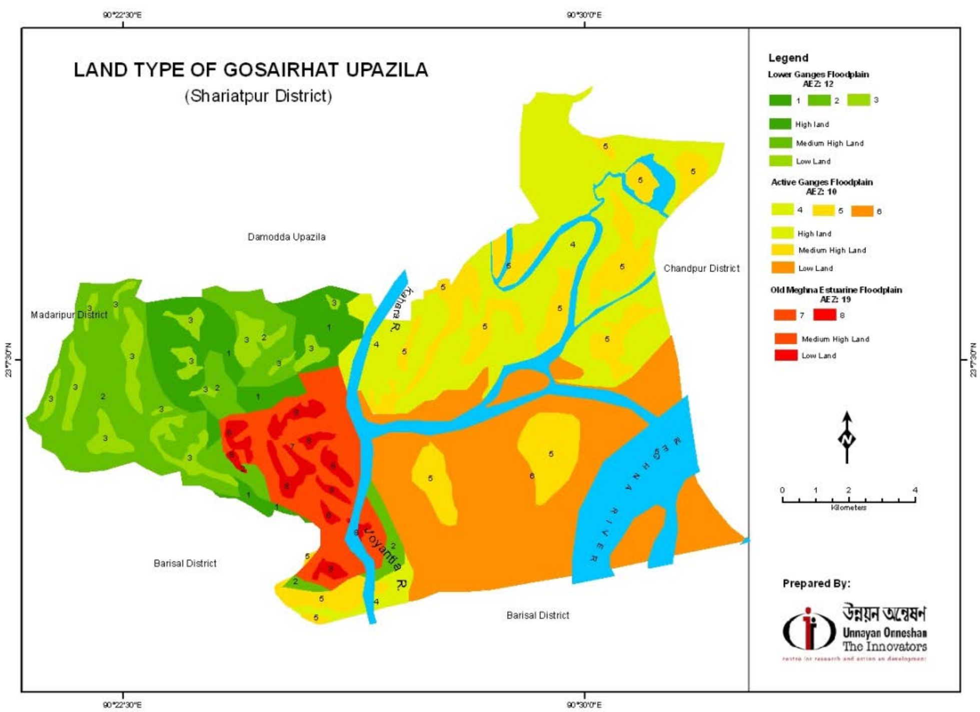


Table 5.2: Zone wise distribution of Land in the Gosairhat Upazila

Zone	Land Type	ID	Area in Hectares	Area in Sq km	Total Area in Sq km	Percentage (%)
Lower Ganges Floodplain AEZ: 12	High Land	1	952	9.52	177.86	5.35
	Medium High Land	2	2209	22.09		12.42
	Low Land	3	925	9.25		5.20
Active Ganges Floodplain AEZ: 10	High Land	4	4424	44.24		24.87
	Medium High Land	5	2551	25.51		14.34
	Low Land	6	1679	16.79		9.44
Old Meghna Estuarine Floodplain AEZ: 19	Medium High Land	7	902	9.02		5.07
	Low Land	8	517	5.17		2.91
Others (Rivers, Canal and Ponds)			3627	36.27		20.39

Source: Authors calculations based upon SRDI

The total land type of Gosairhat upazila, according to the Soil Resource Development Institute (SRDI), has been divided into three major categories. The first one is lower Ganges floodplain (AEZ-12); the second one is active Ganges floodplain (AEZ-10) and the last one is old Meghna estuarine floodplain (AEZ-19). Each agro-ecological zone is divided into three major categories according to the land type for detailed understanding of the penetrated area.

Figure 5.3: Land types are shown in pie chart

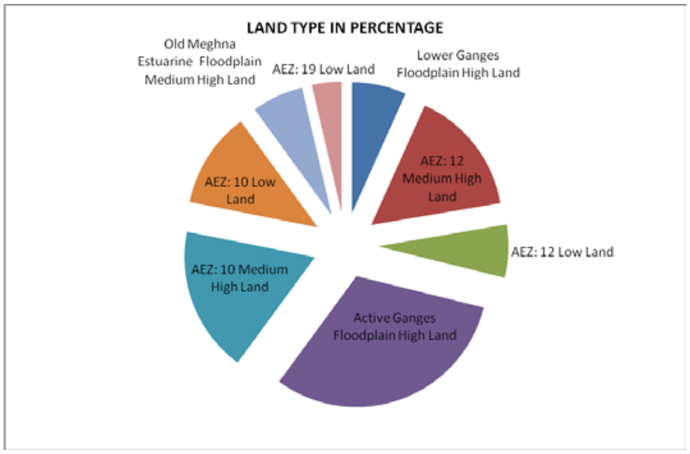


Figure 5.4: IPCC Scenario B1 and B2

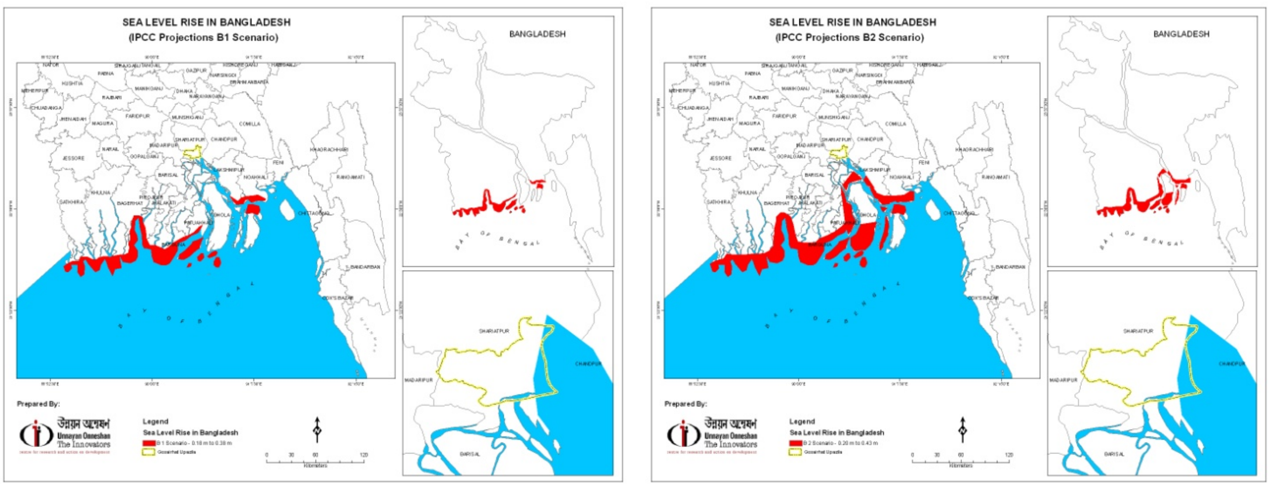


Table 5.3: Penetrated area according to IPCC Scenario

	Penetrated Area in Hectares	Penetrated Area in Sq km	Total Area in Sq km	Percentage (%)
Scenario B1	-	-	177.86	-
Scenario B2	-	-		-

Source: Field survey, 2011

The B1 scenario has been predicted for year 2100 against the best estimated temperature increase of 1.8°C (the likely range is 1.1-2.9) compared to the year 1980-1999 (the upper end of the sea level rise has been counted),and the emission at 600 ppm. Under this low ambitious scenario the Gosairhat upazila seems to be less affected by further tidal inundation. However, still there is risk of salinity increase due to sea water intrusion in the lower Meghna and the Jayantia River during high tide, therefore some people may migrate considering future risk.

The B2 scenario has been developed for the year 2100 against the best estimated temperature increase of 2.4°C (the likely range is 1.4-3.8) compared to the year 1980-1999 (the upper end of the sea level rise has been counted) and the emission at 800 ppm. Under this scenario the Gosairhat is less likely to be affected from tidal penetration directly; however salinity may increase in soil and surface water due to sea water penetration at the lower Meghna and the Jayantia River and contribute to some sorts of migration.

Figure 5.5: IPCC Scenario A2 and A1F1

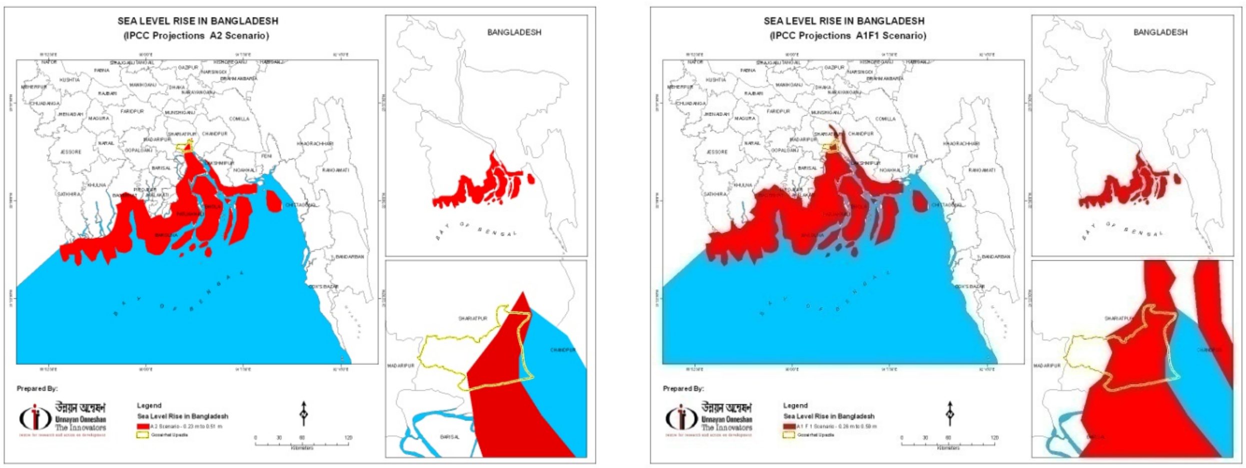


Table 5.4: Penetrated area according to IPCC Scenario

	Penetrated Area in Hectares	Penetrated Area in Sq km	Total Area in Sq km	Percentage (%)
Scenario A2	7013	70.13	177.86	39.43
Scenario A1F1	12010	120.10		67.52

Source: Field survey, 2011

Under the A2 scenario, the global average sea level rise at the end of the century has been projected against the best estimated temperature (3.4° C) increase, the likely range is 2.0-5.4, compared to the year 1980-1999 (the upper end of the sea level rise has been counted), the scenario is estimated against the emission 1250 ppm. According to the scenario, 70.13 Sq km and of the total land area of Gosairhat upazila will be under the coverage of tidal inundation at the end of the century. It implies that more area will be saline affected and existing saline effected area will experience an increased salinity level. Counting population density as 787 person/ Sq km it is estimated that a total of 55,226 people will be forced to migrate out of 1,40,061 people which corresponds to 39.4% of total population at Gosairhat upazila.

Table 5.5: Percentage of migration due to climate change

	Total Population	Population Density in per Sqkm	Penetrated Area in Sq km	Total Area in Sq km	Migrated Population	Percentage (%)
Scenario A2	1,40,061	787	70.13	177.86	55,226	39.43
Scenario A1F1			120.10		94,518	67.48

Source: Field survey, 2011

The A1F1 scenario has been projected against the emission 1550 ppm and the best estimated temperature 4° C compared to the year 1980-1990 where the likely range of temperature is 2.4°C-6.4°C. Under this scenario it is assumed that 120.10 Sq Km area of Gosairhat will be penetrated by tidal water which will cause either temporary or permanent migration of 95,518 people; that means 3 people in every 5 has to migrate. As of late temporary migration or seasonal migration occurs due to unexpected flooding and other natural disasters.

Key Findings:

- According to the IPCC Projections, B1 scenario is to be expected out of the threat of tidal penetration and B2 scenario is likely to be beyond the threat of tidal penetration of land area of Gosairhat upazila.
- Under A2 and A1F1 scenario it has been found that 39.43% and 67.52% of the land area of Gosairhat Upazila will be penetrated.
- Permanent migration will be occurred according to A2 and A1F1 scenario. The number of migrated population in A2 and A1F1 scenario is 55,226 and 94,518. There are 39.49% and 67.48% of the total population migrate within 21st century according to A2 and A1F1 scenario.

6.1 OVERALL SCENARIO OF BANGLADESH

Overall scenario of migration and displacement in Bangladesh by the effect of riverbank erosion, drought and sea level rise due to climate change are discussed below:

6.1.1 Riverbank erosion and Displacement in the Perspective of Bangladesh

The population density in Bangladesh is reported to be 1263.16 per sq km in 2010. Population density in three different regions of Bangladesh depends upon the total number of population and the total area. In 2011, 34.43 Sq km have been eroded in the Kazipur upazila of Sirajganj district. If compared to the national scenario, then the total eroded area in Bangladesh due to riverbank erosion is 10280 hectares or 102.80 sq km.

Table 6.1: Bank erosion/accretion along the different rivers for the period of 1984-93

		Jamuna	Ganges	Padma	Upper Meghna	Lower Meghna
Bank erosion rate (m/yr).	Left	*100	-20	38	7	66
	Right	*84	56	121	-9	182
Maximum bank erosion rate (m/yr)		*784	665	620	NA	824
Bank erosion (ha/yr)		*5,020	2,240	1,800	48	1,172

Source ISPAN, 1995 Note: * Rates derived for the period 1984-92

The rate of forced migration due to riverbank erosion in the Kazipur upazila of Sirajganj district is 9.35 percent in 2011. If the riverbank erosion occurs accordingly to the year of 1984-93, the number of displaced population is 1, 29,853 in the Jamuna, Ganges, Padma and Meghna river in the current year.

Riverbank erosion and accretion in the different floodplain are common and natural processes. The people of Bangladesh cope with this situation as because it is itself a natural process.

6.1.2 Drought, Migration and Displacement in the Perspective of Bangladesh

Drought is the most multifaceted other than least understood of all natural hazards in Bangladesh. Drought damages the agricultural land and hence creates pressure on economy as well as the environment. This study has attempted to adopt the RS and GIS techniques for drought detection.

Figure 6.1: Drought in the North-West part of Bangladesh

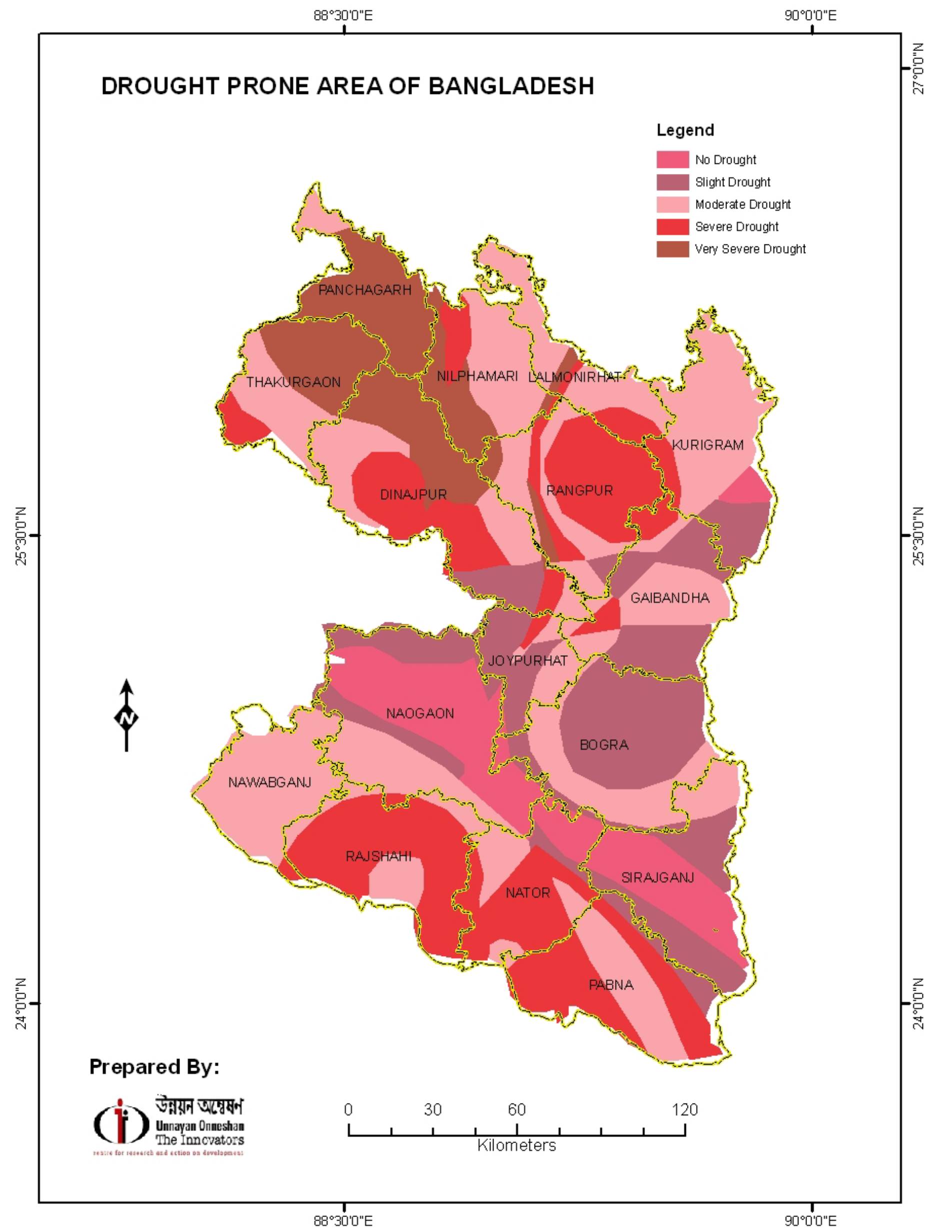


Table 6.2: Area facing agricultural and meteorological drought risks in the north-west region

Sl. No.	Drought Risk	No. of District	Name of Districts	Area (Sq km)	% of Area
1	No risk	2	Sirajgong, Naogaon	5437.34	16.86
2	Slight risk	4	Kurigram, Nawabgong, Bogra, Joypurhat	7322.45	22.71
3	Moderate risk	5	Rangpur, Rajshahi, Pabna, Natore, Lalmonirhat	9581.58	29.72
4	Severe risk	3	Dinajpur, Nilphamari, Gaibanda	6867.32	21.29
5	Very Severe risk	2	Panchagarh, Thakurgaon	3036.31	9.42
Total		16		32245	100

Source: 3rd International Conference on Water & Flood Management (ICWFM-2011**)**

The percentage of areas in each districts of the north-west region facing combined drought risk has been presented. Sirajgong and Naogaon are the two districts free from drought risk. Slight and moderate risk areas encompass 22.71 percent and 29.72 percent of total geographical area. Severe and very severe risk prevails in nearly 21.29 percent and 9.42 percent of the area which comprise of districts that are major producers of food grains as well as different vegetables.

In 2011, 113.23 sq km area faced drought in the Sundarganj upazila of Gaibandha district and if the shifting of temperature keeps on happening continuously, the very severe drought prone area in Bangladesh is 3036.31 sq km and the population density of the north-west region of Bangladesh is 985.49 per sq km. The rate of temporary or seasonal migration is about 5, 98,450 people in the recent year 2011.

6.1.3 Sea level rise and Displacement in the Perspective of Bangladesh

Bangladesh is highly at risk to sea level rise, as it is a densely populated coastal country of flat relief comprising wide and thin ridges and depressions (Brammer et al., 1993). World Bank (2000) showed 10 cm, 25cm and 1 m rise in sea level by 2020, 2050 and 2100; affecting 2%, 4% and 17.5% of total land mass respectively. Milliman et al. reported 1.0 cm per year sea level rise in Bangladesh.

Table 6.3: Sea level rise (SLR) in Bangladesh and its possible impacts

Year	**2020**	**2050**	**2100**
Sea level rise	10cm	25cm	1 m (high end estimate)
Land below SLR	2 % of land (2,500 km^2)	4 % of land (6,300 km^2)	17.5 % of land (25,000 km^2). Patuakhali, Khulna and Barisal regions will be most affected

Source: Adapted from World Bank, 2000

According to the UNEP (1989) 1.5 m sea level rise in Bangladesh coast by 2030 , affecting 22,000 Sq. km which is 16% of total landmass with a population of 17 million (15% of total population) affected. Since this scenario was calculated in 1989, the expected rate of sea level rise has been modified because of uncertainty. this situation will occur in about 150 years from now. However, number of potential population affected by the projection of World Bank by one metre sea level rise (17.5 million) and that of UNEP by 1.5 metre sea level rise (17 million) is similar.

The research paper revealed that 1 m sea level rise in the coastal region of Bangladesh by 2100, affecting 25,000 Sq. km which is 17.5% of total landmass with a population of 31.5 million people displaced.

REFERENCES

1. Agrawala, S., Ota, T., Ahmed, A.U., Smith, J., and Aalst, M.V. (2003) *Development and Climate Change in Bangladesh: on Coastal Flooding and the Sunderbans.* Organisation for Economic Co-operation and Development (OECD), Available at: http://www.oecd.org/dataoecd/46/55/21055658.pdf OCED, 2003, [Accessed 20 July, 2011]

2. American Statistical Association (ASA) Series, 1997, *What Is a Survey?* Available at: http://www.webpages.uidaho.edu/~redgeman/Sampling%20PDF%20Files/focusgroups.pdf [Accessed 20 July]

3. Bronen, R., 2008, Alaskan communities rights and resilience *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

4. Brown, O, (2008a), The numbers game *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

5. Brown, O, 2008b, Migration and Climate Change, International Organizations for Migration, Geneva, Switzerland

6. CARE International, (2008) In search of shelter: mapping the effects of climate change on human migration and displacement.

7. Climate change Cell (CCC, 2007), *Climate Change and Bangladesh*, Department of Environment, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. Availableat.http://www.bdresearch.org.bd/home/climate_knowledge/cd1/pdf/Bangladesh%20and%20climate%20change/Climate%20change%20impacts%20,vulnerability,%20risk/Climate%20Change%20And%20Bangladesh.pdf [Accessed 20 April 2011]

8. Dun, O., & Gemenne, F., (2008), Defining 'environmental migration' *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

9. Food and Agriculture Organization of the United Nations (2011) Water quality for agriculture, file:///C:/Documents%20and%20Settings/station18/Desktop/MemoryLubna%20%28I%29/L.%20Seal/All%20Documents%20for%20Salinity/FAO%20Leaching%20requirement.htm [Accessed 20 July]

10. Intergovernmental Panel on Climate Change, IPCC (2007), *Climate Change: 2007 Synthesis Report,* Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf [Accessed 15 March 2011]

11. Intergovernmental Panel on Climate Change (IPCC) , Contribution of Working Group I to the Fourth Assessment Report 2007b, "Climate change 2007: Climate change impacts, adaptation and vulnerability – summary for policy makers", Paris, April

12. Jacobson, J.L. (1988). Environmental Refugees: a Yardstick of Habitability, Worldwatch paper 86, Worldwatch Institute, Washington DC

13. Kirsch-Wood, J., Korreborg, J and Linde, Anne-Marie, 2008, What Humanitarians need to do *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

14. Laczko, F., and E. Collett, 2005, *Assessing the Tsuanmi's Effects on Migration*, International Organization for Migration.

15. Litchfield. W. A. (December, 2010) Climate Change Induced Extreme Weather Events & Sea Level Rise in Bangladesh leading to Migration and Conflict. Available at file:///C:/Documents%20and%20Settings/Unnayan%20Onneshan/Desktop/Bangladesh.html

16. McLeman, R.2006"Global warming's huddled masses", *The Ottawa Citizen*, 23 November.

17. Morton, A., Boncour, P., and Leczko, F., 2008, Human security policy challenges *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

18. Myers, N., "Environmental refugees: An emergent security issue", 13th Economic Forum, Prague, May 2005

19. Myers, N. & Kent, J. 1995 *Environmental exodus: an emergent crisis in the global arena*. Washington, DC: The Climate Institute

20. Myers, N. 1997 Environmental refugees *Popul. Environ.* 19, 167–182.

21. Myers, N., 2002, Environmental Refugees: a growing phenomenon of the 21st century. Philosophical Transactions of the Royal society, London, UK. 357, 609-613.

22. Stavropoulou, M., 2008, Drowned in definitions? *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

23. Steiner, A., 2008, Forwarding at Forced Migration Review *in* Couldrey, M. & Herson, M. (eds) Forced Migration Review, Issue 31, Refugee Studies Centre, University of Oxford, UK.

24. Stern, N., (Ed.), *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, 2006, p. 3.

25. Stern, N. (Ed.) 2006 *The Economics of Climate Change: The Stern Review,* Cambridge University Press, Cambridge

26. World Bank, 2000, *Bangladesh: Climate Change & Sustainable Development*, Report No. 21104 BD, Dhaka. Available at http://www wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2001/04/13/000094946_01033105302920/Rendered/PDF/multi0page.pdf, [Accessed 20July, 2011]

Durban Discussion Dossier

- **Impacts of Changing Climatic Condition and Increasing Population on Food Security in South Asia: Based on Different Scenarios**
- **Accounting Climate Induced Migration in Bangladesh: An Exploratory GIS Based Study**
- **Implications of Climate Change on Crop Production in Bangladesh: Possible Adaptation Techniques**
- **Innovation in Livelihood Adaptation: Examples from RESOLVE, Bangladesh**

Unnayan Onneshan - The Innovators
16/2, Indira Road, Farmgate
Dhaka-1215, Bangladesh
Tell: + (880-2) 8158274, 9110636
Fax: + (880-2) 8159135
E-mail: info@unnayan.org
Web: www.unnayan.org