The impacts of cyclones Sidr and Aila on the health of the coastal people of Bangladesh

Thesis Submitted to Middlesex University in partial fulfillment of the award of Doctor of Philosophy

By

Russell Kabir
M00337597

MIDDLESEX UNIVERSITY, LONDON, UK

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Dedication

To

My parents Professor M.Kabir and Anjuman Ara Kabir

&

wife Urmi

&

my little princess Manha

DECLARATION OF ORIGINALITY

I declare that this thesis contents of original work undertaken solely by myself at Middlesex University between 2010 and 2014: where work by other authors is referred to, it has been properly referenced. Part of my research has been presented in conferences as well as published in journals and I have given a fuller list of information.

I hereby declare that any Internet sources published or unpublished works from which I have quoted or drawn references have been reference fully in the text and in the contents list.

Name: Russell Kabir

Signature:

Date:

Name of Supervisors

Dr. Hafiz T.A.Khan
(Director of Studies)

Dr. Emma Ball

Professor Kay Caldwell

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ABSTRACT

Global climate change is now a reality and this change is mainly happening due to global warming. The world has begun to witness the consequences of climate change with the increased frequency of extreme natural events like cyclones, tsunamis, hurricanes and floods. Populations affected by these extreme natural events are left helpless, miserable and in limitless agony. Due to its geographical location, topography, high population density, poverty and lower adaptive competence Bangladesh is considered to be highly vulnerable to natural disasters in the world. Climate changes have triggered an increase in the incidences of natural disasters (like cyclones) over the coastal region of Bangladesh. The coastal part of the country is the most vulnerable and the southwestern part of the coastal area is identified as environmentally handicapped by climate change. Climate change is openly threatening the very existence of people's lives and livelihoods in Bangladesh.

In recent times Bangladesh was hit by two consecutive cyclones *Sidr* in 2007 and *Aila* in 2009. The effects of climate change on the environment interacts with the health and population in Bangladesh at numerous complex levels. There are direct health effects through various vector and waterborne diseases, but arguably more important indirect effects as well. So far, little is known about climate change and its impact on human health in Bangladesh. This study was devised following the recent super cyclone Sidr that hit Bangladesh in November 2007 and cyclone Aila that hit in May 2009. The study aims to assess the impact of climate change on health of the coastal population of Bangladesh. This study was conducted in the cyclone Sidr affected area Amtali Upazila of Barguna District and in the cyclone Aila affected area Koyra Upazila of Khulna district. A questionnaire survey was used to collect primary data from households of the affected populations. Focus groups with health service providers of the affected areas was also employed. A mixed method approach was used in this research. Quantitative data was analysed using descriptive statistics, frequency distribution, chi-square, correlation analysis and logistic regression analysis. Thematic analysis was used to analyse qualitative data.

This research concludes that climate change largely affects human health in Bangladesh. Natural disasters due to climate change are affecting the general and mental health of the population of the affected areas. Prevalence of diarrhoea, skin diseases, hepatitis (jaundice) and other infectious diseases has increased after the cyclones. The risk of injury and death also increased during the time of natural disaster. According to the health service providers', climate change affected the mental status of people. On the other hand, the focus group discussion revealed that women, children and older adults are the most vulnerable group and are facing serious health concerns due to climate change. A majority of the health professionals, service providers and local community of coastal areas of Bangladesh are aware of the health impacts of climate change but their knowledge regarding health protection measures is limited. It is hoped that the findings of this research will have enormous policy implications.

Key words: Climate change, Sidr, Aila, Natural disaster, Human health, Coastal areas, Health effects, Bangladesh

ABBREVIATIONS

ADB	Asian Development Bank
AIDS	Acquired Immune Deficiency Syndrome
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BMD	Bangladesh Meterological Department
BUET	Bangladesh University of Engineering and Technology
CCC	Climate Change Cell
CCVI	Climate Change Vulnerability Index
CDC	Centre for Disease Control and Prevention
CEGIS	Centre for Enviornment and Geographic Information Services
CFC	Chlorofluorocarbon
CI	Confidence Interval
CO_2	Carbon Dioxide
CRI	Climate Risk Index
CRED	Centre for Research on the Epidemiology of Disasters
DALY	Disability Adjusted Life Year
DF	Degree of Freedom
DH	Department of Health
DGHS	Directorate General of Health Services
DHF	Dengue Haemorrhagic Fever
DMB	Disaster Management Bureau
DMIC	Disaster Management Information Centre
DSWD	Dangerous Substance in Water Directive
ECBP	Emergency Capacity Building Project
EEA	European Economic Area
ENSO	E1 Nino Southern Oscillation
EPA	Enviornmental Protection Agency
ESSP	Earth System Science Partnership
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GECHH	Global Environmental Change and Human Health
GO	Government Organization
GOB	Government of Bangladesh
GSFC	Goddard Space Flight Centre
HAV	Hepatitis A Virus
HPA	Health Protection Agency
HIV	Human Immunodeficiency Virus
ICDDR,B	International Centre for Diarrhoeal Disease, Bangladesh
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature

JJS	Jagrata Juba Shangha
LDC	Least Developed Countries
KPH	Kilometre Per Hour
MDG	Millennium Development Goals
MIS	Management Information System
MoEF	Ministry of Environment and Forest
MOFDM	Ministry of Disaster Management and Relief
MOWR	Ministry of Water Resources
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheirc Administration
NGO	Non-government Organization
N_2O	Nitrous Oxide
OCHA	Office for the Coordination of Humanitarian Affairs
OFDA	Office of Foreign Disaster Assistance
PAHO	Pan American Health Organization
PRC	People's Republic of China
RTI	Respiratory Tract Infection
SAARC	South Asian Asscoiation for Regional Cooperation
SE	Standard Error
SLE	St Louis Encephalitis
SOI	Southern Oscillation Index
SPSS	Statistical Packages for Social Sciences
SRES	Special Report on Emission Scenarios
SST	Sea Surface Temperature
UCL	University College London
UFHWC	Union and Family Health Welfare Centre
UK	United Kingdom
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNFCCC	United Nations Framework convention on Climate Change
UNDP	United Nations Development Programme
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children Emergency Fund
UNISDR	United Nations International Strategy for Disaster Reduction
UP	Union Porishod
USA	United States of America
UV	Ultra Violet
VOC	Volatile Organic Compound
VBD	Vector-Borne Disease
WFP	World Food Programme
WMO	World Meteorological Organization
WHO	World Health Organization

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Part of this research have been published and presented in the following journals and conference proceedings and conferences:

Conference Presentations

Understanding Climate change and its impact on human health in Bangladesh. 4th International Conference on Climate Change: Impacts and Responses at The University of Wachington, Seattle, Washington, USA, 12-13 July 2012.

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INTRODUCTION

Chapter 1: Introduction

1.1 Background to the research

Health includes the physical, social and psychological wellbeing of people. It could be argued that the weather or climate has been known to affect human health since the time of Hippocrates. Climate change is linked to human health in various ways. As the Science Plan for the Earth System Science Partnership Joint Project on Global Environmental Change and Human Health (ESSP GECHH) observes, " *is widely understood that human societies and the well-being and health of their populations depend on the flow of materials, services and cultural enrichment from the natural world*" (GECHH, 2007:1).

The theme of the World Health Day (2008) concentrated on 'protecting health from climate change'. It stated that the changing pattern of the climate is likely to affect human health including vector borne diseases, safe drinking water, secure shelter, food supply and social relations (WHO, 2008). In 1969 the Apollo moon shot provided an extra ordinary photograph of this planet suspended in space. This transformed individuals' thought about the biosphere and its limit. Climate and weather has a powerful impact on human health and wellbeing and the change is happening now and started as long as 100 years (Islam, 2010).

Over the past century (1906-2005), global average surface temperatures have increased by 0.74 ± 0.18 °C (IPCC, 2007). Based on observations of global air ocean temperatures and changes in (among others) snow/ice extent and sea levels, the Intergovernmental Panel on Climate Change (IPCC) concluded that it is 'unequivocal' that the climate system has warmed (IPCC, 2007). Most of the warming since the middle of the 20th century is *very likely* (subjective probability of >90%) to be due to the human-induced increase of atmospheric greenhouse gas concentrations (IPCC, 2007). Various impacts on physical and biological systems have been observed (IPCC, 2007). According to McMicheal *et al*, (2009:2123), "*Climate change arises in the context of a world that is now experiencing systemic disruptions to environment- and hence risk to health, wellbeing and social functioning. To address climate change, public health should therefore consider risks at whole population level*."

Based on the Special Report on Emission Scenarios (SRES) 'Temperature projections for the end of the 21st century range from 1.1 to 6.4 °C, compared to 0.6 °C from end-20th century' (IPCC, 2000, 2007). These changes in the global average temperature have a wide variety of effects on global, regional and local levels. Effects include changes (average and extremes) in temperature, sea levels, precipitation and river runoff, drought, wind patterns, food production, ecosystem health, species distributions and phenology, and human health (IPCC, 2007).

Modern climate system models are much more inclusive than in the 1990s, allowing individual to learn more about how the Earth`s climate system replies to human and natural generated effects (McMichael, 2006). Recent understanding of how sea surface temperature affects the characteristics of tropical storm and cyclones, and how ocean subsurface temperature, thermocline deaths and thickness affect activity of the E1 Nino Southern Oscillation (ENSO) cycle, tropical cyclone intensification and landfall prediction will further enrich modelling capacity (McMichael, 2006)."*The health impacts from the gradual build-up of pressure on the natural, economic, and social systems that sustain health, and which are already* *under stress in much of the developing world, may contribute as much, if not more, as acute shocks such as natural disasters or disease epidemics*" (Neira *et al*, 2008:424).

The long-term good health of populations depends on the continued stability and functioning of the biosphere`s ecological and physical systems, often referred to as life-support systems (McMichaeal, 2003). The United Nations Environment Programme (UNEP) suggests that poor environmental quality is directly responsible for some 25 per cent of all preventable ill health worldwide (UNEP, 2002). The World Health Organization (WHO) reports that every year "*about 1.2 million people die from causes attributable to urban air pollution, 2.2 million from diarrhoea largely resulting from lack of access to clean water supply, sanitation, and from poor hygiene, 3.5 million from malnutrition, and approximately 60,000 in natural disasters"* (WHO, 2009:2).

Health effects are expected to be most severe in elderly people with infirmities or pre-existing medical conditions, children and the poor (Neira *et al*, 2008). A recent study by Bhuiyan and Khan (2011) shows that older adults in Kazakhstan suffered from skin disease, cardiovascular problems and respiratory problems due to climate change effects. Research also showed evidence of climate change effects on vector-borne and other infectious diseases (Haines *et al*, 2006). It is now evident that vector borne diseases have incresed with the recent climate change in Europe (Purse *et al*, 2005). Due to latitudinal shifts there is growth of tick-borne encephalitis in northern Europe (Lindgren *et al*, 2000; Skarphedinsson *et al*, 2005). In 2003, a heat wave in Europe was an extreme event and the summer of the same year was probably the hottest in Europe since 1500 (Luterbacher *et al*, 2004). According to climatologists this heat wave in 2003 was due to human induced global climate change (Stott *et al,* 2003). Increases in the intensity of tropical cyclones are also due to climate change (Emanuel, 2005; Webster *et al,* 2005). In the USA, Hurricane 'Katrina' (2005) caused major damage to the coastlines of Louisianna, Mississippi and Alabama (Haines *et al,* 2006). The UN General Secretary Ban Ki-moon in his opening speech for Climate Summit 2014 addressed climate change by stating "let us seize the 2015 challenge: a final push for the MDGs, new directions on energy and climate, an inspiring new development framework and a low carbon path beckons- a path that can create jobs and improve public health while safeguarding the environment" (United Nations Partners on Climate Change, 2013).

Natural disasters have created many hazards time and time again in different countries and have affected multiple countries in South Asia (Satapathy and Subhasis, 2009). The impact of climate change will be felt by different parts of the world; poor countries like Bangladesh are going to be worst hit. The gradual rise of average air and oceanic temperatures will change the rainfall and snowfall patterns, droughts and heat waves, the intensity of tropical cyclones floods and sea level rise. Bangladesh is considered to be highly vulnerable in the context of climate change. It is frequently at the mercy of the forces of nature, especially water from the sky, land and sea. The effects of climate change on the environment interact with the health and population in Bangladesh at numerous complex levels. There are direct health effects (through various vector- and waterborne diseases) as well as indirect effects. Threats to water supply, crops, and food production and thus nutritional status and effects on population movement (especially loss of rural agricultural and homestead lands driving very rapid urbanisation) are all associated with undesirable health, economic and social consequences. In light of this the impact of climate change on various infectious diseases and other health problems are discussed in this research. The present research provides knowledge, awareness and constraints of the population due to climate change. Thus the research helps to consider strategies, which could be employed to combat with climate, change induced diseases and health problems. It also helps policy-makers, programme implementers and administrators to take appropriate and feasible activities and actions in the climatic vulnerable areas.

1.2 Understanding Climate Change

The Earth is the only place in the solar system, which supports life. The earth has probably four different layers: atmosphere, biosphere, lithosphere and hydrosphere. These four layers have a common impact and collectively affect the weather. Climate is defined as an average weather condition of an area characterized by its own internal dynamics and by changes in external factors that affect climate (Trewartha and Horn, 1980). Weather is the sum total of the atmospheric variables at a given place for a brief period of time, expressed by daily conditions. The elements of weather and climate are similar but the events are not identical. The mean and variability of climatic variables like temperature, precipitation and wind over a period of time (at least 30 years) are generally used to describe climate (Islam and Neelim, 2010).

Changes in climate occur as a result of both internal variability within the climate system and external factors like natural and anthropogenic (McMichael *et al,* 2003). The climate system evolves with time under the influence of its own internal dynamics and due to changes in external factors that affect climate (called ‘forcings’). External forcings include natural phenomena such as volcanic eruptions and solar variations, as well as human induced changes in atmospheric composition. Solar radiation powers the climate system. There are three fundamental ways to change the radiation balance of the Earth: The first is by changing the incoming solar radiation (e.g., by changes in the Earth's orbit or in the Sun itself); The second is by changing the fraction of solar radiation that is reflected (called 'albedo'; e.g. by changes in cloud cover, atmospheric particles or vegetation); and by altering the long wave radiation from Earth back towards space (e.g. by changing greenhouse gas concentrations). Climate, in turn, responds directly to such changes, as well as indirectly, through a variety of feedback mechanisms (IPCC, 2007).

Climate change is currently the widely most discussed issue among the recent global environmental changes. There is enough evidence that humans are responsible for creating an overburden on the Earth's biological systems. As stated by Vitousek *et al,* (1997) Human alteration of earth is substantial and growing. Between one-third and one-half of the land surface has been transformed by human action; the carbon dioxide concentration in the atmosphere has increased by nearly 30% since the beginning of Industrial Revolution; more atmospheric nitrogen is fixed by humanity than by all natural terrestrial sources combined; more than half of all accessible fresh water is put to use by humanity; and about one-quarter of the bird species on Earth have been driven to extinction. By these and other standards, it is clear that we live on a human dominated planet.

1.3 Problem formulation

Research on climate change and human health is a relatively new and challenging area in epidemiological research. According to the UN Intergovernmental Panel on Climate Change, human and natural systems exposure to climate change will vary across the world. McCarthy *et al,* (2001) stated that changes in seasonal river flows, increase in floods and droughts, decreased food security and loss of biodiversity are alarming factors for Asia, Africa and Latin America (mainly in the delta regions, low lying small island states and many parched areas where drought and scarcity of water are problematic even without climate change). The United Nations set out eight millennium development goals for the poorest nations in the world (UN, 2000). The goals aim to address poverty reduction, literacy, sex inequality, malnutrition, child deaths, maternal mortality, major infections, environmental stability and development of global partnership.

Climate is a bride to the achievement of Millennium Development Goals (Stern, 2007). These effects of global climate change are evident now. These effects are multidimensional and the effects are not the same across the globe because of differing geographical locations and levels of development (Rosenberg and Maheswary, 1982). Developing countries are experiencing an increase in the frequency of natural disasters due to climate change (Drabo and Mbaye, 2011). The question always remains 'are these countries really ready to tackle them as well as the consequences of climatic disasters?'

Climate change affects everywhere but it is extreme in some countries (like Bangladesh) because of their geographical location (Rahman *et al*, 2011). Due to its geographical setting it is very easy to destroy and damage the ecological balance of

Bangladesh (Salequzzaman and Stocker, 2001). Bangladesh is a small country with a population of 162,221,000 (WHO, 2011). Mountains and hills cover three-fourths of the country with a funnel shaped Bay of Bengal in the south making the country more vulnerable to natural disasters. Abnormal rainfall and earthquakes in the Himalayan region creates disaster situations. Effects of *El-Nino*-Southern Oscillation (ENSO) and climatic change have a great impact on the overall future disaster scenarios in the country (State of Environment, 2001).

The climatic conditions of Bangladesh are influenced by a number of global and regional scale factors. These factors include geographical location, the effect of North South continental scale atmospheric pressure gradient (terrestrial to oceanic), the influence of jet stream stretched from South East Asia to Northern Africa on the monsoon wind system, change in the solar albedo due to land use, land cover change in the region and its impacts on wind pattern, fluctuations in the terrestrial and sea surface temperature (Islam and Neelim, 2010:1). Bangladesh is already evidencing the adverse impacts of global warming and climate change. The following impacts have been observed: hotter summers, irregular monsoons, untimely rainfall, heavy rainfall over short periods (causing water logging and landslides), very little rainfall in dry periods, increased river flow and inundation during monsoon, increased frequency, intensity and recurrence of floods, crop damage due to flash floods and monsoonal rain, crop failure due to drought, prolonged cold spells, salinity intrusion along the coast (leading to scarcity of potable water and redundancy of prevailing crop practices), coastal erosion, river bank erosion, deaths due to extreme heat and cold, increasing mortality, morbidity, prevalence and outbreak of dengue, malaria and diarrhoea etc. (CCC, 2008).

Due to the warmer climate in Bangladesh there is a greater chance of spreading many diseases, such as malnutrition, malaria and cholera. As stated by Halady and Rao (2009) food shortages will cause malnutrition, warmer climatic conditions will be conducive for mosquitos and other insects to carry malarial germs and flooding will pollute the water resulting in increased incidences of cholera. Rodo *et al,* (2002) also suggest that an increase in E1 Nino intensity will add to the increase of the cholera cases in Bangladesh. A rise in the surface temperature is also a source for various deadly diseases such as malaria and dengue (Agrawala *et al*, 2003). Ahmed (2006) claims that natural disasters cause extreme suffering for populations below the poverty line. Climate change may disrupt the social, economic, political, cultural and ecological life of Bangladesh. The expected climatic impacts on Bangladesh according to IPCC are summarized in Box 1:

Natural hazards such as floods, cyclones, droughts and earthquakes are increasingly the source of immense misery to human lives, although the frequency of such events as a whole may not be increasing (World Disasters Report, 1994). Cyclones today have become a major feature of climate change. According to IPCC (2007) tropical cyclones and extreme weather events are due to greenhouse gas mitigation efforts. Emanuel (2005) stated that the intensity of cyclones have increased in the last 30 years. Yet the relationship between cyclones and climate change is argumentative. This could be because it's a rare event and problematic to discover changes in causal frequencies and severity (Landsea *et al,* 2006). Like other disasters, the direct health impacts of cyclones include deaths and injuries. Some of the important indirect health impacts include significant outbreaks of communicable, water-related and other diseases, e.g., diarrhoea, hepatitis, malaria, fever, pneumonia, eye infections, and skin diseases.

Box 1:

- Average increase in temperature in Bangladesh will be 1.3°C in 2030 and 2.6°C for the year 2070;
- There will be a seasonal variation in temperature in Bangladesh: 1.4°C in the winter and 0.7°C in the monsoon in 2030, and in 2070 the figure will be 2.1°C and 1.7°C, respectively;
- By 2030, an additional 14.3 per cent of the country will become extremely vulnerable to floods, while existing flood-prone areas will face increasing flooding;
- A mere one metre rise in sea level will inundate 18 per cent of landmass and directly affect 11 percent people and virtually will force to loose the Sundarbans;
- Monsoon rainfall may increase by 11 per cent and 27 per cent by the year 2030 and 2070,respectively;
- Up to 40 per cent of investment in development and infrastructure will be affected due to climate change;
- General cyclonic activity in the Bay of Bengal has become more frequent, in recent times creating rougher seas;
- Due to changes in the hydrological cycle there can be epidemic morbidity and mortality (mainly due to diarrhoea);
- Increased coastal temperatures will cause diseases in the coastal districts of Bangladesh.

Source: IPCC (2001:327; 2007); Deb *et al*, (2009).

Bangladesh has been plagued by innumerable natural disasters over the years. So far the country has faced tropical cyclones, tidal surges, tornados, floods, droughts and river erosion. According to the UNDP (2010) about four percent of the world's cyclones hit Bangladesh. Coastal areas, especially heavily populated mega delta regions in South, East and South-East Asia, are at greatest risk due to increased flooding from the sea (IPCC, 2007). The occurring frequency of cyclones along the Bay of Bengal has increased in response to a rising Sea Surface Temperature (SST). Cyclonic intensity has also increased with a corresponding increase in surge height in newly inundated shoreline (Ali, 1999). It is furhter stated that cyclone formations from depressions will also increase if there is an increase in 2°C in SST. Agrawala *et al*, (2003), however, suggested that there is no reason to assume that cyclone tracks will shift under climate change- meaning that an increasing number of cyclonic storms will likely hit Bangladesh under climate change.

Table 1.1: The cyclones over Bangladesh at a glance

Date	Year	Maximum wind speed (km/hr)	Storm surge Height (meter)	Death toll
May 11	1965	161	3.7-7.6	19,279
15 December	1965	217	2.4-3.6	873
01 October	1966	139	6.0-6.7	850
12 November	1970	224	6.0-10.00	300,000
25 May	1985	154	3.0-4.6	11,069
29 April	1991	225	6.0-7.6	138,882
19May	1997	232	3.1-4.6	155
15 November	2007	223	6.1-9.1	3363
25May	2009	170	5.2-10.0	400

Source: (Bangladesh Meteorological Department, 2009)

A higher population density increases vulnerability to climate change (especially water related disasters) in Bangladesh (Agrawala *et al*, 2003). Over a period of 100 years, 508 cyclones have affected the Bay of Bengal region, 17 percent of which caused landfall in Bangladesh. A severe cyclone occurs almost once every three years.

Although the frequency of cyclones is not unusual compared to other cyclone hotspot countries, the impact it causes stands out: 53 percent of the cyclones that claimed more than 5,000 lives took place in Bangladesh (GOB, 2008).

In recent years, Bangladesh was hit by two consecutive cyclones *Sidr* in 2007 and *Aila* in 2009. Paul (2009) found that cyclone *Sidr* which hit Bangladesh on 15th November 2007 caused 3,406 deaths and over 55,000 people sustained physical injuries. Heavy rain accompanying cyclones and tidal waves due to wind effects caused extensive physical destruction, casualties, damage of crops, livestock and flooding in total 30 districts across the South Western coastal district of Bangladesh (Ministry of Flood & disaster Management, 2008). Cyclone *Sidr* affected nine districts of Bangladesh. The most devastated districts were Bagerghat, Barguna, Patuakhali and Pirojpur (Davidson, 2008).

After Sidr, the Government of Bangladesh (2008) carried out a rapid initial assessment of the damage. Their assessment found a widespread outbreak of waterborne disease, respiratory tract infection (RTI) and other related infections. People in the nine-surveyed area were at risk of communicable diseases- diarrhoea, dysentery, acute respiratory infection and pneumonia. Children aged five years or younger were vulnerable (Ministry of Flood & Disaster Management, 2008).

Cyclone *Aila* hit the southern coastline of Bangladesh hard on the 25th May 2009. It was really a unique event as a storm like this had not hit the Sunderbans within the last three decades (Das, 2009). Satkhira and Khulna districts of Bangladesh suffered the heaviest damage along with Bagerhat, Pirojpur, Barisal, Patuakhali, Bhola, Laksmipur, Noakhali, Feni, Chittagong and Cox's Bazar (Roy *et al*, 2009). There had been an outbreak of diarrhoeal disease in cyclone *Aila*-hit coastal areas of Khulna as an acute scarcity of drinking water and food worsened the sufferings of thousands. Although no official data was available on the Diarrhoeal deaths, an approximate figure of 15 deaths was reported by the locals in Koyra, Paikgacha and Dacope (Roy *et al*, 2009).

To find out the impact of climate change on health of the coastal population, the researcher decided to concentrate on the two major cyclones, which had recently hit Bangladesh, cyclone *Sidr* and *Aila*. There is growing scientific evidence from the literature that a changing climate is responsible for these kinds of natural disasters and in turn these natural disasters are directly and indirectly affecting human health.

1.4 Climate and Climate Change in Bangladesh

Climate change is not just an environmental issue but influences many other social and economic factors such as poverty, health and economic development (ACCA, 2009). Since its independence in 1971, Bangladesh struggles to overcome under-development and poverty; the country faces the additional challenge of climate change. It is ironic that Bangladesh will be the worst victim of climate change even though she had no role of causing it (Islam, 2009). Bangladesh is the 5th most disaster prone country (Table 1.2) among the 173 countries in the world according to the World Disaster Risk Report 2012.

Table 1.2: World Risk Index

Rank	Country	Risk (%)
1.	Vanuatu	36.31
2.	Tonga	28.62
3.	Philippines	27.98
4.	Guatemala	20.75
5.	Bangladesh	20.22
6.	Solomon Islands	18.15
7.	Costa Rica	17.38
8.	Combodia	17.17
9.	El Salvador	16.89
10.	Brunei Darussalam	15.92

Source: (World Risk Report, 2012:9)

Figure 1.1: Map of Bangladesh

Source: (www.maps.com)

Located between the Himalayas and the Bay of Bengal and with three mighty rivers (Ganges, Brahmaputra and Meghna) converging on its territory, Bangladesh is prone to floods, torrential rains, erosion and cyclones (GoB and European Commission, 2008). The total area is 147,570 sq km and consists mainly of low and flat land and a network of more than 230 major rivers with their tributes and distributaries crisscrossing the country (DMB, 2010).

Table 1.3: Climatic parameters that might impact different sectors of different geographical locations of Bangladesh

Climate and Related Elements	Critical Vulnerable Areas	Resultant impact
Temperature rise and drought	North-west	• Agriculture (crop, livestock, fisheries) • Water scarcity • Energy • Health
Sea Level Rise and Salinity Intrusion	Coastal Area, Island	• Agriculture (crop, fisheries, livestock) • Water (water logging, drinking water, urban) • Human settlement • Energy • Health
Floods	Central Region, North East Region, Char land	• Agriculture (crop, fisheries, livestock) • Water (urban, industry) • Infrastructure • Human settlement • Health • Disaster • Energy
Cyclone and Storm Surge1	Coastal and Marine Zone	• Marine Fishing • Infrastructure • Human settlement • Life and property
Drainage congestion	Coastal Area, Urban, South West	• Water (Navigation) • Agriculture (crop)

Source: (Nishat *et al*, 2011:12)

The population of Bangladesh is now approximately 154.7 million (The World Bank, 2013). Around 52% percent of the civilian labour force of the country is engaged in agriculture and 14% is engaged in industry (DMB, 2010). According to BBS (2011) 2.6 million people in Bangladesh are unemployed and the national literacy rate is 56.8%. The water sector is particularly vulnerable to climate change. Other socio-economic sectors like agriculture, fisheries, forestry, natural environment etc. will also be affected due to the change in climate and its associated impact on the water sectors (ADB, 1994; ADB, 2008; Choudhury *et al*, 2005; Fung *et al*, 2006; Islam *et al*, 2008). Access to drinking water is also insecure in some parts all year round due to saline intrusion in the coastal area, where large part of the country's groundwater is contaminated with arsenic (MoWR, 1999).

Spatial distribution of population is important in the context of climate change. It is estimated that about 79% (70% inland plain and 9% inland hills) of people live somewhat away from the sea and the remaining 21% (15% coastal plain and 6% coastal hills) accounts for populations in the coastal districts (MoEF-UNDP, 2006). The Germanwatch Long-Term Climate Risk Index (CRI) 2011 has identified Bangladesh as the country most affected by extreme climate events during 1990- 2009 (Harmeling, 2010).

According to MoEF, (2009) Bangladesh is the most vulnerable country to climate change and the condition will degrade in the coming years. Floods, tropical cyclones, storm surges and droughts are likely to occur more frequently and severely in the future. Research indicated that disasters are part of a process and not an independent event. This is true for Bangladesh as it has faced a chronicle of disasters related to the socioeconomic dynamics and management of the state (Society for Environment and Human Development, 1998). Since 1970, about 39 million people have been displaced by major natural disasters like cyclones and floods in Bangladesh up until the year 2009 (Mahmood, 2012).

1.5 Climate in Bangladesh

Bangladesh is a country on the Tropic of Cancer which has a tropical monsoon climate characterized by heavy seasonal rainfall, moderately warm temperatures and high humidity. Regional climatic differences in this flat country are minor (Banglapedia, 2006).

Bramer (2002) categorized the climatic seasons in Bangladesh into 4 categories:

1. Pre-monsoon (March to May) with high temperatures and high evaporation rates
2. Monsoon (June to September) with a high intensity of rainfall occurrence.
3. Post-monsoon (October-November) decreased rainfall with hot and humid temperatures.
4. Dry or winter seasons (December to February) this is coolest, driest and sunniest stage of the year.

The average temperature of the country ranges from 7°C to 13 ° C during winter and 24° C to 31°C during summer (BBS, 2010). April is the hottest month of the year with an average temperature of 27 °C in the east, 31°C in the west central part and during the summer time the temperature reaches 40°C in the western part (Banglapedia, 2006). Extreme temperatures vary between about 4°C and 43°C except near the coast where the range is lower and during the rainy season the mean maximum temperature over most of the country is about 31°C. The mean minimum temperature during the winter season is 9°C in the northern parts of the country. The temperature starts rising quite sharply from late February throughout the country (Rasheed, 2008).

Mean annual rainfall is the lowest in the west (1250-1500 millimetre) and highest in the North, East and South (>2500 millimetre). From June to September the country sees 80% of its rainfall (Islam and Neelim, 2010). The maximum rainfall is recorded in the coastal areas of Chittagong and northern part of Sylhet district, while the minimum is observed in the western and northern parts of the country (BBS, 2010). A rainy season that concurs with a summer monsoon brings high humidity, heavy rainfall and during the winter season cold air flow enters the country from the eastern side; this wind is the part of the winter monsoon circulation of the South Asian subcontinent (Banglapedia, 2006).

A wind generating from the south of the country during early summers and late monsoon of 160 kilometres per hour causes waves to peak as high as 6 metres in the Bay of Bengal and is responsible for causing floods in the coastal region. In summer, severe cyclones can develop in the Bay of Bengal during the October-November period, with the most severe cyclone hitting the coastline of Bangladesh on 12th November 1970, wind speed of 224km/hr (BBS, 2010). During the winter period the general direction of winds over Bangladesh is northerly and winds are generally light with speeds reaching to 50-100 km/hr (Rasheed, 2008). Bangladesh experiences a hot summer with high humidity from late March to late June and a cooler but still a hot and humid monsoon from later June through October and a cool dry winter from November to the end of February (BBS, 2010).

1.5.1 Why is Bangladesh at Risk of Climate Change?

Islam (2009:14) identifies five major causes why Bangladesh is at risk due to climate change:

I. Submergence of a large part of the country

A sea level rise caused by global warming will submerge a large part of Bangladesh. Most of Bangladesh is below an elevation of 10 meter above the sea level. (IPCC, 2007:47) notes that due to global warming the sea level has risen at an alarming average rate of 3.1 mm per year during 1993-2003 and may rise in future by about 7 meters as a result of the melting of the Greenland Ice Sheet. This would imply the submergence of about 70 percent of Bangladesh.

II. Salinity Intrusion

Some part of Bangladesh that will escape direct submergence will be affected by salinity intrusion that will harm agriculture, vegetation and flora and fauna in general.

III. Destabilizing of rivers

Receding Himalayan glaciers will render Bangladesh rivers completely dry during the winter period while increased precipitation in summer will aggravate flooding.

IV. Increase in extreme weather events

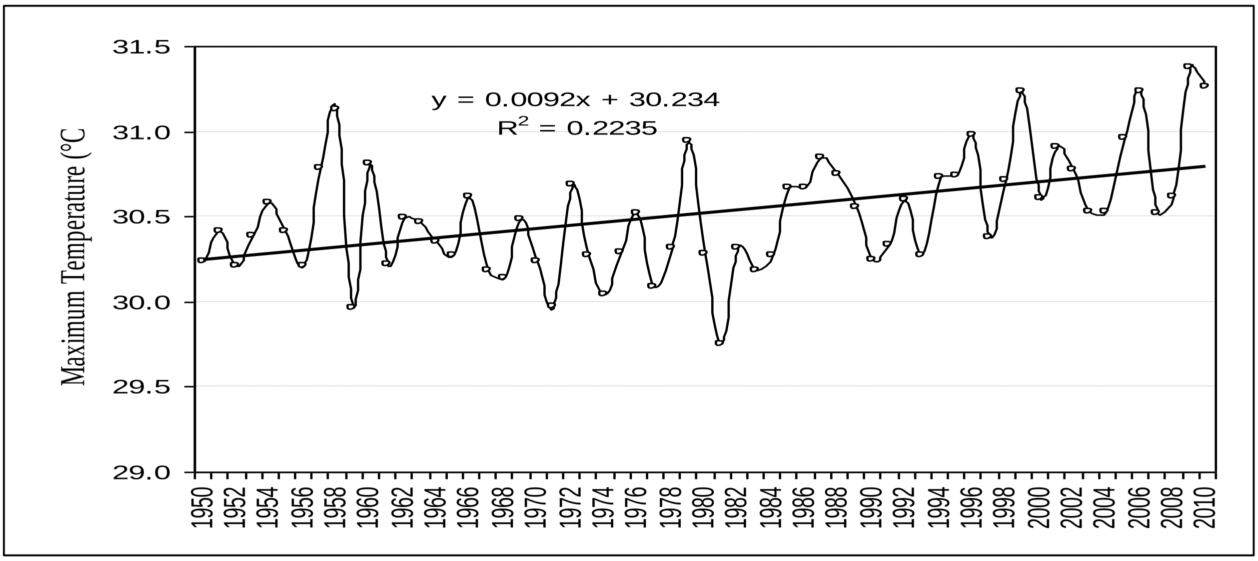
Increase in the frequency and scope of extreme weather events, (another consequence of climate change) will devastate the coastal area of Bangladesh.

V. Spread of diseases and epidemics

Spread of known and new diseases will take a much heavier toll in Bangladesh, a tropical country prone to vector borne and water bone diseases.

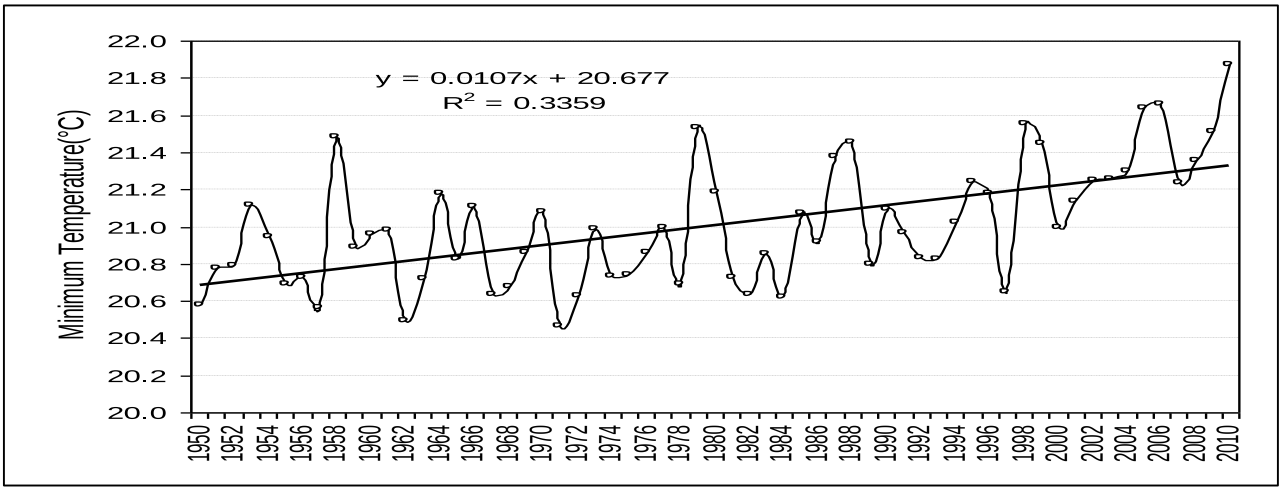
Climate change is creating a double injustice for Bangladesh as informed by Islam (2009). Firstly Bangladesh faces devastating consequences of changing climate. Though she is not responsible for changing it and she is least capable of facing these consequences she is still counted as one of the Least Developed Countries (LDC). A change in the precipitation and temperature due to global warming in Bangladesh is already evident (Mizan and Bijoy, 2009). Temperature trends both minimum and maximum have shown increased tendency in the last 60 years from1950-2010 (Habib, 2011) as shown in figure 1.2 and 1.3.

Figure 1.2: Temporal variation of annual maximum temperature of Bangladesh during 1950-2010



Source: (Habib, 2011)

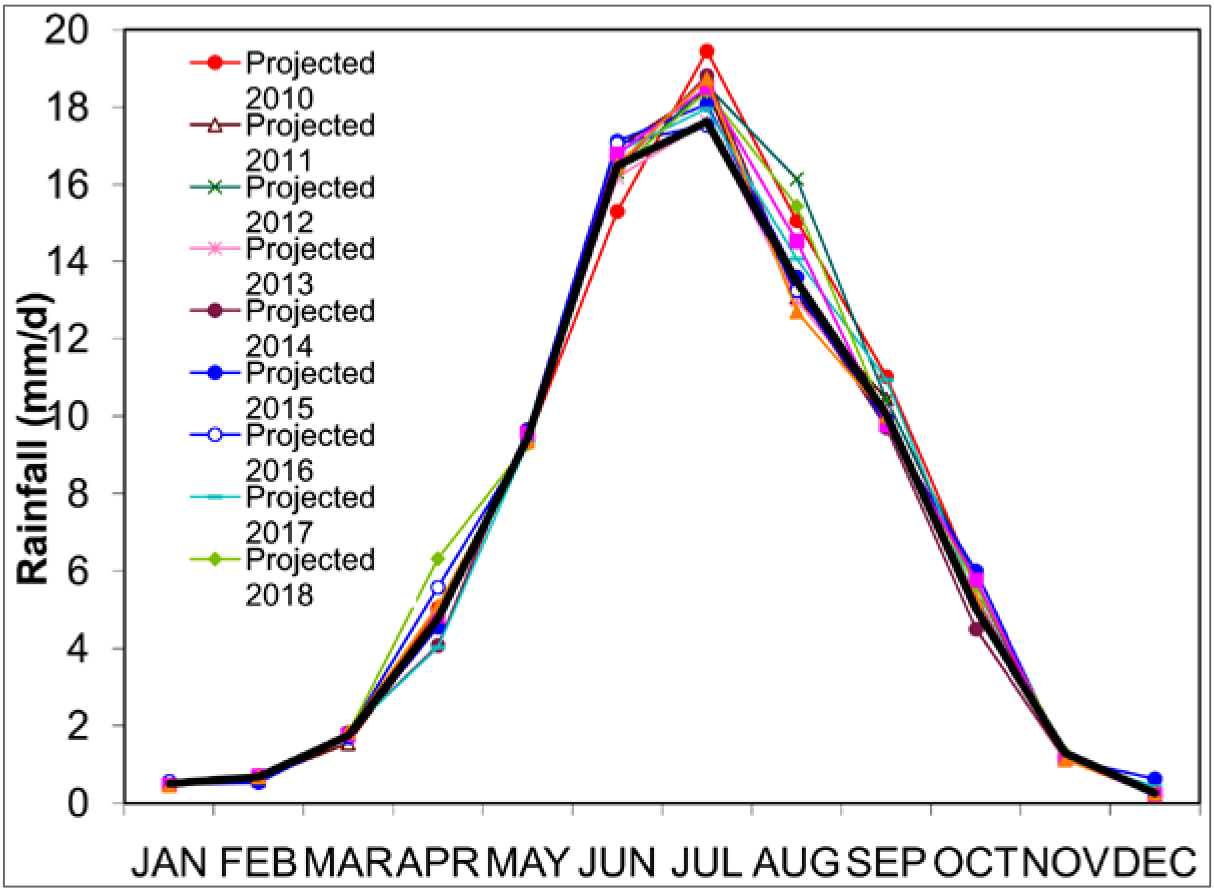
Figure 1.3: Temporal variation of annual minimum temperature of Bangladesh during 1950-2010



Source: (Habib, 2011)

Temperartures are increasing in the monsoon months mainly during June, July and August (MoEF-UNDP,2006). Islam (2008) predicted that in the coming years from 2010-2020 rainfall (figure 1.4)will follow some histoical patterns and will be surplus in the months April, July, August and September . A shortfall of rain will also be observed in some months.

Figure 1.4: Annual cycle of projected rainfall (mm/d) in Bangladesh with normal

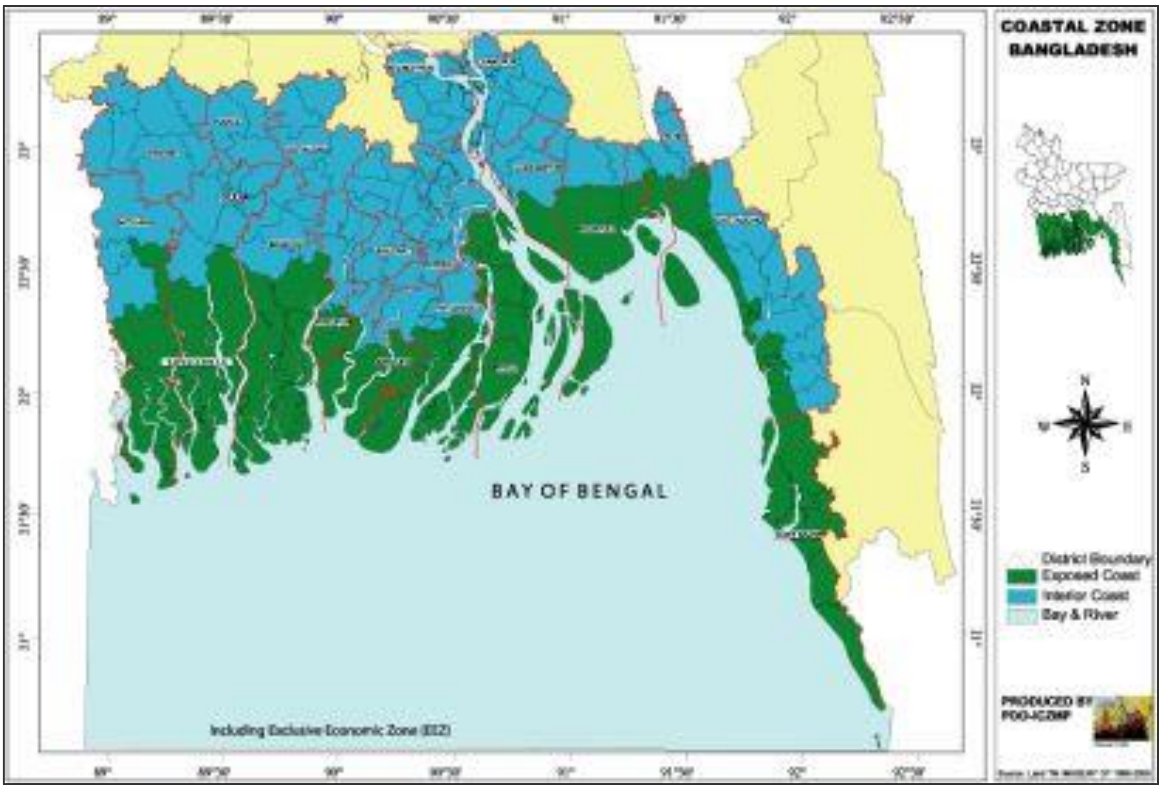


Source: (Islam,2008:98)

1.5.2 Coastal Areas of Bangladesh and Sea level Rise

The coastal region of Bangladesh is situated in the south of the country (Islam and Gnauck, 2010).The total length of the Bangladesh coastline is 710 km (Mohal *et al*,2006) which is 32% of the land area of Bangladesh . Currently 40 million people live in the coastal areas of Bangladesh (Pender,2008). Kausher *et al*, (1993) defined a coastal zone as the area covered by five greater districts of Bangladesh adjoining the sea, these are Khulna, Barisal, Patukhali, Noakhali and Chittagong shown in figure 1.5.

Figure 1.5 :Coastal Zones of Bangladesh



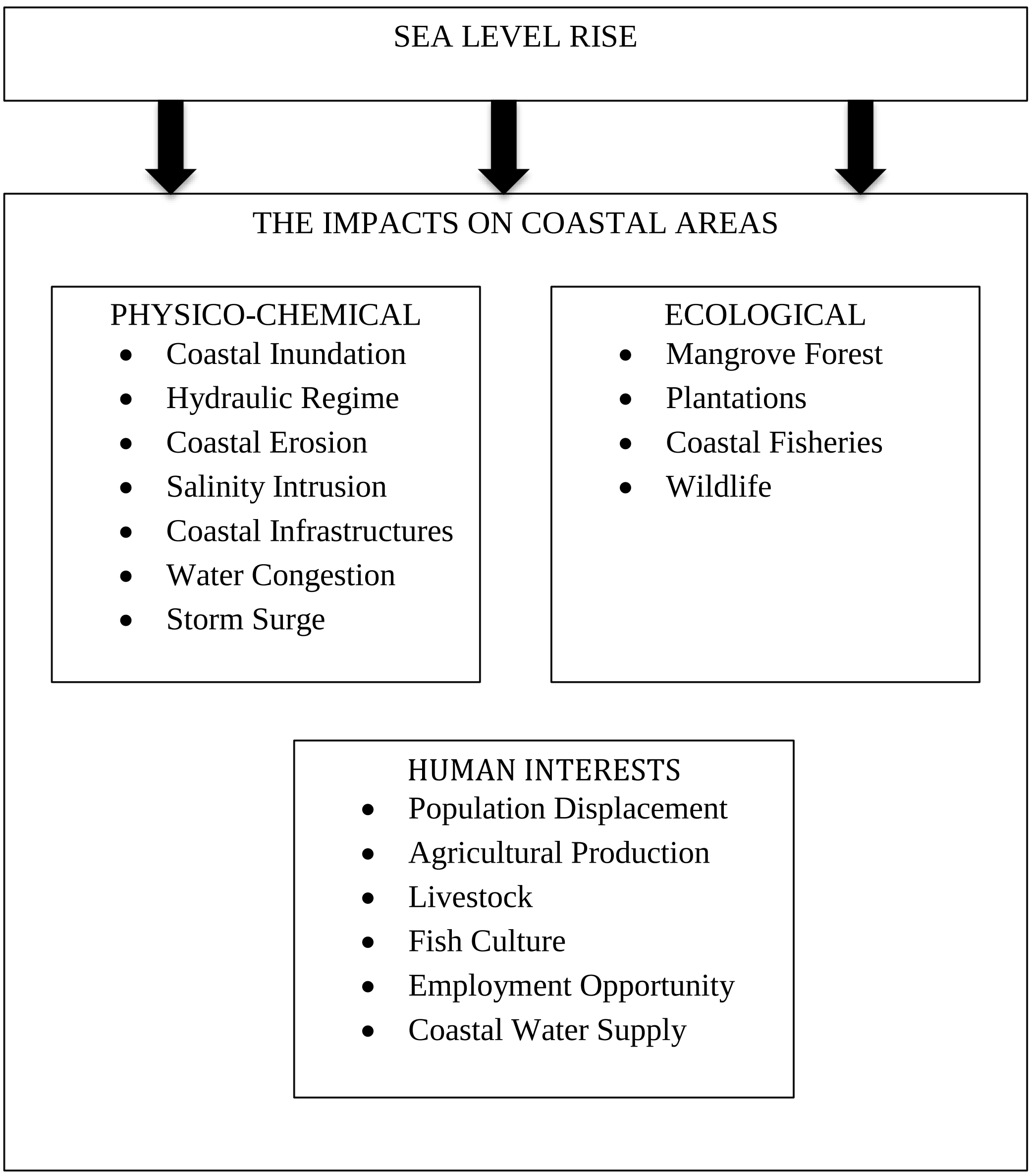
Source: (Islam, 2007:56)

Coastal areas are one of the most dyanmic parts of the eath’s surface , they have some of the most delicate ecosystems for example mangroves, wetlands, coral reefs, dunes and beaches and also they are home to large populations of humans (Mukhopadhyay *et al*,2012). The populations of the coastal regions of Bangladesh are living under the poverty line, for example Khulna and Barisal (southern part) and Rajshahi (northern part) and environmental degradation is one of the main reasons for poverty. The main occupations of the coastal people are farming, fishing and agricultural labourers whose livelihoods depend mainly upon the natural ecosystem (Akter, 2009). Coastal areas are influenced by incidents deriving from long distances away and not caused by human interventions. For example, cyclones and tsunamis have their origin at sea but can destroy a coastal area and can leave a long lasting impact (Amin, 2008). Recent changes in climate have increased the frequency of severe cyclonic storms that will affect the livelihoods and income of the poor people of the coastal zones (Quadir and Iqbal, 2008). The atypical geography of Bangladesh causes not only life giving monsoons but also catastrophic natural disasters to which now have added to climate change and sea level rises (Ali, 1999). The low structures of the coastal zones give rise to variable interactions between sea and freshwater with a strong backwater effect, the freshwater leads the coastal zone during monsoon and the saline water meddles inland during the dry season when there is a lower flow (Concern Universal- Bangladesh, 2009).

Chao *et al*, (2008) said that Bangladesh has already been affected by sea level rises over the last 8 years at a very regular pace and it will perpetrate its effect on Bangladesh in the coastal areas and through the coastal area to all over Bangladesh (Hossain,2010). The low lying areas of coastal Bangladesh having elevation within meters from the mean sea level will be completely submerged in sea water (Ahmed,2008).Tanner *et al*, (2007) informed that a rise in sea level is causing coastal erosion and he predicted that 3% of land will be lost to the sea by the year 2030 and 6% by the year 2050. Sea level rises could potentially force around 33 million of their land by 2050 and up to 43 million off their land by 2080 (Mohal & Hossain, 2007). Ahmed (2009) reported that the components of the enviornment likley to be affected by sea level rises may be grouped under three categories. These are- physico-chemical, ecological and human interest as shown in Figure 1.6. The rise in sea level will have some impact on the coastal wetland especially the salt marhses and mangroves are vulnerbale because they are usually a few feet within sea level (IPCC,2007).

The coastal zone is directly affected by salinity (Karim *et al*,1990). Sea level rises will increase salinity in the river water as well as in the groundwater in Bangladesh. Presence of salinity in the water may cause some health problems like hypertension and other indirect effects such as diarrhoea or stroke, skin diseases, acute respiratory infection and gynecological diseases (Shahid, 2009; Vineis *et al*, 2011 and Water Aid Bangladesh,2007).

Figure 1.6: Enviornment Impacts of Sea level rise in Bangladesh



Source: (Ahmed,2009:93)

This was supported by Khan *et al*, (2011) .They reported that from Dacope, a rural coastal town in Bangladesh, the water salinity in drinking water was very high and the annual hospital prevalence of hypertension in pregnancy was higher in the dry season and is likely to be aggravated by climate change induced sea level rises. The costal water supply in terms of population coverage is very poor and this salinity intrusion will make it much worse.In Bangladesh, enviornmental changes influence population migration in two ways, for example, events like floods, cyclones and riverbank erosion may force affected populations to leave their homes temporarily and in most cases people return to their place of origin whereas it has been in slow onset processes like coastal erosion, sea-level rises , salt water intrusion, changing rainfall pattern and drought which can cause permanent forms of migration (Siddiqui, 2011).A sea surface temperature of more than 26.5 °C is one of the strongest predictions for tropical cyclone formation . The temperature of the Bay of Bengal is much higher than this and the variability and trends of sea surface temperatures, sea level rises, rainfall pattern and wind speed during the monsoon and tropical turbulences (e.g. depressions and frequent cyclones) have an adversative effect on the livelihoods of the coastal inhabitants. It causes the deaths of millions of people and damages the environment, infrastructure and resources (Quadir and Iqbal, 2008). Ali (1999) suggests that the future rising of sea surface temperature due to climate change would increase the intensity and frequency of cyclones in the Bay of Bengal area.

1.6 Natural Disasters in Bangladesh

Bangladesh is a country where devastating natural disasters are such a common phenomenon it could be argued that they have become part of everyday life. In the last 30 years Bangladesh has been hit by more than 100 cyclones and about 60 flash floods and other natural disasters like drought and heatwaves (Ahsan *et al,* 2011). The main disasters that affected the country in the last few decades are cyclones and floods as given in table 1.4.

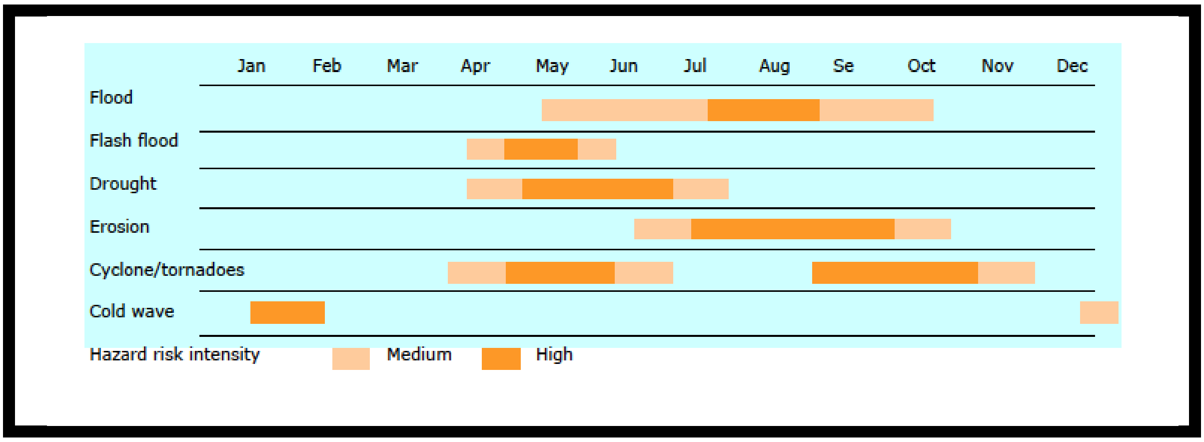
Table 1.4: Main disasters in Bangladesh since 1965

Date		Hazard	Death toll	Main affected districts
11May	1965	Cyclone	19,279	Barisal
15 December	1965	Cyclone	873	Cox's Bazar
01 October	1966	Cyclone	850	Noakhali
12 November	1970	Cyclone Bhola	300,000 to 500,000	Bhola
25 May	1985	Cyclone	11,069	Noakhali
August-September	1988	Flood	1,378	
29 April	1991	Cyclone Gorky	140,000	Cox's Bazar, Chittagong
19 May	1997	Cyclone	155	Cox's Bazar, Chittagong
July-September	1998	Flood	1,100	
July-August	2004	Flood	747	
15 November	2007	Cyclone Sidr	4,000	Bagerhat, Pirojpur, Barguna, Patuakhali
25 May	2009	Cyclone Aila	190	Sathkhira, Khulna

Source: (Riquet, 2012:8)

The southwest coastal region of Bangladesh has historically experienced extreme climatic events claiming millions of lives and destroying the infrastructure and agricultural land (Kulsum and Azam, 2009). The pre-monsoon and post-monsoon are transitional periods, from the months of March to May and October to November and cyclonic storms rise from the Bay of Bengal during these two periods (Riquet, 2012). Cyclones from the post-monsoon periods are usually more destructive. The diagram below is a climate hazard calendar showing climate related hazard risks for Bangladesh.

Figure 1.7: Climate Hazard Calendar



Source: (Climate Change Cell, 2007:5)

1.6.1 Cyclone

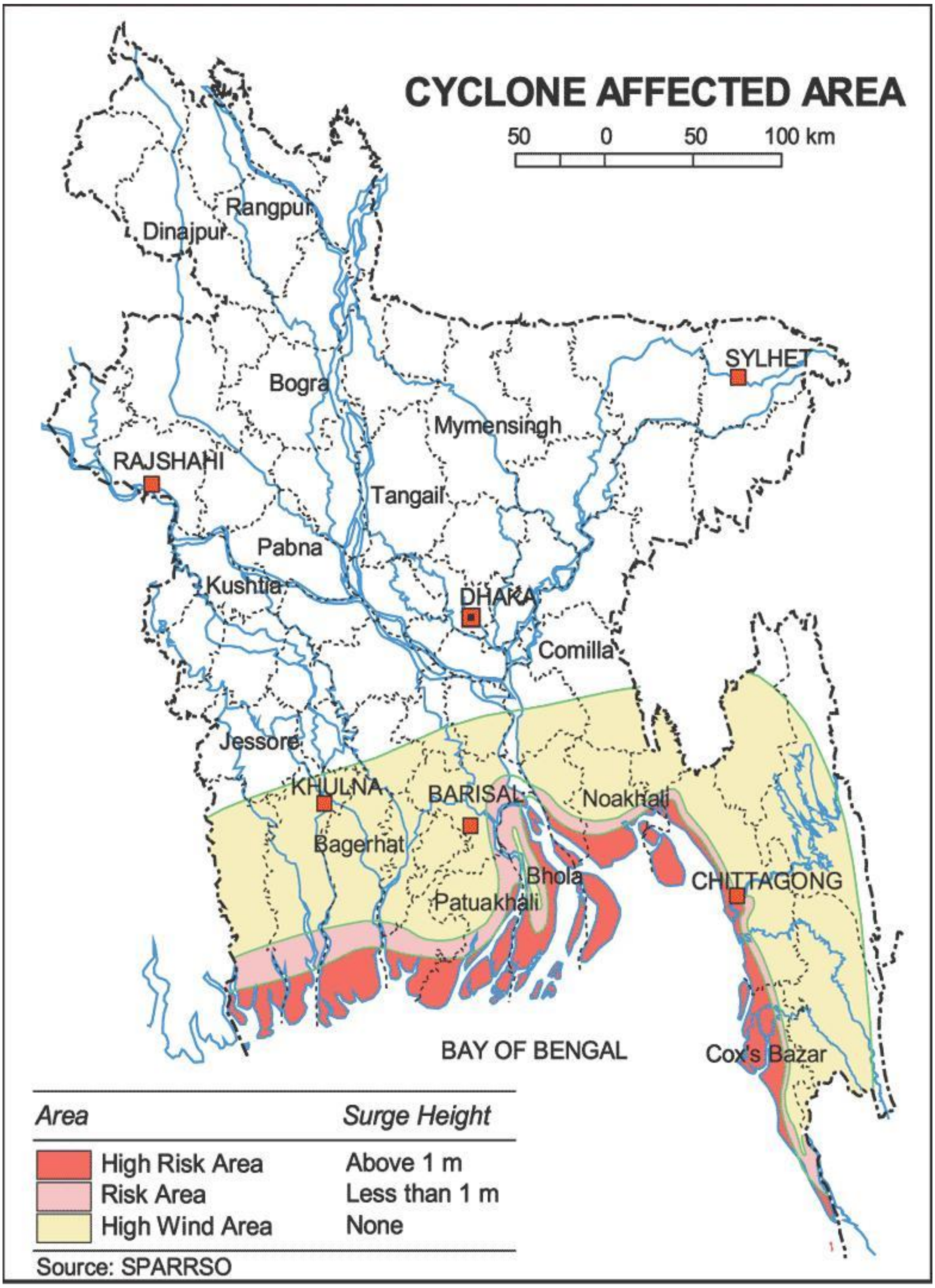
The key feature of the Bangladesh monsoon is that most of the depressions or disturbances formed in the Bay of Bengal during the monsoon period are ruled by the movement of the tropical disturbances originated from the Pacific. When the ENSO index is positive and high, Walker circulation is strong, lower atmospheric wind in the Pacific goes towards to the east and as a result tropical disturbances are carried westwards which move into the Bay of Bengal. When the Walker circulation is weak, the Hadley circulation is strong and the lower atmospheric wind in the Pacific is westerly and therefore the tropical disturbances move away from the Bay of Bengal and causes deficit of rain or drought in the region. When E1 Niño is weak or moderate at a time that Hadley circulation may not be very strong it allows some tropical disturbances to cross into the Bay of Bengal and enter up into Bangladesh region causing floods and cyclones (Choudhury, 2012). The cyclonic disturbances are 5 to 6 times higher in the Bay of Bengal than on the Arabian Sea; the ratio of tropical cyclones between the Bay of Bengal and the Arabian Sea is 4:1 (Alam, 2011). Cyclones that affect Bangladesh normally originate between 5° and 15° N latitude in the Southern Bay of Bengal and proceed in the northerly and northwesterly direction and then change their direction towards northeastwards to hit the Bangladesh coast (Rasheed, 2008). Using SST data for the Bay of Bengal for the period 1951-1987, Joseph (1995) has shown that SST has been increasing since 1951. Ali (1999) provided justification that not only the frequency of cyclones along the Bay of Bengal would increase as a result of Sea Surface Temperature (SST), cyclonic intensity would also increase. He anticipated that an increase of 2°C in sea surface temperature would increase the probability of cyclone formation from the depression in the coastal areas of Bangladesh.

During the period of 1960 to 1970, there occurred ten severe cyclones in Bangladesh with an average of one cyclone per year (Choudhury, 2012). Cyclone Sidr (2007) and Cyclone Aila (2009) provide recent examples of devastating storm-surges in Bangladesh.

1.6.1.1 The Great Cyclone of 1970

In Bangladesh, the great cyclone of 12 November 1970 is regarded as the most disastrous in terms of causalities. It caused indescribable human misery and the official death figure was 500,000 the highest so far caused by a cyclone (Choudhry, 2012). Cyclone Bhola wiped out villages and the cyclone destroyed 45% of the population (167,000) of the coastal area of Tazumuddin, Upazila and nearly 46,000 fishermen in the cyclone-affected region lost their lives (Kerry, 2005, Choudhury, 2012). On 29 April 1991, the cyclone that hit the coastal areas of Bangladesh can only be described as a supercyclone. The 1991 cyclone resulted in an estimated 138,000 deaths on the offshore islands of Kutubdia and Sandwip, and in the coastal low areas from Chittagong to Cox’s Bazar (Bern *et al*, 1993).

Figure 1.8 Cyclone affected areas in Bangladesh



Source: (Bangladesh Disaster Knowledge Network, 2013)

1.6.1.2 Cyclone Gorky 1991

The velocity of the cyclone was so intense that when it was at sea it was estimated to be at a speed of 240 km/hour, that earning its termed as a supercyclone. Its dimensions were larger than the area of Bangladesh; the coast of Bangladesh is only a few feet above sea level, which made the storm surge with the strong wind cause colossal damage in coast areas (Choudhury, 2012).

1.6.1.3 Cyclone Sidr 2007

Category IV cyclone Sidr hit Bangladesh on 15 November 2007 with winds of upto 240 kilometers per hour causing major destruction to life, housing, livelihoods and productive infrastructure (WFP, 2007).

Box 2: Summary of Cyclone *Sidr*

Formed	November 11,2007
Enter to land	November 15,2007
Dissipated	November 16,2007
Highest winds	215 km/h (130mph)
Lowest Pressure	944 hPa(mbar)
Damage	$450 million (2007 USD)
Areas affected	Bangladesh and West Bengal, India

Source: (BUET, 2008)

Cyclone Sidr was accompanied by heavy rain and tidal waves due to wind effects namely storm surges reaching maximum heights of about 20 feet in some parts of the country. It caused massive damage to infrastructure, crops, causalities and flooding in low-lying areas (GoB, 2008b).

Table 1.5: Cyclones affecting Bangladesh since 1960

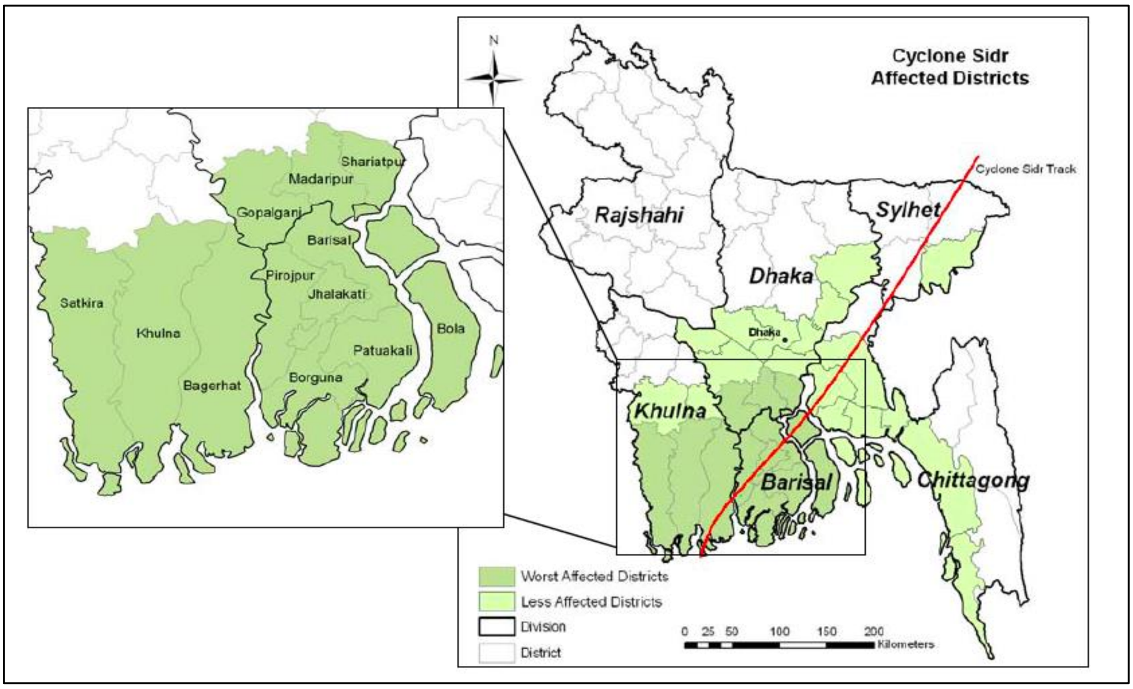
Date	Maximum wind speed in km/hr	Storm surge ht (in ft)	Deaths
09 October 1960	162	10	3000
30 October 1960	210	15-20	5,149
09 May 1961	146	8-10	11,466
30 May 1961	146	20-29	NA
28 May 1963	203	14-17	11,520
11 April 1964	NA	NA	196
11 May 1965	162	12	19,279
31 May 1965	NA	20-25	NA
14 December 1965	210	15-20	873
01 October 1966	146	15-30	850
11 October 1967	NA	6-28	NA
24 October 1967	NA	5-25	NA
10 May 1968	NA	9-15	NA
17 April 1969	NA	NA	75
10 October 1969	NA	8-24	NA
07 May 1970	NA	10-16	NA
23 October 1970	NA	NA	300
12 November 1970	223	20-30	5,00,000
08 May 1971	NA	8-14	NA
30 September 1971	NA	8-14	NA
06 November 1971	NA	8-18	NA
18 November 1973	NA	8-13	NA
09 December 1973	122	5-5	183
15 August 1974	97	5-22	NA
28 November 1974	162	7-16	A few
21 October 1976	105	105	8-16
13 May 1977	122	NA	NA
10 December 1981	97	6	02
15 October 1983	97	NA	NA
09 November 1983	122	NA	NA
03 June 1984	89	NA	NA
25 May 1985	154	10-15	11,069
29 November 1988	162	5-10	2,000
29 April 1991	225	20-25	1,40,000
02 June 1991	100	6	NA
02 May 1994	200	NA	170
25 November 1995	100	NA	6
19 May 1997	225	15	126
26 May 1997	150	10	70
20 May 1998	120	NA	03
15 November 2007	240	20-25	3,300
17 April 2009	90	NA	03
25 May 2009	140	13	190

NA: Not Available

Source: (Choudhury, 2012:11)

Bangladesh is divided into six administrative divisions – Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet. Three divisions Barisal, Khulna and Dhaka were severely affected by *Sidr*. These divisions are again subdivided into districts; there are 64 districts in Bangladesh (GoB, 2008a). The Government identified that the 12 affected districts (figure 1.9) by cyclone Sidr were- Bagerhat, Barguna, Barisal, Bhola, Gopalganj, Jhalokhati, Madaripur, Patuakhali, Pirojpur, Satkhira, Khulna and Shariatpur Disctricts (WFP, 2007). The most affected districts were- Bagerhat, Barguna, Patuakhali and Pirojpur (Davidson, 2008). About 18.7 million people from the 12 districts were affected and one-third of them live in the four worst affected districts in the coastal region. According to a Government official report cyclone *Sidr* took away 3,406 lives and 1,001 were missing. More than 55,000 were injured and nearly 9 million people in 30 districts were affected (GoB, 2008a).

Figure 1.9: Districts affected by Cyclone *Sidr*



Source: (GoB, 2008a: 4)

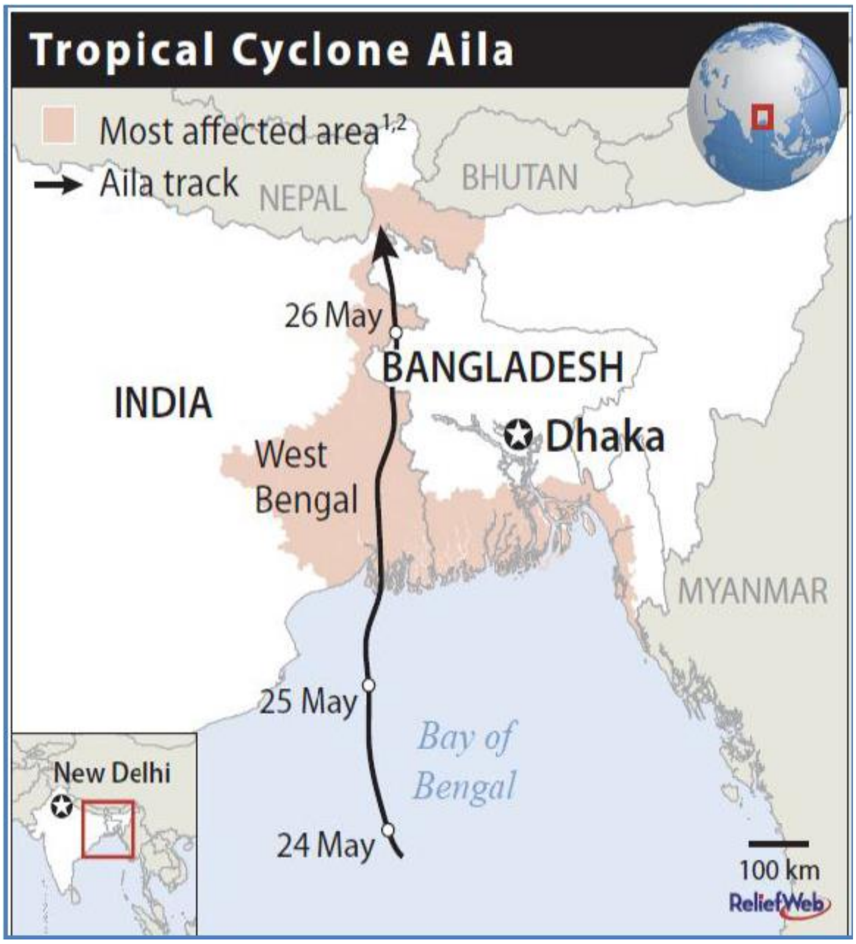
The hardest hit area was Barguna where 423 people were killed according to the local officials (BUET, 2008). Most of the deaths were caused by tidal surges, collapsing houses, falling trees and flying debris (Merlin Bangladesh, 2008). Barguna was the most at risk district. The people of Barguna are not aware of the negative impact of climate change. They still don't get any information on this issue but locals people have already reported that climate change has already begun to affect their professional life (Rahman, 2012).

The cyclone destroyed food storages and ordinary people's small stockpiles, killed thousands of animals used for meat and milk and felled over a million fruit trees and people had to struggle for their daily subsistence (GoB, 2008b). When the cyclone was over, many people had no shelter and lived under the open sky for many days. There was a scarcity of drinking water as the source of drinking water and local ponds were contaminated by both animal and human corpses (Choudhury, 2012). Official reports suggest that a total of 11, 612 hand tube wells and 7,155 ponds were fully and partially damaged in 12 highly affected districts (GoB, 2008b). Fishing industries and shrimp hatcheries were badly hit in the affected areas as the cyclone ravaged the production areas of shrimp, which was the major economic source of income for them (Merlin Bangladesh, 2008).

1.6.1.4 Cyclone Aila 2009

Category I Cyclone Aila was the second tropical cyclone derived from the Northern Indian Ocean during 2009. The disturbance that formed on 21 May 2009 and over the following days slowly emerged into a cyclonic storm called Aila.

Figure 1.10: Track of Cyclone Aila



Source: (Riquet, 2012:13)

It became a severe cyclonic storm on 25 May (United Nations, 2010). The wind speed of cyclone Aila was about 65-75mph and thus it was regarded as a category 1 cyclone (Kumar *et al*, 2010). The impact of cyclone Aila was tremendous. It struck the southern districts of Barisal and Khulna divisions of Bangladesh. Ashasuni and Shamnagar subdistricts of Satkhira district, Koira and Dacope upazila of Khulna district, Sorankhola and Morrelganj subdistricts of Bagerhat district were severely affected (as shown in figure 1.11).

Figure 1.11: Aila affected areas. The black marked areas were highly affected and other areas that are marked as blue on the graph were less affected

Source: (World Food Programme, 2009 www.foodsecuirtyatlas.org)

Almost 3.9 million people were affected by cyclone Aila and many people were stranded in flooded villages because of the high tidal surge. Water levels rose 7-10 feet and inundated several hundred houses, crops fields and water resources (GoB and WHO, 2009). The direct and indirect impact of cyclone Aila resulted in 190 deaths and approximately 7100 injuries (DMB, 2009). During the cyclone a small percentage of affected people could manage to take themselves to a cyclone shelter and some of them took shelter on the roads and roofs of the schools, colleges, madrasas, mosques and local government buildings (Kumar *et al*, 2010).

Due to the annihilation of the road networks and damage to the river embankments, the communications of all these affected areas were hampered. More than 60,000 people migrated from the affected areas for income opportunities (International Agencies, 2009). The affected areas were without electricity for over 24 hours (Concern Universal, 2009).

Table 1.6 Devastation caused by Cyclone Aila

Sector	**Quantity**
Affected Districts	11
Affected upazilas (Sub-districts)	64
Affected Unions	195(fully) 334 (partially)
Affected Households (families)	6,13,778
Affected Population	3,928,238
Houses damaged	243,191(fully) 370,587 (partially)
Crops	3,23,454 acre
Livestock deaths	150,131
Educational Institutes	445(fully) 4,588(partially)
Embankments (Kilometers)	237
Institutions	445
Roads (Kilometers)	2,233(fully) 6,621(partially)
Bridges/Culverts	157

Source: (DMB, 2009 www.dmb.gov.bd)

While the situations of 9 other affected districts was improving, the condition of Khulna and Sathkira districts continued to deteriorate due to the ongoing monsoon season and breaches in the embankment (Riquet, 2012). Concern Universal (2009) reported that the main source of drinking water of the affected population was ponds and due to saline water contamination there was water scarcity in the areas and a high saline intrusion was caused by the damage in the embankments during the cyclone. A review by Oxfam in 2011 reported that severely affected families are still displaced and living on the embankments. Families are living outside the embankment ring with their land inundated with salt water. Families who have just returned home (migrated from the area before cyclone) don't have enough income opportunities to feed their families .Due to less income opportunities, affected families have been reduced meals to one per day and the quality of food decreased (Oxfam, 2011). The main livelihood in the affected areas were fishing and more than 60% people were directly or indirectly involved in fishing sectors. Due to Aila they lost their fishponds and are still inundated with broken embankments. Income losses continue for a large number of people. Many people lost their boats; many are damaged and need repairing and many people had to sell their boats to cover everyday expenses (International Agencies, 2009).

Even after a year of a minimum amount of support from the government and non-government agencies, the worst affected, were still suffering from food insecurity and nutrition situation. At the end of 2011 it was found that few pockets of the affected population were still unable to recovering and remained vulnerable (Riquet, 2012). Roy (2009) reported that after the cyclone 95 percent of the affected and waterlogged areas were without safe sanitation, safety tanks were overflowing and leaching out to the surface water. People were forced to defecate on open water and used the polluted saline water for household use. Rahman (2012) cited that after Aila, salinity has increased five times more than before in the cultivated land of coastal areas and it is making it impossible to get safe drinking water and hygienic sanitation for everyone. Due to salinity the lands have been unworthy to plough paddy and the coastal population of the affected districts have been suffering from the negative impacts of climate change and this has put the the earning source of people in these areas in danger. According to Riquet (2012) the scale of this disaster could be common in the future and could be even higher if a cyclone similar to Bhola and Gorky hits the country.

1.6.1.5 Cyclone Bijli 2009

In April 2009, cyclone Bijli veered away from the southern coastal areas of the country without causing any serious damage (Ahmed *et al*, 2010). Cyclone Bijli damaged the embankments at many places and water surges entered into many dwellings causing displacement of many people in Khulna and adjacent areas. The worst affected areas were Shamnagar, Assaumi, Borguna and Golachipa and the official causality figures were 180 (Choudhury, 2012). About 200,000 people were displaced by cyclone Bijli and though the intensity of the damage was not as high as Sidr, in the year 2009, two cyclones hit Bangladesh –cyclone Bijli in April 2009 and cyclone Aila in May 2009 (Akter, 2009).

1.6.1.6 Cyclone Mahasen 2013

Cyclone Mahasen struck the southern coast of Bangladesh on 16 May 2013, whipping remote fishing villages with heavy rain and violent winds that flattened mud and straw huts and forced the evacuation of more than 1 million people. The main section of the storm reached land on Thursday 16 May 2013 and instantly started weakening. Its forward movement also slowed giving the indication that towns in its path would have to weather the storm for longer (The Guardian, 2013). Thousands of people in several coastal districts have no roof over their heads as Mahasen destroyed their properties. A large number of people have been living under the open sky since the cyclone hit the coast. Some of the families were able to build unstable shanties salvaging materials from their destroyed homes while others had nothing to rebuild their house with. Many affected people were hungry and in desperate need of drinking water (The Daily Star, 2013).

1.6.2 Floods

The main cause of flooding in Bangladesh is rainfall. Bangladesh is situated in the monsoon belt with the Himalayas in the north, which places Bangladesh in the heavy rainfall region. About 80 percent of rainfall occurs during the 5-month period from May to September (Choudhury, 2012). The major rivers of Bangladesh have lost gradient during past years and their conveyance capability has diminished drastically. So, during the monsoon rainfall it will complicate the drainage system and will increase the duration of floods (Ahmed *et al*, 1998). Other factors that may cause flooding in Bangladesh are: (i) loss of floodplains and wetlands due to excessive development and population growth (ii) change in the base level of rivers due to local sea level rises (iii) deforestation in the upstream territory (iv) changes in river courses due to seismic and neotectonic shifts (Bhattacharya, 2009).

Bangladesh has experienced disastrous floods in 1954, 1955, 1987, 1988 and 1998 and among these the 1988 floods were some of the worst in Bangladesh's history resulting in 5338 deaths and affecting 32 million people (Kunii, 2002). Islam (2008) predicted that rainfall in Bangladesh, due to climate change would increase the incidences of floods in flood vulnerable areas. The flood of 1998 is considered one of the worst natural disasters faced by the country and the flooding continued for a duration of 65 days and affected 67% of the area of the country. This 1998 flood caused a huge burden on the national economy, human activities and disrupted the livelihood systems in urban and rural areas (UNEP, 2001). In the year 2007 from July to September, the country experienced a destructive double round of floods and 3 million people from 46 districts were affected (GoB-MoFDM, 2007). Ahmed (2006) predicted that under the climate change scenario about 18 percent of current lowly flooded areas of Bangladesh will be vulnerable to a higher level of flooding and 12 to 16 percent of new areas will be at risk of various degrees of inundation.

1.6.3 Droughts

Bangladesh is affected by droughts every five years during pre-monsoon and post-monsoon periods (Anik *et al*, 2012). In Bangladesh a drought is defined as the period when moisture content of the soil is less than the required amount for satisfactory crop growth during the normal crop-growing season. Seasonal and contingent droughts are more prevalent in Bangladesh and they are mainly caused by irregularities in rainfall (Shafi, 2009). Droughts are more common in the northwestern districts of Bangladesh (Bangladesh Bureau of Statistics, 2010). There were severe droughts that hit the country in 1951,1961, 1975, 1979, 1981, 1982, 1984, 1989 and 1995 (Mizan and Bijoy, 2009). Food production was diminished during the 1978-79 drought and probably 50 to 100 percent more than was lost in the great flood of 1974; it shows that droughts can be as destructive as major floods or cyclones for Bangladesh (Paul, 1998).

If droughts continue for a prolonged period it can affect the agricultural production (rice production) and cause human misery (UNEP, 2001). Overall, higher temperatures, higher rates of evaporation and changing rainfall patterns are responsible for causing a decline in agricultural production in Bangladesh. For example, higher temperatures have been found to reduce high yielding varieties of *aus, amon* and *boro* rice (GoB, 2005). Agriculture in Bangladesh is the main food production sector. It is under tremendous pressure due to an increased demand for food despite there being a lack of land and water resources. Global climate change further threatens food security for a large part of the population of the country (Hassan and Rahaman, 2010).

1.6.4 Other Natural Disasters

River erosion is a silent natural hazard that affects Bangladesh every year during the beginning of the monsoon period. It caused immeasurable misery to a large number of people (Shafi, 2009). Since 1973, over 158,780 hectares of land had eroded in 2010 (CEGIS, 2010). In the past 40 years, the Bhola district came down from 6,400 square kilometres to 3,000 square kilometres due to river erosion and if this rate continues for the next 40 years the entire Bhola district will be lost to the river (Rahman, 2012). It is estimated that about 5% of the total floodplain of Bangladesh is directly affected by erosion and it has been found that about 94 subdistricts of the 489 subdistricts of the country are affected by river erosion (Bangladesh Bureau of Statistics, 2010).

In the last 10 years severe cold waves have become common in Bangladesh (Roach, 2005). It is common especially in the North West region of the country by causing havoc on the transportation system. During this period the temperature goes down to 6 ° C and causes death amongst older people, loss of agricultural products and disruption of normal activities (Shafi, 2009).

An earthquake is the trembling or shaking movement of the earth’s surface (Bangladesh Bureau of Statistics, 2010). Bangladesh is not entirely free from the threat of earthquakes. The most vulnerable places are: the northern belt of greater Sylhet, Mymensingh and the eastern parts of Rangpur Districts (Choudhury, 2012). Bangladesh has faced earthquakes with magnitudes between 7.0 and 8.7 on the Richter scale (UNEP, 2001). Records suggest that more than 100 moderate earthquakes have occurred in Bangladesh since 1900 and 65 of them took place after 1960 (Khan *et al*, 2001). Underwater earthquakes, which generally strike the Pacific and Atlantic coasts, cause tsunamis. If any tsunami is produced in the Northern Indian Ocean it may cause a heavy loss of lives and properties in Bangladesh because it is situated at the tip of the V-shaped bay (Khan, 2001).

1.7 Health problems due to climate change in Bangladesh

According to the World Bank (2000) Bangladesh is a country, which is highly vulnerable to infectious, waterborne and other types of diseases and millions of people suffer from diarrhoea, skin diseases, malaria, mental disorders and dengue etc.

Flooding may cause higher ground water recharge near to the surface during a monsoon in Bangladesh and will cause the groundwater to become more vulnerable to pesticide and fertilizer pollution (Shahid, 2009). The main source of drinking water in Bangladesh comes from groundwater and the existence of pesticides in groundwater may damage the nervous, reproductive and endocrine system (US Geological Survey, 1998). A study in populations displaced by the catastrophic 1998 floods in Bangladesh was responsible for diarrhoea followed by respiratory infections and watery diarrhoea was responsible for the most common cause of death in the all age groups under 45 (Malik, 2008). Schwartz *et al,* (2006) suggested that cholera is the predominant cause of flood associated diarrhoeal epidemics in Dhaka.

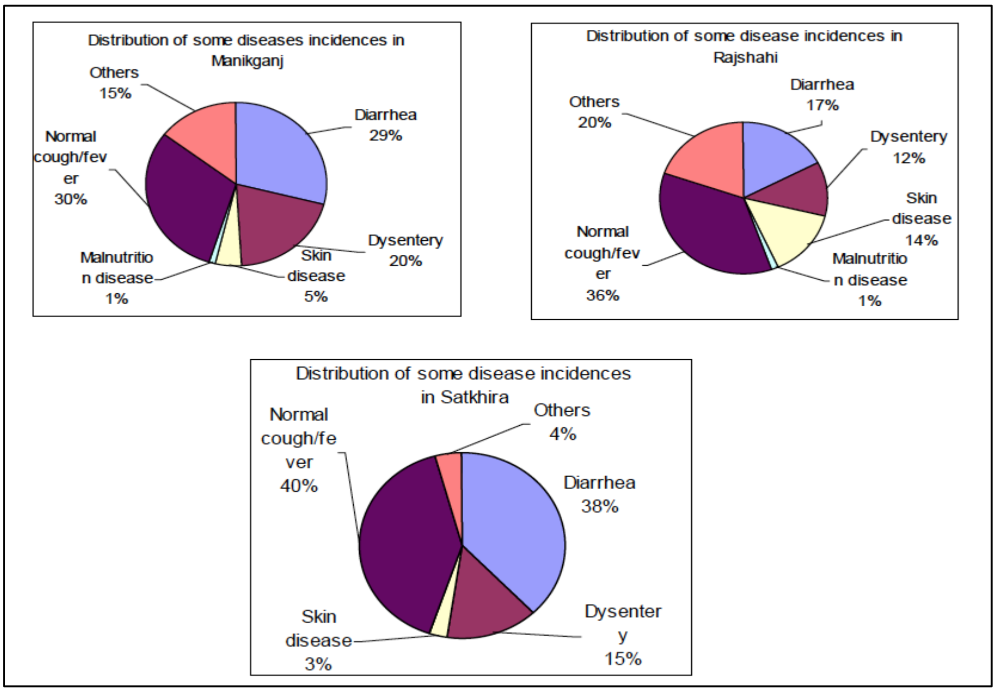
Khan *et al*, (2011) in their recent study found that salt intake from drinking water is responsible for hypertension in pregnant women in Dacope a rural coastal area in Bangladesh and rising sea levels, storm surges, cyclones and withdrawal of upstream freshwater were the main reasons for salinity intrusion. Temperature has been found to be one of the agents for transmission dynamics of cholera in Bangladesh due changing climate. The last eighteen years of data looking at temperature and cholera correlation showed that cholera epidemics have a relationship with shifting temperatures. It is also connected with ecological variables like rainfall and tide (CCC, 2009b).

Rahman (2008) has said that heat waves have implications for Bangladesh as the elderly population and children suffer most during extreme temperatures. He also found that not enough studies have been done to show the relationship between heat waves, death, illness and the prevalence of diarrhoeal diseases during warm temperatures. A study conducted by Amin *et al,* (2011) in Rangamati, Sylhet and Faridpur districts over the period 1972-2002 found that there is an impact on malaria due to climate change and they found that a rise of yearly average maximum temperature, yearly total rainfall and yearly average humidity is associated with malaria prevalent in the Rangamati district. They also found that a yearly rise in the average maximum and minimum temperature in Sylhet and Faridpur districts is also responsible for increasing malaria prevalence in these areas.

Hashizume *et al,* (2008) used time series data (from Dhaka city) to find a strong correlation between high temperatures and an increase in rotavirus diarrhoea.The findings also suggested that low humidity and a high river–level rise increase the incidence of rotavirus diarrhoea in Bangladesh. It is clear that a rise of temperature due to climate change will increase diarrhoeal diseases in Bangladesh. Rickshaw pullers, people working in industries and farmers working in the open field are very much vulnerable to extreme temperature rises and children and elderly people specially living in the cities due to the effects of urban heat island (Shahid, 2009).

A study conducted by the Bangladesh Centre for Advanced Studies (BCAS) after the devastating cyclone of 1970 revealed that 25-30% of women in the affected areas had died from the cyclone (Mirza, 1992). Cholera may occur after any natural disaster such as a cyclone (WHO, 2010). CCC (2009a) conducted a study on the tree districts of Bangladesh namely Rajshahi, Satkhira and Manikganj.

Figure 1.12: Health problems faced during hazard periods in Rajshahi, Satkhira & Manikganj



Source: (CCC, 2009a: 39)

The study results reveal that seasonal and annual rainfall is positively correlated with diarrhoea cases in Rajshahi and Sathkria and dry reason rainfall has a correlation with diarrhoea in Manikganj. Skin diseases, diarrhoea and malnutrition are also positively correlated with temperature in Rajshahi and Satkhira.Nipah virus infection has been becoming endemic in Bangladesh as the incidence of this infection has been continuously found since 2001. The outbreak of dengue has occurred over the past 40 years. Medical communities in Bangladesh were unfamiliar with the presence of dengue fever before 2000 (Ahmed, 2011). Outbreaks cause a high burden of disease and can damage public health services; this will lead to a considerable public health and economic impact (Griffith *et al*, 2006). The quantity and brutality of cyclones in Bangladesh is associated with varied mortality rates (shown in Table 2.14). The two deadliest cyclones of 1970 and 1971 caused more than 500,000 and almost 140,000 deaths respectively (Haque *et al*, 2012).

Table 1.7: Cyclone severity and deaths in Bangladesh

Year	Number of death	Wind speed	Severity Index
1960	8119	210	5
1961	11466	146	5
1963	11520	203	5
1964	196	NA	NA
1965	20152	210	5
1966	850	146	5
1969	75	NA	NA
1970	500300	223	6
1973	183	122	5
1974	50	162	5
1985	11069	154	5
1986	12	100	4
1988	9590	162	5
1989	573	NA	NA
1990	132	102	4
1991	138958	225	6
1994	170	200	5
1995	172	100	4
1996	545	70	3
1997	410	225	6
1998	233	112	4
2007	4234	250	6
2008	15	80	3
2009	197	95	4

NA= Not Available

Source: (Haque *et al*, 2012:151)

The 1970 and 1991 cyclones which hit Bangladesh in the dead of the night made it hard for the devastated people to look for shelter .The main cause of death was drowning and more illiterate or less literate people aged 6 years and over died compared to their literate counterparts (Chowdhury *et al*, 1993).

Table 1.8: Death rates by age group in 1991 cyclone

Age Group	Death rate per 1000	Number of deaths
0-14	154.5	871
15-59	40.0	188
50+	134.0	147
All ages	105.5	1206

Source: (Chowdhury *et al*, 1993)

The table below shows respondents suffering from various diseases due to the 1991 cyclone. Diarrhoea, malaria, cough and colds together account for more than 65 and 70% of respondents in Chakoria and Moheskhali respectively.

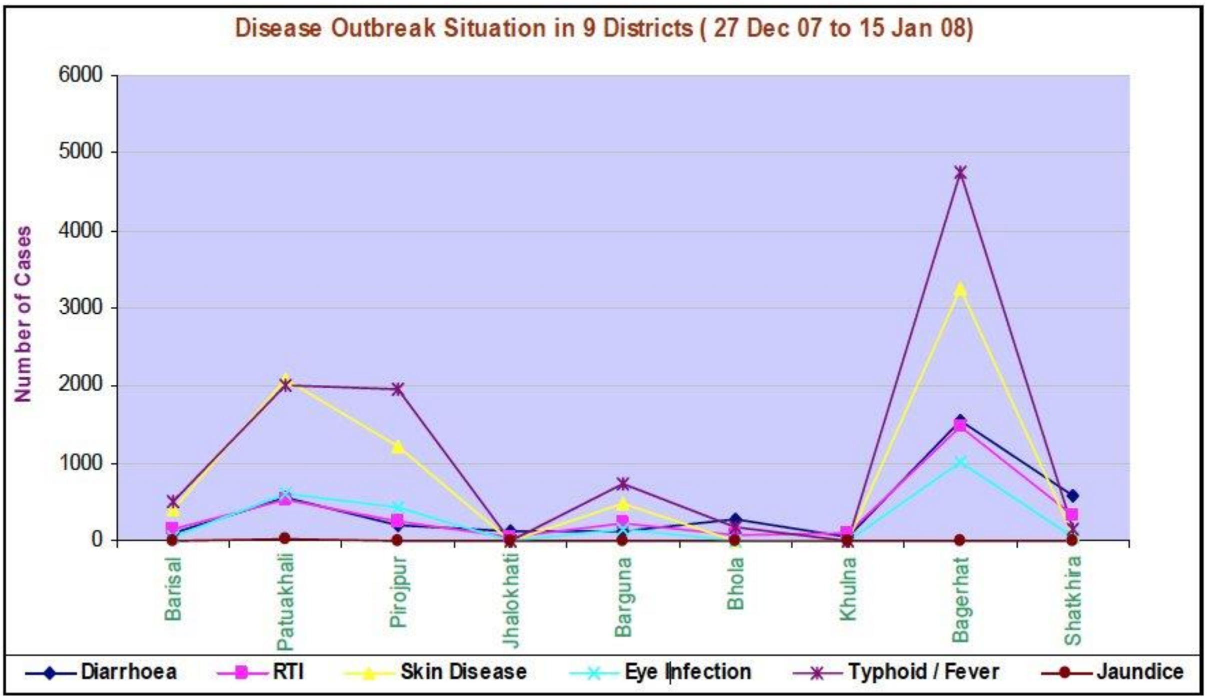
Table 1.9: Diseases and injuries from the 1991 Cyclone

Types of Diseases	Percentage of respondents	
	Chakoria	Moheskhali
Diarrhoea	30.00	38.18
Dysentery	11.91	7.27
Malaria	20.00	21.27
Fever, cold and cough	15.45	10.00
Skin Diseases	6.36	8.18
Wounded/injured during cyclones	3.64	5.46
Others (jaundice, eye problem etc)	12.64	9.09

Source: (Hoque and Islam, 2003: 151)

Post-cyclone Sidr, there was a massive outbreak of waterborne diseases and other diseases in the most affected areas. Previously an outbreak of this scale had not occurred (Paul *et al,* 2011). This study also revealed that Sidr related illnesses were significantly associated with household income and gender. In their study they also reported that the number of Sidr induced deaths and injuries were higher than the number of persons suffering Sidr related illnesses. Access to public health systems was also affected (Merlin Bangladesh, 2008). Post the disaster situation, WHO (2008) reported an increase in the following : fever ,typhoid skin diseases (in respective order) Bagerhat district showed the highest number of reported cases . About 50% cases were in the less than 14 years of age group (as given in figure 1.13).

Figure 1.13: Disease Outbreak Situation in 9 Districts after Sidr



Source :(WHO, 2008)

A study by Karim *et al*, (2013) carried out in three villages of the Dumuria subdistrict of Khulna district reported climate related health problems such as anaemia and pneumonia. The impact of climate related disasters on women's health is much worse with deaths, diseases, injuries occurring from water-borne diseases, snakebites, drowning, slipping, large tree structures falling, lack of medical facilities, malnutrition, lack of pure drinking water and a lack of proper sanitation facilities (Sharmin and Islam, 2013). Poor health and calorie deficiency make women vulnerable to climate induced natural disasters and these conditions lessen the womens' adoptive capacity and capability to natural disasters (Rahman, 2013).

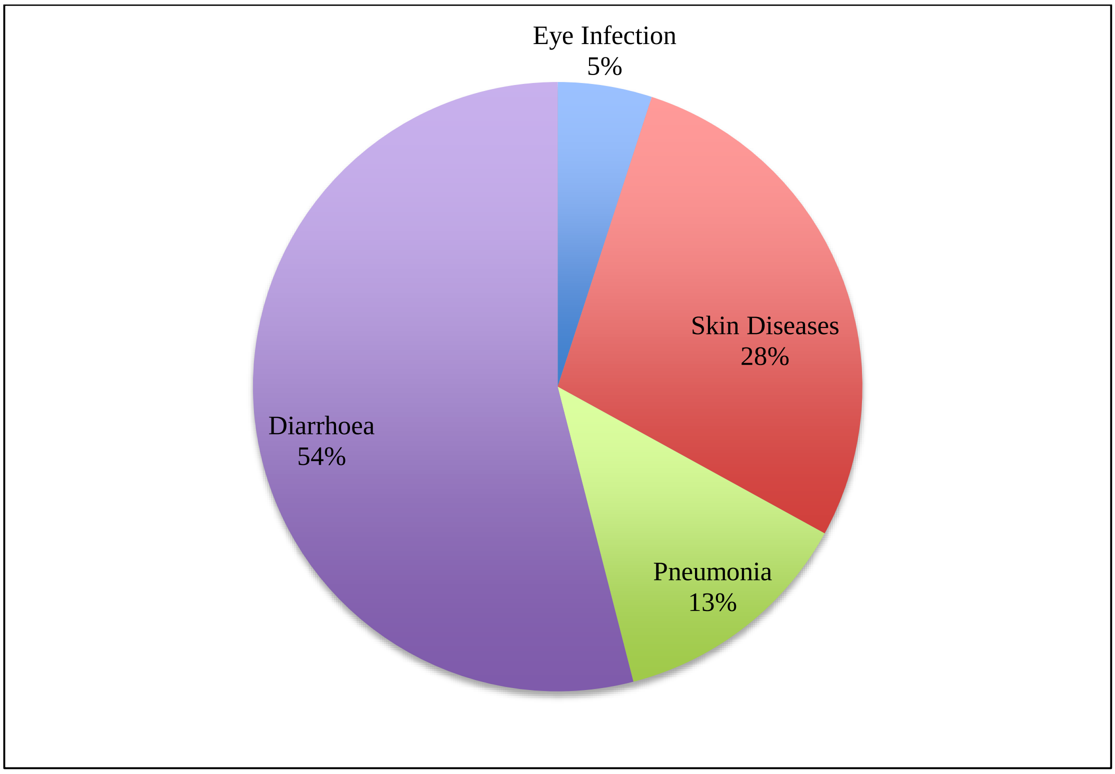
Women over 40 years of age were killed more than in the male population in the 1991cyclone (Cannon, 2002). Rahman (2013) also stated that in post disasters women's health conditions deteriorate terrifyingly due to the community having a different perspective of their health and hygiene needs and secondly negligence of the basic needs due to socialization.

Women are normally responsible for looking after their family members and also are the only member to fetch drinking water for others. Water-borne diseases are widespread among those who are already suffering from nutrition deficiency (Rahman, 2013). Post natural disasters pregnant, breastfeeding and menstruating women are at greater risk of compromising their health. Post disaster, a lack of breastfeeding and sanitation materials and contraceptive pills pose a threat to the health status of these women and increases the likelihood of sexually transmitted diseases (Rahman, 2013). Ahmed *et al*, (2010) reported on the health status of fishing families in coastal areas of the Bagerhat district situated in the southwest part of Bangladesh. The study found that fishing families have an extremely poor health status and they often suffer from diarrhoea, cholera and lack of nutrition. This poor nutrition in the coastal areas has been linked to birth defects, night blindness, maternal mortality and stunted growth of children.

It has been reported that diarrhoea broke out in the Cyclone Aila hit areas of the Khulna district due to a scarcity of pure drinking water and food shortages. In the Koyra subdistrict at least 10,000 people were affected by diarrhoea, about 5,000 more in the Dacope and Paikgacha subdistrict and 15 deaths were reported in Koyra, Paikgacha and Dacope (Roy *et al*, 2009). It was suspected that Respiratory Tract

Infection (RTI) was the main reason because most of the affected people were living without shelter or in a temporary shelter in cold winter. Living in such crowded and non-hygienic conditions may also cause different health problems like fever and skin diseases (Paul *et al*, 2011). A good sanitation system is one of the basic requirements for healthy living. Wash Cluste, WaterAid and UNICEF (2009) reported that 80% of people had sanitary latrines before cyclone Aila, but after the cyclone most of them are now using a hanging latrine.

Figure 1.14: Distribution of patients by morbidity of Post-Aila Health problems



Source: (MIS & DGHS, 2010:95)

Mehedi *et al*, (2010) conducted a study on the cyclone Aila migrants of the southwest coastal region who have taken shelter in Khulna city and adjacent areas. The study report shows that a large number of affected people took shelter on tiny embankments; women including adolescent girls were facing problems of sanitation and sexual harassment on the crowded embankment. Due to water logging, people could not move from the shelters to collect food, and malnutrition and infectious diseases affected as a result to the older citizens and children. Save the Children (2009) reported in their assessment report about diarrhoea and skin disease cases after one month of cyclone Aila. People also got infections by bathing in the ponds (Uttaran, 2010).

The health complexes are very small and the communities were living far away, for this reason, affected people were not able to visit health complexes, union health centres and community clinics. Instead they used to go to village doctors and birth attendants who were found to have no training and who were unaware of basic treatment for common illnesses. There were reports of psychosocial depression among people and there was no support provided (United Nations, 2010). It has been reported that only 3 to 4% people were able to reach Upazila clinics or hospitals (ECBP, 2010).

1.8 Aims of the research

The key aim of this research is to assess the potential impacts of climate change on health of the coastal people in Bangladesh. To fulfil the broad aim, the study has the following specific objectives:

(I) ***To investigate the characteristics of the household living in the climate change affected areas.*** Climate change is expected to have major physical impacts on agriculture, industry, disaster, infrastructure, health and energy consequently on people`s livelihood in terms of employment, income and consumption (food security). Various groups in society will experience the impacts in various degrees dependent upon their initial economic conditions (poor and non-poor) location (coastal and non-coastal, rural and urban) and gender (Mizan and Bijoy, 2009) and also the impact on the vulnerable people in the affected area.

(II) ***To evaluate the direct and indirect impact of climate change on the health of the people in the climate affected area.*** This objective helps to identify the health problems that are directly related to climate and weather and also the indirect impact that result from environmental changes. This study investiages the relationship between the possible climatic factors (environmental) and the onset of various emerging diseases and infectious diseases including the vector and rodent diseases and water and food borne diseases among the climate affected population.

(III) ***To identify potential health problems before and after climate induced natural disasters.*** This study compares the before and after scenarios of health problems among climate affected people. Health problems data collected from households and compared.

(IV) ***To critically evaluate the experiences of the people of the climate affected area.*** To address this objective a focus group interview conducted with health professionals, community workers, NGO workers and the local community to evaluate their perceived current and historical health problems. Also this comes up recommended action, which has been taken into consideration in the future to address the health issues.

(V) ***To find out the key determinants of health outcomes in the climate affected areas of Bangladesh.*** This research tries to find out the important factors associated with climate change and also tries to explore whether the general community has knowledge and awareness about climate change and health problems and the relationship between the two.

1.9 Disposition/ Layout of the research

The general information of research structure is based on the construction of 9 chapters. The following diagrammatic format gives a birds eye view of the breakdown of this research project and what is expected in each chapter in summary.

Chapter 1: This particular chapter focuses on the background to the research problem with relevant research aim and objectives, background and the researcher`s motivation towards selection of the research topic. This chapter also provides an over view of the whole scenario of the research project with valid justification and foundation.

Chapter 2: This specific chapter, Literature Review demonstrates the real knowledge, which has direct or close connections with the research objectives. This chapter overhauls the opinions of various authors and organizations that express their knowledge through books, research journals and the Internet. Therefore this chapter focuses on providing solutions from secondary sources and is able to provide the basis for the primary data collection.

Chapter 3: Chapter 3 is based on research methodology that has equal importance as other chapters. In this chapter the relevant research techniques for the project is discussed in detail by focusing on relevant components of the research design. The chapter also includes relevant and detailed research approaches, qualitative and quantitative methods, sample size determination and techniques of relevant data collection strategies. It also contains ethical consideration and quality assurance of data.

Chapter 4: Chapter 4 covers findings from the ‘objective 1’ which are the characteristics of the households living in both Sidr and Aila affected areas.

Chapter 5: This is one of the key chapters of this thesis. This chapter is explores and presents the direct and indirect effects of cyclone Sidr and Aila in both the areas.

Chapter 6: This chapter covers all key determinants of climate change in Bangladesh. A comparison should be done before and after health conditions of the affected household in Sidr and Aila affected areas. Findings are shown in this chapter.

Chapter 7: This is the last chapter of presenting the findings. This chapter contains qualitative data findings that have been collected by Focus Group Discussion from the officials and local community of the climate affected areas.

Chapter 8: In this chapter the data collected is discussed on the grounds of data presentation. It covers and critically analyses the data presented in the result chapters. The comparison is carried out by evaluating the secondary data from different literature. This chapter also covers the recommendation, suggestion and conclusion, which are constructed based on the findings.

1.10 Summary

This chapter has reflected upon the whole scenario of the research project including the background of the study, formulation of the research problem, importance and significance of the research, aim and objectives of the research and side-by-side understanding of climate change.

LITERATURE REVIEW

Chapter 2: Literature Review

2.1 Introduction

"Literature review is an integral part of the research process and makes a valuable contribution to almost every operational step" (Kumar, 2011:31). The main purpose of a literature review is to set a background for the development of a research objective and questions by evaluating the theoretical and empirical evidence (Saunders *et al,* 2009). By embarking on such a quest, the research was developed firstly by reviewing current relevant research papers and review articles that have been carried out so far to date on human health implications due to climate change. Finally this chapter concludes by describing how this present research is built on by finding the deficits in the literature. A literature review not only provides information but also finds a direct link between the authors' work and the work done by others (Boote and Beile, 2005). The review of the literature is done in a proper way it supports and enhances the research (Creswell, 2007). Another purpose of a literature review is to help the researcher to avoid repeated works. While doing the review it is important to know the dimensions and area of the relevant research. Moreover it is vital to have a proper literature search strategy to identify the appropriate literature and their sources too. Different relevant books, journals, conference papers, news articles, thesis works, editorial columns, annual reports, bulletin reports and websites were reviewed by the researcher to obtain information .The most relevant material relating to the present research was considered. Reference lists were also checked from actual or sometimes relevant documents. Key words used for the literature search strategy were: climate change, global environmental change, health, *Sidr, Aila*, natural disaster, Bangladesh. Thus this chapter reviews the relevant works (organized in tabular form as follows):

Table 2.1: Summary of Literature Review

Section	Description
2.2 Causes of Climate Change	The main causes of climate change and its effect on the Earth.
2.3 Climate Change and Health	The association between climate change and its impact on health are discussed under this section.
2.4 Climate Change and Natural Disaster	Climate change and its effects on the increased frequency of various natural disasters are presented in this section.
2.5 Relation between Climate Change and infectious diseases & malnutrition	Climate variability and its relationship with various emerging diseases and the impact on food security is discussed in this section
2.6 Effect of natural disaster on vulnerable population	The effects of climate induced natural disasters on vulnerable populations are explored in this section.
2.7 Research gaps and questions	This section identifies the research gaps in the existing literature and also presents the research questions
2.8 Conceptual Framework	A conceptual framework is drawn based on the research questions.
2.9 Summary	A conclusion of related studies and summary of literature review in this chapter is presented.

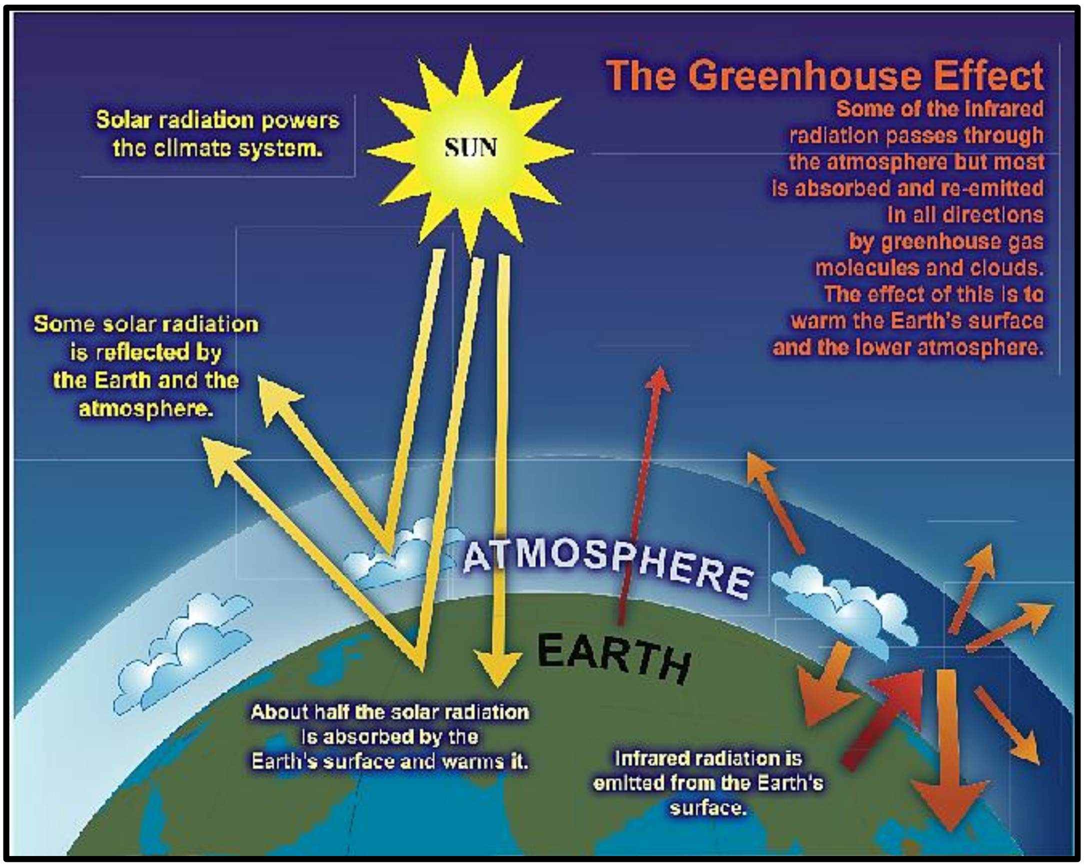
2.2 Causes of Climate Change

The Intergovernmental Panel on Climate Change (IPCC's) Fourth Assessment Report (2007) concludes "Warming *of the Climate system is unequivocal, as is now evident from observations of increases in global average temperatures, widespread melting of snow and ice, and rising global average sea level*". From time to time-human activities have caused stresses on the climate system which are already causing an impact on earth. Almost two decades ago on an international platform, scientific communities and developmental agencies began the 'climate change dialogue' (Harris, 2007).

Both developed and developing countries backed the United Nations Framework Convention on Climate Change (UNFCCC) to address rising global warming concerns. According to the UNFCCC, climate change refers to the change of climate that is attributed (directly or indirectly) to human activity. Above all the components of ecosystems such as food and agriculture, health, industry, settlement and all walks of life are being affected by climate change. "*Climate change is a long–term phenomenon with potentially unpredictable, significant and lasting effects on the environment and human*" (IPCC, 2007: 30). Climate change may also refer to a shift in climate, occurring as a result of human activities (Wigley, 1999). Climate change occurs because of the release of greenhouse gases from time to time. *The "Greenhouse effect" is the name for the physical process whereby energy from the sun passes through the atmosphere relatively freely while heat radiating from the earth is partially blocked or absorbed by particular gases in the atmosphere and also as the sun is warmer than the earth its energy is radiated at a higher frequency which is not absorbed well by gases such as carbon dioxide or water vapour* (Rahman and

Huq, 1989:23). Greenhouse gases include water, vapour, carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbon (CFC), nitrous oxide (N_2O) and tropospheric (O_3) ozone (Aktar and Abdullah, 2010). These greenhouses gases present in the earth's lower atmosphere and traps solar radiation and act as a warm air-blanket surrounding the Earth (Larry, 2010). If the amount of these gases increase in the temperature, the Earth`s temperature will in turn increase. Scientists have termed this phenomenon as global warming and the associated changes to the atmosphere known as climate change (Enayetuulah *et al*, 2004). The primary contributor to global warming is carbon dioxide, which accounts for about 76% of the total greenhouse gases (Nick, 2010).

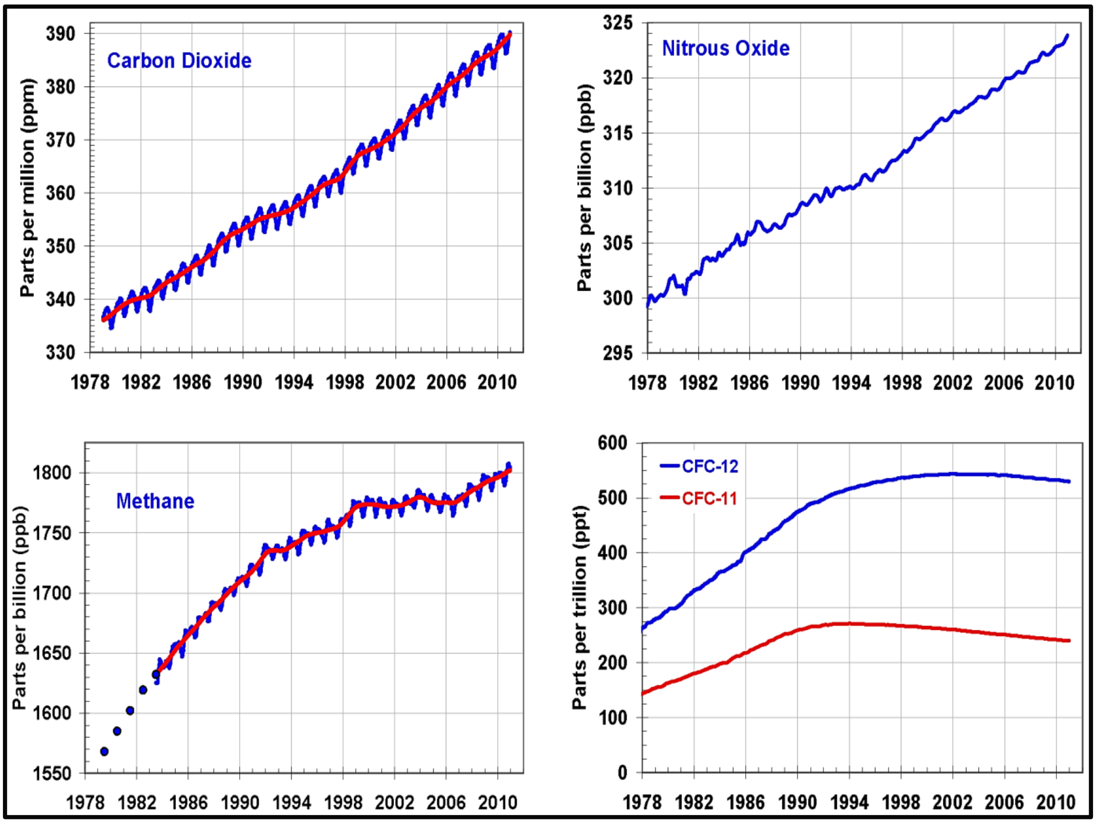
Figure 2.1: The greenhouse gas effect



Source: (IPCC, 2007)

According to Susan (2004) carbon dioxide concentration in the atmosphere has been on the rise due to human activities and will remain in the atmosphere above natural levels for centuries, despite a reduction in carbon dioxide emissions. Carbon dioxide is the most important human-made greenhouse gas. Carbon dioxide has a life time of 100 years which means that one third of the concentration change due to CO_2 emission by human activities will be present for 100 years (Jenkins *et al*, 1999).

Figure 2.2: The rise in greenhouse gas concentrations



Source: (The NOAA Annual Greenhouse gas index, 2011)

By 2100, atmospheric concentrations of CO_2 are projected to be between 490 and 1260 ppm (parts per million). *The IPCC projected that global mean temperature would increase by the end of the 21st century and global precipitation also will increase* (WHO, 2003:31). *Overall agriculture (cropping and livestock) contributes 13.5% of global greenhouse gas emissions mostly through emissions of methane and* *nitrous oxide (about 47% and 58% of total anthropogenic emissions of CH_4 and N_2O respectively) and the largest producer is power generation at 25.9% followed by industry with 19.4%* (Chidumayo *et al*, 2011:19). Since the beginning of the industrial revolution (about 1750 AD), the concentration of all major greenhouse gases has increased in the atmosphere, thereby helping to bring about the changes in climate that the world is currently experiencing (Pollution Probe, 2004). Many scientists have tried to determine the climatological effect of this increase in the greenhouse gas concentration and they have come to a general agreement that the effect will be an increase in surface temperature and this increase is relatively small perhaps less than one degree in tropical regions and more than 10 degrees in high latitudes (Stewart, 1989).

A higher global temperature has quickened the rate of evaporation, leading to an increase in air humidity, therefore intensifying the severity of floods and storms associated with El Nino (Larry, 2010). In the past 10,000 years we have had the good fortune to live in an interglacial period with a fairly stable climate and average global surface temperature, however, even during this stable period significant changes occurred in regional climate. For example about 7000 years ago most of the current Sahara desert received almost 20 times more rainfall than it does today (Miller, 2004: 281). Karl and Knight (1998) and Mason *et al*, (1999) found that increased precipitation is disproportionate to an increase in the frequency of the heaviest precipitation events. Countries, societies, and individuals who have limited adaptive capacity, least resilience and who are exposed to hazards are those that are considered to be most vulnerable (Bohle *et al*, 1994).

A region that is already vulnerable to many non-climatic stresses; climate change and its potential physical and social impacts are likely to exacerbate vulnerability leading to large-scale instability. Climate change is likely to act as a risk multiplier, aggravating water scarcity. Water scarcity, on the other hand, threatens food security by reducing agricultural production as well as hindering human health and economic development (Elasha, 2010). The National Research Council (2001) cited in their report *that higher evaporation rates accelerate the drying of soils after rain events, which causes drier than average conditions in some regions*. Odingo (2009:69) cited that the average temperature in the global ocean has increased to depths of at least 3,000m and that the ocean has been absorbing more than 80% of the heat added to the climate system causing sea water to expand which in turn contributes to rise in sea level. Global climate change is not likely to be spatially uniform and is expected to include changes in temperature and the hydrologic cycle. Associated health effects will vary spatially. This may help to draw the conclusion that climate change will affect most populations in the future and will put peoples' lives and wellbeing at serious risk. This century will observe the rise of surface temperatures to exceed a safe threshold of 2°C above preindustrial average temperature (UCL *Lancet* Commission Report, 2009).

Arunyanart and Limsiri (2011) have found that a slight change in an average global temperature results in an increasing tendency towards the frequency of extreme weather. Climate events in many regions of the world and it causes economic loss , a serious threat to human society and biological diversity of various ecosystems. Blashki *et al*, (2007) stated that global warming threatens to disrupt the physical, biological and ecological support systems on which human health depends. Short-lived greenhouse pollutants emitted largely from fuel combustion cause direct damage to human health from energy use worldwide; these pollutants include two important health damaging agents, sulphates and organic carbon aerosols which generally have global-cooling characteristics damaging to health (Smith *et al*, 2009). Samet (2010) concluded that global warming poses a threat to human health and the positive and negative consequences of health outcomes vary temporally and spatially. *Climate change is gradually affecting the whole planet; some areas of human inhabitation are affected more compared to others* (Newland, 2011:2). The global risk management firm Maplecroft (2011) stated that many of the countries with a fast population growth are rated as 'extreme risk' in the CCVI, including the strategically important emerging economies of Bangladesh (2nd).

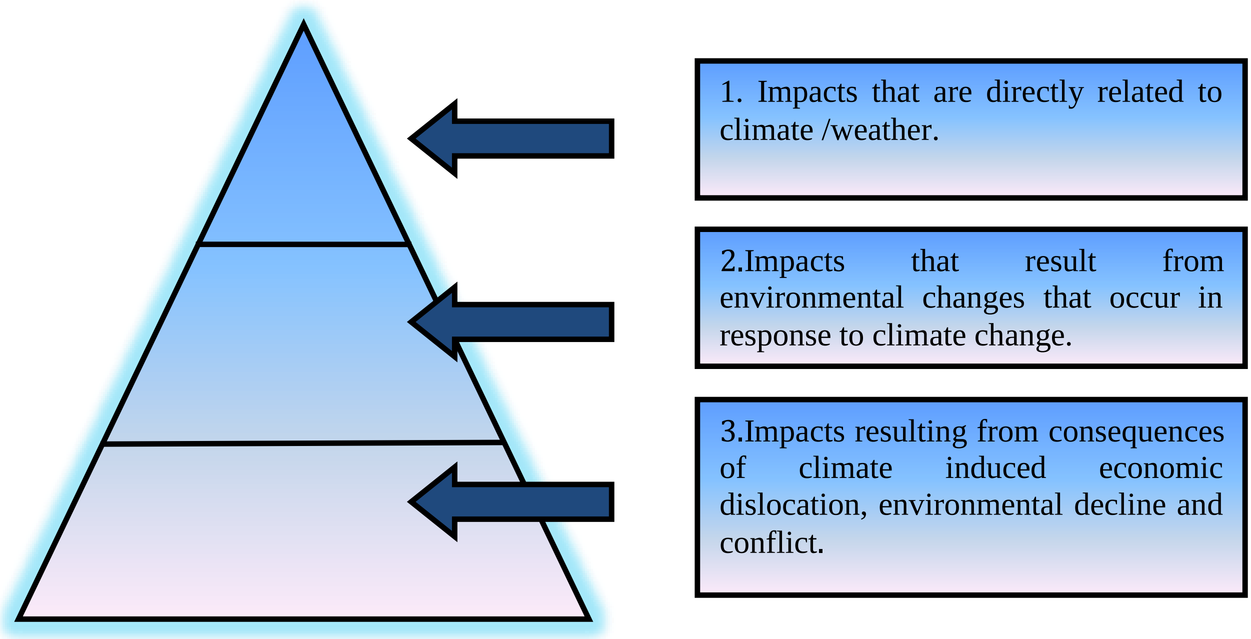
2.3 Climate change and Health

One of the most disturbing implications of climate change is its potentially devastating impact on human health. The Intergovernmental Panel on Climate Change (IPCC) published its Fourth Assessment Report in 2007, which included a global assessment on the impacts of climate change on human health (Confalonieri *et al*, 2007). The conclusion of the health chapter was that: *the health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased diseases due to higher concentrations of ground level ozone related to climate change; and the altered spatial distribution of some infectious diseases* (IPCC, 2007:48).

McMichael (2003:12) cited that "*the long-term good health of a population depends on the continued stability and functioning of the biosphere`s ecological and physical systems is often referred to as life support system*". He also stated that the world's climate system is an essential part of the life support systems and is one of the main large natural systems that are being affected by increased human population, economic activities and greenhouse gas emissions. Climate change and global warming have various health hazards (Poursafa *et al,* 2011).

A report on "Potential Health effects of climate change" by WHO (1990) cited that adverse health impacts can result from changes in the climatic pattern like heat stress, enhanced air pollution, malnutrition due to impaired food productivity and altered pattern of vector born disease. In the words of Haines *et al,* (2006), 'There is ... uncertainty over future climate change (particularly future greenhouse gas emissions), uncertainty about climate/health relations, and most importantly, uncertainty around the degree to which current climate/ health relations will be modified by socioeconomic adaptation in the future. 'The increase in the frequency and intensity of extreme temperatures will have both direct and indirect effects on health. The direct health effects of climate change would include altered rates of mortality and morbidity due to heat waves and thermal stresses in general, respiratory consequences due to changes in patterns of exposure to aeroallergens (spores, moulds etc.) and the direct, often physical hazards of any increase in extreme weather events, including storms, floods and droughts (The Royal Society, 1998:29). Ebi *et al,* (2006) and McMichael *et al,* (2001) categorised health impacts resulting from climate change into three categories:

Figure 2.3: Three broad categories of health impact



Source: Ebi *et al*, (2006:1932) and McMichael *et al*, (2001:196)

Population health status is affected by multiple 'upstream' environmental factors including: climate, physical infrastructure such as housing, energy and social factors (including education, income and livelihoods). Health status, in turn, is a key factor affecting resilience to adverse conditions, including those related to climate change, such as heat stress, floods, droughts, changes in productive ecosystems, altered distribution of communicable diseases and the downstream social and economic effects associated with these (McMichael *et al*, 2003). There is substantial evidence worldwide on the association among specific climate conditions and mortality, illnesses and discomfort (McMichael *et al*, 2003; Riedel, 2004; IPCC, 2007; Ebi *et al*, 2008; Seguin and Berry, 2008; WHO, 2008). There are concerns that climate change will cause excessive deaths from malnutrition because of drought and crop failure

(Schmidhuber and Tubiello 2007), diarrhea [McMichael *et al*, 2004; World Health Organization (WHO) 2004], respiratory diseases (Beggs and Bambrick 2005), and vector- borne infectious diseases, such as malaria (Tanser *et al*, 2003).

WHO predicts that temperature shifts will encourage the spread of infectious diseases. Many of the major killers such as Cholera, Malaria, Dengue and diarrheoal diseases are higly climate sensitive (with regards to temperature and rainfall). In sum, climate change threatens to slow, halt or reverse the progress that the global public health community is now making against many of these diseases (WHO, 2009).

Certain communities are more vulnerable to the impact of climate change due to their location (exposed to climate extremes), poor health status, lack of infrastructure (poor housing quality, lack of services (such as piped water supplies) lack of information or expertise in responding to climate hazards, or lack of economic resources (ability to pay for services, such as electricity, or insurance). In addition, the type of work required by local people can create vulnerability as high levels of physical activity create heat stress risks (Parsons, 2003; Kjellstrom *et al*, 2009). “Direct effects on health due to heat, cold and injuries are some of the acute manifestations resulting due to climate change; these effects can easily be witnessed as a consequence of climate change either in the form of heat and cold waves or direct injuries resulting from heavy rains and wind speeds as witnessed in hurricanes.

There are many indirect effects: communicable diseases e.g.: vector borne disease, diarrheal diseases; ecological disturbances impacting on agent- host-environment relationships; malnutrition resulting due to agricultural impacts leading to food security issues; environmental health related to air and water quality issues, and human behaviour issues such as migrations, and mental health" (Patil, 2012). Both direct and indirect effects cause suffering, disability and death (IUCN, 2011).

After having conducted a meta-analysis of epidemiological data from multiple countries Ezzati (2004) found that total health effects have advanced the understanding of important climate sensitive health risks. Many health outcomes and diseases are sensitive to climate, including: heat-related mortality or morbidity; air pollution-related illnesses; infectious diseases, particularly those transmitted, indirectly, via water or by insect or rodent vectors; and refugee health issues linked to forced population migration. Yet, changing landscapes can significantly affect local weather more acutely than long-term climate change (Patz and Olson, 2006). Scientific evidence clearly shows that the climate is warming, which is causing more extreme weather events such as drought, flooding, cyclones, precipitation variability, storms, snow, storm surges, temperature variability, and wildfires. The World Disaster Report (2006) recently reported that 98% of those affected by dangerous weather events recently are largely stimulated by climate change. Extreme weather events due to climate change are threatening to human health, which are more significant than changed average climatic conditions (National Research Council 2001; Lynch and Brunner 2007; Alexander *et al*, 2009).

2.4 Climate Change and Natural Disasters

Since 1975, natural disasters have claimed the lives of more than 2.2 million people worldwide. Storms, floods, droughts, heat waves and other weather-related phenomena are responsible for two thirds of the fatalities and economic losses from natural disasters (UNISDR, 2009). Climate change increases disaster risks in two ways. Firstly, climate change will likely increase the frequency and/or severity of weather and climate hazards (IPCC 2007). Secondly, climate change will simultaneously increase communities' vulnerability to natural hazards (due to the combined effects of ecosystem degradation, reduced availability of resources, and changes in peoples' livelihoods) (UNISDR, 2009). Natural hazards by themselves do not cause disasters – it is the combination of an exposed, vulnerable and ill-prepared population that results in a disaster (UNISDR, 2009).

A disaster is a very complex multidimensional phenomenon. The damage caused by disasters is immeasurable and varies with geographical location, climate and the type of earth surface and degree of vulnerability (Asimakopoulou and Bessis, 2010:23). WHO (1971) defined a natural disaster as "*an act of such magnitude as to create a catastrophic situation in which the day- to- day patterns of life are suddenly disrupted and people are plunged into helplessness and suffering and as a result, need food, clothing, shelter, medical and nursing care and other necessities of life and protection against unfavourable environmental factors and conditions*". Natural disasters are expected to rise as a result of climate change (Hales *et al,* 2003). *Climate variability can be expressed at various temporal scales like by day, season and year and is an inherent characteristic of climate and so much attention has focused on the influence of E1 Niño-Southern Oscillation (ENSO) on weather patterns in many parts* *of the world* (Hales *et al*, 2003:79). ENSO contributes to the year-to-year variability and extreme weather events, which are more likely during the extremes of the oscillation (Bouma, 1999). For example, during ENSO, Southern African countries and Indonesia face droughts, the western coast of South American countries particularly in Peru and Ecuador experience strong and weak rainfall and also the ENSO has an important effect on the character of annual monsoons in Asia (Kovats and Bouma, 2002).

Easterling *et al*, (2000:2068) categorized climate extremes into two groups:
(1) Climate extremes based on simple climate statistics that includes extremes such as very low or very high daily temperatures or heavy daily or monthly rainfall amounts that occur every year.
(2) More complex event-driven extremes like droughts, floods, hurricanes that do not necessarily occur every year at a given location.

Natural hazards causing disasters are killing more people over time and also increasing the cost (O'Brien, 2006). Over the last two decades disaster events were hydrological, meteorological and climatological in nature (UNISDR, 2009). Floods and droughts are examples of hydrological extreme events. Floods are associated with rainfall from thunderstorms and tropical storms while droughts are associated with a lack of precipitation and high temperatures (Trenberth, 2011). Scientists are working on outlining how global warming is threatening the planet in unanticipated modes like by triggering earthquakes, cyclones, tsunamis, avalanches and volcanic eruptions (Singh and Singh, 2012). In the Caribbean and Western Atlantic, cyclones are called hurricanes (Zibulewsky, 2001).

In the last decade specifically the last 5 years have been identified as being a disaster decade. For example in 2004, 226,408 people died (as shown in Table 2.2) due to Tsunamis. Many people also became homeless. Around 240,000 people have been affected with famine in Nizare and presently people in Malawi are facing the drought and a periodical food shortage. The devastating effect of the cyclones *Hurricane, Katrina and Rita* etc. (Shamsuddoha and Chowdhury, 2007) and the human and economic losses caused by natural disasters in 2008 were on a large scale (Mcbean and Rodgers, 2010). On 11 March 2011, Japan faced its biggest crisis since the Second World War. The earthquake on the coast of Japan which also caused a Tsunami devastated the northeast of Japan leaving many thousands dead or missing, and hundreds of thousands homeless or evacuated from the area (Barnigan, 2011). Hurricane Irene was the first hurricane to hit the United States since Hurricane Ike stuck in September 2008 (NOAA, 2011). A Hurricane storm like 'Irene' can put a third of New York City streets under water and flood many tunnels because of climate change (Singh and Singh, 2012).

Hurricane Sandy is a stark reminder of the rising risks of climate change (Centre for Climate and Energy Solutions, 2012). Hurricane Sandy started in Jamaica on 22nd October 2012. It developed from an elongated tropical wave near the Caribbean (Irish Central, 2012). It was a massive and deadly storm, extending more than 1000 miles and more than 13 feet of water appeared to parts of New York City. More than 8 million people in the northeastern United States lost power, tens of millions more were affected and tragically more than 160 people lost their lives (Steer, 2012).

Table 2.2: The largest Natural Disasters 2000-2011

Popular name	Main Countries affected	Date of event	Type of Hazard	Total number of deaths	Total number of affected
Japan Earthquake	Japan	11 March 2011	Earthquake and Tsunami	5178(As of 17.03.2011)	Not yet known
Haiti Earthquake	Haiti	12 January 2010	Earthquake	222,570	3,400,000
Sichuan Earthquake	China	12 May 2008	Earthquake	87,476	45,976,596
Cyclone Nargis	Myanmar	2 May 2008	Tropical Cyclone	138,366	2,420,000
Java Earthquake	Indonesia	27 May 2006	Earthquake	5,778	3,177,923
Kashmir Earthquake	Pakistan	8 October 2005	Earthquake	73,338	5,128,000
Hurricane Katrina	United States	29 August 2005	Tropical Cyclone	1,833	500,000
Mumbai Floods	India	26 July 2005	Flood	1,200	20,000,055
South Asian Tsunami	Indonesia, Sri Lanka, India Thailand, Malaysia, Maldives, Myanmar	26 December 2004	Earthquake and Tsunami	226,408	2,321,700
Bam Earthquake	Iran	26 December 2003	Earthquake	26,796	267,628
European Heat wave	Italy, France, Spain, Germany, Portugal, Switzerland	Summer 2003	Extreme Heat	72,210	Not reported
Dresden Floods	Germany	11 August 2002	Flood	27	330,108
Gujarat Earthquake	India	26 January 2001	Earthquake	20,005	6,321,812

Source: (World Disasters Report 2010, OCHA 2011)

Freedman (2012) reported that it will take some time to investigate whether climate change was responsible for Hurricane Sandy, however it is very likely and could be argued that climate change made Sandy's impact worse. Climate change stimulated Sandy in three different ways – warming drove a sea level rise and made Hurricane Sandy more destructive, a rise of sea surface temperature from human activities also increased the risk of flooding and water vapour and higher ocean temperature fuelled the storm. On Health Day News Health day reporter Reinberg (2012) reported that the effect of this sudden, violent loss by Hurricane Sandy will be powerful and will have some long-term psychological effect. Typhoon Bopha struck on the 4th December 2012 across the southern Philippine island Mindanao causing the death of 1100 people and destroying nearly 75,000 homes. Livelihoods were destroyed, as people were dependent on plantations like bananas and coconuts. It has been estimated that it will take 7 to 10 years to replace the trees that were damaged (Wilby, 2013).

Poor countries suffer more from climate-induced hazards due to thier intrinsic vulnerabilities to hazards and minimum capacity for risk reduction measures (UNISDR, 2009). IPCC (2001, section 2.8) stated that "*Populations are highly variable in their endowments and the developing countries particularly the least developed countries… have lesser capacity to adapt and are more vulnerable to climate change damages, just as they are more vulnerable to other stresses. This condition is most extreme among the poorest people"*.

Disasters are a possibility in all nations; weather-climate related events are most often recorded in Asia (Mcbean and Rodgers, 2010). Satapathy and Subhasis (2009) cited some of the most recent large scale disasters in Asian countries in their paper which includes- a tropical cyclone in 1998 which caused heavy damage in the Sindh province of Pakistan and then moved into the Indian state of Gujarat (extensive damage in both countries), and a drought in 2000 which gripped parts of India, Pakistan and Afghanistan simultaneously. Monsoon flooding and subsequent river erosion in northeast India, Nepal and Bhutan triggered severe floods in the western districts of Bangladesh in the year 2000. Floodwater is dangerous as reported by EA (2011) and only 15cm of fast flowing water can blow away a person and 60 cm can float a car, flooding covers up manholes and creates hidden dangers, fallen power lines and trees are potentially life threatening and when water levels are high, bridges may be dangerous to walk or drive over.

In the same year (2000) a cyclone crossed the northern part of Sri Lanka and reached the southern tip of India damaging houses, fishing boats and crops. The impact of the Gujarat earthquake in India the next year was felt throughout northwest India and parts of Pakistan. The tsunami of 2004 in the Indian Ocean was a disaster, which crossed boundaries and impacted eleven Asian countries. Of the affected countries, Indonesia had the highest death toll of an estimated 165,708 followed by SriLanka and India as second and third. The massive earthquake in the Himalayan region in 2005 again caused extensive damage to life and the living of people in Kashmir of India and the bordering parts of Pakistan (Guha-Sapir, 2006). The last few decades have seen rapid growth in populations living in flood plains and coastal areas, particularly in developing cities, placing more people in weather related natural disaster areas (WHO, 2008). Climate change has also increased the probability of extreme high temperatures and will also cause extreme and frequent precipitation events and more cyclonic storms (IPCC, 2007). All of these jointly will cause climate related health hazards (WHO, 2008). The consequences of climate change to human health are likely to be significant, with DARA (2010) predicating a 145% increase in human mortality rate between 2010 and 2030 directly attributable to climate change. The association between extreme climatic events and its effect on human health (including the emergence of various infectious diseases) will be discussed in the next section of this chapter.

2.4.1 Heat wave

Increasing temperature causes environmental as well as health hazards, although the human body is capable of maintaining its core temperature at around 37°C, environmental temperature, high humidity, physical exercise and dehydration can disturb the balance (Crowe *et al*, 2009). A heat wave is a combination of humidity and temperature for a prolonged period. Generally the temperature is above the average high temperature. It is an extended period of very high summer temperature with the potential to adversely affect communities (Mohapatra, 2007). According to the World Metrological Organization (WMO) 2010 ranked as the warmest year on record together with 2005 and 1998 (WMO, 2011).

Unlike many climate hazards such as hurricanes, tornadoes, thunderstorms and floods, heat waves are geographically diffused and occur over large areas (WMO & WHO, 2010:4) Increasing local temperature means higher human exposure to heat during the hot season in summer time in any part of the world and can create very unhealthy environment for those who are not able to protect themselves from these extreme heat events by various cooling methods (Kjellstrom, 2009). Heat stress causes heat strain of the human body; increased heart rate and an increased blood flow to the skin. Sweating can not only cause illness and death in older adults, but can also cause dehydration, collapse, heat stroke and death (Parsons, 2009).

Table 2.3: Hottest years on record

	Met Office Hadley Centre & Climatic Research Unit		NOAA National Climatic Data Centre		NASA Goddard Institute for Space Studies	
	Year	Deviation	Year	Deviation	Year	Deviation
1	2010*	0.52	2010*	0.54	2010*	0.58
2	1998	0.52	2005	0.52	2005	0.56
3	2005	0.47	1998	0.50	2007	0.51
4	2003	0.46	2003	0.49	2009	0.50
5	2002	0.46	2002	0.48	2002	0.49
6	2009	0.44	2006	0.46	1998	0.49
7	2004	0.43	2009	0.46	2006	0.48
8	2006	0.43	2007	0.45	2003	0.48
9	2007	0.40	2004	0.45	2004	0.41
10	2001	0.40	2001	0.42	2001	0.40

*Deviation from 1961-1990 global average temperature in °C

Source: (Met Office, 2010)

The risk of heat related morbidity and mortality would increase mainly in the elderly, children those with pre-existing cardiovascular and respiratory diseases, and among the urban poor (Haines *et al*, 2006). The elderly constitute the largest defined group at risk from dying due to a heat wave and elderly people with dementia are particularly at risk (WHO, 2008). Evidence shows that mentally ill people (Ledrans *et al,* 2004), children (Bouchama, 2004) and thermally stressful occupations or those with pre-existing illness (McMichael *et al*, 2006) are also vulnerable. The epidemiological evidence for certain medical conditions as risk factors for mortality in heat waves is less clear but a range of serious conditions could possibly increase the risk of heat related mortality such as diabetes, electrolyte disorders and some neurological disorders (WMO and WHO, 2010). The greatest impact is expected for mid-to high- latitude cities, especially in poor countries (Markandya and Chiabai, 2009). Adverse health effects of heat wave are more pronounced in urban areas (Duncan *et al,* 1999) and areas that are heat sensitive (Kalkstein, 1993). Short term increases in temperature in Eastern and Southern Africa caused malarial transmission and the populations have suffered without previous exposure and lack of immunity (Confalonieri *et al*, 2007 and McMicheal *et al*, 2008). Urban areas are mostly affected because of the urban heat island effect, which causes temperatures to remain higher compared to those in sub-urban and rural areas. The recent example of an extreme heat wave in Europe shows that even developed countries can see a large number of deaths in such events (Haines *et al*, 2006).

Table 2.4: Excess mortality attributed to the 2003 hot summer period in Europe

Population	**Excess Mortality (% increase)**
2003- England & Wales	2091 deaths (17%) in heat wave period (4-13 August)
2003- Italy	3134(15%) in all Italian capital (1June-15 August)
2003-France	14,802(60%) in heat wave (1-20 August)
2003-Portugal	1854 (40%) in August
2003-Spain	4151 deaths (11%) deaths in July and August
2003-Switzerland	975 deaths (6.9%) in June – September period
2003-Netherlands	1400-2200 deaths (3-5%) in June-September period
2003-Germany	1410 deaths in heat wave (1-24 August)

Source: (Haines *et al*, 2005:588)

The 2003 summer heat wave in Europe showed that even high-income countries are vulnerable to extreme weather events. Hot weather increases the mortality rate as it makes life especially harder for older people (Haines *et al,* 2005). In 2003 the whole of Western Europe was affected by heat waves and an excess of 2000 deaths were reported in England and Wales (Johnson *et al,* 2005). France also suffered a lot, it was estimated that 14,800 deaths occurred during the first 3 weeks of August 2003 (Institut de Veille Sanitaire, 2003). A study done by the European Environment Agency reported that by 2080 nearly every summer in many parts of the Europe will be 10% hotter than the current climatic conditions .It also predicted that the Southern part of Europe will face it sooner and every second summer would be hotter than 2003 (EEA, 2004).

Cities in developing countries may be more vulnerable to heat waves (Patz and Kovats, 2002:1095) In South Asia, heat waves have been associated with a high mortality rate in rural populations as well as among the elderly and labourers who work outdoors (IPCC, 2007). The negative impact of heat waves might be partially compensated by a decrease in cold-related deaths during the winter season. According to some studies, the decrease in winter mortality temperate regions might be greater than the increase in heat-related mortality expected in summer (Langford and Bentham, 1995 and Martens, 1997).

A study from the United States showed that the place of death, race and educational attainment indicate vulnerability to temperature- related mortality, reflecting inequalities in health impacts related to climate change (O`Neill *et al,* 2003). Temperature and formation of the ozone at ground level are positively related.

In some of the US cities ozone level is found to have strong positive relations with temperatures above 32°C (Patz and Kovats, 2002). Ground level ozone can cause a number of health effects which have been observed in a broad segment of the population For example: chest pain, coughing, throat irritation and congestion, worsening bronchitis, emphysema, bronchitis, reduction of lung function, inflammation of the lining of lungs and repeated exposure may cause scarring of lung tissue (EPA, 2011). The impact of heat waves and cold spells on mortality in the Netherlands during 1979-1997 supports earlier findings that temperature has a relatively small influence on mortality among those less than 65 years of age (Huynen *et al,* 2001) and it appears that it is the elderly population that are most affected by extreme weather events.

Infants and young children may represent a second, high-risk group (Wyndham and Fellingham, 1978) and this was the case of the heat waves in Brazil (Gouveia, 2003). Lam (2007) shows a link between hot days and child hospital admissions in Sydney. Young children under age six appeared to have become overheated on the hot days and developed a fever .The author also found that children`s hospitalisation for gastroenteritis increased dramatically on hot days. In Europe, increases in emergency hospital admissions among individuals with respiratory diseases have been noted during hot weather but not in those with cardiovascular disease or stroke (Kovats *et al,* 2004, Linares and Diaz, 2008, Michelozzi *et al*, 2009). In London no significant excess in hospital admissions was seen during the 1995 heatwave (Kovats *et al,* 2004), and only a small increase in admissions in people over 75 years of age was observed in 2003 (Johnson *et al,* 2005).

India was affected by an extreme heat wave in June 1998 and was estimated to have caused 2600 deaths over 10 weeks of high temperatures (Kumar, 1998). By contrast, in studies from the USA, heat related increases were noted in admissions for heart diseases (Semenza *et al,* 1999, Schwartz, 2004). A consistent increase has been noted in admissions for renal diseases in Europe (Kovats *et al,* 2004), USA (Knowlton, 2009, Schwartz, 2004) and Australia (Nitschke *et al,* 2009, Hansen *et al,* 2008). Increases have also been noted for other conditions, including diabetes (Schwartz, 2004) and mental disorders (Hansen *et al,* 2008). A study noted that people with mental disorders are more prone to heat stroke (Naughton *et al,* 2002). Extreme hot and cold environments can cause sleep disturbance and central stress pathways (Buguet, 2007). Extreme physical environments with isolation and confinement can cause interpersonal tension and conflict (Palinkas and Suedfeld, 2008). Time series data has been used to assess the disease proportion in a population due to the weather, that is short-term variation in meteorological exposures and strong association has been identified between temperature and daily mortality with diarrhoea (Kovats *et al,* 2005).

2.4.2 Droughts

Drought is one of the major threats among natural hazards to people's livelihoods and socioeconomic development. Droughts tend to occur less frequently than other hazards but whenever it occurs it affects a broad region for seasons or a year at a time (SAARC Disaster Management Centre, 2010:1). A drought is known as a deficiency of rainfall over a period of time within a geographic area resulting in a water shortage for some activity (Wilhite *et al,* 1987). According to NOAA (2002) there are four different types of droughts that impact upon humans:

1. Meteorological: measured precipitation is low for a region

2. Agricultural: the presence of moisture is very low for crop production

3. Hydrological: surface water and ground water supplies are below the normal level

4. Socio-economic: lack of water affects non-agricultural production.

Increasing global temperature may increase the frequency of droughts in the grasslands (Beaudoin, 1990). The E1 Niño cycle has influenced droughts, which is responsible for causing health problems like nutrition, infectious diseases and forest fire leading to air pollution in low-income countries (Bourrna *et al,* 1997). Drought cause less dietary diversity, reduces overall food consumption and thereby causes micronutrient deficiencies (Confalonieri *et al,* 2007). Droughts have their largest impact on population health by threatening food supplies and nutrition. In addition, diarrhoeal diseases, scabies, conjunctivitis and trachoma are associated with poor hygiene and may result from inadequate sanitation as water resources become depleted (Patz and Khaliq 2002; Prüss *et al,* 2008). Droughts and drying can lead to social instability; food insecurity, long-term health problems and damage to or destroying of related livelihoods (Pachauri and Reisinger, 2007).

Drought may increase the risk of air borne particulate matter (Haller *et al,* 1999). Air- borne particulate matter may cause respiratory disease exacerbate existing respiratory co-morbidities, become chronic and present as rhinitis, bronchitis and asthma (Liang *et al,* 2002). Among children, pneumonia and diarrhoeal diseases showed the highest incidence rates during the main dry season in southern Ethiopia (Lindtjorn *et al,* 1992). During droughts, water availability is diminished forcing people to access poorer quality water supply sources and water quality is often degraded. A long drought followed by an intense rainfall generates multiple disease outbreaks as rodent population's boom in the wake of replenished water supplies (IPCC, 2007).

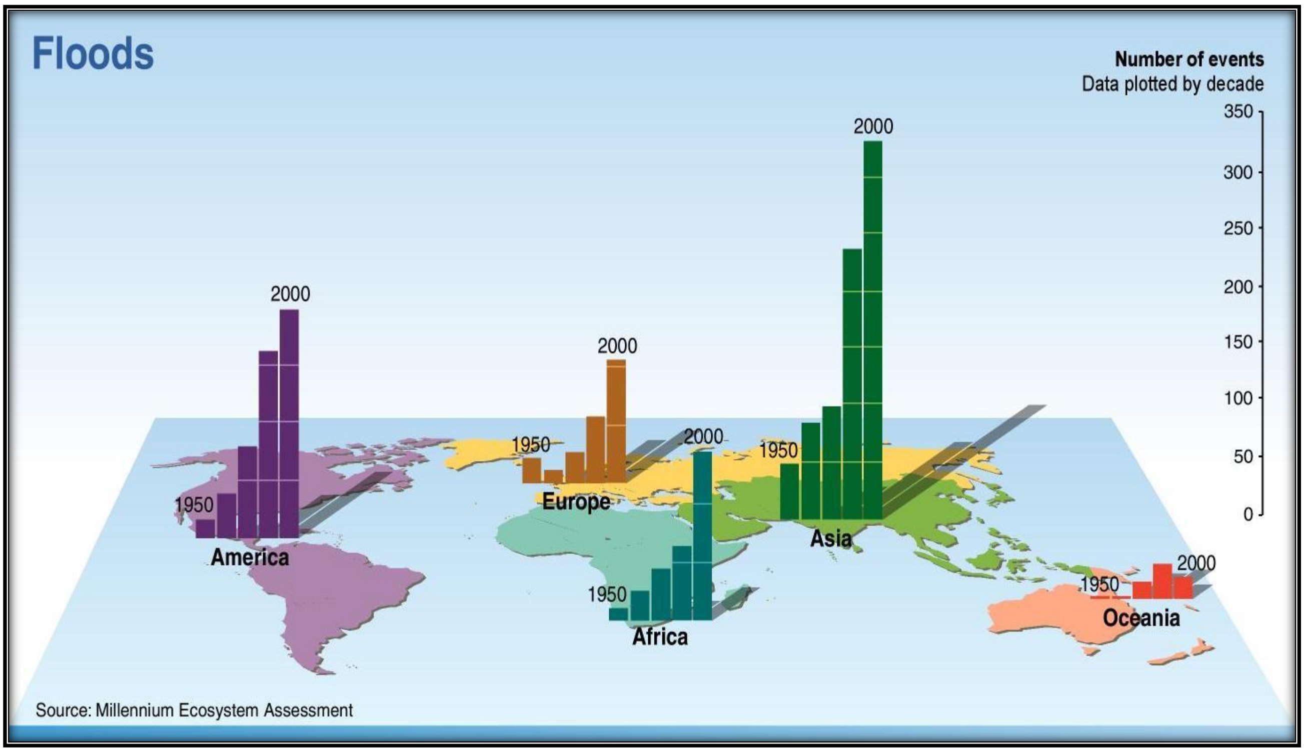
The mental health impact of droughts is also understudied. Droughts may affect farmers making it difficult for them to grow crops, which in turn cause financial anxiety and distress. Droughts can affect family relationships, cause worry, and stress and increase the rate of suicide (Chand and Murthy, 2008). A study conducted in Sri Lanka in 1979 revealed that 43 % of children were malnourished and 41 % of housing units were diet deficient (SAARC Disaster Management Centre, 2010). A study in South Africa shows that HIV/AIDS increases the effect of drought on nutrition (Mason *et al,* 2005). The phenomenon of farmers' suicide in India is a typical example (Sartore *et al,* 2007). In the context of global warming, most of the climatic models project a decrease in precipitation in dry seasons and an increase during monsoons in south Asia (IPCC, 2007). About 1.7 billion people currently live in water stressed countries and this number will increase in the future to 5 billion by 2020 (McMichael et al, 2001). Droughts often result in mass displacement of a population (WHO, 2012). Droughts cause a loss of livelihoods, which in turns triggers people to migrate from rural to urban areas (Confalonieri *et al,* 2007).

2.4.3 Floods

Floods are the most common natural disaster worldwide. *Floods refer to a situation of water accumulation in places that are not normally submerged. Heavy rainfall, melting snow, glacial outbursts and dam-break flows are the main leading causes of floods.* (Guha-Sapir *et al*, 2010:14). Under current climatic conditions, sea levels rise due to glacier melting and changing patterns of weather precipitation may increase the amount and occurrence of flood events around the world (IPCC, 2001). *Over the last 10 years floods in Europe have killed more than 10,000 people and affected 3.4 million people* (Guha-Sapir *et al*, 2010: 14). Climate change may increase the risk of rivers flooding. Widespread flooding, intrusion of salt water, and coastal erosions are expected to be an increasing threat in low-lying areas. The number of people at risk from flooding by coastal storm surges is projected to increase from the current 75 million to 200 million in a scenario of mid-range climate changes, in which a rise of 40 cm in sea level is envisaged by 2080 (McMichael *et al*, 2001).

Nicholls and Leatherman suggests a rise of 1 metre in sea level could inundate low lying areas, affecting 18.6 million in China, 13 million people in Bangladesh, 3.5 million in Egypt and 3.3 million people in Indonesia (Nicholls and Leatherman, 1995). The degree to which floods can cause death and injury depends on the type of flooding. Flash floods from heavy rain falls in short periods are the most deadly because of the overall water volume, high water flow rates and limited warning time (Greenough *et al*, 2001). *Many slow rise river floods events have also been associated with fatalities, for example in 1997 a flood in central Europe caused 200,000 people to become homeless and more than 100 people were killed* (Haines *et al*, 2006:2103).

Figure 2.4: Number of flood events by continent and decade since 1950



Source: (Millennium Ecosystem Assessment, 2005**)**

Studies in the US, Netherlands and UK have shown a consistent pattern of increased psychological problems among flood victims in the five years following a flood. Problems reported include an increase in anxiety and depression and behavioural disorders in children (Ahern *et al*, 2005). The most common flood related deaths occur are drowning and trauma (when hit by objects in fast flowing waters) (Ahern *et al*, 2005). The most immediate effects of floods found are largely death from drowning and injuries caused by being swept against hard objects (Malilay, 1997). Medium term effects include an increase in communicable diseases caused by the ingestion of contaminated water (for example cholera, hepatitis A) and contact with flood waters (for example, leptospirosis) (Kovats and Jonathon, 2002). In Bangladesh in 1988, watery diarrhoea in a population displaced by floods was the most common cause of death for all age groups under 45, followed by respiratory infection (Siddique *et al*, 1991). Post Hurricane Katrina (New Orleans The USA), some individuals developed fungal spores, which lead to respiratory problems. It was known as “Katrina Cough” (Perrin, 2008).

A study in Europe showed that after the flooding of the river Meuse during the winter of 1993-94 soil contaminated with heavy metals. It concluded that there were potential health risks for river-bank inhabitants as a consequence of lead and cadmium contamination (Albering *et al*, 1999). The long-term effects of floods are an increase in communicable infectious diseases that are caused by the congestion of contaminated water, for example cholera, hepatitis and sometimes caused by contamination with water-like leptospirosis (Patz and Khaliq, 2002). Direct and indirect effects of floods are shown in Table 2.5.

Table 2.5: Direct and Indirect health effects of Flood

Direct Effects

Causes	Implications
Stream flow velocity; topographic land features; absence of warning; rapid speed of flood onset; deep floodwaters; landslides; risk behaviour; fast flowing waters carrying boulders and fallen trees	Drowning and Injuries
Contact with water	Respiratory diseases; shock; hypothermia; cardiac arrest
Contact with polluted water	Wound infections; dermatitis; conjunctivitis; gastrointestinal illness; ear, nose and throat infections; possible serious waterborne diseases
Increase of physical and emotional stress	Increase of susceptibility to psychosocial disturbances and cardiovascular incidents

Indirect Effects

Causes	Implications
Damage to water supply systems; sewage and sewage disposal damage; insufficient supply of drinking water; insufficient water supply for washing	Possible waterborne infections (enterogenic E. coli, shigella, hepatitis A, leptospirosis, giardiasis, campylobacter), dermatitis and conjunctivitis
Disruption of transport systems	Food shortage; disruption of emergency response
Underground pipe disruption; dislodgement of storage tanks; overflow of toxic-waste sites; release of chemicals; Rupture of gasoline storage tanks may lead to fires	Potential acute or chronic effects of chemical pollution
Standing waters; heavy rainfalls; expanded range of vector habitats	Vector-borne diseases
Rodent migration	Possible diseases caused by rodents
Disruption of social networks; loss of property, jobs and family members and friends	Possible psychosocial disturbances
Damage to health services; disruption of "normal" health service activities	Decrease of "normal" health care services, insufficient access to medical care
Clean-up activities following floods	Electrocutions; injuries; lacerations; skin punctures
Destruction of primary food products	Food shortage

Source: (Menne *et al*, 2000. Floods and public health consequences, prevention and control measures. UN, 2000)

Hazards may be greater when industrial or agricultural land, which adjoins residential land, is affected. There is insufficient research on flooding that causes chemical contamination to detect any causal effect on the pattern of morbidity and mortality in the affected populations (Euripidou and Murray, 2004). The effect of flooding on the psychology of individuals has more importance than injury and illness, as for most people emotional trauma continues even after the water recedes (Ohl and Tapsell, 2000). A study conducted in England, (following flooding in the town of Lewes), found that significant importance was given to psychological distress on the 12-item general health questionnaire (Reacher *et al*, 2004). IFRC (1999) reported that 50 flood-linked suicide cases were reported in Poland in 1997. Flood victims reported feeling depressed and isolated (Tapsell, 2000). A study by Bennet in 1968 of Bristol floods reported that the effect of flooding on mortality and morbidity due to the result of stress and psychological impact of the disaster (Bennet, 1970). Several studies (Rabkin and Struening 1976; Bedell *et al*, 1977) demonstrated that externally induced stressed alters, for a time, the body`s physiology and thus is linked to mental and physical illnesses. For example, mental stresses are linked with myocardial infection (Bedell *et al*, 1977).

2.4.4 Tropical Cyclones, Hurricanes and Tsunamis

Tropical cyclones are among the most destructive natural phenomena. "*A tropical cyclone is a non-frontal storm system that is characterised by a low pressure centre, spiral rain bands and strong winds. Usually it originates over tropical or sub-tropical waters and rotates clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. The system is fuelled by heat released when moist air rises and the water vapour it contains condenses ("warm core" storm* *system). Therefore the water temperature must be >27 °C. Depending on their location and strength, tropical cyclones are referred to as hurricane (western Atlantic/eastern Pacific), typhoon (western Pacific), cyclone (southern Pacific/Indian Ocean), tropical storm, and tropical depression*"(EM- DAT, 2009).

Global warming can influence the maximum potentiality of tropical cyclones by altering the surface energy flux and upper level cold exhaust (Emanuel, 1987). Webster *et al,* (2005) reported that there is a relationship between hurricane activity and sea surface temperature. An increase in sea level is the most significant threat to the regions facing climate change (Mimura *et al,* 2007).

Table 2.6: Top 10 most important Storm disasters for the period 1900 to 2012 sorted by numbers of people killed at the country level

Country	Date	Numbers of people Killed
Bangladesh, Tropical cyclone	12/11/1970	300000
Bangladesh, Tropical cyclone	29/04/1991	138866
Myanmar, Tropical cyclone	02/05/2008	138366
China P Rep, Tropical cyclone	27/07/1922	100000
Bangladesh, Tropical cyclone	Oct-1942	61000
India, Tropical cyclone	1935	60000
China P Rep, Tropical cyclone	Aug-1912	50000
India, Tropical cyclone	14/10/1942	40000
Bangladesh, Tropical cyclone	11/05/1965	36000
Bangladesh, Tropical cyclone	28/05/1963	22000

Source: (EM-DAT: The OFDA/CRED International Disaster Database www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium)

Climate change may also cause changes to the behaviour of tropical cyclones by modifying their frequency, intensity and preferred regions of occurrence (Sugi *et al*, 2009; Bender *et al*, 2010). Public health consequences associated with tropical cyclones include storm- related mortality, injury, infectious diseases, psychological effects, displacement and homelessness, damage to health care infrastructure, disruption of public health services, transformation of ecosystems, social dislocation, loss of jobs and livelihoods and economic crisis (Schultz *et al,* 2005). Vulnerability to tropical cyclones is becoming more pronounced because the fastest growing populations are in tropical coastal regions (Henderson-Sellers, 1998). Tropical cyclones and floods have had a major impact in South Asia and Latin America in terms of deaths and population affected (Guha-Sapir *et al*, 2004; Schultz *et al*, 2005). Bangladesh has experienced some of the most serious consequences of tropical cyclones in the current century due to the combination of meteorological and topographical conditions (PAHO, 1999). There are approximately 50 tropical cyclones a year globally but some years can have very few and others over a hundred. Many things changing over time can influence the damage from storms, most noticeably population and income (Pielke *et al*, 1998, 2008). Tropical cyclones have caused an estimated 1.9 million deaths worldwide during the past two centuries (Nicholls *et al*, 1995). Over 1300 people died, approximately 2000 people were injured and 1 million people were displaced due to hurricane Katrina which is considered the most expensive disaster in the history of the United States of America (Haines *et al*, 2006). Hurricane Katrina has been associated with a high prevalence of psychiatric morbidity (Chand and Murthy, 2008). The Asia pacific region have also suffered a lot from tropical cyclone associated deaths in the last two centuries, especially Bangladesh and India where 42% and 27% deaths occurred due to cyclones (Nicholls *et al*, 1995).

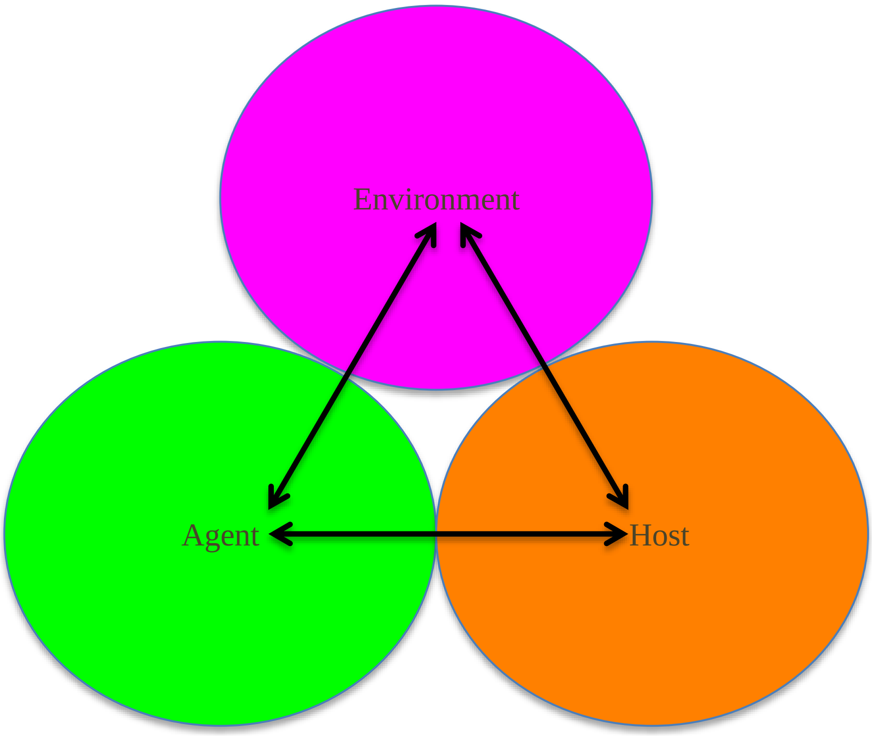
Strong underwater earthquakes, volcanic eruptions or other submarine landslides cause tsunamis. Some tsunamis can be very large; they consist of a series of waves, can run faster than a person and can occur at any time, day or night (DMB, 2010). Following the Asian tsunami, the WHO estimated that 20-40% of affected people suffered from short-lasting mild psychological distress and another 30-50% experienced moderate to severe psychological distress (WHO, 2008). In Sri Lanka alone, the death toll from the tsunami and its aftermath is estimated to be over to 30,000 lives (Dewaraja and Kawamura, 2006). A tsunami in Thailand caused Post-traumatic stress disorder among the 60 % of children (Piyasil *et al*, 2007). Japan ranks second in the world in terms of exposure to cyclones for percentage of population (UNDP, 2004). An earthquake measuring 8.9 magnitudes, the sixth biggest since 1990, struck Japan on March 11, 2011. The earthquake triggered a tsunami with 10m-high waves hitting the northern port of Sendai. Waves swept across farmland, sweeping away homes, crops, vehicles, triggering fires (The Guardian, 2011). Based on official Japanese government figures (10:00 hours, 14 March, 2011), 1,627 people were confirmed dead, 1,962 injured with at least 1,720 missing (WHO, 2011). Research carried out by Fairley *et al*, (1986) has shown that after cyclone Oscar hit the people of Viti Levu one of the islands in Fiji, they suffered from loss of appetite, headaches, exhaustion, dizziness and chest pain. Another study in Orissa, India revealed that there were 97,934 diarrhoea related attacks with 81 deaths during a1-month post-cyclonic period in 6 affected districts (Chhotray *et al*, 2002).

2.5 Relationship between climate change and infectious diseases and malnutrition

The key to a person`s health lies largely in the environment. In fact, much of person`s ill health can be traced to adverse environmental factors such as water pollution, soil pollution, air pollution, poor housing conditions, presence of animal reservoirs and insect vectors of disease (Park, 2005). According to the WHO, 30 infectious diseases have emerged which threaten the health of hundreds of millions of people. Emerging infectious diseases are diseases of infectious origin whose incidence in humans has increased within the recent past or threatens to increase in the near future. These also include those infections that appear in new geographic areas or increase abruptly. The new infectious diseases and those, which are re-emerging after a period of quiescence, are also grouped under emerging infectious diseases (WHO, 2005). Emerging infectious diseases are those whose incidence in humans has increased in the last two decades or which threaten to increase in near future (WHO, 1996). These are: HIV/AIDS, Ebola, Lyme disease, Legionnaires` disease, toxic Escherichia coli, a new hantavirus, a new strain of cholera and a rash of rapidly evolving antibiotic resistant organisms. There has been a resurgence and redistribution of several old diseases on a global scale for example, malaria and dengue fever carried by mosquitoes (Epstein, 2002). During the past two decades it has become apparent that many socioeconomic factors are globally influencing the emergence of new infectious diseases and the patterns of established infectious diseases (Wilson, 1995). According to epidemiological or ecological triad (shown in figure 2.5), the occurrence and causation of a disease depends on agent, host and environment: the interaction among which will determine whether a disease will occur or not (Park, 2005).

Changes in average climatic conditions and climate variability can also affect human health via indirect pathways, these include changes in biological and ecological processes that influence infectious disease transmission and food yields (Patz *et al*, 2003). Climate variability`s effect on infectious diseases is determined largely by the unique transmission cycle of each pathogen. Transmission cycles that require a vector or non-human host are more susceptible to external influences than those diseases which include only the pathogen human and environmental factors (including temperature, precipitation and humidity) and transmission components (including pathogen like viral, bacterial, etc.), vector (mosquito, snail, etc.), non-biological physical vehicle (water, soil, etc.), non–human reservoir (mice, deer, etc.) and human host (Patz *et al*, 2003).

Figure 2.5: Epidemiological Triad



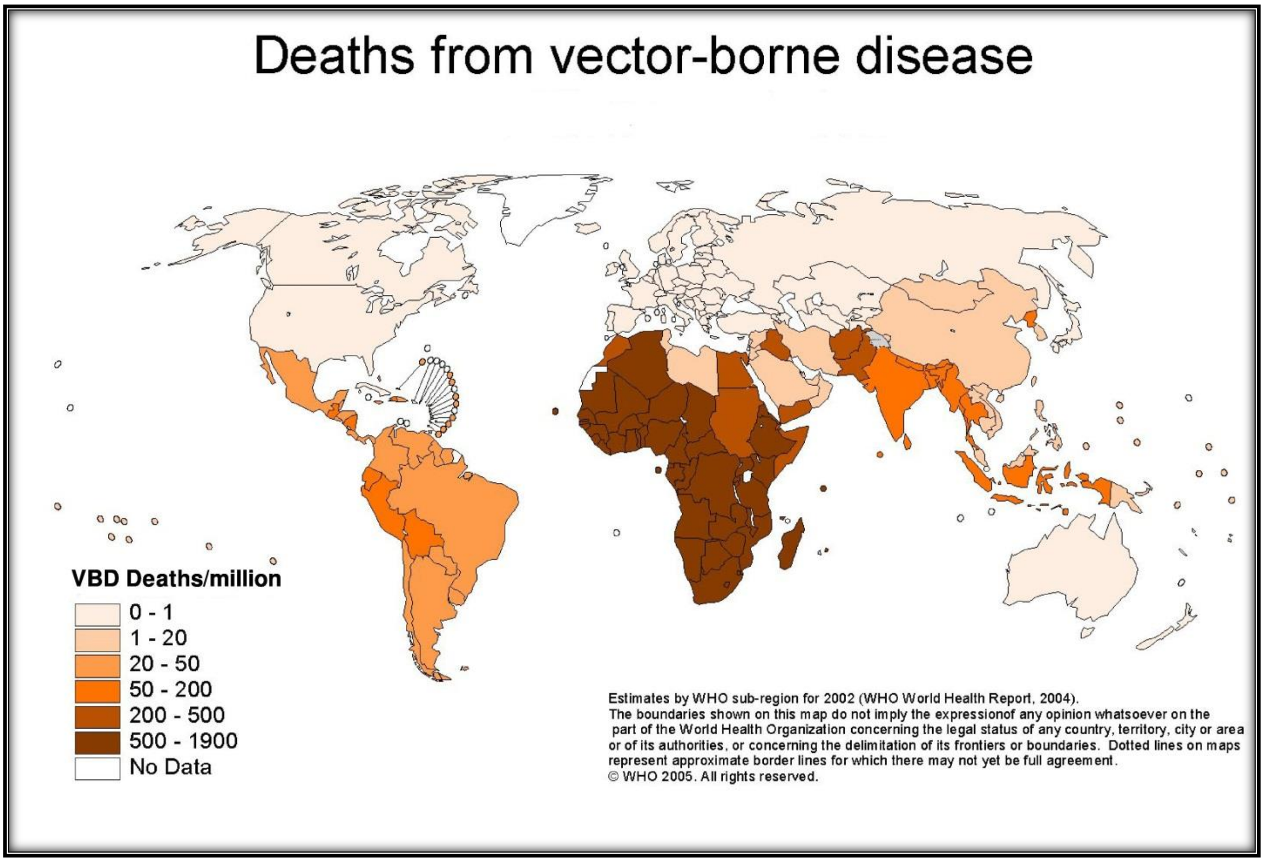
Source: (Park, 2005:30)

Climate change has the potential to affect disease and mortality incidence both directly and indirectly across a wide range of conditions all over the world. Direct effects are those in which human health is decreased due to natural disasters and extreme events, whereas the indirect effects of climate change on human health stem from the alteration of the complex socio-economic-environmental systems that govern disease transmission (McMichael *et al*, 2004).

2.5.1 Vector borne Diseases

Vector-borne diseases, whose agents (parasites, viruses etc) are transmitted by insect vectors such as mosquitoes, flies and triatomine bugs, occur in more than 100 countries worldwide and affect about half of the world's population. Social and environmental factors (including climate change) are key aspects affecting both the transmission and control of such diseases (WHO, 2012). The most prominent vector-borne diseases that are climate-sensitive include: malaria, filariasis, dengue fever, yellow fever, west Nile virus, leishmaniasis, Chagas' disease, Lyme disease, tick-borne encephalitis, plague, varieties of mosquito-borne encephalitis, ehrlichiosis, African trypanosomiasis, and onchocerciasis (Ebi *et al*, 2008; Githeko *et al*, 2000; Kovats *et al*, 2003; Kuhn *et al*, 2005).

Figure 2.6: Deaths from vector borne disease worldwide



Source: (WHO World Health Report, 2004)

The most recent IPCC assessment concludes that climate change has already altered the distribution of some disease vectors and predicted with high confidence that there will continue to be an impact (Perrin, 2008). It is conceivable that climate change could exacerbate this as well as other health issues by changing vector ranges. It is also possible that climate change could produce conditions unfavourable to vectors as well (Lafferty, 2009).

Table 2.7: Major Tropical Vector Borne diseases and the likelihood of change with climate change

Disease	Likelihood of change with climate change	Vector	Present distribution	People at risk (millions)
Malaria	+++	Mosquito	Tropics/ subtropics	2020
Schistosomiasis	++	Water snail	Tropics/ subtropics	600
Leishmaniasis	++	Phlebotomine sandfly	Asia/Southern Europe/Africa/Americas	350
American trypanosomiasis (Chagas Disease)	+	Triatomine bug	Central and South America	100
African trypanosomiasis (Sleeping sickness)	+	Tsetse fly	Tropical Africa	55
Lymphatic Filariasis	+	mosquito	Tropics/ subtropics	1100
Dengue	++	mosquito	All tropical countries	2500-3000
Onchocerciasis (river blindness)	+	blackfly	Africa and Latin America	120
Yellow fever	+	mosquito	Tropical South America and Africa	-
Dracunculiasis (Guinea worm)	?	Crustacean (copepod)	South Asia/ Arabian peninsula/ Central-West Africa	100

Source: (WHO, 2000:20)

Many vector-borne diseases exhibit climate sensitivity although a multitude of other factors affect disease range and incidence (Michael and Hess, 2008:530). Many vector borne diseases are rising due to a changing climate and WHO has ranked them as the most important tropical diseases (WHO, 2000). Also some other factors that influence the disease transmission and disease incidence includes socioeconomic factors like increasing population movements, herd immunity, drug resistance, malnutrition and environmental factors including – changes in land use, deforestation, changing agricultural practices and water management or increasing urbanisation (Perrin, 2008).

There is already evidence of vector species responding to climate change in Europe (Purse *et al,* 2005 Skarphedinsson *et al,* 2005). Campbell (2008) highlights the need for vigilance throughout Europe with the possibility of the arrival of a new species of mosquito that could act as more effective vectors. Gould *et al,* (2006) in their review of factors determining the emergence of arboviruses concluded that climate change may well be the most significant factor responsible for precipitating changes in the prevalence of arthropod –borne diseases in the UK. Temperature affects the rate of pathogen maturation and replication within mosquitoes, the density of insects in a particular area increases the likelihood of infection and vector reproduction, parasite development cycle and bite frequency generally rise with temperature and therefore malaria, tick-borne encephalitis and dengue fever will become increasingly widespread (UCL *Lancet* Commission Report, 2009). *Anopheles* species and *Aedes Aegypti* are dependent on temperature for their survival and there are also temperature dependent incubation periods for the parasites and viruses (Epstein, 2002). Sufficient moisture with warmer temperatures is suitable for increasing mosquito populations with biting rates (blood meals), mosquito activity and abundance (Martnes *et al*, 1997; Patz *et al*, 1996).

2.5.1.1 Malaria

Malaria continues to be a deadly disease and action towards its control remains challenging for researchers and policy makers (Yé *et al*, 2009). Mosquito borne diseases have recently been reported at unusually high elevations in the highlands of Asia, Central Africa and Latin America (Epstein, 2002:172). Diseases like malaria, dengue fever and yellow fever have increased in frequency and distributions in the last decade and the number of deaths are expected to double due to climate change (Attaran *et al*, 2000). Malaria has the largest worldwide burden of any arthropod borne disease (Michael and Hess, 2008). Evidence also shows that there is a strong association between E1 Niño events and malaria epidemics in South Asia regions and South America (Kovats *et al*, 2003). In 1998, malaria was the most prevalent tropical disease with more than half of the world's population living in areas of risk and with an estimated 200 million cases and two million deaths each year (World Health Report, 1996).

Malaria is transmitted by a specific mosquito species within the genus of *Anopheles* (Myers and Patz, 2009). The most common symptoms are headache, weakness, fever, aches, pains, high body temperature, bitterness of the mouth, loss of appetite, nausea and vomiting (Ayeni, 2011). It is a serious disease for children and adults but the consequences for children and pregnant women are graver (UNICEF, 2000). Two impacts of climate change at least have to be considered as major factors: temperature and rainfall patterns. The less important, but easiest to model, is the direct effect of temperature. This has effects on both the mosquito range and survival, and the period of time it takes for mosquitoes to become infectious following biting an infected individual; the shorter the period, the greater the vectoral capacity (Patil, 2012:38). Plasmodium falciparum is one of four types of malaria and is responsible for the majority of deaths. While advances in antimalarial drugs and insecticides in the first half of the 20th century led to the optimistic view that malaria could be eradicated, widespread drug and pesticide resistance, and the subsequent failure of control programs, proved this optimistic view wrong and the world is currently experiencing an upsurge in malaria (Anderson *et al*, 2006:32) It is known from laboratory testing that the vector, the female anopheles mosquito and the malaria parasites are influenced by temperature (Campbell-Lendrum and Woodruff, 2006). Rainfall and temperature are climate factors for infectious disease transmission and slight changes in pattern of rainfall and temperature can impact on the spread of disease transmission (Epstein *et al*, 1998). Small *et al*, (2003) found rainfall was the primary factor in malarial disease transmission in Africa. For most Anopheles vector species of malaria, the optimal temperature for their development lies within 20°C to 30°C (Patz *et al*, 1998).

Table 2.8: Trends in estimated malaria incidence and mortality rates, 2000-2010

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Africa	321	320	319	318	315	308	297	286	271	259	246
Americas	18	14	13	12	12	13	11	9	7	7	7
Eastern Mediterranean	41	37	35	40	29	29	29	35	36	37	33
Europe	16	12	10	8	5	2	1	1	0	0	0
South East Asia	30	29	26	27	27	28	24	23	24	24	22
Western Pacific	4	3	3	3	4	3	3	2	2	2	2
World	79	78	77	78	78	77	74	72	70	68	65

***Cases per 1000 at risk**

Source: (World Malaria Report, WHO, 2011:75)

Tanser *et al,* (2003) found that there is an increased risk of 5-7% for the population in Africa and also suggests that climate change will also lengthen the transmission session in many areas and will cause a 16-28% increase in the total number of person-months exposure. Climate change will have mixed effects on malaria; in some places the geographical range will contract, elsewhere the geographical range will expand and the transmission season may change (Kiszewski *et al*, 2004). Lindsey and Marten (1998) estimated that 260-320 million people would be affected by malaria by 2080 as a consequence of new transmission zones. There were an estimated 216 million episodes of malaria in 2010, of which approximately 81%, or 174 million cases, were in the African region (WHO, 2011). Another study in Kenya shows that meteorological factors were associated with malaria incidence (Yé *et al,* 2007). Bouma and Van der Kay (1996) found the association between precipitation and malaria epidemics in Punjab, India. Epidemic malaria also remains a serious problem in the more arid areas of Gujarat, India (Kovats and Bouma, 2002:159).

Several studies reported the resurgence of malaria in Calcutta city in India in the 1990s (Basu *et al,* 1998; Mandal *et al,* 1998 cited in Khan *et al*, 2011). Ayeni (2011) also concluded that climate change has an influence on malaria transmission but the immediate environment of a person is also a major factor for malaria morbidity. Mantilla *et al*, (2009) concluded that ENSO might be a significant predictor for malaria in Colombia.

A study by Hales *et al*, (2003) found that drought is also a factor for contributing malaria mortality. Possible reasons may be that drought related malnutrition increases an individual's susceptibility to infection (Gill, 1920 cited by Hales *et al,* 2003). Patz *et al,* (2005) cited that due to demographic and drug resistance variables associated with varying quality of long term data it was difficult to establish the association between malaria and past climate in Africa. The 1982 E1 Niño event caused severe floods in Latin America and also increased the incidence of malaria (Russac, 1986). DoH (2008) stated that it is unlikely that there will be outbreaks of malaria within the UK, but they said the picture may change if more effective vectors of malaria arrive in UK.

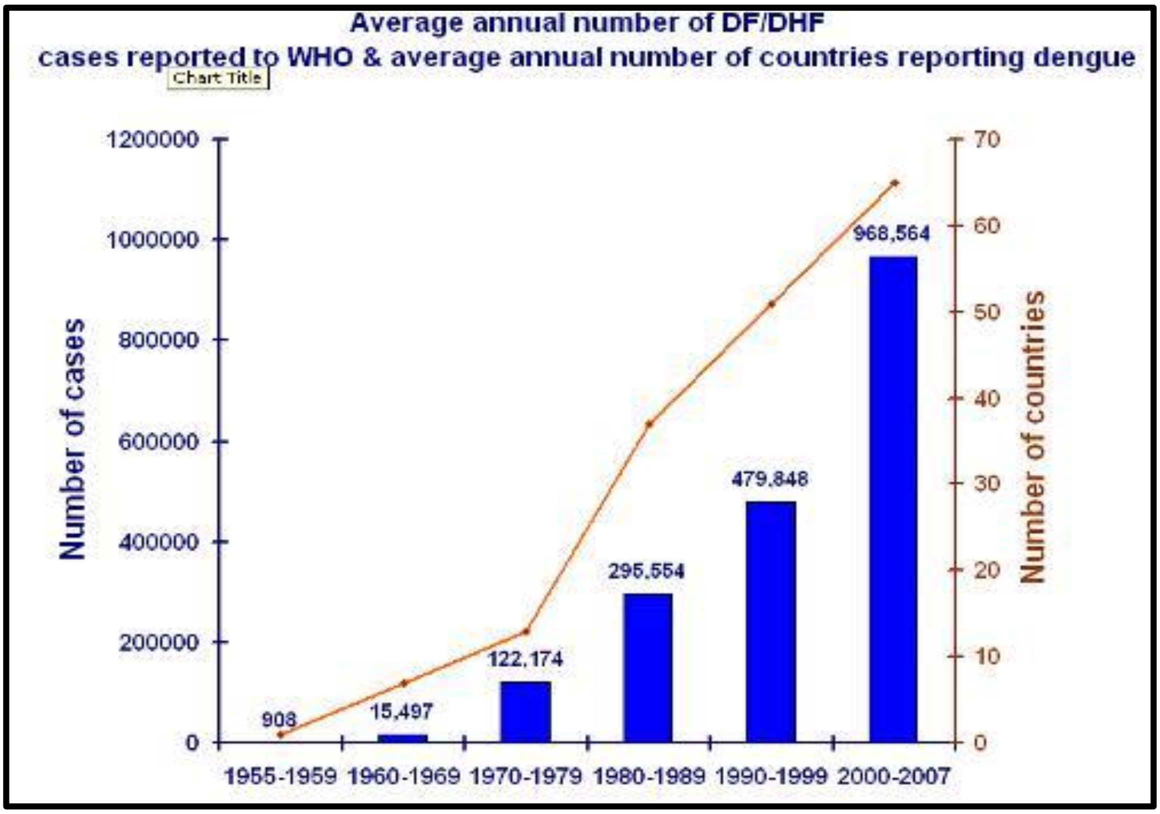
2.5.1.2 Dengue Fever

Dengue is a mosquito-borne infection found in tropical and sub-tropical regions around the world. In recent years, transmission has increased predominantly in urban and semi-urban areas and has become a major international public health concern (WHO, 2012). The Aedes mosquito transmits it. These vectors are associated with human made environments and unlike many of the anopheles mosquitoes they also prefer to feed on people and when there is an epidemic it may spread rapidly (Martens, 1999).

All ages and both sexes are susceptible to dengue fever; children have a milder disease than adults. The illness is characterized by an incubation period of 3 to 10 days. The onset is sudden with chills, high fever, intense headache, muscle and joint pains, which prevent all movement. Within 24 hours retro-orbital pain, particularly on eye movements or eye pressure and photophobia develops. Other common symptoms include extreme weakness, anorexia, constipation, altered taste sensation, colicky pain and abdominal tenderness, sore throat and general depression (Park, 2005). Dengue haemorrhagic fever (DHF) is a more serious illness mainly affecting children and young adults; symptoms include a sudden onset of fever and haemorrhagic manifestations that result in significant fluid loss and may lead to shock (WHO, 2012).

Mosquito-borne diseases are climate sensitive for many reasons. For example: mosquitoes require standing water to breed and a warm ambient temperature is critical to adult feeding behaviour and mortality, the rate of larval development and speed of virus replication (Patz *et al,* 1998). For mosquito –human- mosquito transmission, changes in human behaviour such as water storage, land use and irrigation, patterns of dwelling construction, use of air conditioning and intensity of mosquito control efforts all can interact with climate to alter the human disease (Gage *et al*, 2008). Dengue fever is seasonal and usually associated with warmer, more humid weather (Kovats and Bouma, 2002). From the 17th century onwards there were major epidemics of dengue like illnesses in Asia, Africa and the Americas. In recent decades, the rapid expansion of urban populations, the proliferation of mosquito breeding sites and the failure of mosquito control efforts has exacerbated the risk of transmission (Reiter, 2001).

Figure 2.7: Average annual numbers of Dengue Fever and Dengue Haemorrhagic Fever



Source: (WHO, 2008)

In recent decades the incidence of dengue has increased dramatically around the world. Over 2.5 billion people – over 40% of the world's population – are now at risk from dengue. 1.8 billion (>70%) live in Asia Pacific countries (WHO, 2012). Climate change will increase the area for dengue virus such as Australia and New Zealand (UCL *Lancet* Commission Report, 2009). By the year 2080 about 6 billion people worldwide will be at risk of contracting dengue virus (IPCC, 2007). Dengue is seasonal and usually associated with warmer, more humid weather. There is evidence that increased rainfall in many locations can affect the vector destiny and transmission potential (Hales *et al*, 2003). Climate change, particularly a warmer climate may increase the area suitable for *A. Aegypti* (Zhang *et al*, 2008).

Hales *et al*, (1999) found that there is a correlation between ENSO and monthly reports of dengue cases in the Pacific Islands. Between 1970 and 1995, the dengue epidemics were positively correlated with the Southern Oscillation Index (SOI) (Hales *et al*, 1996). Many countries in Asia experienced the dengue epidemic in 1998, which is due to E1 Niño weather (Hales *et al*, 2003). Cases across the Americas, South-east Asia and Western Pacific have exceeded 1.2 million cases in 2008 and over 2.2 million in 2010 (based on official data submitted by Member States). Recently the number of reported cases has continued to increase. In 2010, 1.6 million cases of dengue were reported in the Americas alone, of which 49,000 cases were severe dengue. An estimated 500,000 people with severe dengue require hospitalization each year, a large proportion of whom are children and about 2.5% of those affected die (WHO, 2012).

Climate change has also been shown to have a direct effect on SLE (St Louis encephalitis) (Hunter, 2003). Evidence for other vector borne pathogens is less clear. A study showed that Lyme disease in the UK showed no correlation with mean summer temperatures (Cannell *et al*, 1999). Gubler *et al*, (2001) found that changes in climate variability and change on infectious agents transmitted by mammals to humans have received less attention. Lyme disease and Hantavirus are found due to flooding (Kovats *et al*, 1999, Hales *et al*, 2003). Parmenter *et al*, (1999) found that human plague cases in New Mexico occurred more frequently correlating with above-average precipitation. Gubler *et al*, (2001) expressed concern over rodent borne diseases due to climate change because of the lack research.

2.5.2 Water borne Diseases

A person`s health may be affected by the ingestion of contaminated water either directly or through food or by the use of contaminated water for personal hygiene and recreation purposes. The term ‘water related diseases’ includes the classical water borne diseases. Developing countries carry a heavy burden of water related diseases, the heaviest being the diarrhoeal disease (Park, 2005).

Water-related diseases include (WHO, 2012):

- Those due to micro-organisms and chemicals in the water that people drink;
- Diseases like Schistosomiasis which have part of their lifecycle in water;
- Diseases like malaria with water-related vectors;
- Drowning and some injuries;
- And others such as Legionellosis carried by aerosols containing certain microorganisms.

Globally waterborne and sanitary-related infections are one of the major contributors to disease burden and mortality (Prüss and Havelaar, 2001). Human health depends on an adequate supply of potable water. By reducing fresh water supplies, climate change may affect sanitation systems and lower the efficiency of sewage systems. This leads leading to increased concentrations of pathogens in raw water supplies. Climate change directly shifts the rainfall pattern and may reduce the water available for drinking and washing and this scarcity of water may force people to use poorer quality sources of fresh water, such as rivers which are often contaminated All these factors can cause water-related diseases in human beings (WHO, 2000). Climate change can also indirectly impact waterborne diseases though changes in ocean and coastal ecosystems. Changes may include changes in pH, nutrients and contaminant runoff, salinity, and water security. These indirect impacts are likely to result in degradation of fresh water available for drinking, washing food, cooking, and irrigation, particularly in developing and emerging economies where much of the population still uses untreated surface water from rivers, streams, and other open sources for these needs.

Even in countries that treat water, climate-induced changes in the frequency and intensity of extreme weather events could lead to damage or flooding of water and sewage treatment facilities, increasing the risk of waterborne diseases (CDC, 2010). Microbes are also transported much more easily through saturated soil than through dry soils (Rose *et al*, 2001). The water-related and food-borne pathogens that are significant at a global level include a species of rotavirus, the hepatitis A and E viruses, members of the norovirus family, species of bacteria within the *Compylobacter* family, the *Shigella* and the *Salmonella* genera including *Salmonella Typhi* and protozoa found within both the *Cryptosporidium* and *Giardia* genera (Ebi *et al*, 2008; Kovats *et al*, 1999). Water-related diarrheal diseases are the primary causes of water-related health problems.

Climate change may affect the growth and survival of disease causing organism related water and food borne illness. The incidence of water and food borne diseases such as gastroenteritis and diarrhoea is known to increase when outdoor temperature increases or immediately after storm and floods (Patil, 2012). Climate change may increase the intensity of flooding around the globe and can affect health through the spread of disease (Noji, 1997). Anon (2000) found heavy rainfall and associated flooding was responsible for an *E.Coli* infection in 1000 people in Walkerton, Canada, among which 65 of them were admitted to hospital and six died. Curriero *et* *al*, (2001) investigated the relationship between rainfall and outbreaks of waterborne diseases in the United States and their results showed that 51% of all outbreaks were due to extreme rainfall. Heavy rain can contaminate watershed by transporting human and animal faecal products and other wastes in ground water (Patz *et al*, 2003). For example, there is a correlation between rainfall and the infectious agents like *Giardia* and *Cryptosporidium* (Atherbolt *et al*, 1998).

Climate change threatens to severely impact the quality and quantity of water particularly regions hit by natural disasters where living conditions are very poor because of weakened infrastructure (Anderson *et al*, 2006). Access to safe water remains an important global health issue (Confalonieri *et al*, 2007). More than 2 billion people live in dry regions of the world and suffer from malnutrition, infant mortality and disease related to contaminated water (WHO, 2005). Nearly 1 million people worldwide do not have access to clean and safe water (Akachi *et al*, 2009).

Contaminated water hinders children's ability to learn, in addition to its impacts on physical growth. Poor water and sanitation has been associated with an increased risk of infections in children (Daniels *et al*, 1990; Huttly *et al*, 1990; Mertens *et al*, 1990) and increased malnutrition (Adair and Guilkey 1997); improved water and sanitation was related to a lower risk of malnutrition (Huttly *et al*, 1990; Daniels *et al*, 1991; Ricci and Becker 1996). Rising temperatures corresponding with increased CO_2 emissions create more suitable habitats for harmful algal blooms. These blooms thrive in warm surface waters and nutrient runoffs from sewage overflows into surface water bodies. Algal blooms produce powerful liver toxins, which are associated with an increased incidence of hepatic cancer. They are spreading from tropical waters to historically cooler waters as surface water temperatures rise. The potent toxins produced by the blooms may contaminate drinking water and pose a serious threat to public health infrastructure (Luber and Prudent, 2009).

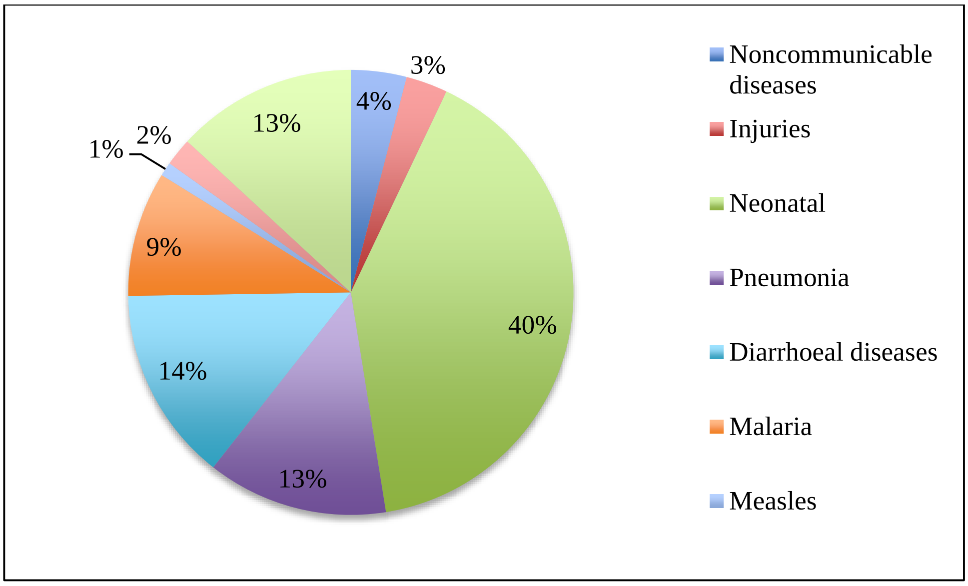
2.5.2.1 Diarrhoea

Diarrhoea is a leading cause of death during complex emergencies and natural disasters. Displacement of populations into temporary, overcrowded shelters is often associated with polluted water sources, inadequate sanitation, poor hygiene practices, contaminated food and malnutrition – all of which affect the spread and severity of diarrhoea. At the same time, the lack of adequate health services and transport reduces the likelihood of prompt and appropriate treatment of diarrhoea cases (UNICEF/WHO, 2009).

Diarrhoea is the passage of 3 or more loose or liquid stools per day, or more frequently than is normal for the individual. It is usually a symptom of a gastrointestinal infection, which can be caused by a variety of bacterial, viral and parasitic organisms. Severe diarrhoea leads to fluid loss, and may be life threatening, particularly in young children and people who are malnourished or have an impaired immunity (WHO, 2012). Rotavirus is the leading cause of acute diarrhoea, and is responsible for about 40 per cent of all hospital admissions due to diarrhoea among under-fives worldwide. Other major bacterial pathogens include E. coli, *Shigella*, *Campylobacter,* along with V. *cholerae* during epidemics. Cryptosporidium has been the most frequently isolated protozoan pathogen among children seen at health facilities and is frequently found among HIV-positive patients (UNICEF/WHO, 2009).

McMichael *et al*, (2004) informed that the climate change that has started from the mid-1970s is already causing 150,000 deaths and approximately five million disability adjusted life years (DALY`s) per year through the increased incidences of diseases such as diarrhoea, malaria and malnutrition in developing countries. Magali *et al*, (2009) cited that the climate change scenario until 2030 is projected to increase the number of diarrhoeal cases by 5-12%. Most of the increase in cases is presented in the in-coastal areas during the months of June, July, August and September. July and September are projected to be the months with a higher increase of precipitation, but not with higher increase of temperature.

Figure 2.8:Major causes of death in neonates and children under five



Source: (World Health Organization (WHO), World Health Statistics, 2011)

Temperature affects pathogen survival (Kovats and Tirado, 2006) and water supply contamination as heavy rainfall leads to diarrhoea outbreaks (Curriero *et al*, 2001; Auld *et al*, 2004) cited in Lloyds *et al*, (2007). Ford (2002) cited that the growth of *Vibrio Cholerae* and other pathogens responsible for diarrheal diseases accelerates in warm conditions. The growth of microbial slime in biofilms in water distribution systems is also sensitive to temperature, and it is likely that microbes in biofilms acquire resistance to disinfectants at high rates. An increase in temperature of 1°C minimum or maximum was responsible for 12% and 16% cases of dysentery in China (Sarkar, 2007).

Climate changes all around the world, which have an impact in Europe, are demonstrated by the fact that recent cases of cholera have been imported to Europe from Kenya, where spreading epidemics have been linked to the El Niño phenomenon, originating from the Pacific Ocean (Bezirtzoglou *et al*, 2011). E1 Niño also influences the childhood diarrhoeal disease (Patz *et al*, 2005). Checkley *et al* (2000) found that when the ambient temperature in Lima, Peru increased by more than 5°C in the wintertime, the number of daily admissions for diarrhoea increased by more than two folds. Zooplankton (copepods) is the reservoirs for *Vibrio Cholerae* and other enteric pathogens (Colwell, 1996) Zooplankton blooms in response to the warming SSTs associated with E1 Niño (Patz *et al*, 2005).

Studies suggest that limited water availability fails to deliver a significant reduction in diarrhoeal diseases (Esrey *et al*, 1991). There are relatively few studies that have investigated the effects of rainfall on morbidity, particularly diarrhoeal disease. A recent study using hospital visit data in Dhaka found that rates of disease increased during high and low rainfalls (Hashizume *et al*, 2007). Climate change aggravates the water scarcity (Ahern, 2006). Research done by Lloyds *et al,* (2007) reported that diarrhoea morbidity would increase with water scarcity. More widespread water scarcity in the future may, through increased diarrhoea, have far reaching consequences, including an impact on the growing burden of chronic disease in low- and middle-income countries (Lloyds *et al*, 2007).

In low income countries diarrhoeal disease incidences are associated with low monthly rainfall (Lloyd *et al*, 2007). In Fiji, diarrhoea reports among infants increased by 2% per unit increase in rainfall and by 8% per unit decrease in rainfall. When the temperature variable was lagged by 1 month, there was approximately a 3% increase in diarrhoea cases per degree increase in temperature in the previous month (Singh *et al*, 2001). Lloyds *et al*, (2007) said that rainfall is negatively correlated with diarrhoea.

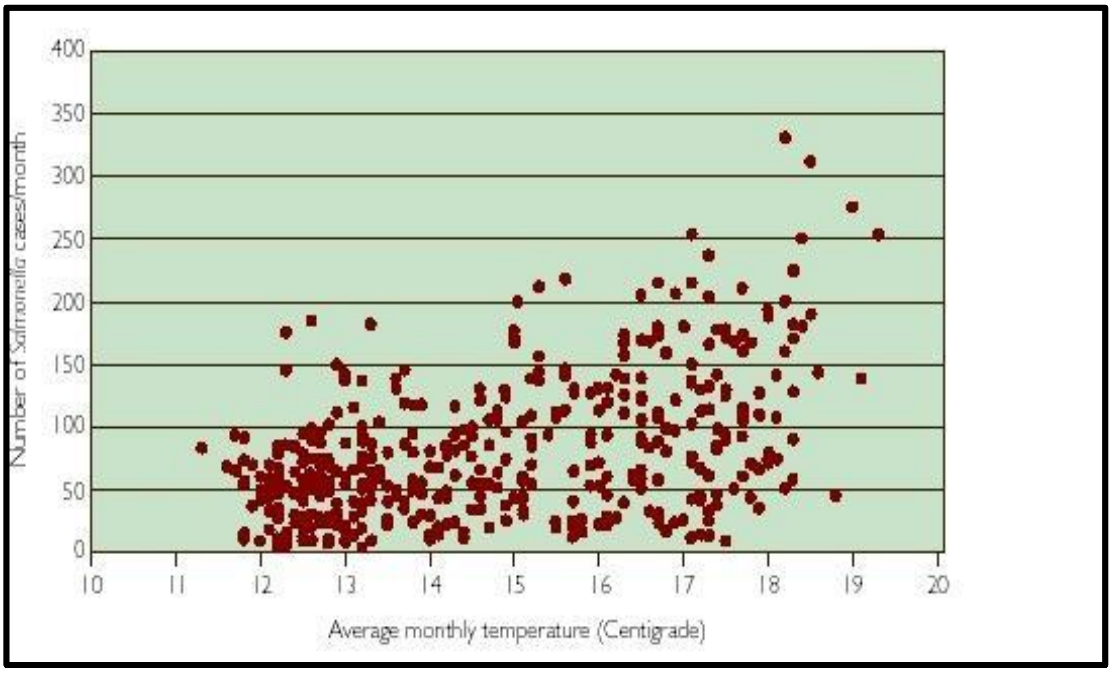
Both floods and droughts increase the risk of diarrheal diseases (Majra and Gur, 2009). Acute diarrhoea and acute respiratory disease increased in Nicaragua following Hurricane Mitch and the associated flooding (Campanella, 1999). Biswas *et al*, (1999) found that diarrheal cases increased after the flood in West Bengal in India in the 1993 flood. Fever, diarrhoea and respiratory diseases were the major health problems among children aged under five years in the 1998 floods in Bangladesh (Kunii *et al*, 2002). A study by Joshi *et al*, (2011) found that the economic condition of the household is associated with the prevalence of diarrhoea in flood exposed and non-exposed areas among the low age group of people in Uttar Pradesh in India.

2.5.3 Food Borne Diseases

Foodborne illness is a health concern in many countries (Lake *et al*, 2009). Climate change can have both a direct and indirect impact on the occurrence of food safety hazards at various stages of the food chain. Climate change affects the microbial population of the macro-environment (soil, air and water) and the population of pests or other vectors, thereby contributing to the occurrence of diseases attributable to fungi, bacteria, viruses and insects (Deb *et al*, 2012). In Bahia, Brazil, a 1988 outbreak of gastroenteritis that killed 88 people living near the Itaparica dam was linked to a large bloom of cyanobacteria in the dammed lake (Teixera *et al*, 1993). Bentham and Langford (2001) found in the UK that the monthly incidence of food poisoning is correlated with temperatures occurring in the previous two to five months. High temperature was responsible for 30% of Salmonella cases in continental Europe (Kovats *et al*, 2004).

Ambient temperature may influence people's behaviour, which in turn may affect the chance of a foodborne illness occurring. For example, increased temperature may lead to elevated consumption of raw foods such as fruit and salad (at risk of cross-contamination), and higher temperatures may encourage riskier cooking practices such as barbecuing. Finally, warmer temperatures may lead to increase outdoor recreational activity, which makes it more likely that people will be exposed to environmental sources of the relevant gastrointestinal pathogens (Lake *et al*, 2009). According to Thomas and Capon (2011) climate change will affect the power supply in Australia and due to power supply failure in warmer conditions there will be accelerated growth and spread of food borne bacteria. In New Zealand, researchers found that in the last 30 years salmonella infections were related to the average temperature (Woodward and Scheraga, 2003).

Figure 2.9: Relationship between mean temperature and monthly reports of Salmonella cases in New Zealand.



Source: (Woodward & Scheraga, 2003:64).

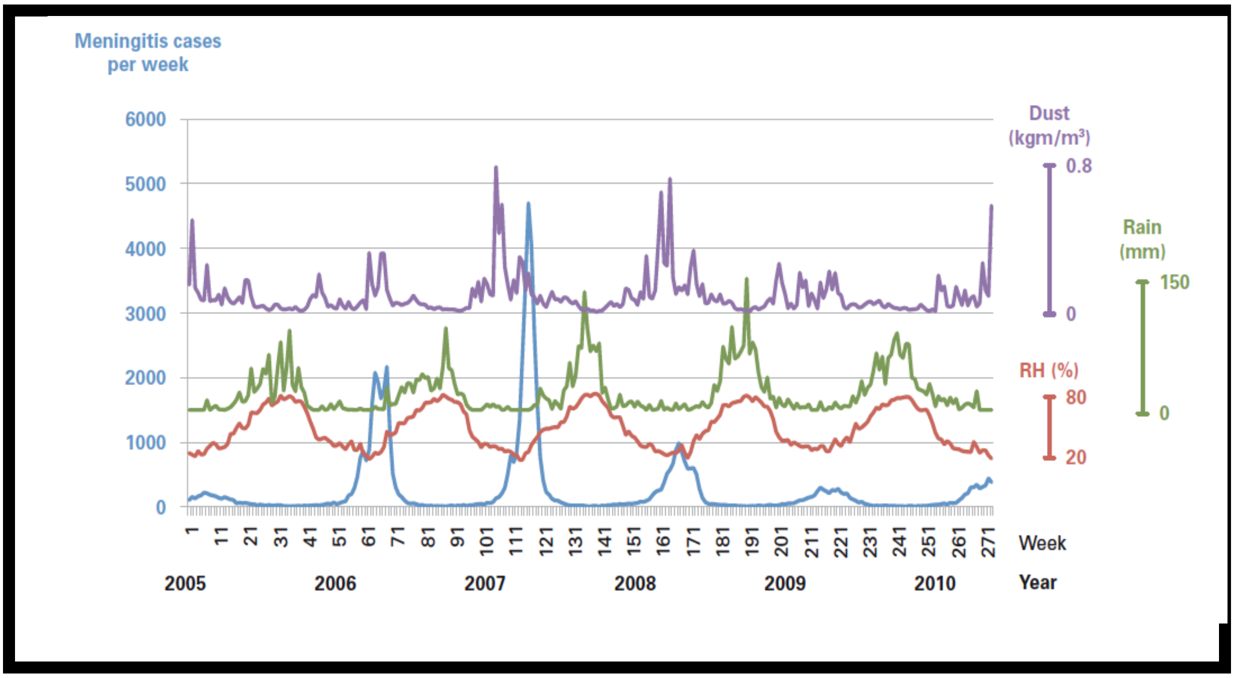
Hepatitis A Virus (HAV) is found in the feaces of people with the liver disease known as hepatitis A. People can get HAV by drinking water or eating food contaminated with the virus (Pollution Probe, 2004). Just after the Tsunami in December 2004 in Indonesia, both hepatitis A & E virus cases were reported (Weekly Epidemiological Record, 2005).

A time series analysis report in Jinan, Northern China, Zhang *et al,* (2008) established that maximum temperature (one month lag), minimum temperature (one month lag), rainfall (one month lag), relative humidity without lag and air pressure (one month lag) were significantly correlated with Bacillary Dysentery cases.

2.5.4 Other Infectious Diseases

Towers *et al*, (2013) indicated in their study that influenza epidemic severity and time of onset is associated with average winter temperature of 2011-12 in US and these warmer winters are harbinger of mild influenza. WHO and WMO (2012) found seasonal patterns have some influence on meningitis (a disease of the meninges). WHO reports that the increase in dust concentrations and reduced humidity level increases the incidences of meningitis. For example, a study in Burkina Faso showed that meningitis cases increased in the dry, hot and dusty season (as shown in Figure 2.10).

Figure 2.10: Data from Burkina Faso (2005-2011) Meningitis cases increases in the dry, hot and dusty season



Source: (WHO and WMO, 2012)

HIV (Human Immunodeficiency Virus) transmission occurs as a consequence of human behaviours: unprotected sex, injection drug use and sharing needles. Food insecurity, poverty, social inequality, poor access to health services, unequal power relations between the genders and substandard infrastructure are the conditions in which HIV/AIDS flourishes (Bolton and Talman, 2010). There is wide agreement that climate change will cause population displacement creating new migrants and refugees through severe storms, droughts, floods and rise of sea level. All these elements together with food insecurity and increased poverty are likely to reduce the available health services. Combined these factors combined will influence the progression of HIV and other infectious diseases (UNEP UNAIDS, 2008).

2.5.5 Malnutrition

Today's world food profile, as a baseline for future projections, underscores the need for gains in both the production of food and access to it (Sen, 1981). Malnutrition remains a serious international public health, social and economic problem (McMicahael, 2001). Climate change will affect nutrition through different causal pathways that impact food security, sanitation, water and food safety, health, maternal and child health care practices and many socioeconomic factors. Climate change negatively affects food availability, conservation, access and utilization and exacerbates socioeconomic risks and vulnerabilities (Patil, 2012).

Malnutrition affects all age groups, but it is especially common among the poor and those with inadequate access to health education, clean water and good sanitation. More than 70% of children with protein-energy malnutrition live in Asia, 26% live in Africa, and 4% in Latin America and the Caribbean (WHO, 2000).

Malnutrition essentially means “bad nourishment”. It refers to not enough as well as not too much food, the wrong types of food, and the body's response to a wide range of infections that result in the malabsorption of nutrients or the inability to use nutrients properly to maintain health. Clinically, malnutrition is characterized by an inadequate or excess intake of protein, energy, and micronutrients (such as vitamins), and the frequent infections and disorders that result (WHO, 2000).

Presently, close to one billion of people suffer from hunger, nearly 560 million being in Asian countries, mainly in Bangladesh, People’s Republic of China (PRC), India, Indonesia and Pakistan (FAO 2010; FAO 2011). The IPCC has concluded with “medium confidence” that climate change would increase the number of hungry and malnourished people in the 21st century by 80 to 90 million (cited in Campbell-Lendrum *et al,* 2003). Food-borne illness and food insecurity, are both likely outcomes of climate change and may lead to malnutrition (Deb *et al*, 2012). Climate change affects food, nutrition security and further undermines current efforts to reduce hunger and protect and promote nutrition. Additionally, undernutrition in turn undermines the resilience to shocks and the coping mechanisms of vulnerable populations, lessening their capacities to resist and adapt to the consequences of climate change (Patil, 2012).

Undernutrition is a fundamental cause of stunted physical and intellectual development in children, low productivity in adults, and increases susceptibility to infectious diseases (Anderson *et al*, 2006). Malnutrition and undernutrition in pregnant women are a global cause of low birth weight and other poor birth outcomes that are associated with later developmental deficits (Deb *et al*, 2012).

Undernutrition already affects 3.5 million children and maternal deaths annually, and 35% of burden of diseases of children younger than 5 years (Black *et al*, 2008). Undernutrition diminishes immunity to disease, which, of itself, depletes nutritional status – a vicious, deleterious cycle for children (Akachi *et al*, 2009). The effects of diarrhoea malaria and respiratory diseases on children are further aggravated by undernutrition (Mihrshahi *et al*, 2007).

Population displacement and violent conflict may represent common pathways for large vulnerable populations when they suffer from water scarcity, hunger and natural disasters. Population displacement is associated with increased mortality and morbidity for a variety of reasons (Myers and Patz, 2009). It has been found that malnutrition increased upto 50% in refugee populations in Africa (Toole and Waldman, 1993). In areas where surface water supplies become insufficient, for instance the reduced water flow from glaciers melting due to climate change or from reduced rainfall, a local population may become more dependent on ground water. In some geographic areas this may create higher intakes of arsenic in drinking water (Kjellstrom, 2009). Recently rural to urban migration has been found as the main source of HIV transmission (White *et al*, 2003).

2.5.6 Climate change and Air Quality

Air pollution is thought to be one of the major contributors of today's climate change (Deb *et al*, 2012). It has long been recognized that climate and weather exert a profound effect on air quality, with the worst episodes of pollution in both the summer and winter being associated with stagnant air under anticyclonic conditions. This means that changes in climate could influence air pollution and the health problems associated with it (Bentham, 1999).

Recently it has been found that outdoor air pollution was responsible for 1.4% of total mortality, 0.4% of all disability-adjusted life years, and 2% of all cardiopulmonary diseases (Ostro, 2004). Air pollution has many adverse health effects, which would have a long-term impact on the components of the metabolic syndrome. In addition to the short-term effects such as premature labour, intrauterine growth retardation, neonatal and infant mortality rate, malignancies like leukaemia and Hodgkin lymphoma respiratory diseases, allergic disorders and anaemia, exposure to criteria air pollutants from early on in life might be associated with dyslipidaemia, increases in stress oxidative, inflammation and endothelial dysfunction which in turn might have long-term effects on chronic noncommunicable diseases (Kelishadi & Poursafa, 2012) Higher temperatures and elevated carbon dioxide (CO_2) concentrations also lead to increased emissions of ozone-relevant VOC (Volatile Organic Compound) precursors by vegetation (Hogrefe *et al*, 2005). Ozone formation is faster and greater when the air temperature increases, as happens with climate change (WHO, 2006).

Exposure to ozone at levels that are already common in British cities in the summer has been shown to reduce lung function in fit individuals as well as in those with chronic conditions such as asthma. Ozone levels have also been linked to rates of emergency admissions to hospital for conditions such as asthma (Bentham, 1999) and Anderson *et al*, (1996) found that the number of daily deaths in London during the summer shows a significant positive association with ozone. Dear *et al*, (2005) and

Filleul *et al*, (2006) using multiple regressions found that ozone and heat both have an effect on daily mortality rate in French cities.

Ozone is also associated with acute myocardial infarction. Particulate matter is associated with a variety of pathophysiological changes including systemic inflammation, deranged coagulation and thrombosis, blood vessel dysfunction and atherosclerotic disease, compromised heart function and deep venous thromboses. An increased burden of PM2.5 (particle pollution) is associated with increased hospital admissions and mortality from cardiovascular disease, as well as ischemic heart disease (Patil, 2012). EPA (2010) suggests that the impact of climate change on air quality is significant on a local and regional scale.

Climate change alters the concentration and distribution of air pollutants and interferes with the seasonal presence of allergenic pollens in the atmosphere by prolonging these periods (Patil, 2012). Substances like pollen and mould, which produce allergic reactions referred to as 'aeroallergens', can aggravate allergic rhinitis and several respiratory diseases, namely asthma and chronic obstructive pulmonary disease. Furthermore, in the specific case of respiratory diseases, aeroallergens could also worsen these diseases through its interrelation to other harmful air pollution (CDC, 2009). Reports from Europe and North America indicate that the pollen season starts earlier and earlier, most likely due to climate change (IPCC, 2007).

Climate change may also affect air quality through indirect pathways such as unanticipated effects resulting from mitigation measures introduced to reduce greenhouse gas emissions. An example is the use of improved insulation in workplaces and homes to reduce fuel consumption, which may have a detrimental effect on indoor air quality. In contrast, milder winters may reduce levels of indoor air pollutants such as nitrogen oxides and particulates, through a reduction in the use of heating (Spickett *et al*, 2011).

2.6 Climate Change and Vulnerable population

The scientific use of the term ‘vulnerability’ has its roots in geography and natural hazards research, but this term is now a central concept in a variety of other research contexts such as ecology, public health, poverty and development, livelihood and food security, sustainability science, land use change, and climate change impacts and adaptation. Each disciplinary field defines ‘vulnerability’ in different ways (Gain *et al*, 2012). “*Vulnerability is an often used term in relation to the potential of groups of people to be adversely affected by climate change*” (Nabua *et al,* 2010:346). O’ Brien *et al*, (2009) articulated vulnerability at a local level as the deterioration of environmental, human health and wellbeing. Kyung-Soo *et al*, (2012) has also explained vulnerability as the extent to which changes could harm a system and how a community can be affected by the impact of a hazard. Barrameda (2010) has suggested that poor households are often the most vulnerable to typhoons and flooding due to their socioeconomic standing-location in unsafe and flood prone areas.

Macchi *et al*, (2000) said that people who live in marginal lands and whose livelihoods are highly dependent on natural resources are among the most vulnerable to climate change. IPCC (2007) claimed that poor populations from the rural areas of the developing world are already suffering from food insecurity and are likely to suffer most from the severe effects. This is supported by the study of Gunter *et al*,

(2008) who stressed that the indigenous people's individual capability to adapt to climate change is determined by many factors such as poverty, landlessness and illiteracy. There is a growing body of research about the effects of climate change on the health of populations who are at immediate risk due to catastrophic weather and geologic events (Watt and Chamberlain, 2011).

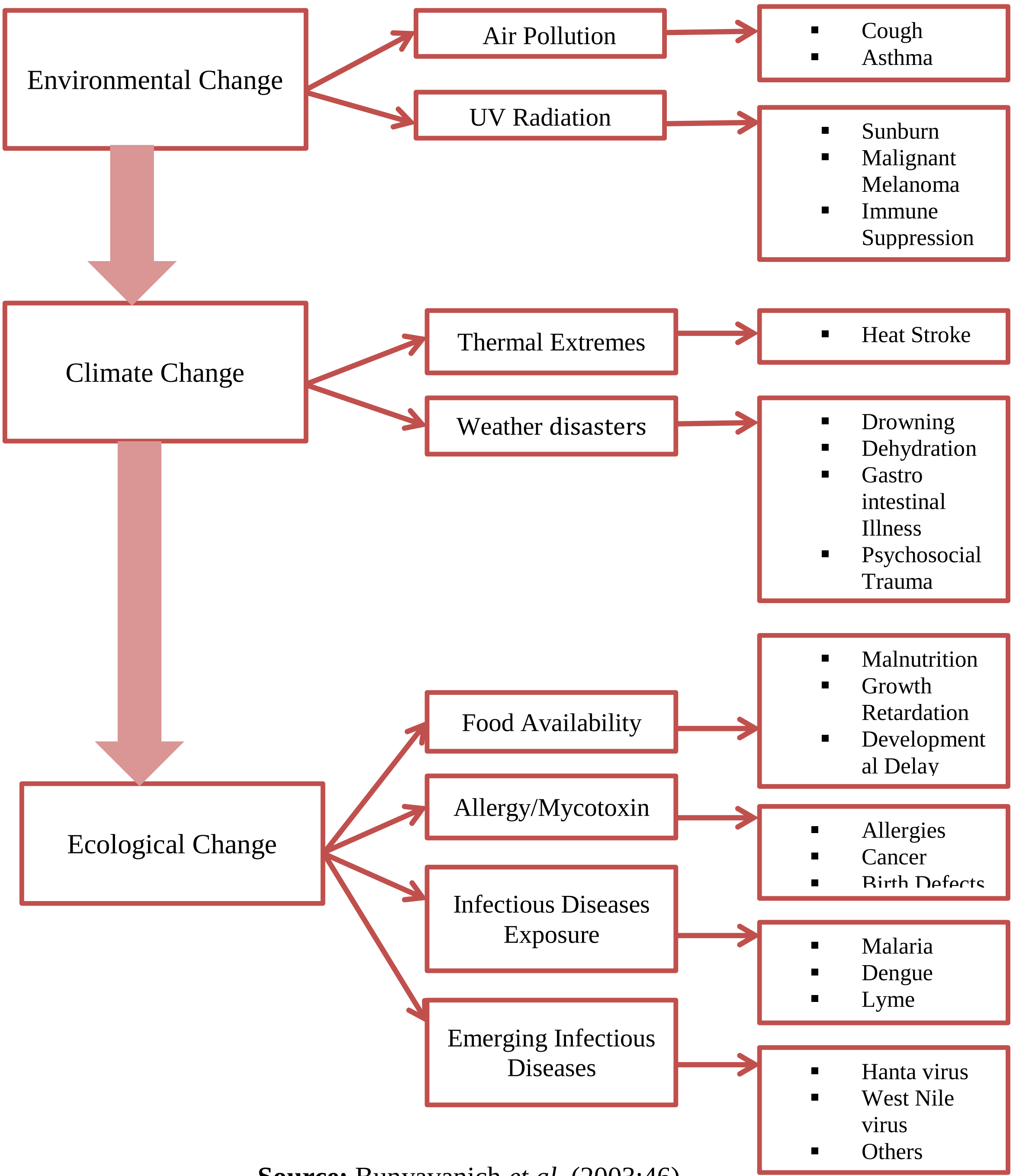
2.6.1 Children

Today's children will grow up in a world of life-threatening weather: violent storms, depression and mental health conditions, breakdown of families and communities (Climate Institute, 2011), unexpected droughts, expanding deserts and food scarcity (Goodland, 2010). Sarkar (2007) stated that poor people are more vulnerable to climate change during extreme weather events. Séguin and Berry (2008) identified that children, infants and adults who are socially disadvantaged and with a pre-existing illness are at a higher risk of climate change. The number of children affected by disasters resulting from climate change is expected to increase to up to 175 million in the next ten years compared to 66.5 million in the 1990s (Tanner, 2010). Children may be an especially vulnerable subpopulation because of their developing physiology and anticipated long-term exposure (Bunyavanich *et al*, 2003). In Uganda, unsafe drinking water is the main cause of child mortality (Black *et al*, 2003). The potential child health effects of severe weather include drowning, gastrointestinal disease, malnutrition, and psychological trauma. Weather catastrophes destroy homes prompting refugee camps that harbour infectious diseases.

Climate change may also undermine life support systems, including water, forests, and other resources. The resulting social disruption, economic decline, and population displacement will negatively affect the psychosocial development of children, as children are vulnerable to emotional trauma when they experience sudden changes in lifestyle, social networks, or security (Bunyavanich *et al*, 2003). Just after the 2004 tsunami disaster, 14–39% of children in the coastal communities of Sri Lanka suffered from post-traumatic stress disorder (Deb *et al*, 2012).

Just two years after Japan's triple- earthquake, tsunami and nuclear disaster, new psychological stresses are emerged among the displaced survivors, particularly the children and the elderly people (Markus, 2013). Fakheri and Goldfarb (2011) stated that there is a positive correlation between increased temperatures and renal stone formation and they said that dehydration produces lower urine volume and higher super saturation of stone forming salts. As a consequence there is an increased risk of renal problems among children. A study has shown that young children failed to meet the need for increased cardiac output in extreme hot conditions (Jokinen *et al*, 1990). Because of the lack of immunity, children experience high levels of both mortality and morbidity from malaria, approximately 86% of malaria deaths occur in children younger than 5 years (WHO, 2011).

Figure 2.11: The relationship between environmental change, climate change, ecological change and child health



Source: Bunyavanich *et al*, (2003:46)

Both mothers and children are at a higher risk of getting malaria than the general population (Watt and Chamberlain, 2011). Durkin *et al,* (1993) found that children aged 9-12 years were very aggressive to others after the flood compared the pre-flood situation. Children are not only susceptible to current environmental risks but these early effects of climate change on their health could leave a lasting impact on their potential human capital as they move into their adult life and eventually onto subsequent generations (Akachi *et al*, 2009).

2.6.2 Women

According to Giddens (2006), women and men will respond differently in differing contexts. He suggests that gender will determine what is expected, permitted and valued."*When a community is faced with a natural disaster like floods and droughts the manner in which men react to the situation is different from the way women will face a similar situation*" (Ongoro and Ogara, 2012:79).

Gender inequality is another important factor. In developing countries, women are among the most vulnerable to climate change; they not only account for a large proportion of the agricultural workforce but also have few alternative income opportunities. Women's livelihoods depend more on the ecosystems that are threatened by climate change (MADRE News, 2009). When poor women lose their livelihoods, they slip deeper into poverty and they suffer from inequality and marginalisation due to their gender (Mitchell *et al*, 2007).

Women manage households and care for family members, which limits their mobility and increases their vulnerability to natural disasters and other local sudden climate change (UCL *Lancet* Commission Report, 2009). In developing countries the lives of women are more stressful and normal practice is that women should produce new workers by bearing children. So, as a whole, women will care for their present workers- their husbands, sons and their daughters (Coêlho *et al*, 2004). There are some studies that have shown that men and women are equally affected by disasters. During droughts women are more anxious and distressed than men (Coêlho *et al*, 2004). In Nigeria, during flood periods and dry seasons, temporary migration of men to urban areas results in an increase in workload for women and exposes them to physical and sexual abuse (Agwu and Okhimambe, 2009).

Women and girls whose social roles make them more in need and in charge of water procurement will be most affected if they have to walk further to reach water sources in rural areas or to queue longer in water lines in urban areas. When disasters strike and they are brought to evacuation centres, their special health, safety, and sanitation requirements are often not considered, and they consequently suffer (DSWD & UNDP, 2012). If heat exposure is high enough to force a person to slow down in their daily physical activities, the time women spend in poor communities of tropical countries on collecting water, food or fire wood will get longer, shortening the time available for other important household activities potentially creating health risks for the whole family (Kjellstrom, 2009).

In 2003 more women died than men during a heat wave in Europe (WHO, 2011). There may be some physiological reason for the increased risk among elderly women (Burse, 1979 cited in WHO, 2011). Goh (2012) found in his review paper that women in particular are primarily responsible for providing for households with food security and they reduce their food intake so that others can eat more.

In a recent study by the London School of Economics, the University of Essex and the Max-Planck Institute of Economics, a sample of 141 countries, in which natural disasters occurred during the period 1981-2002, was analysed (Neumayer and Plümper, 2007). The main findings were: (a) natural disasters lower the life expectancy of women more than that of men; (b) the stronger the disaster, the stronger this effect on the gender gap in life expectancy; (c) the higher the women's socio-economic status, the weaker the effect on the gender gap in life expectancy. The study concluded that it is the socially constructed gender-specific vulnerability of women built into everyday socio-economic patterns that leads to the relatively higher female disaster mortality rates compared to those of men.

Lack of clean water, privacy and access to sanitation increases stress and worry among women after a disaster. It also causes health hazards to them as they are constrained from going to the toilets or must sacrifice personal hygiene needs (Barrameda, 2010). Access to clean water is integrally linked to reproductive health. In Uganda, one of the countries in Sub-Saharan Africa, pregnant women still have to walk long distances to access water and often the water is polluted. Since pregnancy causes a naturally induced immune suppression they are at greater risk for waterborne illnesses (Watt and Chamberlain, 2011). The vulnerabilities of women and children are further confounded by poverty, food insecurity, and general health status. Natural hazards and extreme weather events further compromise their situations (Watt and Chamberlain, 2011).

In low and middle-income countries, physical work, infections due to immune system clampdown, mood changes due to hormonal release, postpartum depression with heavy work related and family responsibilities make pregnant women vulnerable (Rylander *et al*, 2013). The possible complications during pregnancy with a pregnant woman are particularly more vulnerable to malaria as they are twice as appealing to malaria carrying mosquitoes as to non-pregnant women (WHO, 2011).

Table 2.9: An overview of possible diseases and complications to maternal and newborn health related to climate change

Diseases/ Complication
Spontaneous abortion
Premature contractions
Low birth weight
Premature delivery
Increased neonatal mortality
Dehydration
Renal Failure
Vector borne diseases
Malnutrition and food insecurity
Diarrhoea
Respiratory diseases
Water scarcity
Exposures to toxic chemicals
Worsened poverty
Natural disasters
Population displacement

Source: (Rylander, 2013:3)

Makhseed *et al*, (1999) found that pregnant women suffer from hypertension more during the month of June when the temperature is very high. Assam, in northeast in India, (famous for its tea gardens), has noted noticeable climate changes over the past 60 years. The mean annual temperature has risen by more than 1° C since 1950. When Bangladesh was hit by a flood and cyclone in 1991 the death rate was 5 times higher for men than women and like most Asian countries Bengali women have never learned to swim (Pender, 2008). Séguin et al, (2008) found a statistical correlation between maternal and newborn mortality and morbidity. Weather events also highlighted the point that unclean water and inadequate sanitation played a major role.

Some studies have found a relationship between meteorological conditions and the incidence of eclampsia in pregnancy .The rate increases during different climatic conditions like low temperatures, high humidity, high precipitation or sometimes the first few months of the rainy season (Duncan, 2007; Crowther, 1985; Agobe *et al*, 1981; Obed *et al*, 1994; Neela and Raman, 1991; Subramaniam, 2007). Rylander *et al*, (2013) cited in their review paper that extreme weather events results in food insecurity; lack of safe drinking water and increases the risk of infections for pregnant mothers and also affects access to pregnancy care. This lack of pregnancy care will further increase the risk for complications during delivery, which increases the risk of maternal and infant mortality. They also reported that a good number of pregnant women in the Southern Hemisphere contracted malaria, dengue fever and Schistosomiasis as a result of changing disease pattern and population migration. A recent study has found that climate change is also having a serious impact on poor women due to increased flooding. The women of farmers who have lost their livelihoods due to floods have to leave home in search of work while young girls have to leave school early to look after the children at home. The rate of child marriages has also increased recently. Parents of these poor families think that this way they can give their girl children a better future. Increased flooding and rising temperatures has also increased the incidences of malaria in these tea regions (The Daily Climate, 2013).

In 2004 during the Indian Ocean Tsunami, the ratio of women killed to men was more than three to one. This is because women worked in their home and many did not evacuate. They chose to stay back to look after the children, family members and others unable to swim or climb trees (traditional clothing restricted their mobility). After the tsunami women experienced verbal, physical and sexual abuse in the resettlements areas, particularly around the toilets (Oxfam International, 2005). Poor women and girls in developing countries often find themselves in greater danger than men and boys at times of flooding, earthquakes and other disasters because of social and cultural inequalities that restrict their access to information and skills such as swimming (Aboud, 2011). Climatic events have a more psychological and emotional toll on women, as they are unable to carry out the tasks and roles of providing care to their children and other family members (GoH, 2012).

Gender inequalities have also been found in early warning information for evacuation procedures and arrangements. In some cases women were less informed about natural disasters and were not allowed to take decisions to evacuate the place. For example, in Bangladesh, Cyclone ‘Gorky’ in 1991 caused an estimated number of deaths of 90000 women from 140,000 fatalities (Ikeda, 1995). Increased waterlogging due to climate change also affected the mental health of the mothers in Bangladesh. It has been found that mothers in the affected area live in a state of mental trauma thinking of the sudden drowning of their children (Neelormi, 2009).

2.6.3 Older Population

Globally the proportion of an older population is growing faster than any other age group. In the year 2000, 600 million people were 60 years or older, by 2025 the figure will reach 1.2 billion and in 2050 around 1.9 billion (Hutton, 2008; Bhuiyan and Khan, 2011; Masa and Khan, 2014). Population ageing will place an increasing burden on national health care systems (Kabir *et al*, 2013).

Older people are the most vulnerable in this changing climate. As people grow older the biological mechanism of the body declines and they're disposed to age related chronic diseases, reducing their movement capacity and strength and they are also at a greater risk due to the use of medication that affects their body to cope with external stressors (Haq *et al*, 2013). It has been projected that in 2020, three quarters of all deaths in the developing world could occur due to age-related diseases (Gavazzi *et al*, 2004). Changes in the climatic conditions with an unstable environment in the developing nations causes water shortages and less crop production which in turn affects their income, livelihood and food security. Older people from poor communities will be affected by health impacts due to climate change (Haq *et al*, 2013). Semenza *et al*, (1990), Naughton *et al*, (2002) and Vandentorrn *et al*, (2006) cited that isolation and little mobility are also key risk factors during hot weather. Elderly people in hospital and residential care homes need particular attention in this hot weather (Hajat *et al*, 2007). Social isolation and a limited income are also associated with heat-related illnesses among older people (Filiberto *et al*, 2009). There was a 64% increase in the deaths of older people in the 2009 heat wave in Victoria, Australia (Victorian Government Department of Human Services, 2009). Liu *et al*, (2006) reported that elderly people suffered from Post-traumatic stress disorder after the 1998 heatwave in China. Flynn *et al*, (2005) said that physiological changes in renal function and water and electrolyte homeostasis that occur with increasing age are risk factors for an older population in extreme hot weather.

The effects of climate change are variable, depending on pre-exposure health status, psychological well-being, and social characteristics (Geller and Zenick, 2005). Bhuiyan and Khan (2011) concluded that climate change is largely affecting older adults' health in Kazakhstan. Older people are also disproportionately more likely to die as a result of hurricanes. For example, as a result of Hurricane Andrew, older people were more likely to die of indirect causes, such as heart attacks during evacuation (Combs *et al*, 1996). Social and economic factors increase the vulnerability of some older people because socioeconomic disadvantages restrict the capacity of individuals to avoid the negative health impacts of climate change, mitigate those impacts, or cope with them if they cannot be mitigated or avoided (Filiberto *et al*, 2009). People, who are poorer, less educated, less connected to transportation, and who have smaller social networks will be at a greater risk for negative outcomes in natural disasters (Haq *et al*, 2008). Sawai (2012) reported that the 2011 Japan earthquake and the tsunami caused extreme vulnerability of older people with an estimated 64% of total deaths being in older people. Naumova *et al*, (2003) cited that older people are vulnerable to gastrointestinal diseases from waterborne pathogens due to changes in the immune system. The World Health report (2002) found that diarrhoea is the second or third most common cause of death among the older people over 60 years of age in developing countries.

2.7 Research gaps and questions

The exisitng literatures on climate change suggest that emissions of greenhouse gases due to human activities are responsible for global warming and other climatic changes. Howver, there appears to be little epidemiological evidence from reliable sources that precisely links increased incidences, prevalences and severity of climate sensitive infectious diseases and other health problems. Similarly it can be said that based on the existing literature, there is lack of reliable research, which specifically shows an association between the present and probable increases in the frequency and severity of extreme weather events with climate change. The extreme weather events expose the communities to the threat of unusually high incidences of mortality and morbidity as well as increasing different health problems. It appears that to date there are no peer-reviewed papers that focuses on post disaster health problems examining the direct and indirect impacts of climate change on health. Methods to estimate the burden of disease attributable to climate change needs to be developed as well as methods to estimate future health risks due to climate change. This kind of research is hindered by a lack of useful data and key health variables (WHO, 2009).

There is a lack of quality long-term data to establish the long-term impacts of climate change on health. This is made even more difficult because of unsystematic and inefficient approaches of data collection. Health surveillance data is available, but to make valid interpretations of the data and to assess the impacts of climate change on human health are likely to be complicated and challenging. Health risks will vary over time and location. The assessment of how climate change impacts on health is a complex process and multiple uncertainties should be considered for better understanding. In view of this and the added complexity of climate change impact on health, a mixed method approach was chosen for this research, as monomethod would not sufficiently address the issue of assessing the impact of climate change on health. The literature suggests that climate change has an impact on the live and livelihoods of humanbeings by affecting the employability, food security and their health. Climate change may affect all population groups but women, children and the elderly are mostly affected. Evidence indicates that disparities exist between men and women's rights and control over key assests. In particular rural women from developing nations have fewer rights, which make them more vulnerable to climate change. There is limited evidence of the differential impacts of climate related events on human's physical, psychological and emotional health. Based on these limited studies and existing literature on climate-induced disasters the following research questions were developed.

RQ_1: What are the possible impacts of climate change induced natural disasters on human health in Bangladesh?

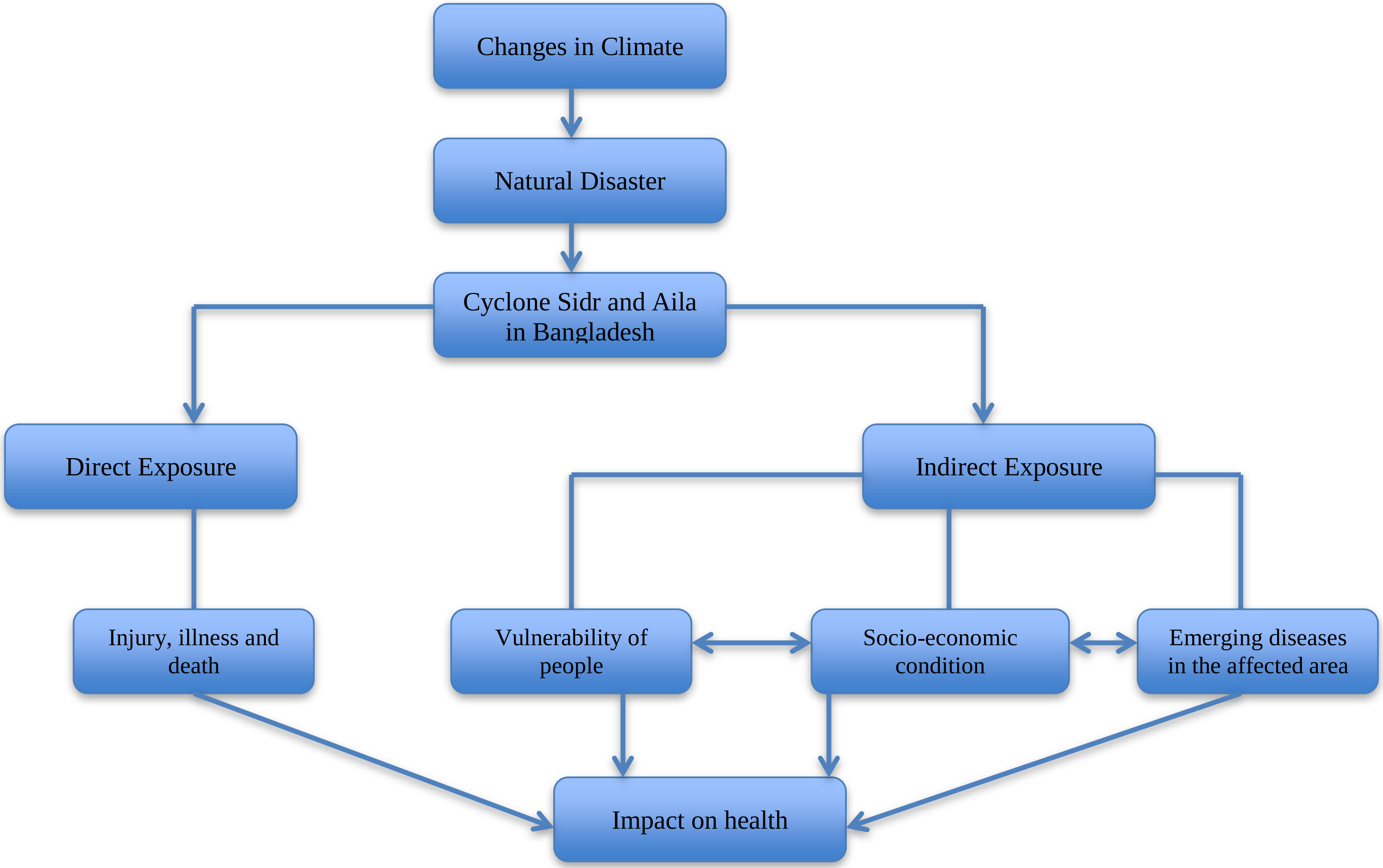
RQ_2: What are the key determinants of health outcomes in the climate affected areas of Bangladesh?

RQ_3: What will be the effect of climate change on vulnerable people of Bangladesh?

2.8 Conceptual Framework

A conceptual framework is the foundation for understanding the research issues and linkage among the different variables. It helps as a guiding principle for analysing the research issues. Reichel and Ramey (1987) describe a conceptual framework as a set of broad ideas and principles taken from relevant fields of enquiry and used to structure subsequent presentation. A change in climatic conditions can have direct and indirect impacts on the health of the people living in Bangladesh. Direct impacts (caused by weather extreme) include thermal stress, death/injury during cyclones and storms and so on. Indirect impacts include health consequences due to environmental change and ecological disruption and diverse health conditions including trauma, infectious, malnutrition and psychological. This research attempts to find out the direct and indirect impacts on human health caused by natural disasters (due to climate change) in *Aila* and *Sidr* affected areas. The conceptual framework used to find out the impact of climate change on health used for this research is presented in Figure 2.12:

Figure 2.12: Conceptual Framework



2.9 Summary

Changing climate and its impact has drawn considerable importance in the public health arena. The whole world is vulnerable to climate change especially the developing world but research on climate change and its impact on human health is scarce. Climate changes adversely affect the ecosystem and make it conducive for the water-borne and vector-borne diseases.

The literature review reveals that there is an emerging body of evidence that shows that climate change is happening. To date, public health problems in relation to climate change have not appeared prominently in policy and practice debates. This is due to the lack of empirical evidence of how health is affected by climate change at a community level. Despite the detailed review of the literature above, the main limitation lays in a lack of appropriate longitudinal health data that makes attribution of adverse health impacts due to the changing nature of the climatic scenarios. There is a lack of information on climate and health in low-income countries and middle-income countries. Again, it has been found that the impact of climate change is primarily seen in low and middle-income countries in the public health sector so; epidemiological research for the populations of these countries is a priority. Bangladesh due to its geographical position is facing many possible harmful consequences due to climate change. Climate change related health problems are a major issue for Bangladesh due to the present and future concerns of climate change on the country. Peoples' health is determined by the natural environment and the ecosystem services that it provides. The future health of communities and population is directly threatened by human activity on the very environment that supports our lives. IPCC Working Group I (2013:10) in their fifth assessment report revealed, "*Human influence on climate system is clear.*

This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming and understanding of the climate system".

Healthy people help to build and develop a nation. Bangladesh is already carrying the burden of a high population in a small country in addition to increased natural disasters, fading and contaminated natural assets and the future burden of increased health problems will make it harder for the country to achieve its developmental goal. Climate change induced health impacts have grown as a prominent research problem for other countries in the world. Evidence shows that there is still a lack of research and competence in this sector. Existing literature shows there is a link between climate changes and various diseases, changes in the health of people, the rate of mortality and morbidity and a lack of safe drinking water. The impact on vulnerable population has not received as much importance as it requires. Due to climate change prevalence, various infectious diseases are increasing and there are some re-emerging diseases in some parts of the world. Climate related natural hazards like cyclones, floods, sea level rises and salinity intrusion will deteriorate the health of the people of the country. This research offers to contribute to the literature by providing evidence of climate change and its impact on human health in Bangladesh.

METHODOLOGY

Chapter 3: Methodology

3.1 Introduction

This chapter deals with the methodology and methods employed in this study. "*Methodology is influenced by world view and the underlying beliefs and attitudes concerning the world we live in, and how we can obtain knowledge about it*" (Corbin and Strauss, 2008:5). To achieve the aim and objectives of this research, this chapter describes in the detail the method used. No one can deny the importance of research methodology in enabling the research questions to be answered. Adams *et al,* (2007) opined Research Methodology as the science and philosophy behind all research and it gives a proper and systematic way to conduct the research. Bryman and Bell (2007) define research methodology as an organised way of finding a solution to a problem.

This study has used a mixed method approach. This is usually known as 'triangulation'. This means 'getting proper information from more than two or three places (Green *et al,* 2002). A Quantitative approach is used to try and establish the statistical relationship between extreme climatic events and human health. On the other hand, Qualitative approach is trying to gain insights into the questions of how different group of people respond to climate related events and their experiences on health. In this research, a quantitative approach using a questionnaire survey and a qualitative approach using an interview guide was adopted.

The salient features of this chapter comprise of: selection of study area, research design, sampling technique, sample size determination, method of data collection, field work plan, and techniques used for analysis, consideration of ethical issues and the study limitations. The following table shows an overview of research tools to be used to address the research objectives for chapters 4-7.

Table 3.1: Chapters with broad objectives and methods used

Chapters	Broad objectives of the research	Methodology Used
Chapter 4	To investigate the socio-economic characteristics of the households living in the climate affected areas	Household survey using structured questionnaire.
Chapter 5	To evaluate the direct and indirect impact of climate change on the health of the people in the climate affected areas.	Household survey using structured questionnaire.
Chapter 6	To identify potential health problems before and after climate induced natural disasters & To find out the key determinants of health outcomes in the climate affected areas of Bangladesh.	Household survey using structured questionnaire.
Chapter 7	To critically evaluate the experiences of the people of the climate affected areas.	Focus Group Discussion using interview guide

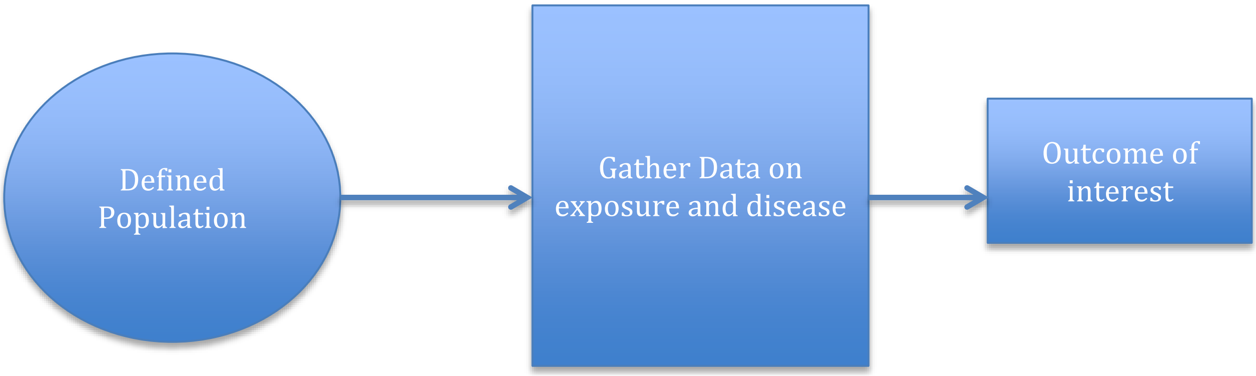
3.2 Research Design

A research design is a plan, structure and strategy of investigation conceptualized so as to obtain answers to research questions or problems. The plan is the complete scheme of programme of the research. Kerlinger (1986) stated that it is an outline, which covers the writing of the hypothesis to the final analysis of data. The choice of the research design reflects the decisions about the priority being given to range of dimensions which include - causal connection between variables, generalizing to larger groups of individuals than those actually forming the part of the investigation, understanding the behaviour and the meaning of the behaviour in specific social context, over time appreciation of social phenomenon and their connections (Bryman and Bell, 2007).

“Epidemiological approaches are useful for developing vulnerability to climate sensitive diseases, determining the early health effects due to climate change and estimating potential health risks associated with global environmental change” (Ebi and Patz, 2002:120).

The study is a descriptive cross-sectional. “*Cross- sectional studies are aimed at determining the frequency or level of a particular attribute such as specific exposure, disease or any other health event in a defined population at a particular point in time”* (Silva, 1999:213). In epidemiological research, cross-sectional studies are appropriate for the purpose of understanding association between exposure to risk factors and the outcome of interest. This research is trying to find out the impact of the risk factor (climate change) and changes in health conditions of people (outcome of interest) in a defined population.

Figure 3.1: The design of a cross-sectional study



The study group chosen in the cross-sectional study is a cross-section of a population. In this research, the sample drawn from cyclone Sidr and Aila affected coastal populations are representative of climate-affected populations of Bangladesh. The idea is to select people in such a way that they are representative of the whole population so that information collected from the study sample can be generalized directly to the whole population. According to Babbie (1989) this kind of study is suitable when it is required to find out the cause-effect relationship by taking a cross-section of the population at a time.

This research is investigating individual level of distribution of exposure, disease and health related problems in the community. Ebi and Patz (2002) reported that cross-sectional studies are useful for answering particular questions especially for a population where it is essential to know the distribution of exposure, disease and health related problems at individual levels. The main advantage of the cross-sectional research design for this study was that the researcher was able to collect and compare several variables at the same time. The collection of data was less expensive in terms of time and cost and helped the researcher to collect information at point in time. Analysis was conducted using IBM SPSS (a statistical software version 21).

Figure 3.2: Flow chart of research methodology and structure

Key Research Objective:
To assess the potential impacts of climate change on health of the coastal people in Bangladesh

Specific Research Objectives:

1. To investigate the characteristics of the households living in the climate affected areas.
2. To evaluate the direct and indirect impact of climate change on the health of the people in the climate affected areas.
3. To identify potential health problems before and after climate induced natural disasters.
4. To critically evaluate the experiences of the people of the climate affected areas.
5. To find out the key determinants of health outcomes in the climate affected areas of Bangladesh.

Research Design and Methods

- Cross-sectional study
- Mixed Method approach
- Pilot survey
- Questionnaire survey & Focus Group Discussion
- Multistage cluster sampling and judgemental sampling
- Data analysis- thematic analysis, descriptive statistics, freuqncy distribution, correlation, logistic regression

3.3 Methodological Approach:

This research has used a mixed method approach i.e. a combination of both qualitative and quantitative methods. According to Blaikie (1991) qualitative and quantitative methods have become central in dissenting philosophical exemplar for many researchers. Quantitative methods fall into the category of 'Positivist' model whereas qualitative methods are typically 'Constructive' epistemology.

Quantitative research is 'a formal, objective, systematic process in which data are used to obtain information about a scenario (Burns and Grove, 2005). The advantage of using quantitative method is that all gathered data has its reflection in statistics, which can be easily found and verified. This makes it highly credible in comparison to qualitative approach as said by Newman and Benz (1998). Quantitative research finds out the association among variables. The reason for using quantitative research in this study is to establish the relationship between the variables like changes in the climatic condition and health of the people. A quantitative method has been applied to meet the important research objectives of this research. The study started with a quantitative method in which the variables were tested to meet the research followed by a qualitative method, which involved a detailed exploration with a few cases and individuals.

The usage of quantitative data can be advantageous in formulating the hypothesis but may at the same time cause vagueness. The disadvantage of quantitative data may leave many doubts as to areas, which were not covered (Creswell, 2003). Quantitative methods are used when the research issue is clearly outlined and answers are received in a summarized format when asked questions. For example, structured household survey had been used in this research.

As mentioned by Stainback and Stainback in 1984 cited by Duffy (1987) that quantitative research attempts to structure the situation by identifying and isolating the specific variables and by employing specific measurement devices to collect information on these variables whereas qualitative research attempts to get a complete or holistic view of what is being studied.

> "*The main focus in qualitative research is to understand, explain, explore, discover and clarify situations, feelings and perceptions, attitudes, values, beliefs and experiences of a group of people. The study designs are therefore based on deductive rather than inductive logic, are flexible and emergent in nature, and are often non-linear and non-sequential in their operationalization"* (Kumar, 2011:104).

Ambert *et al,* (1995) described qualitative research as the researchers who conceive the idea and reflect back during the process of data collection and dig down the realities to peel up new layers of information in an iterative fashion. This proves that qualitative research is comparatively flexible. For example, in this research it is adding more depth to quantitative findings and unearthing new clues to the answer of the research objectives. Qualitative techniques are useful to get complex and inconclusive answers. In this research, focus group discussions have been used to analyse respondent's statements.

According to Oakley (1998) ‘this type of research instead of ‘yes or no’ gives a full and detailed picture. The main drawback of this type of research is the lack of focus towards understanding multidimensional issue. There is a huge probability that the final results of the research will be affected by bias and interpretations of the researcher. Choice of subjects and sources of information can potentially affect the research findings. Bowling (1997) said that there no research method is without bias. Webb *et al,* (1966) recommended the use of triangulation method to enhance the validity of findings. Denzin (1989) argued that triangulation elevates researchers above the personal biases that stem from single methodologies and by combining the methods; researchers can overcome the deficiencies that flow from one method. Onwuegbuzie and Johnson (2006) suggest that one method is nearly always used to support and inform the other method in a mixed method study. Tashakkori and Teddlie (2009) define a mixed method approach as one in which the researcher collects and analyses the data, interprets the findings and draws inferences using both qualitative and quantitative methods in a single study. Darbyshire *et al,* (2005) supported that a mixed method research offers complimentary insights and understanding of the data, which cannot be accessed through a single method.

Whether quantitative and qualitative approaches are used depends upon the research objectives. A mixed method approach was regarded as suitable for meeting the research objectives. This study employed predominant quantitative approach because it was deemed to be appropriate in investigating and analysing the impact of climate change on human health in Bangladesh. Adopting mixed methodology requires in-depth data required to meet the aim of any research. Therefore, both quantitative and qualitative data collection approaches were employed in the study.

Mileti (1987) and Quarantelli (2002) said that qualitative approaches, such as in-depth interviews and observations, are useful tools for understanding people's responses to the disaster. It allowed a dialogue to explore the impact of a disasters as well as adding 'depth' to findings from quantitative method or exploring the meaning of quantitative findings (Green and Thorogood, 2009). Qualitative data collection through Focus Group Discussions (FGDs) was conducted to supplement the quantitative data. Halkier (2006) confirmed that focus groups are group interactions and discussions about a subject that has been selected by the researcher himself.

The reasons for selecting mixed method approach for this research are given below:

(1) Mixed method research allows the use of a wide range of data collection tools to address the research problem. This research has used a questionnaire survey, focus group discussion and case study approach for data collection so this is not restricted to specific data collection tool usually associated with either qualitative or quantitative approach.

(2) Using a mixed method approach helps the researcher to apply findings to a wider population and tries to limit the bias from each method (Risjord *et al*, 2001).

(3) To meet the aim of the research, neither a qualitative nor quantitative approach alone could provide a satisfactory answer. Only a qualitative appeoach can evaluate the experiences of people. To find out the direct and indirect impacts and to compare the pre and post disaster situation a quantitative approach is suitable.

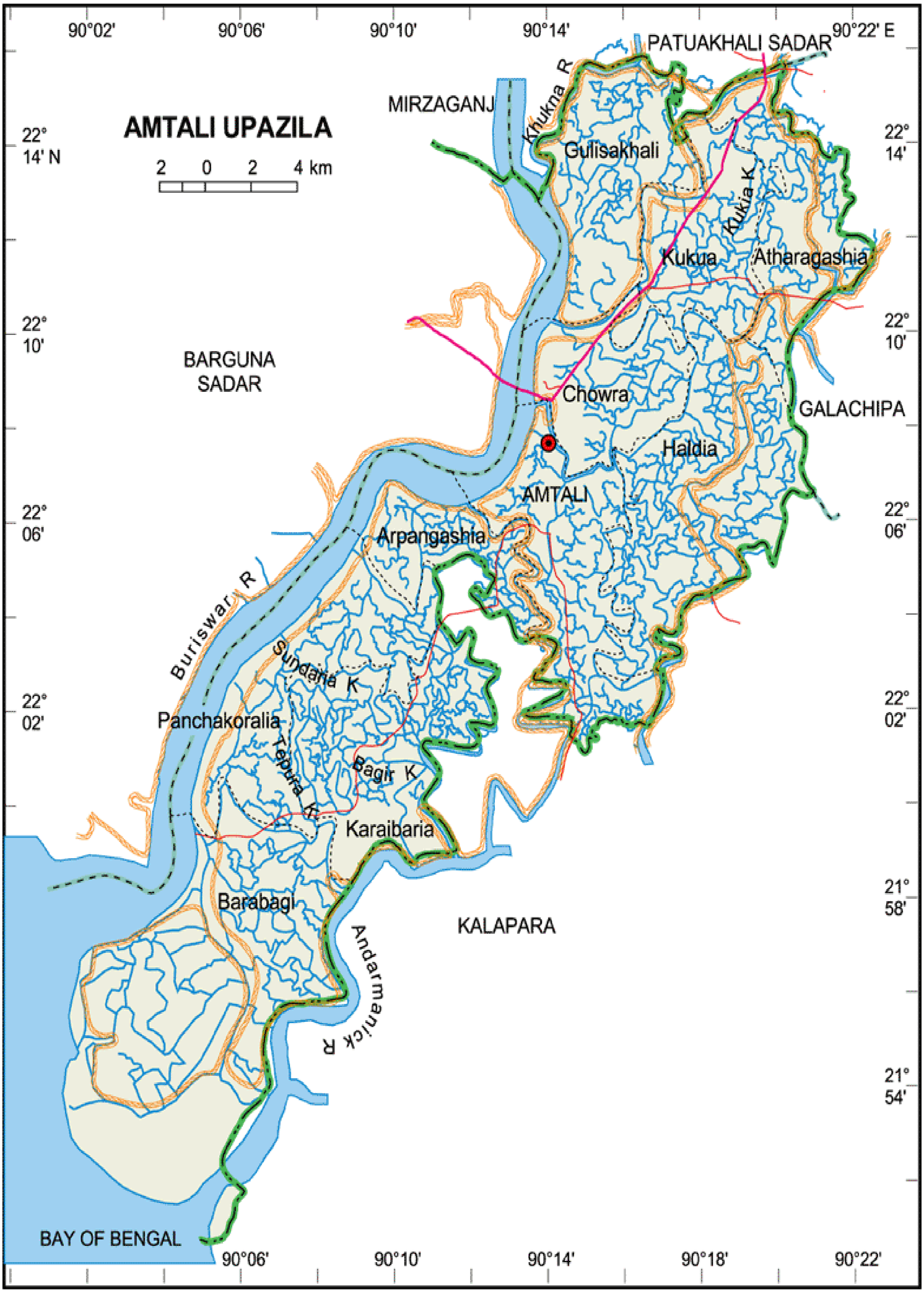
3.4 Study Place and Target Population

The study was conducted in the South West part of Bangladesh (the two most vulnerable Coastal Districts namely Barguna and Khulna were selected. The administration of Bangladesh is divided into several hierarchal units and these units are Division, District, Upazila and Union. Each village is serviced by a Union and Family Health Welfare Centre (UFHWC). This is the only public primary health care available to villagers with one medical doctor; one paramedic and several nurses serve it (Haque *et al,* 2013).

Barguna was the worst hit district by cyclone Sidr (2007). Most of its flood ridges were washed away and people are faced with the daily difficulty of tidal seawater engulfing their land (Reliefweb, 2009). Baliatali village and Ghopkhali village of *Amtali upazila* of Barguna was selected for data collection. Khulna district was worst damaged by cyclone Aila (2009). In Khulna district, Aila has hit 6 upazilas out of 9. Reports stated that 545,954 people were affected in the district, which includes 120,203 families. According to data, Koyra was the most affected upazila by cyclone Aila (Roy *et al,* 2009). The UN Joint Aila Assessment Mission (2010) reported that the population of Koyra upazila is 215,015 and 38,514 households out of 43,003 households (approximate) were affected by Aila. The Barabari village of *Koyra upazila* of Khulna district was selected for data collection.

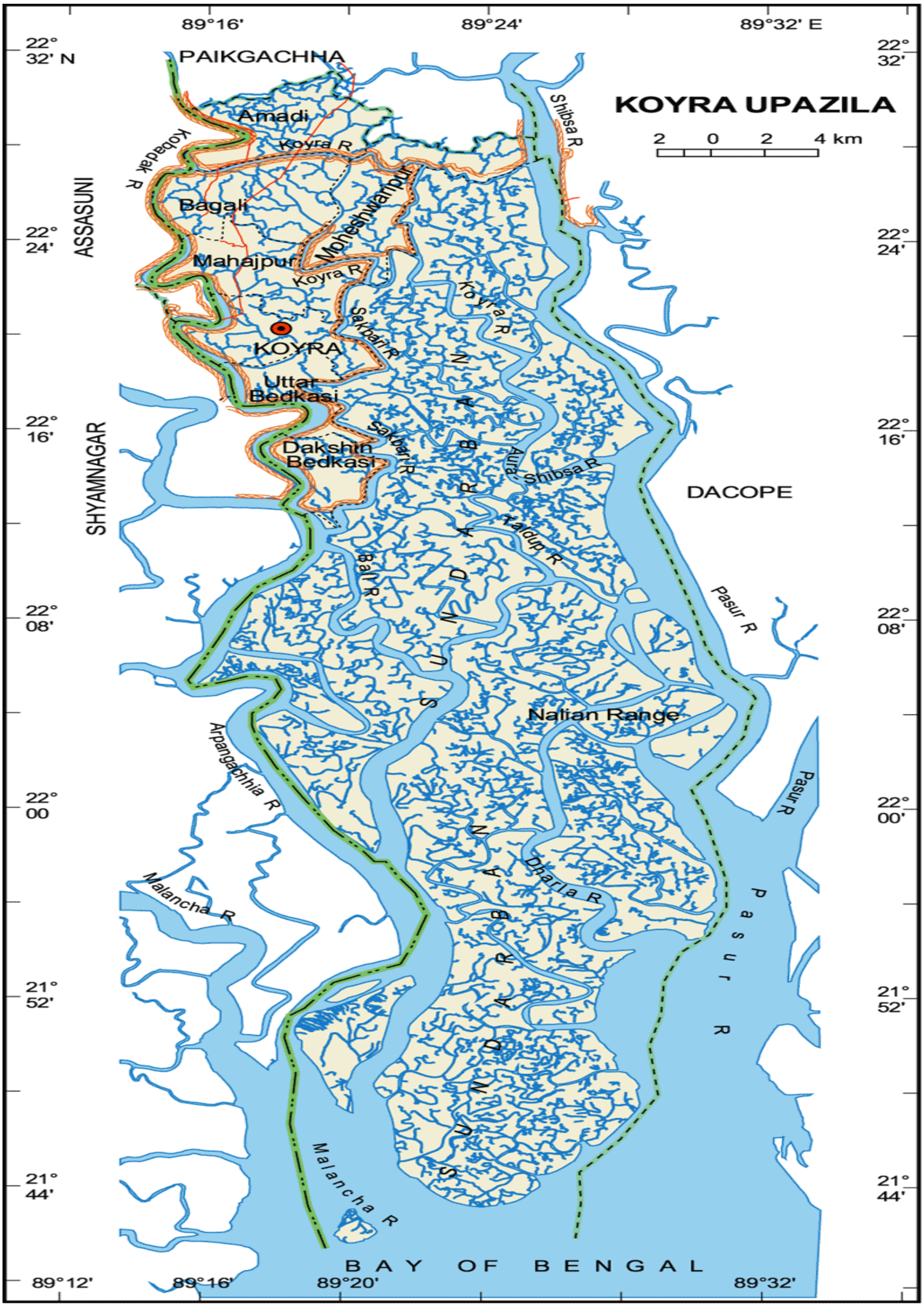
The reasons for selecting the villages are: (1) they are significant areas affected by both the cyclones Sidr and Aila (2) Most of the households in these areas were damaged by the cyclones, and (3) The selected areas cover the sample population from both urban and rural areas.

Figure 3.3 Sidr affected areas



Source: (Banglapedia, 2006)

Figure 3.4 Aila affected areas



Source: (Banglapedia, 2006)

3.5 Pilot Survey

Pilot studies are generally carried out to identify the possible pitfalls, as well as to critique, test and validate the research instruments (Baker, 1999; Fink, 2006; Adams *et al*, 2007). Pilot studies also allow the researcher to develop more specific understanding of the research topic and provides experimental learning in order to become familiar with methodological considerations of the research.

A pilot survey visit to the selected areas was done in June-July 2011. A total of approximately 125 households were interviewed from cyclone *Sidr* and *Aila* affected areas and a FGD with a number of 10 persons was conducted only in the Sidr affected area. The objectives of the pilot study were:

(1) To ensure that questionnaire was coherent and had the same meaning to all the respondents.

(2) To identify the drawbacks of the questionnaire by highlighting the questions that they found to be ambiguous or which they were uncomfortable. The questions were modified, some questions were added to collect new types of data, some unwanted questions were removed and the questions were arranged sequentially to help in the analysis.

(3) To have a clear idea of approximately how long it would take to complete an interview.

(4) To meet the health service providers from Union level, officials from government and non-government organizations and people from the local community.

(5) To carry out an initial assessment of the villages and communities to determine the number of households that can be approached.

3.6 Sampling Procedure

"You cannot study everyone everywhere doing everything"

(Miles and Huberman, 1994:27)

Sample size determination is a key step in designing an epidemiological study and an adequate sample size helps to ensure that the study will provide reliable findings (Kasiulevičius *et al,* 2006). "*Sampling is the procedure or technique of selecting a suitable sample for the purpose of determining parameters or characteristics of the whole population"* (Adams *et al*, 2007:87). A sample is selected to represent the group of people that are the main subject of the research. Nayak (2010) stated that whatever the aim of the research, it can be performed precisely and accurately when the sample size of the research is appropriate.

In a complete survey, the required information is collected from each and every element of the population. Thus it becomes costly and time consuming. On the other hand, in a sample survey, the required information is collected from selected elements only. For this reason, it has some basic advantages over a complete survey in the sense that it reduces cost, saves times and offers a greater scope and accuracy of the data. It is necessary, however, that the selected samples should represent a reasonable true picture of the entire population. The advantage of having a large sample size is that more information can be gathered and it reduces the uncertainty. Using a large sample size for the research sometimes can be expensive and more time and effort is required. Keeping in the mind about the time and financial constraints the researcher decided to select a sample size that will be feasible for this research.

As mentioned above, the study consisted of both quantitative and qualitative methods. The aim of using sampling in quantitative research is to make a valid conclusion about the group, which represents the whole population. Qualitative research sampling helps either to achieve as much as possible information about the different features of individuals and in-depth knowledge about an event (Kumar, 2011). A focus group was conducted in both Sidr & Aila affected areas. The qualitative data was collected by using a focus group discussion (FGD) from the following the two groups of respondents.

Group 1: Consists of knowledgeable people from Upazila and Union level (a union on an average 20,000 population). The target participants were NGO staffs, schoolteachers, school headmasters, social workers, community leaders and local government officers.

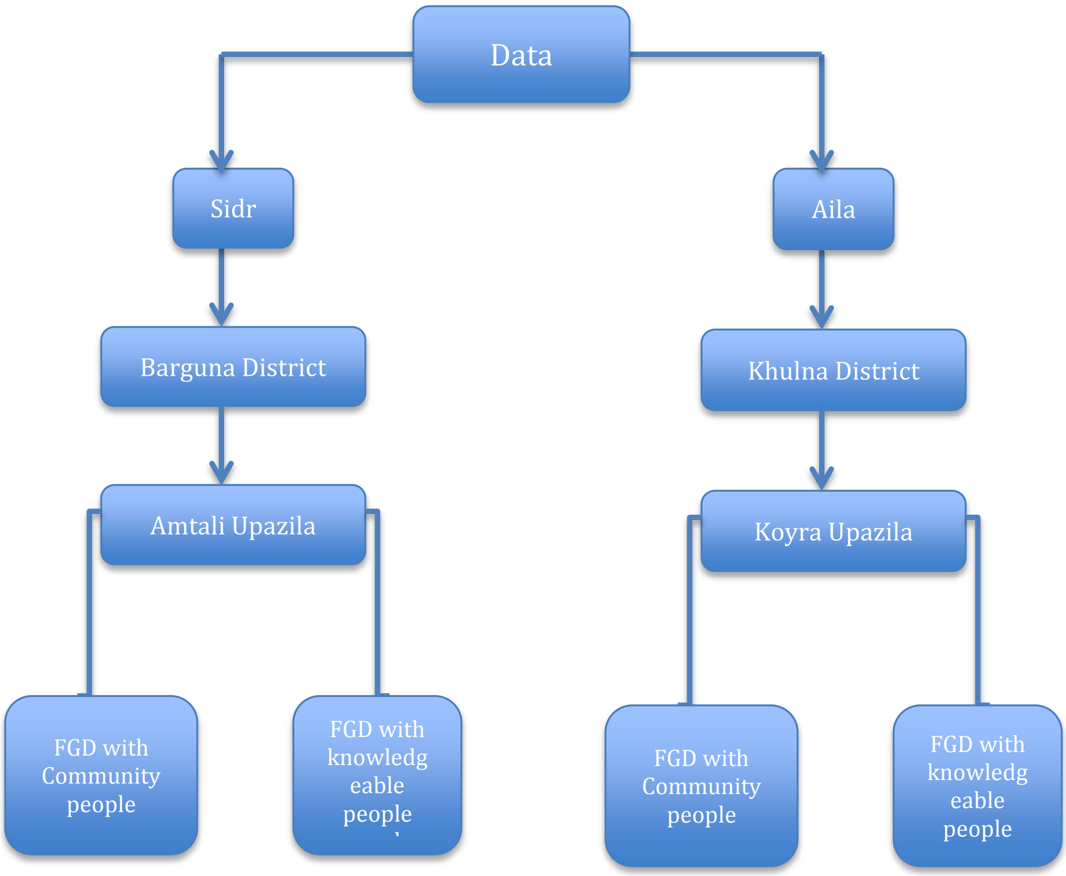
Group 2: Consists of members of the local community, which included former UP (Union Porishod) member, farmers, businessmen, fishermen, community members, housewives and a current UP member.

3.6.1 Sample Size for the FGD

Several government and non-government organizations are working in the affected area. For each FGD with the knowledgeable people, a maximum of 10 persons, one from each organization working in the affected area was selected. Figure 3.5 shows that two FGDs were conducted in each area. The researcher used judgemental sampling to select respondents for the FGDs. In judgemental sampling a cross-section of the sample selected by the researcher conforms to some criteria (Adams *et al*, 2014). This type of sampling is more common in qualitative research

(Kumar, 2011). According to the researcher these people were best positioned to provide the needed information for the study.

Figure 3.5: **Samples for focus Group Discussion in *Sidr* and *Aila* affected areas**



3.6.2 Sample Size for quantitative Data

For the quantitative data, a multistage cluster sampling design was used. The two districts Barguna and Khulna were the primary units. The sample size was determined by using the statistical technique. The cluster is census enumeration area. A total of approximately 1000 households were selected by using the simple random sampling technique as tertiary units from the upazilas (secondary units) of these two districts. The head of the household or family was given priority to respond to the questions. In the absence of the head, another other senior member of the family was given the opportunity. Particularly on health related questionnaire all members of the family answered some question.

3.6.3 Sample Size Determination

The sample size was determined by using the following cluster sampling
Formula: $n = Z^2 q / r^2 p$ ×design effect

n= Required sample size, Z= 95 % Confidence value

p= proportion of target population will be affected by the climate change

q= 1-p

r= relative error which is assumed to be 8% (the lower is the value of r the higher is the sample size; similarly the higher is the value of r the lower is the sample size)

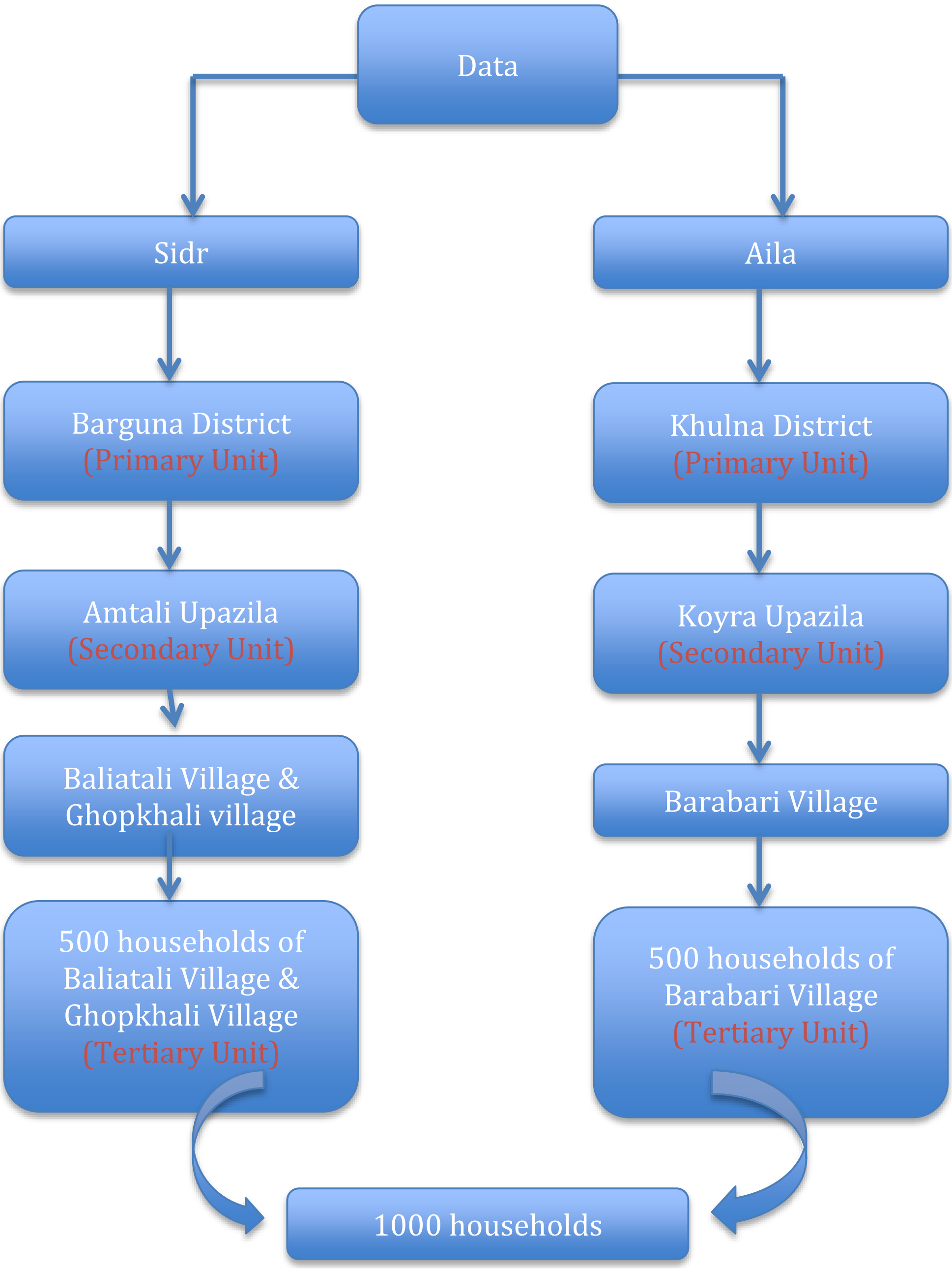
In the absence of any information on p we assume p= 50%

Z= 1.96, p=. 50, q=. 50, r=8%, assuming design effect =1.5

Putting the above values n is estimated as 600. Now multiplying by design effect 1.5, n will be equal to 900.

Considering non-response rate of about 10% the sample size was determined approximately 1000.

Figure 3.6 Sampling Plan for Quantitative Data Collection



3.7 Data Collection Methods

Data collection is an important aspect of research design and the skills required to meet the research aims and answer the research questions depends on the effectiveness of data collection (Adams *et al,* 2007). For quantitative methods, face-to-face interviews were conducted using a questionnaire with the affected households in the *Sidr* and *Aila* affected areas. According to Monette *et al,* (1986:156) '….. *interview involves an interviewer reading questions to respondents and recording their answers.*' The aim of using this method in this research is that the researcher can probe for more specific answers and can repeat and clarify a question when the response indicates that the respondents misunderstood the question. The method supports the subject matter of this research and the response rate will be higher. It enables the researcher to record the spontaneous answers, observe non-verbal behaviour and to assess the validity of the respondent's answer directly.

Figure 3.7: Data Collection Methods

In this research the researcher to collected qualitative date via a focus group discussion method. "*Focus groups are a form of strategy in qualitative research in which attitudes, opinions or perceptions towards an issue, service or programme are* *explored through a free and open discussion between members of a group and the researcher*"(Kumar, 2011:127).

With this approach the researcher is able to get better perspective of the issue and potential problems are revealed. It also helps to interpret evidence generated from a quantitative study. Also this process helps the researcher to explore views and generate questions in ways that was difficult with face-to-face interviews (Kitzinger, 1995). The researcher has opportunity to talk directly to the respondents in order to clarify, elaborate and get a better understanding of thier ideas and views. Wong (2008) argued that researcher control over the group discussion could be a problem and time can be lost when the discussion drifts from the original issue. Conducting focus group is very expensive but it has been argued that it is a relatively low cost research tool in comparison to others (Wall, 2001). It does not require a lot of preparation and arrangements (Davies, 2007). Adams *et al,* (2014) claimed that focus groups require a lot of preparation and planning.

In the context of health care, compared to other methods, focus group discussions are the most suitable in assessing the public experience and understanding of illness better (Kitzinger, 1993; Ritchie *et al,* 1994). It is an ideal for investigating unexplored areas of human experience and clarifying ambiguous ones (Powel and Single, 1996). Other data and information collection techniques were also employed. For example, a large volume of literature was reviewed on climate change in Bangladesh and climate change globally to find out the research gaps.

3.8 Questionnaire Designing

The type of questionnaire to be used depends on the type of population, the nature of the research question and resources available (May, 1997). A structured questionnaire was used for collecting the quantitative data as it provides uniform information and is easy to count answers (for data analysis). Questionnaires have many advantages. These include being able to reach a wider audience and being cost effective. However, there are also disadvantages of questionnaires. Sometimes it is not possible to customise them to individuals (as it is possible with other methods of data collection). Furthermore, they can sometimes be abstruse and therefore may convey different meanings to respondents. Close-ended questions were asked to respondents in this research. The questions included in the questionnaire were developed bearing in mind the aim and objectives of the research. The literature review conducted by the Researcher also enabled the identification of important variables to add in the questionnaire.

The interview guide for the focus group was designed after a thorough literature review (to get more in-depth knowledge on the issue and to get a better understanding the subject matter). Both the questionnaire and interview guide are given in the appendix section at the end of this thesis. As the participants were non-English speaking, the questionnaire and the interview guides were translated into Bengali versions. Whilst conducting the interviews the researcher spoke in Bengali language, which was then translated into English by the researcher for analysis.

3.9 Data Collection Process

The field study for primary data collection process started in December 2011 and lasted for about a month. For data collection purposes, two undergraduate students from a private university in Bangladesh assisted the researcher. Proper training was provided to them before collecting information from households. Appropriate steps were adopted in order to collect accurate information and all interviewers were very much aware about this. Objectives of the data collection were shared with the survey assitants prior to the study. The household questionnaire and FGD interview guide were clearly explained and the questionnaire was translated into local language, which is Bengali.

The first target area was surveyed was Baliatali and Ghopkhali village of Amtali Upzila of Barguna District (Sidr affected) at the beginning of December 2011. The journey from Dhaka to Amtali was made by bus. With the help of the local people of Amtali, the researcher got a chance to meet the Chairman of the Upzila. After getting permission from the chairman, the researcher started collecting the primary data. A total of 500 household heads were interviewed from Amtali upazila and it took almost 12 days to complete the survey in Amtali. There were no transport facilities in the villages so the interviewers walked down the village and interviewed the households. During the data collection stage, tasks were allocated to each team member and every evening a crosschecking was carried out to avoid any overlapping. The second phase of the interview started at the Aila affected Khulna district. Barabri village of Koyra upzila was selected for data collection purpose. During the household questionnaire survey interviewers repeated complex questions that the respondents had not understand and asked for further elaboration of replies that prompted the respondents to elucidate further on the answers provided to questions asked. The interviewers had faced some challenges whilst doing the interviews. They took a lot of time, effort and cost (especially considering that the research was self-funded).

A total of four FGDs were conducted for the purpose of the research. A focus group discussion requires considerable planning and preparation. The researcher conducted all the sessions as a moderator and two other assistants helped with taking notes. With the help of the chairman of the Amtali upzila, participants were selected for the FGD and Baliatali Primary School was hired for conducting the session. The FGDs in Koyra disctrict was conducted in the conference room of JJS (Jagroto Jubo Songho) NGO. JJS NGO and local UP members helped to contact the participants for the FGD. Refreshments were arranged for the participants during the session. After registering the participants for the sessions, an explanation of the aims and purposes of the research was provided and it was assured that all information would be treated anonymously. The focus group rules and procedures were then explained to all the participatns.

The FGD allowed the researcher to talk to more people and hence it helped him to grasp more breadth and variation of the perceptions and understandings in the field. A flexible approach to timing was adopted with sessions planned to last for approximately between two to two and half hours. During the fieldwork the researcher kept notes of his experiences, thoughts and opinions along the way.

3.10 Ethical Considerations

An Aawareness of ethical issues is a fundamental part of research. Denscombe (2010) states that social researchers are expected to approach their work in an ethical manner. Safeguards that protect populations under investigation need to be an integral part of the whole research project, from data collection to dissemination. The researcher was aware of the ethical codes for researchers, which are standard in the UK. The researcher obtained an approval from the Director of Studies of this PhD Programme before conducting the fieldwork in accordance with the guidelines of Middlesex University. The form is attached with this thesis in Appendix III.

Institutional approval: the researcher sought approval from the centres. In this process; accurate information about the research was provided. A written letter that explains the research idea as well as a copy of the research proposal was provided to each study site. The researcher obtained approval prior any research activity at the specified locations.

Confidentiality and anonymity: the respondents were assured that all information would be kept confidential according to the Data Protection Act 1998 and that information collected was only available to people who were directly involved in this research. The anonymity of the respondents was maintained. The data was analysed in such a way that an individual's identity could not be disclosed to the public. No harm was caused to any respondents who were involved in this research.

Informed consent: The subject was free to choose whether to collaborate in the research activity or not. Accordingly cover letters explaining the purpose of the questionnaires and the right to accept or refuse to participate in the survey was given to the respondents of the study and to the people in charge. At the beginning of each interview, an explanation of its purpose was clearly given.

3.11 Quality control and quality assurance

The research was evaluated based on reliability and validity. This is to ensure that the quality of the research and to guarantee that steps were employed to enhance the reliability and validity of the research where necessary.

3.11.1 Validity

Validity refers to the issue of whether or not an indicator or set of indicators that is devised to gauge a concept really measures that concept (Bryman and Bell, 2007:165). There are two sorts of validity in research-one is internal validity and the other one is external validity. Internal validity is the extent to which the research condition is controlled so that the independent variable causes an effect or change in the dependent variable (Berg and Latin, 2004). The researcher selected groups of people who were directly and indirectly affected by climate change for this research study in order to assess the impact on their health. Data was collected and recorded from affected people through face-to-face interviews. Here climate change is the independent variable and the research main aim is to find out the impact of climate change on the health of the coastal people.

Having completed the survey, the researcher then analyzed the gathered data through different statistical models. On the other hand, according to Last (2001), external validity is also referred to as the generalizability of the research study. The result of the research study is transferable to other groups of the interest or population. The researcher strongly believes that the result of this study will be transferable to groups of people who are affected by climate change in another place.

3.11.2 Reliability

Reliability refers to the consistency of a measure of a concept (Bryman and Bell; 2007: 163). A research instrument can be called reliable when the participant reaction to a particular question in the identical way in repetitive times. There are two ways by which reliability is measured. One is by checking the stability of measurements using a test-retest method (repeatability) and second by examining internal consistency or applying the split half method (Adams *et al,* 2004). The test-retest method of assessing the reliability of data was found to be suitable for this study because it will provide the same result when the questionnaire will be administered with the same population on repetitive time. Reliability can be assured by selecting the most appropriate method for analysing the data and by carefully documenting all the steps of analysis to make sure future replicability. For reliability measurement, 5% randomly selected questionnaires were reinterviewed independently to check the consistency of the responses.

3.12 Data management and analysis plan

The design and plan for a particular analysis depends on the approach has been taken and the type of outcome expected for the analysis purpose (Guest *et al*, 2012). The qualitative data was analysed using a thematic analysis. The qualitative data obtained through FGDs conducted with community people, service providers and NGO and GO staffs and Upzila Officers. Thematic analysis technique was used to analyse the qualitative data. "Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data" (Braun and Clarke, 2006:6). A theme captures something important about the data in relation to research question, and represents some level of patterned response or meaning within the data set. This study will provide a rich description of the data set and will provide some important themes. The identified themes are linked to the data themselves as they are constructed from the data. Detailed analysis stages are explained in chapter 7.

The quantitative data was analysed using the statistical package of social sciences (IBM SPSS) software version 21. Coding and data entry from the questionnaire were completed just after the filed study from Bangladesh. This data obtained from the questionnaire that carried out to the target households. The head of sample the household interviewed using a questionnaire. To meet the first objective of this research, which is investigating the socio-economic characteristics of the affected respondents- age, sex, religion, marital status, income, and employment status information explored using descriptive statistics and frequency distribution (Chapter 4). Also this chapter contains information on mass media access, quality of accommodation of the respondents and about the area they are living in. Information about the vulnerable group of people in the climate affected area and the effect on women during climate change is also explored in this chapter.

To meet the second objective of this research is to evaluate the direct and indirect impact of climate change on the health of the affected people. Results and findings of this chapter are discussed in Chapter 5. For analysis purpose, the researcher has identified the dependent variables and independent variables. Knowledge on climate change among the affected population is also explained in this chapter.

The sixth chapter of data analysis provides a comparison of health problems among the climate affected area people before and after Sidr and Aila. All the households' members' information has been analysed in this chapter. It gives a detailed picture of the diseases that have increased after Sidr and Aila. This chapter also includes the key determinants of health outcomes of climate change in the affected areas of Bangladesh. The researcher has tried to find out the other important factors that are responsible for climate induced health effects on the affected population. This analysis helps to achieve the 3rd and 5th objectives of the research.

The last analysis chapter (7th Chapter) contains a qualitative analysis of the Focus Group Discussion. A thematic analysis has been used to analyse the qualitative data. Nvivo software version 10 was used for the analysis purpose. This chapter supports to discover the experiences the climate affected people and health service providers.

3.13 Summary

A critical review of different paradigms has been explained in this chapter as well as an explanation given for the selected approaches used in the study. The main approach is a mixed method approach. The quantitative and qualitative data collection technique were analysed and shown to suit the needs of this investigation. This chapter also presented the data collection process, the sampling methods suitable for the research and ethical issues related to the research were critically discussed.

Data analysis and Findings

Chapter 4: Characteristics of the Household

4.1 Introduction

This chapter explores the characteristics of household living in climate-affected areas. This description will provide a clear understanding of the respondents who are included in the study. The first part of the analysis will show the profile of households and their composition. Secondly, it will show the socioeconomic characteristics of the households and the quality of accommodation. In the third section, it will show the results of the main sources of drinking water for affected households and their toilet facilities. Fourthly, it will present the results of knowledge about climate change from the cyclone *Sidr* and *Aila* affected population and it will discuss the perception of climate related changes in the affected areas. This section also explains about mass media access. These analyses were carried out using frequencies and percentages.

4.2 Profile of the Households

This section of the analysis shows the demographic characteristics of households as follows: gender of the household, age of the household, religious status, marital status, educational status and level of education (primary, secondary, higher secondary and above) and the number of years they have lived in the area. Table 4.1 shows that 52 % respondents are from cyclone Sidr affected areas and 48.2% respondents are from cyclone Aila affected areas. About 87.6% of respondents of the Household heads are male, 72.6% of households are Muslim followed by 27.4% of households are Hindu. The majority of the household heads (36%) are aged over 50 years and only 22.6 % are below 30 years. In both the cyclone-hit areas, 92% of household heads are married; only 4.8% household heads are widowed. About 73.9% respondents are educated. Among them 43.5% respondents have studied up to primary level and 25.2

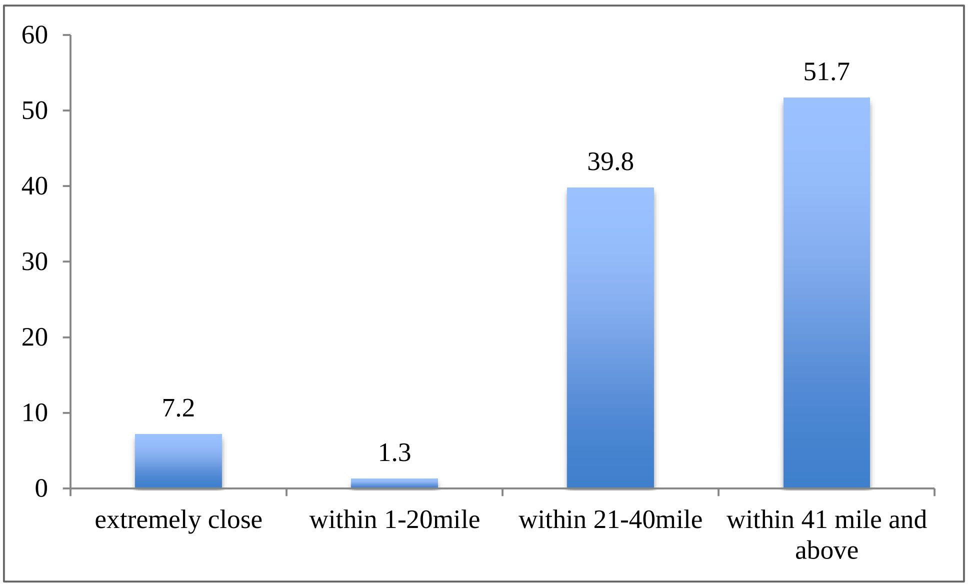
% respondents have completed their secondary education. The statistics show that 44.2% of respondents have/had been living in the affected areas from 21 to 40 years and 15.6% respondents have/had been residing in the area for 61 to 80 years.

Table 4.1: Summary of the demographic characteristics of the households

Variables	Frequency	Percent
Survey Area		
Sidr	504	51.8
Aila	469	48.2
Gender of the Household Head		
Male	853	87.6
Female	120	12.3
Age of the Household Head		
<30	220	22.6
30-39	196	20.1
40-49	202	20.8
50 above	355	36.5
Religious Status		
Muslim	706	72.6
Hindu	267	27.4
Marital Status		
Married	890	91.5
Single	20	2.1
Divorced	10	1.0
Separated	6	0.6
Widowed	47	4.8
Educational Status		
Yes	719	73.9
No	254	26.1
Level of Education		
Primary Education	424	43.5
Secondary Education	246	25.2
Higher Secondary Education	29	2.9
Higher Secondary Education above	20	2.1
Living in this area		
Less than a year	9	0.9
1-20 years	79	8.1
21-40 years	430	44.2
41-60 years	297	30.5
61-80 years	152	15.6
81-100 years	6	0.6

Figure 4.1 displays that 7.2% of the households are extremely close to the seashore while 52 % of households are within 41 miles or above from the seashore.

Figure 4.1: Distances (in mile) of the household from sea level



4.3 Household Composition

Table 4.2 shows that in the Sidr affected areas 57.7% households have 2-4 family members. Approximately 67% of households have 1-2 female members in the household. 28.6% of households have a member in their family who are over 60 years of age. At least 11% households have a disabled member of the family. For the household composition of the Aila affected areas, the statistics show that 63.3 % of households have 2-4 family members and 70.4% households have 1-2 female members. At least 25% of households have members who are over 60 years of age. About 15% of households have a disabled family member and among them 8.3% have a physical disability.

Table 4.2: Household composition in affected areas

Variables	Sidr	Aila
	Percent	
Members in the family		
1 member	2	1.3
2-4 members	57.7	63.3
5-6 members	30.4	26.7
7 or more members	9.9	8.7
Female members in the family		
No female member	0.8	0.4
1-2 members	66.7	70.4
3-4 members	29.0	27.7
4 or more members	3.6	1.5
Members over 60 years of age		
No member	61.9	66.5
1 member	28.6	24.9
2 -3 members	8.9	8.5
4 or more members	0.2	
Children in the family		
No children	24.0	24.0
1 child	30.0	30.0
2-3 children	43.8	43.8
4-5 children	1.6	2.1
6 or more children	0.6	
Disabled members in the family		
Yes	10.7	14.5
No	89.3	85.5
Type of disability		
Physical	2.8	
Developmental	1.8	8.3
Mental	0.6	1.3
Learning	1.2	1.1
Sensory	1.4	1.9
Others	0.2	0.9

4.4 Socioeconomic Characteristics

Table 4.3 shows the socioeconomic characteristics of the households. About 30% of the heads of households are involved in agricultural work and approximately 17% of households are fishermen. A vast majority of household spouses do household work (82%). Most people earn a very low income (less than 3000 Taka). This means that about 58% people earn below the extreme poverty level.

Table 4.3: Socioeconomic Characteristics of the Head of Household for total sample

Variables	Frequency	Percent
Main Occupation of the Household Head	290	30.0
Agriculture	161	16.6
Fishing	60	6.2
Business	101	10.4
Household work	39	4.0
Unemployed	37	3.8
Service	53	5.5
Skilled labourer	129	13.3
Unskilled labourer	9	0.9
Retired	8	0.8
Van or Rickshaw puller	79	8.2
Taxi or CNG or Bus driver	1	0.1
Other		
Occupation of the spouse		
Agriculture	12	1.3
Fishing	28	3.1
Business	8	0.9
Household work	732	82.2
Unemployed	10	1.1
Service	11	1.2
Skilled labourer	14	1.6
Unskilled labourer	41	4.6
Van or rickshaw puller	4	0.4
Taxi or CNG or Bus driver	30	3.4
Monthly Income of the Household Head		
<=3000 Taka	557	58.0
>3000 Taka	404	42.0

4.5 Quality of Accommodation

Table 4.4 shows that in both cyclone affected areas most of the households are made of tin shade. Approximately 5% of households in the Sidr affected areas are made from Kacha compared to 7.2% of households in the Aila affected areas. All these are not strong enough to protect from cyclones.

Table 4.4: Types of materials used to build the household

Variables	Frequency	Percent
Sidr		
Kacha	25	5.0
Semi Pucca	2	0.4
Pucca	1	0.2
Tin shade	464	92.1
Gole Pata	6	1.2
Other	6	1.2
Aila		
Kacha	34	7.2
Semi Pucca	19	4.1
Pucca	3	0.6
Tin shade	388	82.7
Gole Pata	14	3.0
Other	11	2.3

4.6 Household assets

Figures 4.2 and 4.3 show that 66% of households in the Sidr area and 73.6% of households in the Aila affected area have mobile phones. Approximately 23% and 15.4% of households in the Aila affected areas have radio and television. Only 16.3% of households in the Sidr affected areas have electricity whereas approximately 15.6% of households have electricity in the Aila affected areas

Figure 4.2: Assets of the households in Sidr affected areas

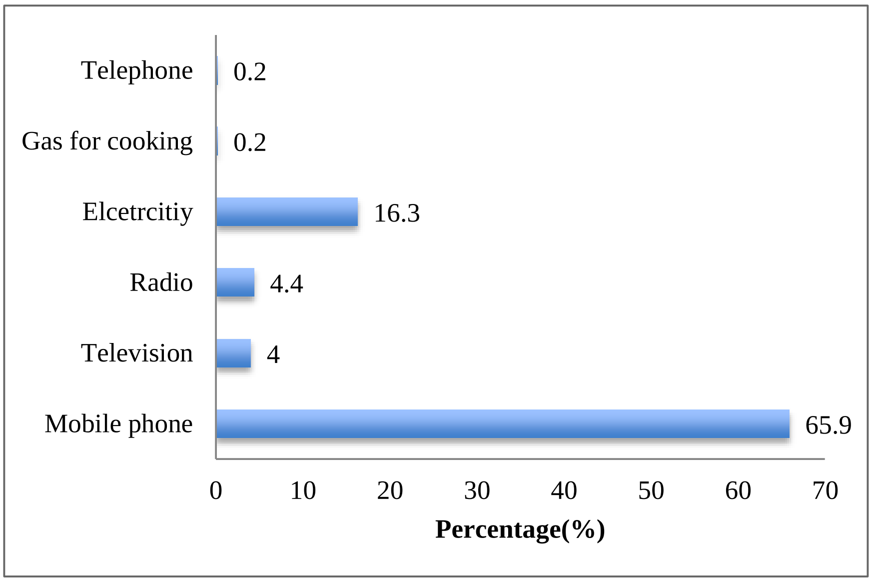
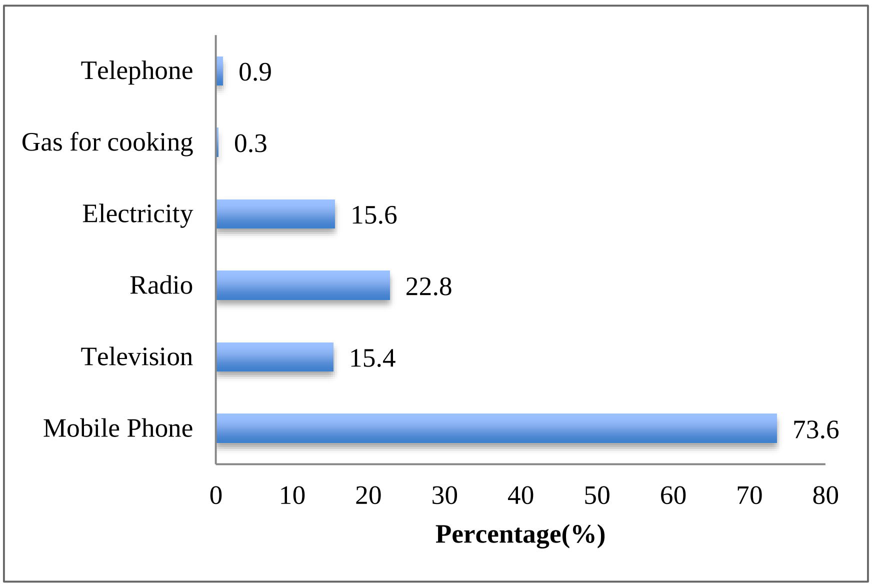


Figure 4.3: Assests of the households in Aila affected areas



4.7 Sources of Drinking Water and Toilet Facility

Table 4.5 shows that 52% of households in the Sidr affected areas travel more than 100 miles to fetch drinking water for household use and approximately 55% of households have to travel more than 100 miles in the Aila affected areas. The results also show some gender bias in regards to the person who is responsible for fetching drinking water. It is mostly wives (80%) who are responsible for fetching drinking water in Sidr affected areas and similar results were found in the Aila affected areas. Also 65.5% of wives are responsible for managing the drinking water for households.

Table 4.5 Distanced travelled to fetch drinking water

Variables	Frequency	Percent
Distanced travelled to fetch drinking water		
Sidr		
Does not apply	44	8.7
More than 100m	262	52.0
Less than 100m	198	39.3
Aila		
Does not apply	23	4.9
More than 100m	256	54.6
Less than 100m	190	40.5
Person responsible for fetching drinking water		
Sidr		
Husband	12	2.4
Wife	401	79.6
Sons	22	4.4
Daughters	17	3.4
Others	29	5.8
No one	23	4.6
Aila		
Husband	5	1.1
Wife	307	65.5
Sons	12	2.6
Daughters	27	5.8
Others	93	19.8
No one	25	5.3

Figures 4.4 and 4.5 show that approximately 99% of households use Deep tube well as their main source of drinking water in the Sidr affected areas whereas as 52 % of households' main source of drinking water in the Aila affected areas are Deep tube well, 46% of households use tube well.

Figure 4.4: Sources of drinking water in the Sidr affected areas

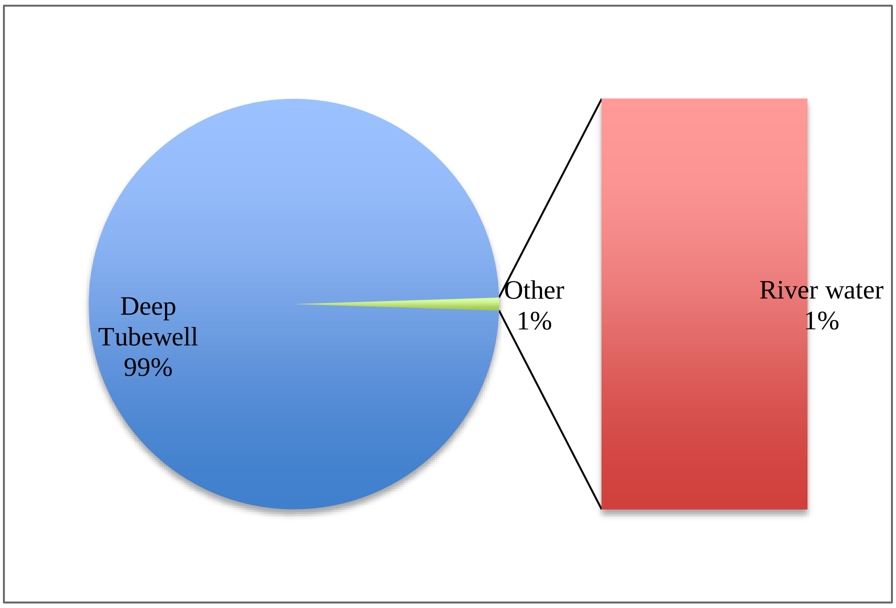


Figure 4.5: Sources of drinking water in the Aila affected areas

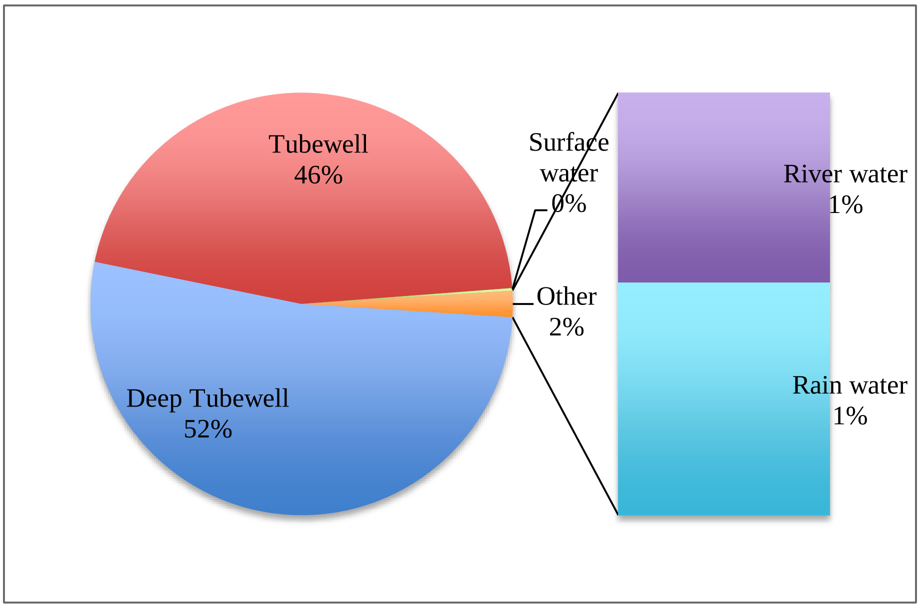


Table 4.6 shows that approximately 88% of households use pit or slab latrine. Around 8% of households use open latrine in the Sidr affected areas while approximately 84% of households use pit or slab latrine in the Aila affected areas.

Table 4.6 Toilet Facilities in the Households

Variables	Frequency	Percent
Sidr		
Septic tank or modern-toilet	4	0.8
Pit or slab latrine	442	87.7
Open latrine	39	7.7
Hanging latrine	8	1.6
Water sealed	10	2.0
Other	1	0.2
Aila		
Septic tank or modern- toilet	24	5.1
Pit or slab latrine	393	83.8
Open latrine	36	7.7
Hanging latrine	2	0.4
Water sealed	8	1.7
Other	6	1.3

4.8 Mass media Access

Table 4.7 shows the results of mass media access. Only 5% of households listen to the radio every day and 13.3% of households watch television 1 to 3 days in a week. Approximately 98% of households don't read newspapers in the Sidr affected areas. In the Aila affected areas, approximately 19% of households listen to the radio every day, 23.2% households watch television 1 to 3 days in a week and only 7 % of households read a newspaper less than once in a week.

Table 4.7: Mass Media Access

Variables	Frequency			Percent		
	TV	Radio	Newspaper	TV	Radio	Newspaper
Sidr						
Everyday	45	25	2	8.9	5.0	0.4
4-6 days	47	33	1	9.3	6.5	0.2
1-3 days	67	22	3	13.3	4.4	0.6
Less than once in a week	36	28	5	7.1	5.6	1.0
Don’t watch/listen/read	309	396	493	61.3	78.6	97.8
Aila						
Everyday	66	88	13	14.1	18.8	2.8
4-6 days	32	18	7	6.8	3.8	1.5
1-3 days	109	34	19	23.2	7.2	4.1
Less than once in a week	81	35	34	17.3	7.5	7.2
Don’t watch/listen/read	181	292	394	38.6	62.3	84.0

4.9 Knowledge and Perception about Climate Change

Table 4.8 shows about 87% of households have heard about climate change in the Sidr affected areas and approximately 90% know about climate change in the Aila affected areas. About 71.4% of households have heard about climate change from their friends or relatives and 41.2% of households have heard about climate change from non-government agencies. Around 48% of households from both the cyclone-hit areas strongly agreed that the weather pattern is generally changing. Approximately 98 % of households have observed the changes in the weather pattern in the last 10 years. 70% of household respondents said that climate change is affecting them personally.

Table 4.8: Knowledge about Climate Change

Variables	Frequency	Percent
Heard about climate change		
Sidr		
Yes	437	86.7
No	67	13.3
Aila		
Yes	421	89.8
No	48	10.2
Where heard about climate change		
Television	336	34.5
Radio	205	21.1
Newspaper	56	5.8
Friends or relatives	695	71.4
From Government Agencies	138	14.2
From Non-government Agencies	401	41.2
Pattern of weather is generally changing		
Strongly Agree	463	47.6
Agree	477	49.0
Neutral	15	1.5
Disagree	4	0.4
Strongly Disagree	14	1.4
Last 10 years seen changes in weather pattern		
Yes	955	98.1
No	18	1.8
Climate change is affecting you personally		
Often	683	70.2
Sometimes	236	24.3
Seldom	48	4.9
Never	6	0.6
Climate change is affecting the local community		
A great deal	696	71.5
Much	221	22.7
Somewhat	50	5.1
Little	6	0.6

Figure 4.6 shows that temperature increases (97%) and frequent natural disasters (89%) have been observed by households from both Sidr and Aila cyclone- affected areas due to climate change

Figure 4.6: Changes observed by the respondents

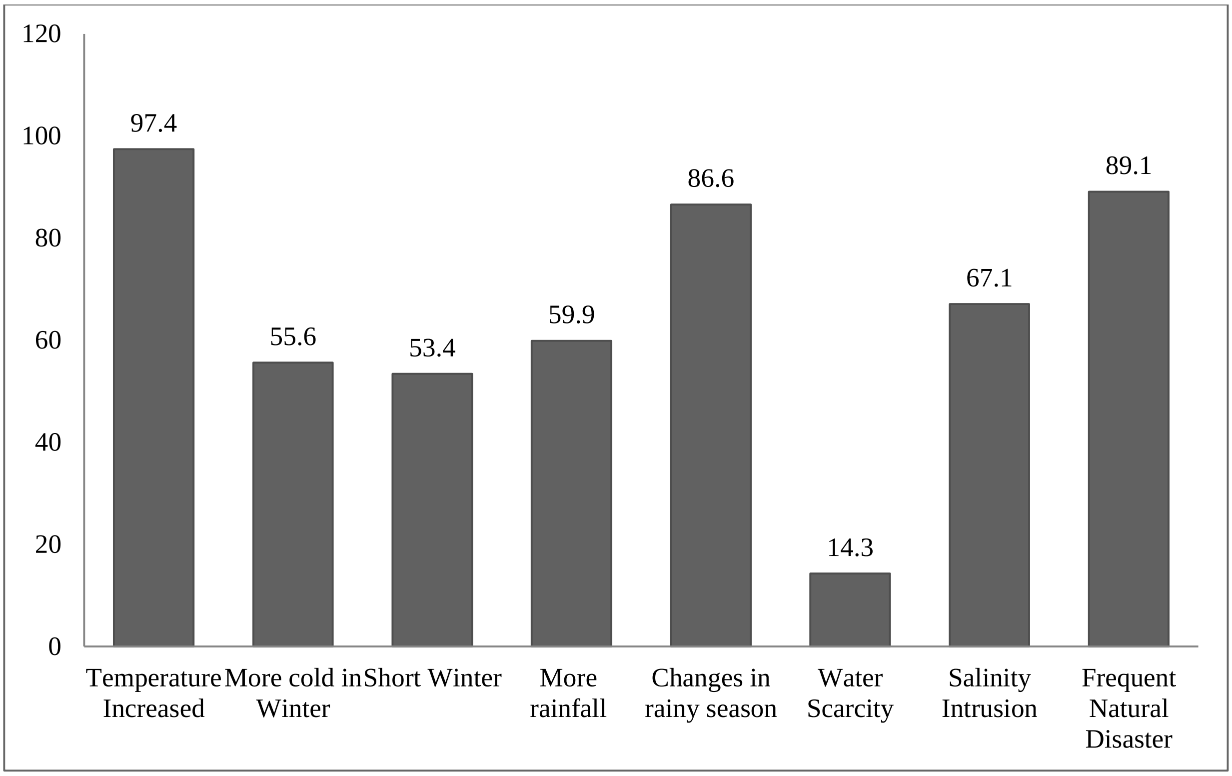


Table 4.9 is shows that approximately 61% of household respondents reported that climate change is affecting their health status, 93% of household respondents think that climate change is not beneficial for them and around 61% of participant households regarded climate change as a great threat to their area. Around 93% of household respondents from the cyclone-hit areas stated that climate change is causing changes in their livelihood. More than 90% of respondents from both areas said there is reduction of crop yield due to climate change. About 94% of respondents from the Aila affected areas and 88% of

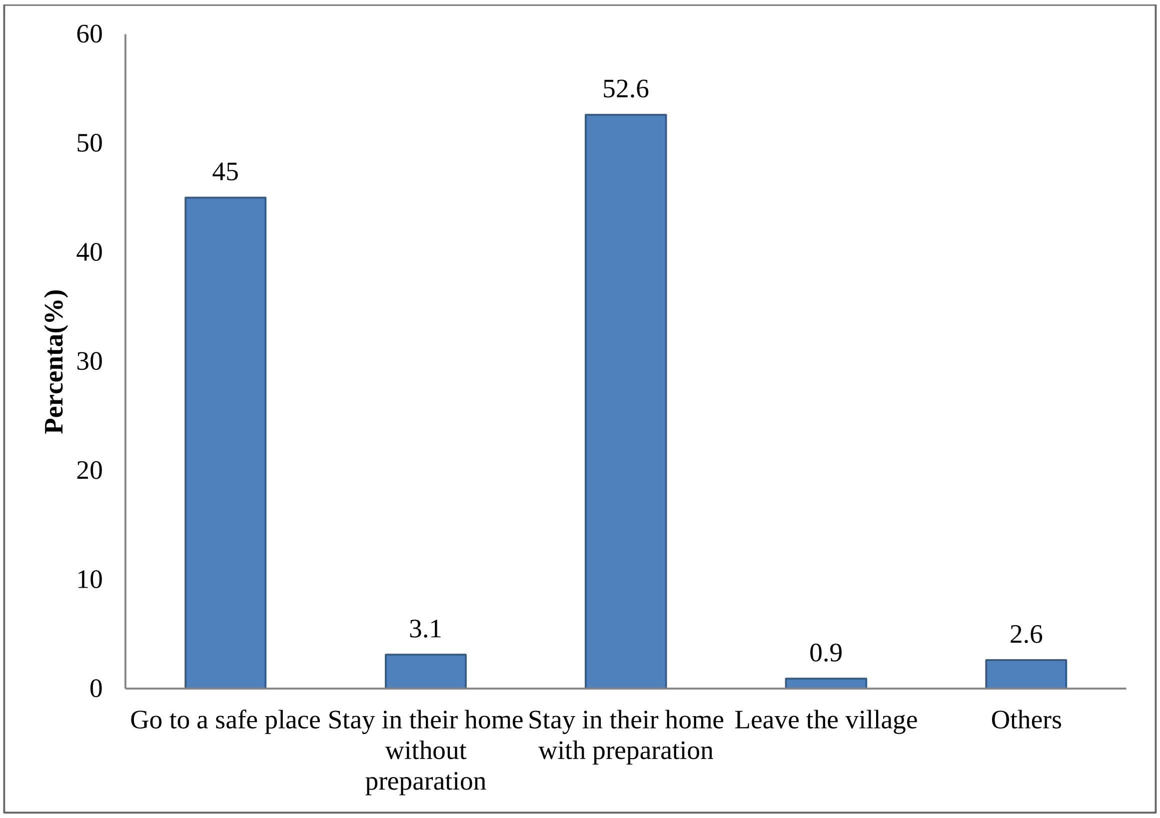
respondents from the Sidr affected areas reported that their hardship has increased in daily life due to climate change.

Table 4.9 Perception about climate change

Variables	Frequency	Percent
Climate change is affecting health		
To a great extent	591	60.7
Somewhat	332	34.1
Very little	20	2.1
Not at all	30	3.1
Climate change is beneficial for you		
Yes	45	4.6
No	907	93.2
How serious is climate change in your area	10	1.0
Not serious at all	16	1.6
Moderately serious	4	0.4
Neither	351	36.1
Serious	592	60.8
Very serious		
Climate change is causing-		
Sidr		
Changes of livelihood	473	93.8
Reduction of income	412	81.7
Loss of employment	233	46.2
Reduction of job opportunities	188	37.3
Reduction of crop yield	475	94.2
Increased food prices	462	91.7
Increase of family's other expenses	424	84.1
Hardship increased in daily life	444	88.1
No impact	1	0.2
Aila		93.6
Changes of livelihood	439	93.0
Reduction of income	436	51.6
Loss of employment	242	45.2
Reduction of job opportunities	212	91.7
Reduction of crop yield	430	88.5
Increased food prices	415	91.7
Increase of family's other expenses	430	94.0
Hardship increased in daily life	441	1.1
No impact	5	

Figure 4.7 shows that 45% of household respondents said that they go to a safe place when there are changes in the weather conditions, around 52% of household respondents reported that they stay in their home with preparation.

Figure 4.7: Where they take shelter when there are changes in the weather conditions



4.10 Summary

This chapter outlined the results of characteristics of the households in the affected areas. The main occupations of the people in the studied areas are agriculture and fishing. There are no significant differences found in the household composition between the affected villages. The women of the households are mainly responsible for fetching drinking water for their families. The results also show that the majority of the respondents know about climate change and the significant changes they have observed and experienced are; rises in temperature, frequent natural disasters, increased salinity and changes in the rainy season.

Chapter 5: Direct and Indirect Effects of Climate Change

5.1 Introduction

This chapter presents the direct and indirect effects of climate change on the health of the people in the climate-affected areas of Bangladesh. The first section of this chapter covers the descriptive statistics of the household respondents, natural disasters, financial effects on households and the immediate effects of natural disasters on households using frequency tables, percentages and graphs. Secondly, it discusses the results of climate change and its association with Sidr and Aila in the affected areas. This was followed by a non-parametric test using Chi-square test to evaluate the direct and indirect impacts of climate change on the health of the people. All analyses for statistical significance ($p<0.05$) have been conducted utilising Pearson's Chi-Square. These analyses will provide a basis for the discussion of the statistical analysis in Chapter Eight using multiple regression analysis.

5.2 Natural Disasters in the affected areas

This segment of analysis presents information about the respondents based on the natural disasters in the affected areas. The vast majority of the respondents 98% hadfaced cyclones in the last 10 years and 99% had faced floods in their areas. About 56% of respondents said that there was the presence of long standing saline water in the coastal areas. Almost 99% of respondents from both Sidr and Aila affected areas reported that the scale of natural disasters has increased recently. About 98.5% of respondents from Aila affected areas and 92.7% respondents from Sidr affected areas think that climate change is responsible for the natural disasters (shown in Table 5.1).

Table 5.1:Statistics of Natural Disasters in the affected areas

Variables	Total		Sidr		Aila	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Types of natural disasters faced in the last 10 years						
Cyclone	960	98.7	499	99.0	461	98.3
Floods	964	99.1	499	99.0	465	99.1
Riverbank Erosion	861	88.5	398	79.0	463	98.7
Droughts	518	53.2	249	49.4	269	57.4
Earthquakes	204	21.0	40	7.9	164	35.0
Extreme Heatwaves	173	17.8	9	1.8	164	35.0
Storm surge	513	52.7	269	53.4	244	52.0
Water salinity	542	55.7	146	29.0	396	84.4
Others	9	0.9	4	0.8	5	1.1
Recently the scale of disasters has increased						
Yes	961	98.8	494	98.0	467	99.6
No	6	0.6	5	1.0	1	0.2
Don't Know	4	0.4	4	0.8	1	0.2
Climate change is responsible for natural disasters						
Yes	929	95.5	467	92.7	462	98.5
No	2	0.2	2	0.4	0	0
Don't Know	42	4.3	35	6.9	7	1.5
Local area hit by natural disasters very frequently						
Yes	956	98.3	493	97.8	463	98.7
No	6	0.6	4	0.8	2	0.4
Don't Know	11	1.1	7	1.4	4	0.9

5.3 Financial effect

Around 98% of respondents from both the areas suffered financially just after the disaster (see Table 5.2). About 21.4% and 62.5% of respondents respectively received financial support from nongovernment organizations and government organizations in cyclone Sidr affected areas. The number of respondents in Aila affected areas who received non-government support was higher than Sidr affected areas.

Table 5.2: Financial effects on households and support received

Variables	Sidr		Aila	
	Frequency	Percent	Frequency	Percent
Suffered financially after the disaster				
Yes	493	97.8	460	98.1
No	11	2.2	9	1.9
Extent of financial suffering				
Enough	479	95.0	459	97.9
Not enough	25	5.0	6	1.3
Financial support from Non-Government Organization				
Yes	108	21.4	257	54.8
No	396	78.6	212	45.2
Financial support from Government Organization				
Yes	315	62.5	419	89.3
No	189	37.5	50	10.7

5.4 Immediate effect following the disaster

The statistics show that 96% of respondents were fearful about their death and injury during and immediately following the cyclone hit areas. Around 31% of household respondents reported that one or more members of their family were injured. 48.3% of household respondents also reported the death of one or more family members during and immediately following the cyclone. It was also revealed that 84% of households were destroyed during the cyclone and 4% of household respondents said that they lost their family members when the natural disaster hit their areas. This is shown in Table 5.3.

Table 5.3:Effect on the households during and immediately following the disasters

Variables	Total		Sidr		Aila	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Fear about death and injury						
Yes	935	96.1	485	96.2	450	95.9
No	38	3.9	19	3.8	19	4.1
Anyone seriously injured						
Yes	305	31.3	191	37.9	114	24.3
No	668	68.7	313	62.1	355	75.7
Anyone died						
Yes	470	48.3	302	59.1	168	35.8
No	503	51.7	202	40.1	301	64.2
Lost any family member						
Yes	39	4.0	24	4.8	15	3.2
No	934	96.0	480	95.2	454	96.8
Household seriously damaged or destroyed						
Yes	824	84.7	413	81.9	411	87.6
No	149	15.3	91	18.1	58	12.4

5.5 Climate change and natural disasters

Figures 5.1 and 5.2 present the information on whether or not climate change is responsible for cyclone Sidr and Aila in their respective areas and 95% of respondents from the Sidr and 97% of respondents from the Aila affected areas think that climate change played a role in cyclone Aila and its devastating effect on their lives.

Figure 5.1: Climate Change is responsible for Sidr

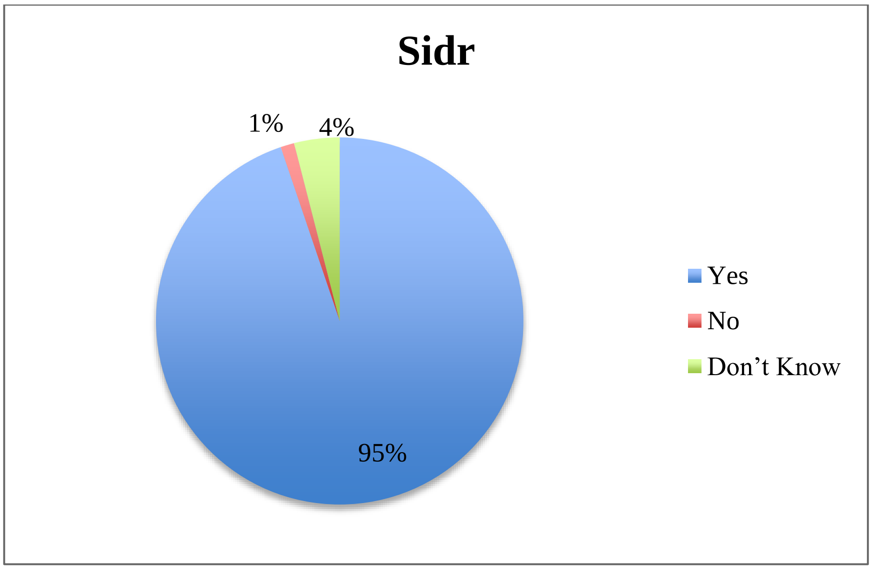
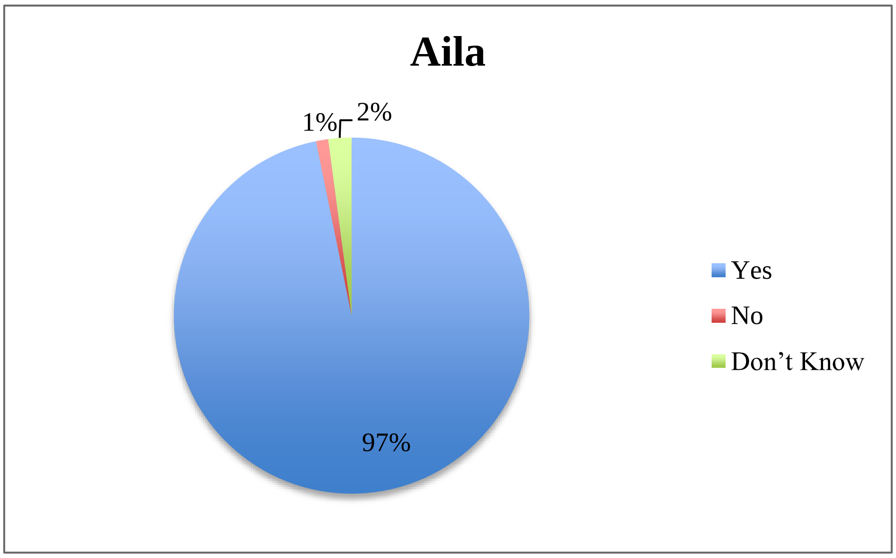


Figure 5.2: Climate Change is responsible for Aila



5.6 Health of the people and emerging diseases

Figure 5.3 displays the distribution of respondents based on their response to whether the changing environment is good for their health. Approximately 92% and

94.5% of household respondents from both affected villages said the changing environment is not good for their health

Figure 5.3: Is a changing environment good for health

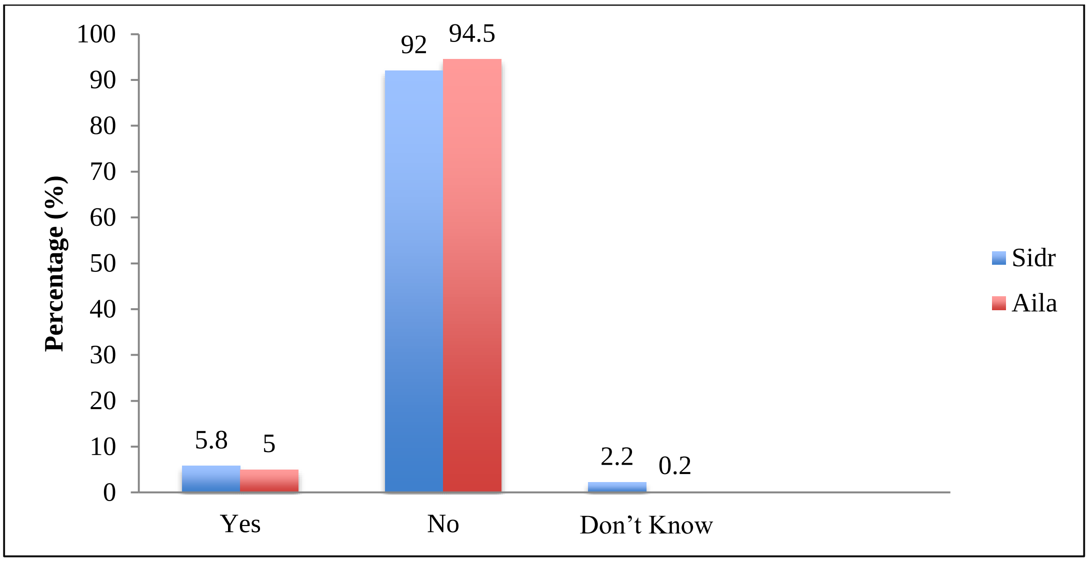
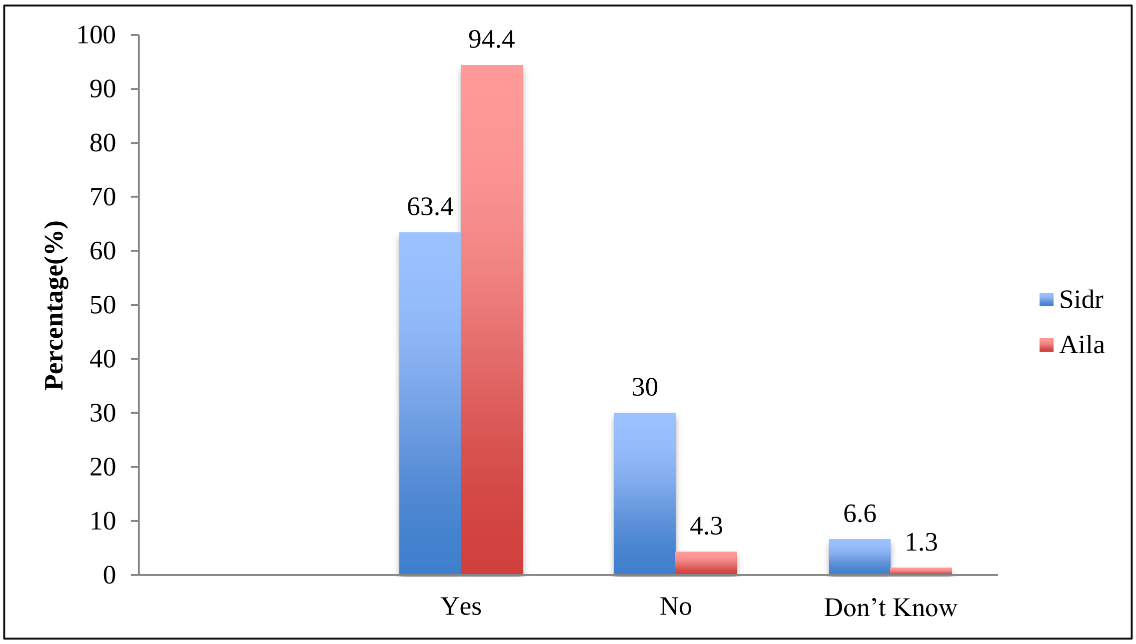


Figure 5.4 reveals that about 63% of household respondents had heard about emerging diseases from Sidr hit areas and about 94% of household respondents from Aila affected villages had heard about emerging diseases in the area.

Figure 5.4: Heard about emerging diseases in the area



In considering emerging diseases in the affected areas (Table 5.4) about 58% of household respondents said "yes" emerging diseases are common nowadays in the cyclone Sidr blown areas 61% of household respondents said "very much yes" in Aila affected areas. Almost 99% of responses from Aila attacked areas said that climate change is indirectly responsible for emerging diseases. Of the responses, about 96% of people in cyclone Aila areas acknowledged that emerging diseases pose a threat to human health and 56% of responses from Sidr areas said that emerging diseases are having a serious impact on health.

Table 5.4: Emerging diseases in the affected areas

Variables	Frequency	Percent
Emerging diseases are common nowadays		
Sidr		
Very much yes	36	7.2
Yes	292	58.1
No	170	33.8
Don't Know	5	1.0
Aila		
Very much yes	286	61.2
Yes	175	37.5
No	5	1.1
Don't Know	1	0.2
Climate change is indirectly responsible for emerging diseases		
Sidr		
Yes	299	59.4
No	7	1.4
Don't Know	197	39.2
Aila		
Yes	444	98.7
No	1	0.2
Don't Know	4	0.9
Emerging diseases having serious health effects		
Sidr		
Yes	285	56.5
No	34	6.8
Don't Know	184	36.6
Aila		
Yes	432	96.0
No	15	3.3
Don't Know	3	0.7

5. 7 Effects of Sidr and Aila

Table 5.5 reveals the effects of Sidr and Aila on health conditions of the affected population. Almost 99% of responses from both the affected areas opined that human suffering increased after the cyclone. Around 98% of respondents from cyclone Sidr and Aila hit areas indicated that health conditions of people were poor after the cyclone. About 68% of household respondents reported from the Sidr areas and 51% respondents from Aila areas that their family members suffered from different health problems. Almost 99% of responses from Aila struck areas showed that people suffered from mental health problems due to the cyclone.

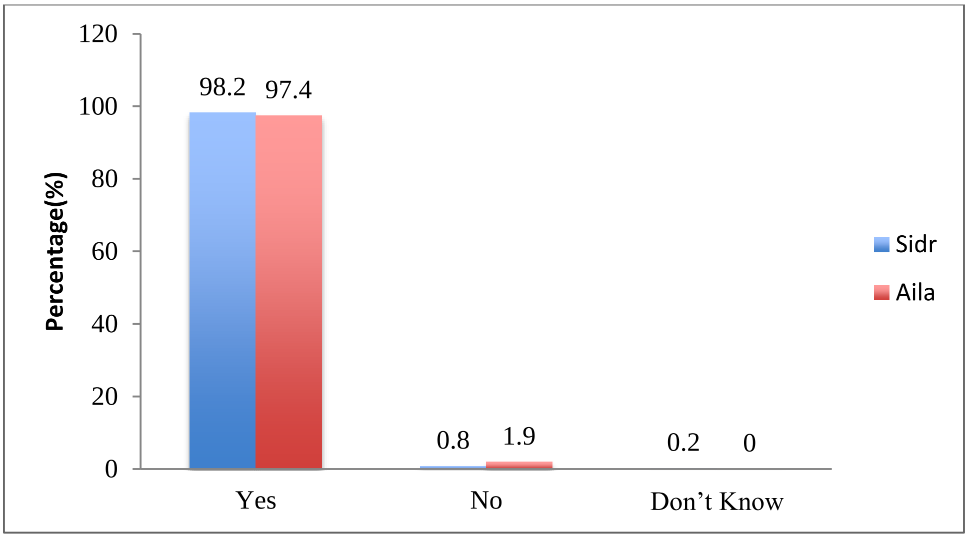
Table 5.5: Sidr or Aila affects the health conditions of the people

Variables	Sidr		Aila	
	Frequency	Percent (%)	Frequency	Percent (%)
Climate changed affected the surrounding environment				
Yes	487	96.6	462	98.5
No	3	0.6	4	0.9
Don't Know	13	2.6	1	0.2
Increased human suffering				
Yes	498	99.2	462	99.1
No	3	0.6	2	0.4
Don't Know	1	0.2	1	0.2
Worsened health conditions				
Yes	492	97.8	459	98.7
No	5	1.0	2	0.4
Don't Know	6	1.2	4	0.9
Anyone in the family suffered health problems during the last disaster				
Yes	346	68.7	242	51.6
No	154	30.6	219	46.7
Don't Know	4	0.8	8	1.7
Cyclone affected mental health				
Yes	339	67.4	460	98.9
No	96	19.1	0	0
Don't Know	68	13.5	5	1.1
Anyone suffered from mental health problems				
Yes	316	62.7	432	92.9
No	105	20.8	8	1.7
Don't Know	81	16.1	23	4.9

5.8 Climate change and Infectious Diseases and Malnutrition

Figure 5.5 displays that almost 98% of household respondents from both areas faced the shortage of pure drinking water just after the cyclone ravaged the area.

Figure 5.5: Scarcity of pure drinking water



Figures 5.6 and 5.7 reveal that according to the household respondents, about 92% of responses from Sidr affected areas and 100% of responses from Aila affected areas support the statement that there was an outbreak of infectious diseases due to scarcity of water.

Figure 5.6 :Outbreak of infectious diseases due to shortage of water in Sidr area

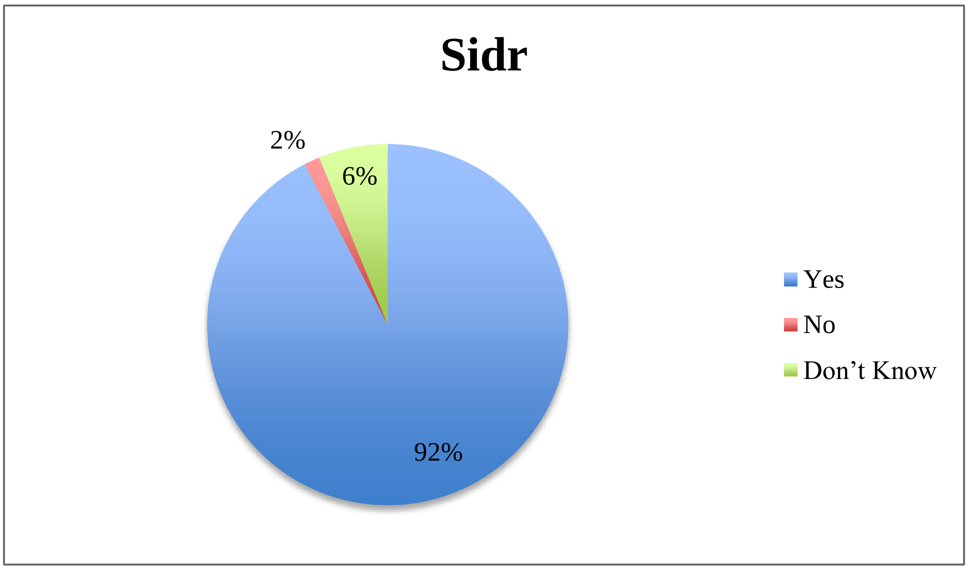


Figure 5.7:Outbreak of infectious diseases due to shortage of water in Aila area

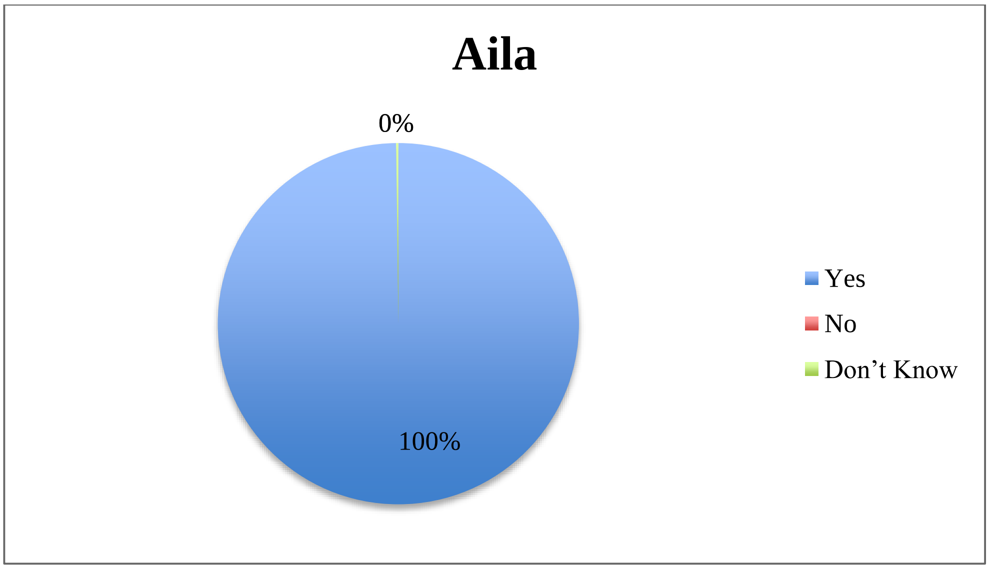


Table 5.6 indicates that almost 91% and 97% of household respondents from both affected areas respectively said that they suffered from malnutrition. 90% of household respondents from Sidr and 74% of household respondents from Aila affected areas revealed that they had no food at home just after the cyclone

Table 5.6: Effect of climate change on infectious diseases and malnutrition

Categories	**Sidr**		**Aila**	
	Frequency	Percent	Frequency	Percent
Sidr or Aila responsible for the outbreak of infectious diseases				
Yes	471	93.6	464	99.8
No	3	0.6	0	0
Don't Know	29	5.8	1	0.2
Had difficulty in managing food				
Yes	479	95.0	438	93.4
No	23	4.6	24	5.1
Difficulties faced regarding food availability				
No food at home	449	89.1	348	74.2
No money to buy food	331	65.7	282	60.1
Local food shops destroyed	271	53.8	350	74.6
Scarcity of food	334	66.3	317	67.6
Others	6	1.2	19	4.1
Suffered from malnutrition				
Yes	461	91.5	456	97.2
No	17	3.4	6	1.3
Don't Know	22	4.4	2	0.4
Sidr or Aila responsible for malnutrition				
Yes	403	80.0	439	93.6
No	101	20.0	30	6.4
Local health centre was affected				
Yes	4	0.8	23	4.9
No	425	84.3	380	81.0
Don't Know	73	14.5	62	13.2

5.9 Non-parametric Test

In this section of the analysis chapter, a non-parametric test called Chi-square test has been carried out. In this test the dependent variable is named as climate change caused Sidr and Aila. The meaning of direct and indirect impact of climate change has already been discussed in the literature review chapter.

5.9.1. Direct impact of Climate Change

The results in Table 5.7 indicate that the dependent variable, climate change, is directly responsible for increased natural disasters in the affected areas and the Pearson chi-square test is significant at a 5% level. There is no association found between climate change and change of occupation of the household respondent. Similar results have been observed for damaged toilet facilities and scarcity of pure drinking water. The surrounding environment affected by climate change induced natural disasters in the affected area also scored significantly using the Chi-square test. The natural disasters due to climate change increased human suffering and the affected population found it difficult to manage their daily food during and after the disaster. As shown in the table below, damage to the household and injury to persons is found to be directly related to climate change causing Sidr and Aila.

Table 5.7: Direct Impact of Climate Change

Variables	Pearson Chi-square Test Value	Degree of Freedom	Aymp.Sig. (2-sided)
Increased natural disasters	77.754	1	.000
Change of occupation	1.607	1	.205
Increased human sufferings	17.959	3	.000
Difficulty in managing food	19.759	2	.000
Surrounding environment	40.523	2	.000
Household damaged	6.388	1	.011
Injury to anyone	4.033	1	.045
Damaged toilet facility	0.445	1	.505
Scarcity of pure drinking water	0.452	1	.502

5.9.2 Indirect Impact of Climate Change

The results in Table 5.8 show that the dependent variables are significantly associated with climate change causing Sidr and Aila (p<0.05). Climate change is indirectly affecting our health. Due to natural disasters like Sidr and Aila, crop growing lands are devastated making it harder for people in the affected areas to grow crops. The results show that diseases have emerged in the affected areas and people are falling ill due to these diseases, even after the natural disasters. Sidr and Aila are also responsible for affecting the mental health status of the affected population and it could be attributed that changing climate is not good for human beings. Sidr and Aila due to climate change were found to be significant with increased cases of malnutrition in the areas.

Table 5.8: Indirect impact of Climate Change

Variables	Pearson Chi-square Test Value	Degree of Freedom	Aymp.Sig. (2-sided)
Affect our health	27.743	1	.000
Difficulty in growing crops	6.304	1	.012
Diseases have increased	11.702	1	.001
Is not good for human beings	11.854	1	.001
People suffered mentally	16.561	3	.001
Responsible for Malnutrition	28.166	4	.000
Responsible for the emerging diseases	22.407	3	.000

5. 10. Summary

This chapter has outlined the results of direct and indirect impacts of climate change on the health of the coastal population. The results show that both survey areas are affected by frequent natural disasters and the majority of the respondents reported that climate change is responsible for the increased frequency of disasters in their area. Additionally, this study's results reveal that the indirect impacts of climate change are –health status, mental suffering, increased malnutrition and are responsible for some emerging infectious diseases and direct impacts are - changes in the surrounding environment, destruction of households, food scarcity and injury to people.

Chapter 6: Health problems before and after cyclone and Key determinants of health outcomes

6.1 Introduction

This analysis chapter presents information on the before and after scenario of health problems among the climate-affected people. It also presents key factor's associated with climate change and the affected community's knowledge of the impact of climate change. The first segment of the analysis provides descriptive statistics of the comparison of before and after scenario of health problems from both cyclone Sidr and Aila affected villages. The next segment displays information about the vulnerable population of the community using descriptive statistics. The information has been presented using graphs and tables.

Then bivariate analysis has been performed to find out the occurrence of health problems in both areas after the disasters and to compare the health problems before and after the disasters. A chi-square test has been applied to determine the association between the two categorical variables. A Pearson Correlation analysis has also been used. Correlation analysis is used to measure the degree of association between two variables.

In order to find out the key determinants of health outcomes in the climate affected areas logistic regression analysis has been performed. Regression analysis often displays changes in some phenomenon as a result of some influencing factors i.e., it estimates that the association of the independent or explanatory variable or stimulating factor for predicting the dependent and response variable. In the analysis, any health problems before and after are considered as the dependent or response variables. More details about the variables are discussed in the next section.

6.2 Variables used in the analysis

In this research variables are classified into two categories: (1) Demographic variables (2) Socioeconomic variables

6.2.1 Demographic variables

There are four demographic variables used in this analysis. These are:

1. The age of the household members (at the time of interview) in completed years. The age of the household members are classified into three groups on the basis of their age, i.e. below 5 years, 5-17 years and 18 years and above. It is understood that climate change has variable impacts on different age groups.

2. Gender of the household member is another demographic variable used in this research. Various literature on climate change and its impact has emphasized gender.

3. The number of children living in the family is categorized into four groups: none, 1 child, 2 children and 3 children or more.

4. The religion of the household head variable is classified into two categories: Muslim and Hindu.

5. Survey area: In this research the survey area is divided into categories: Cyclone Sidr affected area and cyclone Aila affected area.

6.2.2 Socioeconomic variables

The following socioeconomic variables are used in this research:

1. The level of education of the household head: in this research the level of education has been classified into three categories (i) no education (ii) primary education and (iii) secondary education and above.

2.Access to Television is defined as the dichotomy of yes and no.

3. Access to radio is also classified into two categories yes and no.

4.Electricity connection in the household is categorized in this research as yes and no.

5. Household monthly income is a very important factor interms of climate change adaptation and health care. The household monthly income were classified into two income groups <=3000 Taka and > 3000 Taka. (Taka is the name of the currency in Bangladesh. 1 USD= 77 Taka as of 26 October 2013)

6.3 Before and after effect of Sidr

This segment of analysis presents the comparison of disease rates and health problems from before and after cyclone *Sidr* affected villages. Table 6.1 shows that the rate of diarrhoea, typhoid, jaundice, skin diseases and respiratory problems has significantly increased just after the cyclone hit the area. The table shows that diarrhoea cases has increased from 27 % to 51% and skin disease problems increased from 1.6% to 35% after cyclone *Sidr*. Mental health problems and injury to respondents also increased considerably.

Table 6.1:Comparison between before and after effect of cyclone *Sidr* (n=2133)

Health problems	Before		After	
	Frequency	Percent	Frequency	Percent
Diarrhoea	577	27.1	1038	48.7
Typhoid	99	4.6	569	26.7
Food poisoning	18	0.8	49	2.3
Viral infection of eye	9	0.4	235	11.0
Skin diseases	34	1.6	735	34.5
Hepatitis (jaundice)	74	3.5	551	25.8
Respiratory infections	176	8.3	534	25.0
Pneumonia	35	1.6	175	8.2
Malaria	1	0.0	3	0.1
Dengue Fever	0	0.0	1	0.0
Mental Health problem	8	0.4	81	3.8
Injury	27	1.3	144	6.8
Death	1	0.0	6	0.3
Others	22	1.0	196	9.2

6.4 Before and after effect of Aila

Table 6.2 presents the comparison of health problems before and after the effects of cyclone Aila. There is a significant increase in diarrhoeal (79.8%) and skin disease (78.5%) cases after the cyclone. The number of people suffering from respiratory problems also increased (44%) remarkably comparison to previous conditions. Also, the mental health cases increased by up to (9%) just after the cyclone. There are not any reported cases of dengue and malaria.

Table: 6.2: Comparison between before and after effect of Aila (n=1933)

Health problems	Before		After	
	Frequency	Percent	Frequency	Percent
Diarrhoea	322	16.7	1513	78.3
Typhoid	121	6.3	431	22.3
Food poisoning	134	6.9	465	24.1
Viral infection of eye	96	5.0	570	29.5
Skin diseases	72	3.7	1511	78.2
Hepatitis (jaundice)	56	2.9	156	8.1
Respiratory infections	334	17.3	846	43.8
Pneumonia	73	3.8	87	4.5
Malaria	15	0.8	54	2.8
Dengue Fever	2	0.1	6	0.3
Mental Health problem	28	1.4	170	8.8
Injury	46	2.4	175	9.1
Death	5	0.3	21	1.1
Others	42	2.2	206	10.7

6.5 Vulnerable population

This segment of the analysis presents descriptive information about the vulnerable population. As can be seen from Table (6.3) almost every single respondent stated that cyclone Sidr and Aila affected the vulnerable population (older women, children and women) of the affected areas. The severe effects of cyclone Sidr and Aila had an impact on physically and mentally challenged individuals, pregnant women and childrens development.

Table 6.3: Descriptive Statistics of vulnerable population

Categories	Yes		No		Don't Know	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Affect on older people	966	99.3	7	0.7	0	0
Affect on children	964	99.1	0	0	2	0.2
Affect on women	961	98.8	4	0.4	1	0.1
Affect on physically and mentally challenged individual	964	99.1	0	0	2	0.2
Affect on pregnant women	958	98.5	10	1.0	1	0.1
Affect on development on children	949	97.5	9	0.9	6	0.6

Respondents were also asked about if any of the female members of their family faced any kind of violence during and after the violence. Figure 6.1 shows that 39.6 % respondents said that there was violence on women just after the cyclone and 57.7% of respondents said that there was no violence on women.

Figure 6.1: Violence on women after cyclone

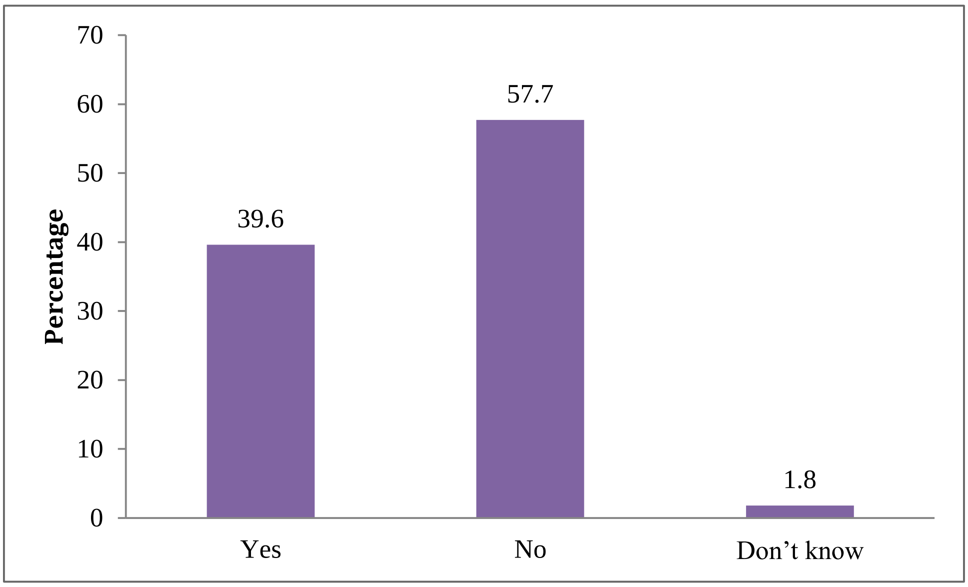
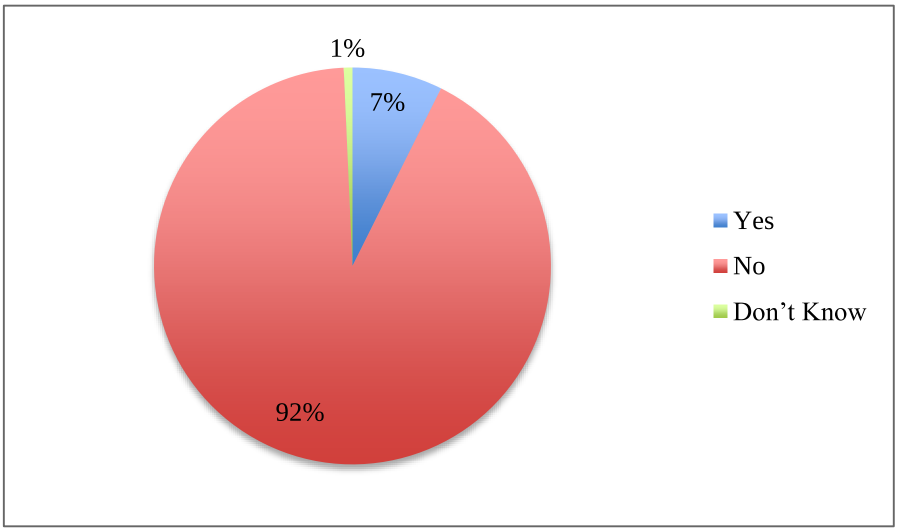


Figure 6.2 presents information on as to whether or not the respondents faced any kind of violence during and after the disaster. Only 7% of household respondents stated that they had faced violence whereas 92% said that they didn't face any type of violence.

Figure 6.2: Faced any kind of violence



6.6 Comparison of health problems by area

Chi-square analysis was performed on selected health problems after the disasters such as as diarrhaea, food poisoning, mental health problems and skin disease. The results are shown in Table 6.4. The results indicate that there is a strong association among the occurrence of diseases by two areas Sidr and Aila. It also implies that irrespective of any type of disaster health problems following occurrence of natural calamity is common.

Table 6.4: Comparison of health problems after cyclone by area

Variables	**Categories**	**Survey area**					
		Sidr		Aila		Total	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Diarrhoea	No	1095	51.3	420	21.7	1515	37.3
	Yes	1038	48.7	1513	78.3	2551	62.7
Chi-square and - *p* –value 380.2; $p < 0.001$							
Food Poisoning	No	2084	97.7	1468	75.9	3552	87.4
	Yes	49	2.3	465	24.1	514	12.6
Chi-square and *p* –value 434.7; $p < 0.001$							
Mental health problem	No	2052	96.2	1763	91.2	3815	93.8
	Yes	81	3.8	170	8.8	251	6.2
Chi-square and *p* –value 43.7; $p < 0.001$							
Skin disease	No	1398	65.5	422	21.8	1820	44.8
	Yes	735	34.5	1511	78.2	2246	55.2
Chi-square and *p* –value 38.0; $p < 0.01$							
Total		2133	52.5	1933	47.5	4066	100.0

6.7 Bivariate analysis of before and after health problems

Bivariate (correlation) analysis has been carried to find out the relationship of health problems among the respondents from before and after cyclone *Sidr*. In this analysis, the dependent variable is health problems after the cyclone. Based on the information collected from the respondents, two dichotomous outcome indicators (1 and 0) were constructed based on whether or not they had the disease before. Here 1 means yes and 0 represents no. Table 6.5 shows that before diarrhoea is statistically significantly associated with after diarrhoea. This means that the household respondents who had diarrhoea and who had not diarrhoea before cyclone Sidr has the probability of having diarrhoea after the cyclone. Similarly, the probability of the households respondents who experienced skin diseases and who did not experience skin diseases before the cyclone have a higher chance of suffering from skin disease problems after the cyclone. The table also shows that mental health problems, respiratory problems and food poisoning are statistically correlated among the respondents in before and after the cyclone Sidr.

Table 6.5 Correlation analysis of selected health problems before and after Cyclone Sidr

		After Diarrhoea	**After skin diseases**	**After mental health**	**After respiratory problem**	**After food poisoning**
Before Diarrhoea	Pearson Correlation	.522**				
	Significance (2-tailed)	.000				
	N	2133				
Before Skin diseases	Pearson Correlation		.073**			
	Significance (2-tailed)		.001			
	N		2133			
Before mental health	Pearson Correlation			.148**		
	Significance (2-tailed)			.000		
	N			2133		
Before respiratory problem	Pearson Correlation				.196**	
	Significance (2-tailed)				.000	
	N				2133	
Before food poisoning	Pearson Correlation					.088**
	Significance (2-tailed)					.000
	N					2133

** Significant at 0.01 level (2-tailed)

The Table below presents the correlation analysis of health problems among the respondents from before and after the cyclone Aila. Table 6.6 shows that health problems like diarrhoea, skin diseases, mental health problems, respiratory problem and food poisoning are statistically significantly correlated with before and after the cyclone. This means that the respondents who didn't have the health problems or who did have the health problems before the cyclone, there is a probability that they will suffer from the health problem after the cyclone.

Table 6.6 Correlation analysis of selected health problems before and after Cyclone Aila

		After Diarrhoea	**After skin diseases**	**After mental health**	**After respiratory problem**	**After food poisoning**
Before Diarrhoea	Pearson Correlation	.135**				
	Significance (2-tailed)	.000				
	N	1933				
Before Skin diseases	Pearson Correlation		.058*			
	Significance (2-tailed)		.011			
	N		1933			
Before mental health	Pearson Correlation			.283**		
	Significance (2-tailed)			.000		
	N			1933		
Before respiratory problem	Pearson Correlation				.201**	
	Significance (2-tailed)				.000	
	N				1933	
Before food poisoning	Pearson Correlation					.409**
	Significance (2-tailed)					.000
	N					1933

** Significant at 0.01 level (2-tailed) * Significant at 0.05 level (2-tailed)

6.7.1 Bivariate analysis of knowledge on climate change and demographic characteristics

Table 6.7 displays the results of a bi-variate analysis of knowledge of climate change and demographic characteristics of the household head. The analysis shows that age is not associated with the knowledge of the household. However, gender of the household is associated with knowledge about climate change. Most household heads are male and have more knowledge on climate change. There is no differential impact on climate change by the two disaster areas i.e. Sidr and Aila. Similarly, religion of the household head and number of children are not associated with knowledge about climate change.

Table 6.7 Bi-variate analysis of knowledge of climate change and demographic characteristic of household head

Demographic Characteristics	Categories	Knowledge about climate change					
		Yes		No		Total	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Age of household head (Years)	<30	198	90.0	22	10.0	220	100.0
	30-39	180	91.8	16	8.2	196	100.0
	40-49	174	86.1	28	13.9	202	100.0
	50+	306	86.2	49	13.8	355	100.0
Chi-square=5.4 and p -value= 0.14							
Gender of household head	Male	759	89.0	94	11.0	853	100.0
	Female	99	82.5	21	17.5	120	100.0
Chi-square=4.2 and p -value= 0.040							
Survey area	Sidr	437	86.7	67	13.3	504	100.0
	Aila	421	89.8	48	10.2	469	100.0
Chi-square=2.2 and p -value= 0.14							
Religion of household head	Muslim	617	87.4	89	12.6	706	100.0
	Hindu	241	90.3	26	9.7	267	100.0
Chi-square=1.5 and p-value= 0.21							
Number of children living in the family	None	190	85.6	32	14.4	222	100.0
	1 Child	290	90.9	29	9.1	319	100.0
	2 Children	289	87.6	41	12.4	330	100.0
	3 Children	89	87.3	13	12.7	102	100.0
Chi-square=3.9 and p -value= 0.27							
Total		858	88.2	115	11.8	973	100.0

6.7.2 Bivariate analysis of knowledge on climate change and socio-economic characteristics

In order to investigate the association between knowledge about climate change and selected socio-economic characteristics of the household heads a bi-variate analysis was carried out with education, access to mass media, access to electricity, income of the household head and access to mobile phone. Exposure to radio is significantly associated with knowledge of climate change but access to TV has no significant impact on it. Socioeconomic variables like education, household monthly income and possessing a mobile phone are significantly associated with knowledge on climate change.

The results demonstrate that these characteristics will play a significant role in creating awareness about the consequences of the occurrence of disasters and its effect on the economy and health. The bivariate relationships also imply that access to radio would increase their knowledge on the impact of disasters and consequently would help coping capacity and the management as shown in Table 6.8.

Table 6.8 Bi-variate analysis of knowledge of climate change and socioeconomic characteristic of household head

Socioeconomic Characteristics	Categories	Knowledge about climate change					
		Yes		No		Total	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Level of education of household head	None	207	80.5	50	19.5	257	100.0
	Primary	373	88.2	50	11.8	423	100.0
	Secondary+	278	94.9	15	5.1	293	100.0
Chi-square=27.0 and p -value= .001							
Access to Television	No	775	88	106	12	881	100.0
	Yes	83	90.2	9	9.8	92	100.0
Chi-square=0.4 and p -value= 0.52							
Access to Radio	No	736	87.2	108	12.8	844	100.0
	Yes	122	94.6	7	5.4	129	100.0
Chi-square=5.8 and p -value= 0.01							
Electricity connection in the household	No	722	88.3	96	11.7	818	100.0
	Yes	136	87.7	19	12.3	155	100.0
Chi-square=3.7 and p -value= 0.85							
Household monthly income	<=3000	476	85.5	81	14.5	557	100.0
	>3000	373	92.3	31	7.7	404	100.0
Chi-square=10.7 and p -value= .001							
Access to mobile phone	No	246	83.1	50	16.9	296	100.0
	Yes	612	90.4	65	9.6	677	100.0
Chi-square=10.5 and p -value= .001							
Total		858	88.2	115	11.8	973	100.0

6.7.3 Bi-variate analysis of occurrence of diarrhoea and demographic characteristics

Table 6.9 displays the prevalence of occurrence of diarrhoea before and after the cyclones Sidr and Aila using demographic characteristics. The results show that there is a significant association between age and diarrhoea in both areas. The occurrence of diarrhoea after the disasters is a common phenomenon and in particular it is a serious health problem for all age groups. The prevalence of diarrhea was also prevalent in the families with 1 or more children in cyclone Sidr affected areas. Religion and gender of the households have no significant association with diarrhoea.

Table 6.9: Bi-variate analysis of occurrence of diarrhoea and demographic characteristics of household

Variables	Categories	Sidr area			Aila area		
		Percent of occurrence of diarrhoea			Percent of occurrence of diarrhoea		
		Before	After	n	Before	After	n
Age of the household member	<5 yr	3.0	40.7	167	3.6	48.6	111
	5-17 yr	22.3	50.2	560	16.3	79.4	514
	18 yr +	31.8	49	1406	17.9	80.4	1308
p -value		0.001	0.091		0.001	0.001	
Gender of the household member	Male	27.7	48.7	1071	18.1	77.8	1002
	Female	26.4	48.6	1062	15.1	78.7	931
p -value		0.478	0.944		0.085	0.636	
Number of children living in the family	None	23.2	38.8	392	13.4	79.2	298
	1 Child	33.9	54.4	607	17.0	77.7	660
	2 Children	24.9	47.9	800	16.4	76.3	708
	3 Children	24.2	51.7	327	20.2	83.7	263
p -value		0.001	0.001		0.200	0.094	
Religion of household head	Muslim	27.1	48.6	2081	18.3	73.3	873
	Hindu	26.7	51.1	45	15.2	82.3	1056
p -value		0.954	0.737		0.071	0.003	

6.7.4 Bi-variate analysis of occurrence of diarrhoea and socioeconomic characteristics

The socio-economic characteristics of the households also associated with the occurrence between the two periods. The percentage of diarrhoea was higher among individuals whose household heads had no formal education. This result is consistent in both the areas and even before and after the natural disasters as shown in Table 6.10.

Table 6.10: Bi-variate analysis of occurrence of diarrhoea and socioeconomic characteristic of household

Variables	Categories	Sidr area			Aila area		
		Percent of occurrence of diarrhoea			Percent of occurrence of diarrhoea		
		Before	After	n	Before	After	n
Level of education of household head	None	33.3	52.5	579	16.5	80.3	461
	Primary	25.7	49.2	1041	15.5	77.6	742
	Secondary	22.5	43.1	506	17.9	77.5	726
p -value		*0.001*	*0.007*		*0.462*	*0.479*	
Household monthly income	<=3000	27.8	52.0	1074	15.0	79.9	1063
	>3000	26.2	45.1	1040	18.9	76.3	848
p -value		*0.383*	*0.001*		*0.023*	*0.060*	
Electricity connection in the household	No	28.1	49.7	1750	17.2	77.2	1605
	Yes	22.1	43.6	376	13.9	83.3	324
p -value		*0.017*	*0.032*		*0.145*	*0.015*	
Access to Television	No	26.8	48.6	2088	17.2	78.3	1738
	Yes	42.1	52.6	38	11.5	78.0	191
p -value		*0.035*	*0.619*		*0.045*	*0.939*	
Access to Radio	No	26.5	48.4	2020	16.5	79.2	1487
	Yes	37.7	53.8	106	17	75.1	442
p -value		*0.011*	*0.278*		*0.833*	*0.071*	
Mobile Phone	No	27.7	47.0	664	13.8	80.6	448
	Yes	26.7	49.4	1462	17.5	77.5	1481
p -value		*0.642*	*0.306*		*0.069*	*0.168*	

6.7.5 Bi-variate analysis of occurrence of Skin disease and demographic characteristics

Table 6.11 displays the occurrences of skin disease before and after the disaster are given in table below. The percentage of skin infections were higher (almost 2% before Sidr) at aged 18 years and above but it increased to 39% after Sidr. The prevalence of skin infections also significantly increased among all ages after Aila. A similar situation is also observed in the case of skin disease among the children in both areas. There is a strong association in skin disease between before and after the disasters in both areas. The results indicate that skin disease is also prevalent following the occurrence of disasters.

Table 6.11: Bi-variate analysis of occurrence of Skin disease and demographic characteristic of household

Variables	Categories	Sidr area			Aila area		
		Percent of occurrence of skin disease			Percent of occurrence of skin disease		
		Before	After	n	Before	After	n
Age of the household member	<5 yr	1.2	7.8	167	0.0	51.4	111
	5-17 yr	1.3	30.9	560	3.1	76.5	514
	18 yr +	1.8	39.0	1406	4.3	81.1	1308
p -value		*0.640*	*0.001*		*0.051*	*0.001*	
Gender of the member	Male	1.9	36.0	1071	3.5	77.4	1002
	Female	1.3	32.9	1062	4.0	78.9	931
p -value		*0.311*	*0.122*		*0.577*	*0.424*	
Number of children living in the family	None	2.0	41.1	392	4.0	81.9	298
	1 Child	1.3	31.1	607	3.0	75.9	660
	2 Children	2.0	38.3	800	3.8	77.4	708
	3 Children	0.6	24.2	327	4.9	81.4	263
p -value		*0.304*	*0.001*		*0.559*	*0.103*	
Religion of household head	Muslim	1.6	34.7	2081	4.6	73.5	873
	Hindu	2.2	28.9	45	3.0	81.9	1056
p -value		*0.736*	*0.418*		*0.074*	*0.001*	

6.7.6 Bi-variate analysis of occurrence of Skin disease and socioeconomic characteristics

Table 6.12 presents that the occurrence of skin infections after Sidr was insignificant among members with access to radio, television and mobile phones and head with no education and also found insignificant after Aila.

Table 6.12: Bi-variate analysis of occurrence of Skin disease and socioeconomic characteristic of household

Variables	Categories	Sidr area			Aila area		
		Percent of occurrence of skin disease			Percent of occurrence of skin disease		
		Before	After	n	Before	After	n
Level of education of household head	None	1.9	33.3	579	4.3	81.1	461
	Primary	2.0	34.9	1041	2.7	78.3	742
	Secondary	0.4	35.4	506	4.4	76.0	726
p -value		0.046	0.749		0.164	0.116	
Household monthly income	<=3000	2.0	36.4	1074	3.3	82.7	1063
	>3000	1.1	32.6	1040	4.4	72.5	848
p -value		0.066	0.066		0.222	0.001	
Access to Television	No	1.6	35.1	2088	3.9	77.5	1738
	Yes	0.0	7.9	38	2.6	83.8	191
p -value		0.428	0.001		0.392	0.047	
Access to Radio	No	1.5	35.0	2020	3.6	78.6	1487
	Yes	2.8	26.4	106	4.1	76.5	442
p -value		0.300	0.070		0.668	0.338	
Electricity connection in the household	No	1.7	34.7	1750	3.8	76.4	1605
	Yes	1.3	33.8	376	3.4	86.7	324
p -value		0.646	0.721		0.725	0.001	
Mobile Phone	No	27.7	33	664	1.3	80.8	448
	Yes	26.7	35.3	1462	4.5	77.3	1481
p -value		0.207	0.299		0.002	0.117	

6.8 Multivariable analysis

This segment of the analysis present results from binary logistic regression. Multivariable analysis shows the effect of each predictor variable while controlling all remaining variables in the model. The logistic regression analysis was performed to investigate the influencing factors which have influence on morbidity and consequently on health of the household members before and after cyclones Sidr and Aila. The findings are shown in Table 6.13.

6.8.1 The Logit model

For this analysis, the Logit Model is described as follows:

=> $\ln\left(\frac{\rho_i}{1-\rho_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 \ldots\ldots\ldots\ldots + \beta_n X_n$

Here $X_1, X_2, \ldots X_n$ are independent variables and $\beta_0, \beta_1, \beta_2, \ldots \beta_n$ are the co-efficient of the independent variables that are to be estimated.

Here, occurrence of health problems before and after the disaster has been considered as the dependent variable. The dependent variable is binary which is the occurrence of the health problems before and after the disaster. Its value is one whereas the occurrence of no health problem before and after the disaster is valued at zero.

The independent variables used in this model are: age of the household member, gender of the member, number of children living in the family, religion of the household and survey area, level of education of household head, access to television, access to radio, electricity connection in the household, access to mobile phone and household monthly income. Considering all the variables in the Logit Model, we have:

⇨ $\ln\left(\frac{\rho_i}{1-\rho_i}\right) = \beta_0 + \beta_1$ age $+ \beta_2$ gender $+ \beta_3$ number of children $+ \beta_4$ religion $+ \beta_5$ survey area $+ \beta_6$ level of education $+ \beta_7$ access to television $+ \beta_8$ access to radio $+\ldots$

Where $P_{i=}$ Probability that health problems occuered before and after disaster

1-P_i = Probability that no health problem occuered before and after disaster

β_0 = Constant and β_1, β_2, β_3, β_4, β_5, β_6, β_7 are the co-efficients are to be estimated.

6.8.2 Logistic regression

The logistic regression analysis shows that age, gender and religion of household member, access to electricity, monthly income, education level of the household head and number of living children in the family have a statistically significant effect on the occurrence of health problems before and after the disasters (Sidr and Aila). The odds ratio of the coefficient age indicates that household members whose aged 18 years and above their health problems is about eight times higher compared to the children aged under five years irrespective of before and after disaster.

The analysis reveals that those households who had access to television compared to those who had no access to television were 20 percent higher chance of being affected by health problems before the disaster and those who had access to television were 66 percent less likely to have morbidity. The odds ratios also demonstrate that access to radio and TV are positively related with occurrence of health problems. These results are contrary to the Researcher's expectations and may be attributed to the small number of households possessing TV and radios and possibly the confounding effects of the radio and TV failed to capture expected direction of the relationships. Access to electricity is negatively associated with health problems as supported by the odds ratio. Households with electricity are 29% less likely to experience health problems that those who did not have access to electricity connection.

Income status of the household has an important impact on the health problems. The higher the income the lower the probability of health problems. For example, households whose income are Taka 3000 and above their health problems are 19% lower than those households whose income is less than Taka 3000.

The number of children in the households is positively associated with health problems. The higher is the number of children the higher the likelihood that they will suffer from health problems. As expected education level of the household head is negatively correlated with the health problems. The higher is the education level of the household head the lower the probability they will suffer from morbidity. For instance, household heads who had secondary education, had a 34% less probability of suffering from health problems than those who had no education. The logistic regression analysis also suggests mobile phones are not an important determinant of health problems since the odd ratio is found to be positive.

The further analysis of logistic regression shows that males are more vulnerable to health problems after the disaster. It is revealed from the logistic regression coefficients that females were 12 percent less likely to have morbidity before the disaster while after the disaster females were 22 percent less likely to suffer from health problems. Similarly, religion of the household head shows that Hindus have a 28% reduction in health problems compared to Muslims. As compared to Sidr area, respondents from Aila area had 2 times a higher risk of getting health problems after the natural disaster. The value of log likely -2 Log likelihood Chi-square suggests model is well fitted and statistically significant ρ-value=< 0 .000.

Table 6.13 Odd ratio from logistic regression analysis assessing the association between explanatory variables and occurrence of health problem before and after the natural disaster

Variables	Categories	Odd ratio (95% C.I. for Odd ratio)	
		Occurrence of health problems before the disaster	Occurrence of health problems after the disaster
Age of household member	<5 yr	1.00	1.00
	5-17 yr	6.31 (4.03-9.87)	2.53 (1.80-3.56)
	18 yr +	7.89 (5.10-12.22)	2.72 (1.99-3.71)
Gender of the member	Male	1.00	1.00
	Female	0.88(0.77-1.00)	0.78 (0.64-0.95)
Religion of household head	Muslim	1.00	1.00
	Hindu	0.72 (0.60-0.86)	1.76 (1.26-2.44)
Access to Television	No	1.00	1.00
	Yes	1.20 (0.87-1.66)	0.34 (0.22-0.54)
Access to Radio	No	1.00	1.00
	Yes	1.18 (0.96-1.46)	1.15 (0.82-1.62)
Electricity connection in the household	No	1.00	1.00
	Yes	0.71 (0.59-0.87)	1.33 (1.00-1.78)
Household monthly income	<=3000	1.00	1.00
	>3000	0.81 (0.70-0.92)	0.65 (0.53-0.80)
Number of children living in the family	None	1.00	1.00
	1 Child	1.35 (1.10-1.65)	1.11 (0.83-1.48)
	2 Children	1.40 (1.14-1.72)	1.38 (1.03-1.84)
	3 Children	1.27 (0.99-1.62)	1.30 (0.92-1.85)
Level of education of household head	None	1.00	1.00
	Primary	0.70 (0.60-0.83)	1.02 (0.80-1.30)
	Secondary	0.66 (0.55-0.79)	0.93 (0.71-1.21)
Mobile Phone	No	1.00	1.00
	Yes	1.14 (0.97-1.33)	1.29 (1.03-1.61)
Survey area	Sidr	1.00	1.00
	Aila	1.11 (0.94-1.31)	1.92 (1.48-2.48)
	Constant	0.10	2.04
	-2 Log likelihood	5091.4	2819.3
	Model Chi-square	202.2 ρ-value=< 0 .000	170.1 ρ-value=< 0 .000

6.7 Summary

This chapter outlines the clear distinguish picture of health conditions of people of cyclones Sidr and Aila. The above findings show that the health problems like diarrhoea, typhoid, food poisoning, skin diseases, respiratory problems and mental problems are significantly increased in post disaster situations compared to pre disaster statistics. The statistics also reveal that women, children and elderly people are the most vulnerable groups during and after the disaster and violence on women are increased after the disaster. The correlation analysis presents from both the affected areas that before and after the cyclone Sidr and Aila, health problems such as diarrhoea, skin diseases, mental health, respiratory problems and food poisoning are statistically correlated. The analysis shows that Sidr and Aila are responsible for increasing the health problems in the affected populations and indirectly affects them by causing problems with crop production which in turn results in food scarcity. The research result obtained from the chi-square analysis suggests that heads of the households who are male have more knowledge about climate change and radio has a positive role in increasing their knowledge about climate change and its impact. The bivariate analysis also shows that post disaster, diarrhoea is a major health problem for children aged five and under. Households members who don’t have any education are also more vulnerable to diarrhoeal disease. The prevalence of skin disease is very high between before and after the disasters in both areas. The logistic regression shows that respondents from Aila area suffered more than those from Sidr areas. The households who had a higher income suffered less compared to those who had a lower monthly income. Households with severak children were more affected by health problems.

Chapter 7: Experiences of the people of climate change affected areas

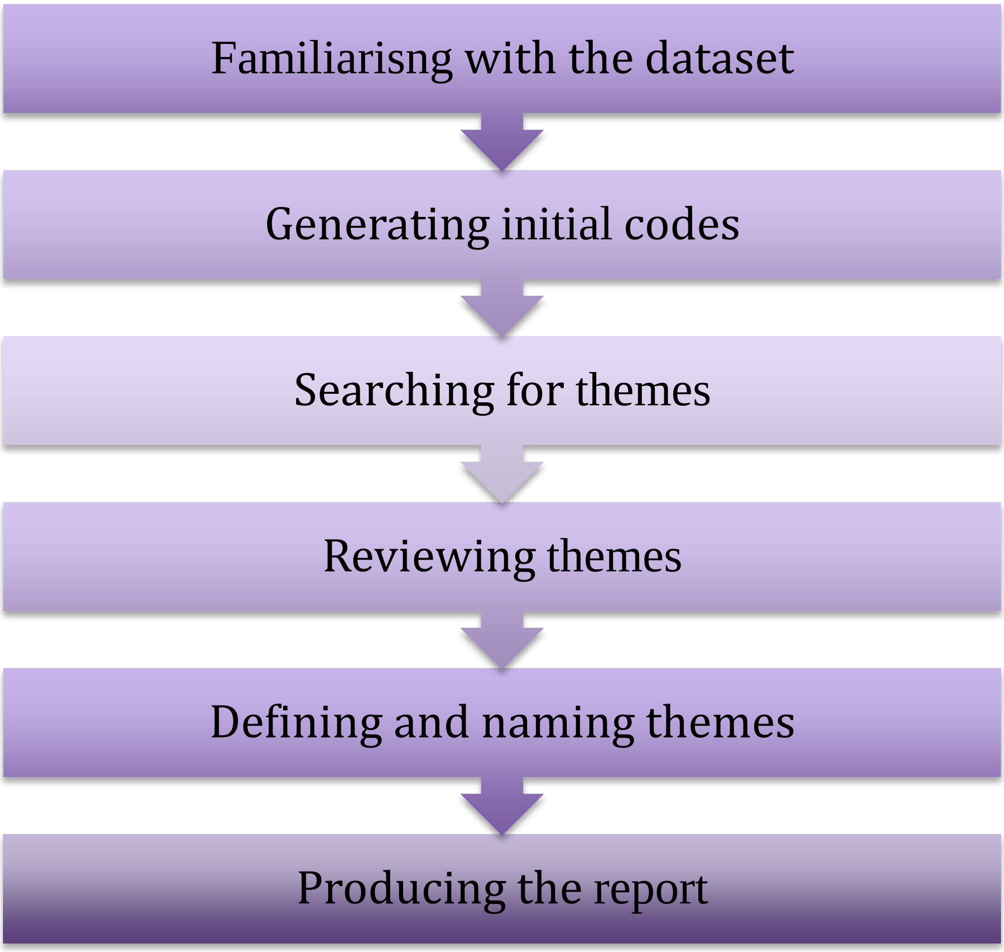
7.1 Introduction

This chapter introduces the experiences of people from climate change affected areas. These experiences emerged from focus group discussions with two groups – service providers and people from the community. As the research objective addressed by this research focused on the experiences of the respondents, it was obvious that a qualitative methodological approach would be most appropriate. Qualitative research is concerned with 'lived experience' (Denzin and Lincoln, 2005). Data analysis in qualitative research is always seen as a challenging task. There are diverse and complex qualitative approaches in research design and thematic analysis is seen as a foundational method for qualitative analysis (Holloway and Todres, 2003).

"*Thematic analysis is a useful approach for answering questions about the salient issues for particular groups of respondents or identifying typical responses*" (Green and Thorogood, 2009:199). There are many reasons for adopting a thematic analysis. One of the benefits is its flexibility. It is comparatively easier to learn, do and is user-friendly to researchers with little or no experience. It is also helpful in highlighting the similarities and differences across the data set (Braun and Clarke, 2006). Thematic analyses moves beyond counting explicit words or phrases and focuses on identifying and describing both implicit and explicit ideas within a dataset, that is called Themes (Guest *et al*, 2012:10). A theme captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set.

7.2 Analysis of qualitative Data

In order to make the best use of the data, this research employed a thematic analysis of the focus group discussion; texts were extracted with the aim of evaluating the affected coastal peoples' experiences' of climate change. To analyse the data, the researcher followed the six phases of analysis as suggested by Braun and Clarke (2006). The six steps of analysis are given below:



Source: (Braun and Clarke, 2006:35)

In the first phase, the transcripts of the focus groups were read several times to obtain a sense of the whole. The researcher carefully went through the descriptive responses given by the respondents to each question in order to understand the meaning they had communicated in the focus group discussions. During this phase, notes were taken to generate an initial list of ideas. In the second phase, codes were developed from the data to identify key themes. After all the focus group discussions had been coded once, codes were then refined to capture the concealed meaning.

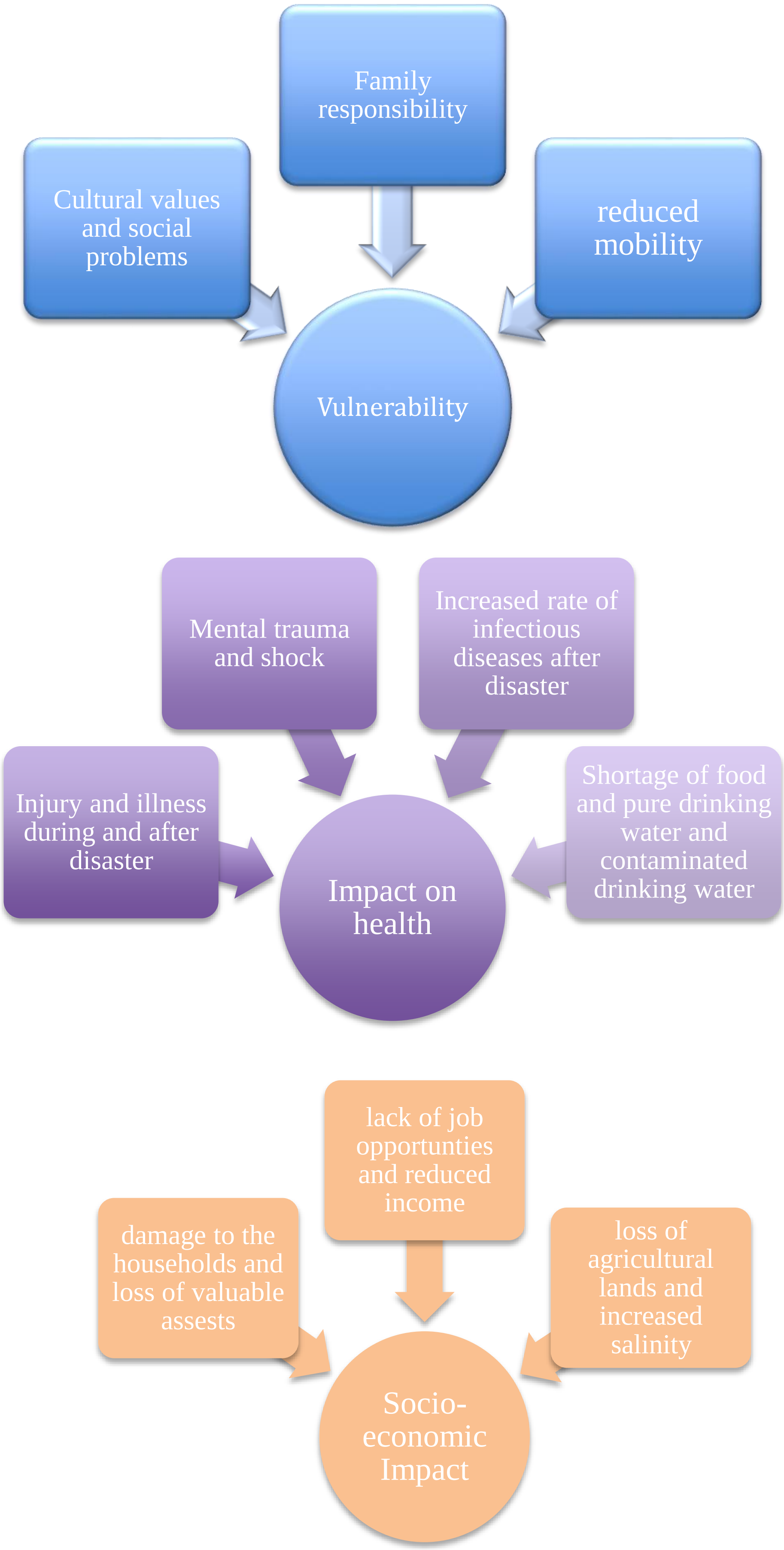
Table 7.1: Data extracted with codes and themes applied

	Data extracted	Coded for	Themes
FGD with community people at Sidr affected areas.	The incidence of diarrhoea and skin diseases increased after cyclone Sidr. Though diarrhoea was in control the cases of skin diseases were very high. (Respondent, Baliatali Village)	1.Diarrhoea and Skin diseases	**Impact on health**
FGD with Health and service providers and other knowledgeable people	There were many cases of diarrhoea and typhoid just after the cyclone hit the area, however people in this village mainly suffered from skin diseases (Union Porishod Chairman, Baliatali Village).	1.Diarrhoea and Typhoid. 2. Skin diseases	

In the next phase, the researcher arranged the different codes into probable themes and then ordered and assembled all the relevant coded data within the prospective themes (as shown in Table 7.1).

In phase four, the researcher reviewed and refined the emerged themes. The researcher went through all the extracted data for each theme and made sure that the extracted data was appropriate to the theme. Information that didn’t fit into any theme was excluded. A thematic map was developed and all the themes were given a name to identify the essence of what actually had been captured from the data in phase five. The last phase and next section of this chapter presents the analysis.

Figure 7.1: Thematic map, showing three main themes



7.3 Themes

The following three themes emerged from the data analysis. They first theme explores the impact on the socio-economic status of the people in the affected areas. The second theme presents the impact on health. Lastly the third theme focuses on the vulnerability of people.

7.3.1 Impact on socio-economic status

For the past 10 years or more significant changes have been observed in the surrounding environmental conditions including the weather and climate of the coastal areas. Natural disasters like cyclones, storms and flooding frequency has increased in the area a lot more than previous times. The respondents of the study pointed out that recent cyclones ‘Sidr’ and ‘Aila’ brought noteworthy changes in their living pattern. People are struggling to go back to their previous quality of life prior to Sidr and Aila. After the cyclones in both the villages, dams were damaged and sea saline water came to the agricultural lands easily. Salinity in the water has increased which has affected the production of crops and agricultural lands are not suitable for growing crops anymore. Most of the residents (in both villages) earn their living by fishing and farming agricultural lands. Production of agricultural products in these lands reduced remarkably after the disaster hit the area and now these farmers are suffering financially. One of the respondents from Borobari Village quoted that:

“*Before Aila hit the area, they used to produce a lot of different agricultural goods including fresh vegetables and fruits. By selling them in the mainstream market they could have earned the money that was sufficient for them to live a year on without any further production, but today this is not possible and also nature is not supporting them*”

Salinity in the coastal area has become severe and saline water mixed with cultivated lands. As a result cultivated lands are becoming abandoned. Due to high salinity, cattle were not getting enough food. This led to farmers finding it extremely hard to use them for ploughing the farming land(s). Poor people who used to cultivate crops and graze their cattle on the open space of shoals said frequent disasters are taking their toll on the agriculture sector forcing them to change their cultivation pattern. Many sweet water fish died due to the influx of saline water whilst water hyacinth and crops were rotten.

Furthermore to these challenges caused in agriculture, climate change has also had also harmful effects on other community sources of livelihoods such as casual labouring, fishing, hunting and crafting. It is worthy to note that many of these livelihoods depend on the performance of agriculture; for example, casual labouring is usually done on weeding and harvesting.

Fishing boats were wrecked after the cyclone. Though fishermen along with other affected population in the villages received some sort of financial support from the Government organizations (GO) and Non- government organizations (NGOs), the financial assistance was not adequate enough for them to buy fishing boats. Some of the families, who lost everything due to cyclones, used the money for re-establishing their living place and meeting their daily needs. One of the Union Porishod (UP) members of the Borobari village said

“We live our life like a wanderer amid insecurity and thwarting as sometimes our crops lands are destroyed by cyclonic storm”. One of the respondents from Balitali village of Amtali Upazila said in a depressed tone *“Me and my family are living a wretched life and have been struggling with poverty since becoming landless.*

Just after the disaster, there was a severe shortage of food and scarcity of pure drinking water in the affected areas. Though some families managed to get some food due to a lack of combustible substances cooking was not easy and they had to live day after day eating raw food. Most of the local food shops were damaged or closed due to a lack of supplies (the lack of supplies being a result of the breakdown in the transport system). Non-government organizations again provided some relief but government help was not adequate.

Most of the households have poor housing conditions that are highly vulnerable to natural disasters. Prior to Sidr and Aila, the financial situation of the community in the affected villages was not great, however, after Sidr and Aila it deteriorated even further. Their living conditions are now poor, however, many GO and NGOs are working to bring back normalcy. There are not enough job opportunities in the local areas and those who were farmers and fishermen are also trying to switch their jobs in order to increase their finances. One of the respondents from the Aila affected region reported,

“*Post Aila, every household is going through mental pressure and anxiety. They are devastated and discarded by losing their agricultural land, households, livestock’s, fishing ponds and so on. People of these areas are still working hard to get back to* *their normal lives. Some of the families started a new life by taking loans from local non-government organizations, but some failed to pay the repayments because frequent disasters made it difficult for them to grow crops. This put them under immense mental pressure".*

The headmaster of Bedkashi Borobari Government Primary School said "*it is very unfortunate that the level of education in the area is not satisfactory as the education rate is too low here. Most of the parents do not send their children to the school due to poverty. Their only choice is to send children to work in order to make living".*

Another teacher from the same school said the student drop-out rate is alarming and more girls are dropping out than boys. He also pointed out that distance is a factor for children not continuing education in this area.

One of the respondents who was severely affected by cyclone Aila stated that due to a lack of job opportunities and to maintain the household expenses, some of the families and in some cases the head of the households are leaving the village and migrating to different cities like Dhaka, Khulna and Chittagong. Some people had migrated to the neighboring country India. Another respondent shared that

"*Many people like me go to the deep forest in the Sundarban to collect honey, crab and fishing to meet our family expenses. It is indeed a risk of life to do this kind of job, as there is a fear of being attacked by the Royal Bengal Tigers and pirates. Hence our life is uncertain, as we have to risk of our life to do this. Once we go out for our* *job, our family members also worry for us and keep praying until we come back. This really is a huge mental pressure which makes our life miserable...”*

People are leading a very miserable life as their income from agriculture and fishing as their only means of livelihoods is just insufficient. This resembles a larger picture of Bangladesh where climate change has threatened the lives and livelihoods of millions of people.

7.3.2 Impact on health

The FGD explored information about recent environmental changes due to climate change and its impact on the health of the coastal population. Specifically the main aim was to get information from the participants about the impact on Health (such as general health situation, mental health and wounds) during Sidr and Aila and after Sidr and Aila. In order to understand the magnitude of the problem, information on the health condition of people in the community before the natural disaster was also gathered. Changes observed and experienced by people in relation to climate change were also examined.

When respondents were asked about question “what does climate change means to you?” They explained the change in the weather condition is climate change to them. Some replied that the increased frequency of natural disasters; temperature rise and sea level rises are all signs of the changing climate in their area.

Chairman of Amtali Upazila quoted:

“ Seasons are changing, its more hotter during summer, winter comes very late and stay for a short period, lands are not suitable for farming anymore, crops growing has reduced, natural disasters hit repeatedly and erratic rainfall are happening due to climate change”

Participants believed that the climate is changing and these changes are not bringing anything beneficial for them. They have been living in these areas for many years and in the last 10 years or more they have witnessed a significant difference in current climatic conditions. Since they are living close to the coast, the changes they have observed are a sea level rise, frequent occurrence of natural disasters like storms, cyclone Sidr and Aila, floods, influx of saline water in the agricultural land, excessive temperature rises during summer time and irregular patterns of rainfall. All these changes are making a substantial impact on their living pattern and health.

Participants were asked about the impact of climate change on health? A number of participants gave their opinions on the issue and they included: during and after the cyclone people in the affected villages suffered from various diseases including diarrhoea, dysentery, viral fever with cough, cold, skin diseases, eye infections, pain, paralysis, jaundice, lack of nutrition, waterborne diseases, typhoid, anaemia, high blood pressure and severe headaches (most common).

One respondent explained, “*Climate change is responsible for Sidr in our area. The saline contaminated and polluted water is responsible for spreading the communicable diseases in the area”.*

A lack of pure drinking water also aggravated the spread of waterborne diseases in the affected areas. According to the participants the main sources of the infectious diseases are polluted and highly saline water, unhealthy sanitation, unclean environment, unhygienic food, excessive hot weather and vector borne infections. Due to climate change, natural calamity is now common in the areas. This changes the natural environment and more infectious diseases are emerging (many of which were not common 20 years ago).

The prevalence of diarrhoea, skin diseases, typhoid fever and jaundice rapidly increased just after Sidr. Local health services lack manpower and the resources to deal with the variety of health problems. During emergency situations this is even more evident. Many of the poorer people have travelled to the nearest town to get better treatment.

The Chairman of Amtali upazila said,

"*Children and other age group people mainly suffered from diarrhoea and jaundice, but he doesn't know if anyone died of diarrhoea or jaundice"* Diarrhoea, typhoid and skin diseases spread rapidly due to Aila affected infected water. Diarrhoea and skin diseases were the most common problems identified by the respondents. Participants could not provide any mortality data from the occurrence of diarrhoea in the area but in each household in the village there were cases of diarrhoeal disease. There were also some cases of amoebic dysentery and bloody dysentery reported in the discussion.

It has been found that "diarrhoea, *typhoid and skin diseases were present like other normal diseases before Aila. Post Aila, excessive polluted water and a shortage of a* *drinking water supply meant that the majority of the families suffered from these diseases"*

When they took shelter in the shelter centre, these diseases started spreading very quickly. There were some cases of respiratory tract infection. A lack of sufficient of food and absence of a nutritious diet in the shelter centre forced people to starve. Eventually they became weaker and more prone to infectious diseases. As a result they couldn't work properly on their land. Some of them were farmers who became so seriously ill after the cyclone, sold their agricultural land(s) to maintain the cost of their treatment. It emerged from the discussion there are some people in the village who lost everything during the cyclone. Some of them became mentally instable and many families lost their children (bodies recovered after the cyclone). Some of them couldn't bear the loss of their near ones and was traumatized psychologically.

One of the participants shared that

" Some of the village women got fainted and lost their mental stability by just seeing the devastation caused by the cyclone Aila in the village and some of them are still recovering from the shock and cant forget the incident from their mind"

Efforts were made to assess the impact of disasters on injuries. Many mentioned that injuries were common during the disaster time. Many people got injured during the cyclone. In Amtali, many people were struck by tin (used to build houses in rural areas), fell under trees, broke their legs and had cuts and bruises on different parts of the body. Injuries to the head and spine were also common. A high number of people were also wounded. During Sidr, the high volume of water washed people away. Boats and other hard objects wounded many. Currently there are many wounded persons who are still suffering from different kinds of side effects. Many are now disabled due to the injury sustained during the cyclone.

To tackle the health problems both GO and NGOs are working in the affected areas. They introduced a new deep tube well for safe drinking water, constructed hygienic toilets, distributed water-purifying tablets; bleaching powder and awareness building programmes were under taken by different agencies. They also distributed general medicines to the people in the community.

When questioning, the current general health situation of the community all the participants agreed that the current health situation is reasonably better now than compared to during and immediately after the disaster. The health situation has improved because of different programme interventions by different local and international agencies. According to the participants the health situation is improving.

7.3.3 Impact on the vulnerable population

When the discussion moved onto the vulnerable population in relation to the cyclones Aila and Sidr, the respondents described the elderly, infants and women as the most affected by the disasters. They endured a difficult time at the shelter centre after the cyclones. Children experienced malnutrition due to a lack of food, which subsequently affected their physical and mental growth. School children couldn’t complete their education on time. Many children also suffered from diarrhoea, dysentery and skin diseases. Elderly people were found with cuts and bruises on hands and legs, broken hands and legs, bruises on their head, injuries to different parts of the body.

Many also died due to falling trees and houses (because of their reduced mobility). In some cases elderly people were found under traps whilst trying to save the lives of others. Both usually were found dead at the same place. Those that survived the adverse conditions now find that their health is deteriorating each day, however, no exact figure of the number of children and elderly people affected was given. Representatives of the GO and NGO also couldn't recall the precise statistics.
Some households did not take any shelter because they were physically unable to reach the shelter because of the adverse condition or it was too far. Some of them didn't understand the significance of the warning and could not hear the warning. They decided to stay at home because they were fearful that the house would be looted. Many people thought that the shelter centres would be unsafe and unpleasant.

One of the Union Porishod Member of Sidr affected village reported,
"*...it's the women who suffered a lot during the disaster time due to a lack of preparation. Many women couldn't ran away because their clothes got stuck on trees. Many of them died after trees fell on them.*"

The majority of the women of the coastal areas homebound and when cyclone stroked they were busy for family livestock and had to make suitable provision prior to go to the shelter. In many cases, it was found that the traditional clothing "Sari" (that women wear in the villages) was responsible for hindering their escape from the cyclone when entrapped with some objects while running. Women were also responsible for the children of their families. In many cases it was noted that children could not evacuate quickly enough and mothers whilst attempting to save their children, died during the cyclones. According to the respondents, most of the women of the households are dependent on their husbands for taking any decision. When the cyclone information came out, it was not available to them and in some cases they had some little information. All of these factors contributed them not evacuating the house and put them in more complicated situation during cyclone.

Co-Chairman of Amtali Upazila shared an incident that he had witnessed,
"*when the cyclone hit the area, a pregnant woman died because the transportation system had broken down in the next town".*

Pregnant women especially went through immense mental and physical trauma and it was later found that many of them gave birth to disabled children. The interviewees described how women were also harassed and abused while they tried to collect food and relief materials for their families. Many of them fainted upon witnessing the severity of the cyclone. Women and teenage girls who stayed temporarily in the shelter centre couldn't use the toilet facility because of the lack of privacy and lack of sanitation products. This caused them to suffer physically and mentally. Mothers could not find a private place to breast-feed their children and they could not take care of children properly, thus creating a social problem. Many families specifically those who are headed by females had to fight even after the cyclones to collect the aid as it involved dealing with dictatorial males and they had little experience for it.

Generally the women from each household walk a fair distance to collect pure drinking water for their families. When the dams broke during the cyclone and salinity increased, they had to struggle more to get water (which affected them physically).

Often mothers starved both days and nights. Any food they managed to get they gave to their children and other family members causing their own physical health to suffer. Most of the women's families broke down when the impact of the cyclone worsened their financial conditions.

The UP member of Koyra Upazila said

"many of the women divorced when they lost their home or assets to the impact of cyclones".

Some of the middle aged women work as a daily domestic help in the houses of affluent people, (there are only a handful in the entire village). By doing this they can get some food and money but when there is no work, they have to remain half-fed or unfed. Women of these affected villages are suffering severely from anaemia, leucorrhoea, infertility and irregular menstruation (as reported by the NGO people who were present in the discussion).

7.4 Summary

The above findings discuss the experiences of cyclone the Sidr (2007) and Aila (2009) affected populations. The participants were aware that climate change is taking place in their area and is responsible for the increasing frequency of natural disasters like cyclone Aila and Sidr. Three themes emerged from the analysis. The first theme discusses how cyclones changed their socio-economic life and into their present status. The second theme explores the health situation of people in the affected areas and their sufferings. The third theme investigates the impact on the vulnerable groups within the population. Coastal people are basically poor and vulnerable people. Despite being affected by the natural calamities frequently, these people continue to live in the coastal areas. Most of these natural hazards are unplanned and are random phenomena. The participants' reaction is guided by their instinctive confidence on Almighty and trust that they have no other option but to stay or survive for existence. Apart from this, these places happen to be their birthplace.

The impact of climate change is creating an adding additional pressure on them that might have detrimental consequences on their livelihoods and health condition. The coastal communities are vulnerable to the impact of climate change more than other communities in the country due to the risk extreme climatic events, high dependency on natural resources, particularly on farming and fishing, limited physical assets and less financial assets.

Health problems, losses of property and agricultural land(s) and near ones have made them mentally unstable. A lack of food and clean water has further increased their sufferings. Many people were injured by the cyclone and the lack of job opportunities in the area has made their life more difficult. People started migrating in the hope of starting a new life. The prevalence of infectious diseases and other diseases have increased dramatically after the climate change. Women, children and the elder population are the most affected group in this calamity. Things are improving for people in these areas. Various government organization and non-government organization are working together to restore normality to the lives of these people.

DISCUSSION & CONCLUSION

Chapter 8: Discussion and Conclusion

8.1 Introduction

It is quite evident from the discussion that human actions are responsible for changing the global climate and it is increasing at an alarming rate. The impacts of climate change have been a major topic of discussion for researchers and scientists. As climate change precedes, the frequency and intensity of extreme weather events such as cyclones, heatwaves, flooding, droughts and heavy precipitation are going to increase noticeably. Although the global frequency of tropical cyclones is expected to decrease or remain essentially unchanged, they may become more intense.

Theory shows that an increase in global temperature produces more powerful cyclones. Generally storms are fuelled by evaporation from the ocean and warmer water means faster evaporation means more energy to power the storm. A great deal of research has been carried out to know the impact of climate change on tropical cyclones, however there are mixed research judgments on this matter. It has been said that the anthropogenic is the main source of climate change. But with the cyclones intensity, every country would struggle to withstand and poor areas would be more likely to suffer heavy losses.

The coastal belt of Bangladesh is a mostly disaster prone area due to its geographical location. Every year natural disasters like cyclones, floods and storms hit the coastal areas and cause serious damage to lives and properties. Climate change has added an extra concern. The country can be one of the worst victims of the negative consequences of climate change and climate related natural hazards. Bangladesh is a land of disaster with a high prevalence of poverty situation, forceing many people to live in disaster-prone areas. The people of Bangladesh lack better alternatives and the capacity to cope with natural hazards. Losses of life, decline in agriculture production, displacement of human beings, losses of valuable livestock, disruption in communication and livelihood system are the ultimate result of all sorts of disasters occurring in Bangladesh. All these have an impact on the health of the population. This study has looked into the health of the affected population of two recently hit cyclonic disasters in Bangladesh due to climate change.

This chapter attempts to show the relationship of all the discussions that were made from chapter one to seven. It presents an association between the research objectives in chapter one; findings from the literature review in chapter two and the research findings from the analysis chapters. This chapter is divided into four sections. The first section of this chapter critically discusses and explains findings of this research, the second section presents the principal contribution of this research then it provides recommendations based on the findings from this research. Last but not least, this section of this chapter displays the limitations of the research.

8.2 Results and Discussion

In this section, the research objectives were revisited and discussed in the extent to which they were met, in light of the research findings and in relation to wider context.

In this research, male respondents accounted for 87% and the vast majority of respondent were aged 50 years and above. About 74% of household heads revealed that they were educated and their main occupations were farming and fishing. A cross-sectional study conducted by Nesha *et al*, (2014) on peoples perception about climate change and its adverse effect on rural Bangladesh reported that the age of the participants of the research was between 30 and 65 years, with about 51% respondents being female. Their main occupations were housewife, farming and private job. Similar findings are shown by Haque *et al*, (2013) and Karim *et al*, (2013). The monthly income of the respondents is less than 3000 Taka. This is consistent with other studies by Alam (2012) and Haque *et al*, (2013).

In both cyclones affected areas most of the households are made of tin shade. In Bern *et al*, (1993) found that the respondents households are mainly pukka. Chowdhury *et al*, (1993) showed that death rates varied by the type of pre-cyclone housing. The greatest numbers of death were reported to occur among habitants living in Kacha houses whilst a low death rate was associated with habitants living in pukka houses. Findings show that the main sources of drinking water from both affected areas are deep tubewell and during disaster times they were dependent on the river or pond water. A preliminary investigation was carried on into the impacts of climate change in the Satkhira district in late 2010. Satkhira is a coastal district and is situated on the southern part of Bangladesh (it was also hit by cyclone Aila). The findings from the research shows that one-third of people depend on ponds for drinking water and 70% of households used pond water for sanitation purposes after disasters (Rabbani *et al*, 2012). About 71% of respondents came to know about climate change from friends and relatives, 21.1% respondents reported getting information on climate change through the radio and 34.5% through television. These results are consistent with a study in Nigeria (Ovuyovwiroye, 2013) but it is different from another state in Nigeria (Adesiji *et al*, 2013) and in Tamilnadu (Guha-Sapir *et al*, 2006), which shows that radio was a common source of information. Overall, the research highlights that media coverage has an influence in providing knowledge on climate change. Rahman *et al,* (2014) revealed that media plays an important role in the awareness of climate change.

About 71.5 % of respondents stated that climate change is affecting the local community. In 2010, research conducted by Kontogianni *et al,* (2012) in one of the coastal areas of Greece ‘Levos Island’, found that the majority of respondents (97.1%) were aware of climate change and 58.8% of them believe that it is influencing their lives. An American study also found that 81% of its respondents believed that climate change is happening and 69% reported that climate change could potentially endanger their lives (Semenza *et al*, 2011). Both men and women of the Guruve district of Zimbabwe observed that there has been a change in climate (Chingarande, 2013). Similar findings are shown in other studies such as Rahal and Baz (2013) and Okonya *et al,* (2013). However, these findings are in conflict to results from a study conducted in Malaysia where 40.9% farmers have no idea about climate change and its vulnerability (Alam, 2013).

This research reveals that males have more knowledge about climate change than females. This may be due to the fact that most of the household heads are male and thus they have a higher mobility of visiting various locations such as local shops, union parishad offices. It is likely that they have regular interactions with community members and as a result they are exposed to knowledge on climate change. This result is similar to a former study conducted in Eastern Uganda by Kisauzi *et al,* (2012) stated that male headed households were found to be the sole significant determinant of knowledge into the cause of climate change. But in another research by McCright

(2010) on climate change knowledge and concern in the American public shows that women knowledge than men.

About 95.5% of respondents revealed that climate change is causing natural disasters and affecting their surrounding enviornments. This in turn causes immense human suffering. They mentioned that the frequency and intensity of cyclones and storm surges have increased. Almost 85 % respondents said that their households were damaged during cyclones and they lost their valuable assets. The results are similar to a previous study conducted in Indonesia after the 2004 Tsunami where 67.3% respondents said their houses were damaged by Tsunami (Guha-Sapir, 2006). The same happened in the coastal region of Vietnam, which has experienced great annual property loss due to intensive storms and floods (Ho and Kim, 2014).

Crighton *et al,* (2011) stated that in recent times Kazakhstan has experienced unprecedented heat waves in the summer and cold spells in the winter, which has affected seriously the health of young and older adults. According to the respondents in this study, it was suggested that the local community are facing effects of climate change and indirectly it is responsible for some emerging diseases in the area.

This research also displays that climate change through natural disasters like cyclone are affecting the agricultural lands of the respondents. It is hard for people to grow crops in the field. Other research also supports the fact that there are adverse effects of climate change on agriculture. Approximately 69% respondents said that there has been a decrease in crop yields due to climate change (Nesha *et al*, 2014). Respondents from Hatiya Island of Bangladesh reported that climate change is affecting agricultural production (Alam, 2012). These findings are consistent with other studies by Toufique and Islam (2014) and Karim *et al,* (2013).

Both *Sidr* and *Aila* affected people are aware of the fact that natural disasters due to climate change is affecting their health. Similar results were found by Bhuiyan and Khan (2011). The respondent household informed that the prevalence of skin diseases followed by infectious diseases and mental illness in the affected area. Paul *et al,* (2010) found in their study that after *Sidr* 38% suffered diarrhoeal diseases, 12% suffered from typhoid and 4 % skin diseases.

When compared with the pre and post effects of *Sidr* and *Aila* on diseases with the family members of the respondents household it became clear that the prevalence of some diseases were very higher in the post cyclone period and some infectious diseases like diarrhoea which were not common before the cyclone, increased in incidence. Diarrhoeal disease outbreak occurred after the 2004 floods in Bangladesh, 1988,1998 and 2004 floods in Bangladesh, 2004 Tsunami in Indonesia, 2005 earthquake in Muzzafardbad Pakistan, floods in Mozambique 2000, floods in China and in USA after Hurricane Allison in 2001 and Katrina 2005 reported in WHO (2006), Schwartz *et al*, (2006), Ding *et al*, (2013) and Kondo *et al*, (2002). The chi-square analysis of this research displays that the percentage of diarrhoea was higher among individuals whose households' head had no formal education. This is consistent with another research on post cyclone Sidr illness in coastal Bangladesh where the researchers showed that the illness rate was higher among the illiterate population than the literate (Paul *et al*, 2011). Bhunia and Ghosh (2011) in their research after cyclone Aila in Sundarban of

West Bengal, India reported an increased number of diarrhoea cases due to contaminated drinking water.

Other health problems that are found significant in this research are respiratory problems, skin diseases, food poisoning, hepatitis and mental health problems. Waterborne diseases and skin infections were also reported in a study in the Delta State of Nigeria related to flooding (Emaziye, 2013). Hepatitis A and E were reported after the 2004 Tsunami in Indonesia (WHO, 2006), respiratory problems reported after the Tsunami and earthquake 2005 in Pakistan (WHO, 2006) and (Baqir *et al*, 2012). Dysentery cases were identified after flooding in Xinxian City, China (Ni *et al*, 2014). Diarrhea, skin and eye infections were identified in Pakistan after flood (Baqir *et al*, 2012). It also implies that irrespective of the type of disaster health problems following the occurrence of natural calamity is common. People of local communities should be provided primary health care support and knowledge in such situations to protect themselves from diarrhoea, skin diseases, food poisoning. Loss of family members, and a loss of employment due to damage to agricultural land and livestocks and reduced fish production are one of the contributing factors responsible for mental disturbance among the coastal communities. Similar results are in line with researches by Rahman *et al*, (2014), Swim *et al*, (2009) and Kazdin (2009).

From the focus group discussion with the local community people and knowledgable people in the community three themes were generated in this research. The themes are: impact on socio-economic status, impact on health of the people and lastly impact on vulnerable population.

The first theme on socio-economic status reveals that recent cyclones Sidr and Aila brought noteworthy changes in their living pattern. People are struggling to go back to their previous quality of life. Most of the residents (in both villages) earn their living by fishing and farming agricultural lands. Production of agricultural products in these lands reduced remarkably after the disaster hit the area and now these farmers are suffering financially. Research by Ferberg *et al,* (2011) on Sami population shows that rapidly changing unstable weather patterns affect their living patterns. A study by Wei *et al,* (2014) among the CDC health professionals in Shanxi province in China reveals that climate change is happening both at global and local levels and would lead to adverse impacts. They also noted that agricultural production, population health and natural ecology had already been affected by climate change in their justification with more extreme weather events.

The research findings also show that their financial life has been affected by climate change and due to a lack of job opportunities and to maintain the household expenses, some of the families and in some cases the head of the households are leaving the village and migrating to different cities. Similar findings are shown in another study by Guha-Sapir (2006) where Tsunami affected unemployment in Tamil Nadu. Climate change affected the livelihood pattern and job security of fishermen in Coromandel Coast of New Zealand (Srikanthan, 2013).

The second theme discussed the about impact on health of the coastal people. Respondents believed that the climate is changing and these changes are not bringing anything beneficial for them. A lack of pure drinking water aggravated the spread of waterborne diseases in the affected areas. According to the participants the main sources of the infectious diseases are polluted and highly saline water. An extreme weather event reduce access to safe drinking water and food and increases the chances of having infectious diseases among the vulnerable pregnant women. A lack of pregnancy care further complicates their health conditions (Rylander *et al*, 2013).

The analysis shows that mental health problems are also a major growing concern for the climate-affected population. The Post *Sidr* and Post *Aila* results show that the number of people with mental health problem has increased dramatically. There are several ways in which local climate change can influence the mental health status of the local population (Berry *et al*, 2007, 2008), A survey among the Tsunami affected population by WHO (2005) revealed that 30-50% of the population suffered from moderate to severe form of mental disorders including anxiety, depression, phobic disorder and adjustment disorder. The symptoms of Post-Traumatic Stress Disorder (PTSD) may persist for months to several years even for life long. **S**o a large proportion of literature suggests that there are fairly consistent estimates of PTSD that can be expected in the first year after exposure (Neria *et al*, 2008).

Women suffer increased mental strain due to the burden of extra social constraints in their lives. During cyclones they are handicapped by fear of shame for leaving the house and taking a shelter. The same was found by Rashid and Michaud (2000) and Rahman (2013).

The third theme explored the most vulnerable population from the climate induced natural disasters. The analysis concludes that women, elderly people and children are the most vulnerable groups of people in the community.

The kind of clothing women wear it causes a major obstruction in their mobility and quick recovery during an emergency situation becomes hard for the vulnerable women. Research by Mehta (2007) and Dasgupta *et al,* (2010) also shows similar results. Climate change affects both men and women, however, the impact is more felt by women. Climate change increases the females' burden of meeting their household responsibilities. During cyclones children and women are more vulnerable because of their physical formation. Most of the females have a low level of education. Women may have been more at risk because they stayed behind to save or search for their children, while others escaped. Results from this research resonate with other research studies by Adebo and Sekumade (2013) Adeniyi *et al,* (2013) and Guha-Sapir *et al,* (2006). Children and the elderly were found most vulnerable during cyclone. They are vulnerable due to health and physical vulnerabilities and because of their inability to run fast. Chidlren are also suffering health problem such as malnutrition. These results are similar to other studies by Devkota *et al,* (2013), Kendrovoski & Spasenovska (2011), Davies *et al,* (2009) and Bhuiyan and Khan (2011). In disaster times, children and babies lack the capacity to escape from the hazard. In study of 1991 Bangladesh cyclone for example, children and older people died more disproportionately than others in population (Chowdhury *et al,* 1993). About 71% of respondents mentioned that children suffer most due to the adverse effects of climate change and this was closely followed by elderly people and women at 63% respectively (Nesha *et al*, 2014). This shows that women are the most vulnerable group who are the worst victim of the climate change followed by children and the elderly population. Other pieces of research show that the elderly population suffer the most adverse health conditions due to changes in weather conditions Grundy (2006), Hansen (2012), Mortreux and Barnett (2009) and Filiberto *et al,* (2009).

8.3 Contribution of this research

1. **A** relatively small number of studies has attempted to find out the impact of climate change on health in climate change literature. There is limited research work on the impact of climate change through natural disasters on human health. This research helps to fill these research gaps. This research has concentrated on two recently occurring cyclones 'Sidr' and 'Aila' affected communities. Climate change literature argues that the intensity and frequency of tropical cyclones in the Bay of Bengal would increase, suggesting that climate change would have a major impact on cyclones in Bangladesh.

2. The research undertaken with the local community and government and non-government officers provides evidence that local people are suffering from a variety of health problems that could be a direct or indirect impact of climate change. These problems include skin diseases, diarrhoea, dysentery, respiratory problems and mental health problem. None of these findings have been confirmed with rigorous epidemiological studies before.

3. The research findings show that there are changes in the socio-economic status of the respondents after cyclone Sidr and Aila hit the area. Affected communities suffered financially as they lost their agricultural lands and fishing boats to sustain live their livelihoods. As a consequence these people are changing their jobs and migrating to nearest towns and cities for better opportunities. This can be an important finding for the climate change research community.

4. This research has provided a valuable facet to the existing literature as little research has been conducted in the past looking at the impact of climate change upon human health. This research has first tried to establish the relationship between climate change and extreme disasters like cyclones in Bangladesh by reviewing the scientific

literature. The theory of tropical cyclones in its current state of development suggests that there is relationship between climate and tropical cyclone activity. Moreover, this research has used a mix method approach to assess the impact of climate change on human health. The methods applied in this research are unique and have never been applied before. The research technique can be applied to studying different extreme weather events in different parts of world. It is more suitable for developing countries where extreme weather events occur more often.

5. The research also shows that climate change has an adverse impact on everyone but the economically disadvantaged people of the coastal areas are the most adversely affected. They also have the least ability and resources to deal with these effects. It has shown that women are particulary more vulnerable during and after the disaster time and due to cultural and social barriers these women are not able to cope with the risks. Their utmost attempt to survive through these bad times takes a lot of personal sacrifice and compassion as well as psychophysical burden. Their coping effors are severly challenged by gender relationships and handicapped by power structure within the household as well as within the community.

8.4 Recommendations

On the whole, climate change will have a shocking impact on Bangladesh. Confronting climate change's adverse impacts of different categories are a formidable challenge and meeting these challenges requires some changes in policies and future research investigations.

1.Climate change makes people life a difficult one and it increases vulnerability in the society such as poor people, children, the elderly population and women. Stakeholders and policymakers should take initiative to develop skills and experience to analyse the changing climate and to identify the causes for change and assess the health effects.

2. There is limited research on understanding the likely health impacts of climate change through natural disasters and also understanding the extent to which climate change will affect the health of the genereal population is under researched. The research gaps and other informations provided in this research leads to a great number of potential research ideas.

3. Knowledge and awareness on climate change related threats should be made available for the coastal population. In addition, research should be carried out to assess the current knowledge and awareness of climate change and its impact of the coastal communities to address the gaps.

4.To reduce the vulnerability of costal communities’ capcity building programmes should be run at household levels to adapt with climate change impacts and different livelihood strategies. Adaptation measures at community level will help local people to strengthen their barriers against climate-related disasters.

5. The coast of Bangladesh is a densely populated area and relocation of coastal people is not possible due to land availability. So it’s a high priority that local people should know about the management climate change impacts. The coastal zone should be protected where it is environmentaly viable.

6. In cyclone prone areas, an adequate number of new cyclone shelters needs to be built on the basis of the population density. Though it can be said that existing cyclone shelters have saved millions of lives already, new structures should be built with modifications to have provisions for women, at least one separate toilet designated for women.

7. Research work on climate induced health problems can aid the Government organization, non-government organizations and other stakeholders and policy makers create strategies to combat climate induced diseases and health problems.

8.Awareness programmes on the impact of climate change on human health would build resilience of the community. For that health professionals need to be trained on climate change and its impact on human health to deal with future difficulties. Training programmes for health professionals and community leaders should be initiated by the government and non-government organizations.

8.5 Limitations of the research

The following limitations have been identified in this research:

- This research has collected information on the other members of the households by questionning the head of the households. This has its inherent limitations as it relies on the knowledge of the respondents.
- In cross-sectional studies exposure and disease data are collected simultaneously, it is sometimes difficult to establish the causal relationship between exposure and disease due to a lack of information on temporal relationships between exposure and disease outcome. According to Martens and McMicheal (2002) in their edited book "Environmental *change, Climate and Health*" stated that there are few opportunities to differentiate exposures at the individual level at climatic research.
- Climate change and human health is a new area for the health researchers. Measuring the impacts of climate change on human health are complex, multifactorial and difficult to isolate. There is not enough information and resources were available as there was no similar type of research has been done before in Bangladesh. Some articles and literature shows there is an association between climate change and human health but no evidence-based research has been done on this issue. This research will try to fill out the gaps in this area.
- The small sample size of of the research is another limitation because it does not allow generalization of the descriptive findings.

8.6 Summary

Scienitific literature clearly shows that extreme weather events are increasing alarmingly. Human induced climate change is a reality now and its threatenting our planet, health and survival. It poses a great risk for our future generation. People have already recognized that there is connection between changes in the weather pattern and appearance of diseases. Research work to measure the impact of climate change on the health of people is still in process of expansion. Government and Non-Gevernment Officials at local and International levels should come together to develop strategies and mechanisms that can be put in place to deal with the health consequences due to climate change.

Bangladesh is a cyclone-prone disaster country. The coast of Bangladesh is hit by cyclones every year. The scientific evidence points out that the vulnerability of Bangladesh may increase as the frequency and intensity of tropical cyclones increases in the Bay of Bengal due to the changing climate. The coast of the country is known as a zone of multiple hazards and as well as opportunities. A devastating cyclone like Sidr and Aila can wipe out the lives of hundreds and thousands of people. The country is also considered as densely populated one, especially in the coastal area so natural hazards like cyclone can affect number of people. For Bangladesh, the primary concerns of the country are their political, social and economical development and it recognize climate change as a separate issue. The fragile economy, high poverty, continuous political unrest and low adaptive capacity make Bangladesh vulnerable to climate change. Policy makers and stakeholders are trying to prioritize climate change as a separate issue but it is becoming part of the agenda in social and economic development and cannot seprate and prioritizes climate change issue without considering it social, economical and infrastructural development. Bangladesh did not have any role in causing climate change. Bangladesh's contribution to green house gas emission concentration in the earth's atmosphere is close to zero but still it is considered as the worst victim of climate change.

Available evidence suggests that there is an impact of climate change on human health in Bangladesh. Climate change is a new concept in environmental health research. Bangladesh with its populated land close to sea level is at particular risk. The study revealed that affected the populations of cyclone *Sidr* and *Aila* have faced so many diseases like diarrhoea, typhoid fever, respiratory problem, hepatitis (jaundice), death and injury and mental health problem. According to the research vulnerable groups were identified. Vulnerable populations like women, children and older adults are facing more serious health consequences due to climate change. Some diseases are emerging in the affected community. The socio-economic situation of the affected population was in dire stress after cyclone hit the area and due to lack of employment opportunities and infrastructural support these people had to face long-term health consequences. Things are improving now as various local governments and non-government organizations are working there and people are getting back to their normal lives. A majority of the health professionals, service providers and local community of coastal areas of Bangladesh are aware of the health impacts of climate change but their knowledge regarding health protection measures is limited.

References and Appendix

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Appendices

Appendix I

Informed Consent Form

Hello. My name is Russell Kabir I am a Doctoral student at Middlesex University. As part of my study I am conducting research on “Impact of cyclones Sidr and Aila and on health of the coastal people in Bangladesh”. I would be very happy if you would kindly provide me some information that will be used for my research purposes only.

I would like to ask you some questions related to the impact of cyclone Sidr and Aila on human health in Bangladesh. I will take 30-45 minutes time from you for asking questions about you and your family members. You will not be given any financial support for taking part in this research. I assure you that the information you will provide will be treated as strictly confidential and will not be shared with anyone except for the purpose of this research. You are free to agree or not to participate in this research. You can drop out in the middle of interview or decide not answer all the questions if you so desire. If you have any question regarding this research you can contact me. I hope you would agree to participate in this research because your opinion will be very useful.

Signature of the interviewer: -------------------------Date: -----------------------------

I have clearly understood that the information I shall give will be kept confidential and will be used for research purposes only. I also understand that if I have any question, I can contact with the researcher. I have understood that, I will not get any financial support/ assistance from this research and can withdraw myself any time I desire.

I agree to take part in thi research.

Signature of the participants/ thumb impression------------------------Date: -------------

Appendix II

HH SI: ☐☐☐

Questionnaire on

"Impact of cyclones Sidr and Aila on health of the coastal people in Bangladesh"

Part A: Personal Information

1.1. Name of the household head:…………………….………………………….

1.2. Gender: 1=Male, 2=Female

1.3. Address:

a. Village:……………………………………b. Union/ Ward:……………………..

c. Upazila:……………………………… d. District:………………………….

1.4. Climate Affected area: (1) Sidr ☐

(2) Aila ☐

Interview start time: ………… : ………… Interview end time: …………. : …………..

Part B

No	Questions	Coding
Sociodemographic, economic and household information		
1.5	How old were you at your last birthday?	Age in years………………….
1.6	Religion	1=Muslim 2=Hindu 3=Other
1.7	Have you ever attended school?	1=Yes 2=No
1.7a	What level of schooling have you last attended?	1= Primary 2= Secondary 3= Higher Secondary 4= Diploma 5= BSc 6= MSc
1.8	Are you single, married, separated widowed or divorced?	1=Married 2=Single 3=Divorced 4=Separated 5=Widowed
1.9	How many members in the family?	
1.9b	How many female members in your family?	
1.9c	How many family members in your household are over 60 years of age?	
1.10	How many children are currently living with you?	
1.10a	What are their ages?	1st child= 2nd child= 3rd child= 4th child= 5th child= 6th child=
1.11	What is your main occupation?	
1.11a	What is your spouse's main occupation?	
1.12	What is your monthly income?	
1.12a	What is your monthly household income?	
1.13	How many years you lived in this village?	
1.14	How far (in mile) do you live from the coastal area?	
1.15	Is there any member of your family is suffering from disability?	1=Yes 2=No
1.16	If yes, what is the type of disability?	1= Physical 2= Developmental 3= Mental 4= Sensory (hearing and vision impairment) 5=Learning

1.17	Please mention whether your household has the following items	1=Mobile Phone 2=Television 3=Radio 4=Electricity 5=Gas for cooking 6=Telephone
	Mass Media Access	
1.18	How often do you watch TV in a week?	1= Everyday 2= 4-6 days 3= 1-3 days 4= Less than once in a week 5= Do not watch 6= Not applicable
1.19	How often do you listen to the radio in a week?	1= Everyday 2= 4-6 days 3= 1-3 days 4= Less than once in a week 5= Do not listen 6= Not applicable
1.20	How often do you read a Bengali newspaper?	1= Everyday 2= 4-6 days 3= 1-3 days 4= Less than once in a week 5= Do not read 6= Not applicable
	Quality of Accomodation	
1.21	What material is your home built of?	1=Kacha 2=Sami Paka 3=Paka 4=Tin shade 9=Other **…………….**
1.22	What is the main source of drinking water for your household?	1=Deep Tube well 2=Tube well 3=Surface water (pond/tank/lake) 4= River 5=Rain water 9. Other……………
1.23	How far do you have to travel to obtain water?	1= Does not apply 2= More than 100m 3= Less than 100m
1.24	Who is responsible for getting the water?	1= Husband 2= Wife 3= Son 4= Daughter 5=Others

1.25	What kind of toilet facility does your household have?	1=Septic tank/modern toilet 2=Pit/slab latrine 3=Open latrine 4=Hanging latrine 5.Water sealed 6=Refuse 9=Other (bush/field/…)…………….
No	**Questions**	**Coding**
	Knowledge on Climate Change	
2.1	Have you heard of "climate change"?	1=Yes 2=No
2.1a	If yes, what you mean with it	……………………….
2.2	Where have you heard about climate change?	1= Television 2=Radio 3= Newspaper 4=Friends/families 5= Government agencies
2.3	Do you feel the pattern of weather is generally changing?	1=Strongly Disagree 2=Disagree 3= Neutral 4= Agree 5= Strongly Agree
2.4	Have you noticed any changes in the last 10 years?	1=Yes 2=No
2.5	Among the following aspects what aspects of changes have you noticed in your area?	1= Temperature Increased 2= More cold in Winter 3= Short Winter 4= More rainfall 5= Less rainfall 6= Changes of rainy season 7= Water Scarcity 8= Salinity intrusion 9= Frequent natural disaster 10= others (please specify)…………………..
2.6a	Do you think climate change is something that is affecting or is going to affect you, personally?	1=Often 2=Sometimes 3=Seldom 4=Never
2.6b	Do you think climate change is something that is affecting or is going to affect the community?	1= A great deal 2=Much 3=Somewhat 4=Little 5=Never

2.7	Do you think climate change in general is or will affect your health?	1=To a great extent 2=somewhat 3= Very little 4=Not at all
2.8	Do you expect changing climate is beneficial for you?	1=Yes 2=No 3=DNK
2.9	Since last 5-10 years how many times your family's main occupation changed?	1= Never change 2= Once 3= Twice 4= Three times 5= Four or Five times 6= Often
2.10	Do you think environment or climate is somehow related with this reason?	1= Yes 2=No 3=DNK
2.11	What is the impact of climate changes in the lives of the affected people?	1= Changes of livelihood 2= increase of income 3= reduction of income 4= Loss of employment 5= Gain of employment 6= Reduction of crop yield 7= Increase of crop yield 8= Increase of food price 9= Decrease of food price 10= Increase of family's other expenses 11= Decrease of family's other expenses 12=hardship increased in daily life 13= increased job opportunities 14= Reduction of job opportunities 15= No impact
2.12	Have you been made aware of the effect of Climate Change by the Local government?	1=Yes 2=No 3=DNK
2.12a	Have you been made aware of the effects of Climate Change by an NGO?	1=Yes 2=No 3=DNK
2.13	Have you been informed of the correct weather patterns or changes taking place in the weather (late or early arrival of rains or heavy rains/cyclone/storms) in time through radio/ television by the Meteorological Department?	1=Never 2=Rarely 3=Sometimes 4= Very often 5= Always
2.14	What do you do when you are informed about the changes taking place in the weather?	1= Go to a safe place 2= Stay in their home without any preparation 3= Stay in their home with preparation 4= Leave the village 5= Others (specify)………………………
2.15	How serious a problem do you think climate change is now in your area?	1= Not serious at all 2= Moderately serious 3= Neither 4= Serious 5=Very serious

Effect of natural disaster		
No	**Questions**	**Coding**
3.1	What are the natural disasters you faced in the last 10 years?	1=Cyclone 2= Floods 3= River erosion 4= Drought 5= Earthquake 6= Extreme Heatwave 7= Strom surge 8= Water salinity 9=others
3.2	Recently has the scale of a natural disaster or disasters increased?	1=Yes 2=No 3= DNK
3.3	Do you think the changing climate is responsible for the natural disaster?	1=Yes 2=No 3= DNK
3.4	In a scale of 0 to 10, how much you would say you have been affected by natural disaster?	10 Severely affected 9 8 7 6 5 Neutral 4 3 2 1 0 Not affected
3.5	Do you think your area is hit by natural disaster very frequently?	1=Yes 2=No 3= DNK
3.6	How many times you have faced any kind of natural disasters in the last ten years?	……………………………..
3.7	What are the things you lost in the last natural disaster?	1= Causalities 2= Furniture 3=Livestock 4=Agricultural land 5=Trees 6=Valuable items 7=Others (please specify)……………….
3.8	Did you suffer financially as a result of the last natural disaster?	1=Strongly Disagree 2=Disagree 3= Neutral 4= Agree 5= Strongly Agree
3.9	Did you find it difficult to grow crops as a result of the last natural disaster?	1=Strongly Disagree 2=Disagree 3= Neutral 4= Agree 5= Strongly Agree

3.10	Did you receive any support or financial assistance from any government after the disaster?	1=Yes 2=No 3= DNK
3.10a	Did you receive any support or financial assistance from any private organization after the disaster?	1=Yes 2=No 3= DNK
3.10b	Was that help or financial support enough to recover the damage or loss?	1=Strongly Disagree 2=Disagree 3= Neutral 4= Agree 5= Strongly Agree

Effect on household during and immediately following the disaster		
No	**Questions**	**Coding**
4.1	Did you ever fear that you might be seriously injured or killed?	1=Yes 2=No 3= DNK
4.2	Were you or was anyone close to you seriously injured?	1=Yes 2=No 3= DNK
4.3	Do you know anyone who died?	1=Yes 2=No 3= DNK
4.4	Were you separated from anyone in your immediate family?	1=Yes 2=No 3= DNK
4.5	Was your home seriously damaged or destroyed?	1=Yes 2=No 3= DNK
4.6	Did you receive any of the following support:	1=Water 2= financial 3= protection 4=shelter 4=food 5=clothing 9=others (please specify)…………..

No	Questions	Coding
Climate change impact on Health		
5.1	In general, how do you rate your health now?	1=very good 2= good 3= moderate 4= poor 5=very poor
5.2	Do you think climate change is affecting your surrounding environment?	1=Yes 2=No 3= DNK
5.3	Do you think the changing environment is good for your health and wellbeing?	1=Yes 2=No 3= DNK
5.4	Did you hear about any new diseases in your area?	1=Yes 2=No 3= DNK
5.5	Do you think these new diseases are getting common nowadays comparing to past years?	1= Very much yes 2=Yes 3= DNK 4= No 5=Not at all
5.6a	Do you think climate change is indirectly responsible for these new diseases?	1=Yes 2=No 3= DNK
5.6b	Do you think these new diseases are having serious health impacts?	1=Yes 2=No 3= DNK
5.6c	Do you know anyone in your family suffering from any new diseases?	1=Yes 2=No 3= DNK
5.6d	Do you know of any other people in your community suffering from any new diseases?	1=Yes 2=No 3= DNK
5.6e	Do you know of any person in the community who died from any new disease?	1=Yes 2=No 3= DNK
5.6f	Did you receive any information and support from the local health centre about the new diseases?	1=Yes 2=No 3= DNK
5.7	In a scale of 0 to 10, how much you would say Sidr/Aila is responsible for the emergence of new diseases in your area?	10 Highly responsible 9 8 7 6 5 Neutral 4 3 2 1 0 Not responsible

5.7a	In a scale of 0 to 10, how much would say that climate change has an impact on your health?	10 High Impact 9 8 7 6 5 Neutral 4 3 2 1 0 Not Impact
Natural Disaster effect on health		
5.8	Do you think Climate change is responsible for Sidr/Aila in your area?	1=Yes 2=No 3= DNK
5.9	In a scale of 0 to 10, how much you would say you Sidr/Aila has affected your health?	10 Severely affected 9 8 7 6 5 Neutral 4 3 2 1 0 Not affected
5.10	Do you think human sufferings in your area have increased after Sidr/Aila?	1=Yes 2=No 3= DNK
5.11	Do you think people's illnesses were more prevalent after Sidr/Aila?	1=Yes 2=No 3= DNK
5.12	What are the health problems faced by people during the last disaster time?	1=Injury 2= Death 3=Illness 4=Mental Problem 5= Infectious Diseases
5.13	Did you have prior knowledge that Sidr/Aila may cause injury and death to people?	1=Yes 2=No 3= DNK
5.14	Do you think Sidr/Aila has worsened the general health conditions of those people who were already ill by that time?	1=Yes 2=No 3= DNK
5.15	Do you think the cyclone has an impact on the mental health of the people?	1=Yes 2=No 3= DNK
5.16	Have you noticed any one suffering from mental health problem as a result of the cyclone?	1=Yes 2=No 3= DNK
5.17	Did Sidr/Aila affect your toilet facility?	1=Yes 2=No 3= DNK
5.18	Was there any scarcity of pure drinking water in your area due to Sidr/Aila?	1=Yes 2=No 3= DNK
5.19	Was there any outbreak of infectious diseases in the community due to shortage of water?	1=Yes 2=No 3= DNK

5.20	Do you think the prevalence of infectious diseases increased after Sidr/Aila?	1=Yes 2=No 3= DNK
5.21	Did you face any difficulty in managing food for your family during the disaster and post disaster time?	1=Yes 2=No 3= DNK
5.22	What were the difficulties you faced regarding food availability food for your family during the disaster and post disaster time?	1= No food at home 2= No money to buy food 3= local food shops were destroyed 4= Scarcity of food in the local area
5.23	Was there any people in your area including your family suffer from malnutrition after the	1=Yes 2=No 3= DNK
5.24	Do you think Sidr/Aila is responsible for malnutrition in your area?	1=Strongly Disagree 2=Disagree 3= Neutral 4= Agree 5= Strongly Agree
5.25	Did Sidr/Aila affect your local health centre?	1=Yes 2=No 3= DNK
5.26	If yes, in what way?	1= local health centre was damaged 2= There are not enough health professionals 3= There are not enough medicines 4= Ceased function 5= No access 9= others (please specify)……….
Impact on Vulnerable population		
5.27	Do you think climate change is affecting the vulnerable people in your area?	1=Yes 2=No 3= DNK
5.28	Has climate change affected vulnerability of older people in your area?	1=Yes 2=No 3= DNK
5.29	If yes, in what way?	1=Increasing 2= Decreasing 3= No change 4= Don't Know
5.30	Has climate change affected the vulnerability of children in your area?	1=Yes 2=No 3= DNK
5.31	If yes, in what way?	1=Increasing 2= Decreasing 3= No change 4= Don't Know
5.32	Has climate change affected the vulnerability of women in your area?	1=Yes 2=No 3= DNK
5.33	If yes, in what way?	1=Increasing 2= Decreasing 3= No change 4= Don't Know
5.34	Do you know if Sidr/Aila had a greater effect on vulnerable group of people?	1=Yes 2=No 3= DNK
5.35	Are the older people are more prone to heat stress comparing to younger people?	1=Yes 2=No 3= DNK
5.36	Has climate change made poor people poorer?	1=Yes 2=No 3= DNK
5.37	Do you think climate change is causing more problems for the disabled people?	1=Yes 2=No 3= DNK
5.38	Do disabled people face more barriers to access to resources when there is scarcity of resources?	1=Yes 2=No 3= DNK

Climate change and women		
No	Questions	Coding
6.1	Do you think women face more difficulties in these situations than men?	1=Yes 2=No 3= DNK
6.2	Is your menstrual cycle regular?	1= Yes 2=No 3= DNK
6.2a	If no, do you think changing weather pattern is affecting your menstruation cycle?	1= Yes 2=No 3= DNK
6.3	Do you think pregnant women go through serious health issues during the disaster time?	1= Yes 2=No 3= DNK
6.4	Is climate change affecting the development of children?	1= Yes 2=No 3= DNK
6.5	Do you think new born babies go through serious health issues during the disaster time?	1= Yes 2=No 3= DNK
6.6	Has the violence from another person to women increases during the disaster time?	1= Yes 2=No 3= DNK
6.7	Did you face any kind of violence during the disaster?	1= Yes 2=No 3= DNK

<u>Section 7 : Pre/Post SIDR/AILA effects</u>

Person 1: **Age:** **Gender:**

No	**Diseases/Illness/Injury**	**Before Sidr**		**After Sidr**		**Before Aila**		**After Aila**	
		Yes=1	No=2	Yes=1	No=2	Yes=1	No=2	Yes=1	No=2
7.1	Diarrhoea								
7.2	Typhoid								
7.3	Food poisoning								
7.4	Hepatitis (jaundice)								
7.5	Respiratory infections								
7.6	Pneumonia								
7.7	Malaria								
7.8	Dengue fever								
7.9	Mental Health Problem								
7.10	Injury								
7.11	Death								
7.12	Skin Diseases								
7.13	Viral diseases of the eye								
7.14	Others (please specify)…………….								

Person 2: **Age:** **Gender:**

No	**Diseases/Illness/Injury**	**Before Sidr**		**After Sidr**		**Before Aila**		**After Aila**	
		Yes=1	No=2	Yes=1	No=2	Yes=1	No=2	Yes=1	No=2
7.1	Diarrhoea								
7.2	Typhoid								
7.3	Food poisoning								
7.4	Hepatitis (jaundice)								
7.5	Respiratory infections								
7.6	Pneumonia								
7.7	Malaria								
7.8	Dengue fever								
7.9	Mental Health Problem								
7.10	Injury								
7.11	Death								
7.12	Skin Diseases								
7.13	Viral diseases of the eye								
7.14	Others (please specify)…………….								

Person 3: **Age:** **Gender:**

No	**Diseases/Illness/Injury**	**Before Sidr**		**After Sidr**		**Before Aila**		**After Aila**	
		Yes=1	No=2	Yes=1	No=2	Yes=1	No=2	Yes=1	No=2
7.1	Diarrhoea								
7.2	Typhoid								
7.3	Food poisoning								
7.4	Hepatitis (jaundice)								
7.5	Respiratory infections								
7.6	Pneumonia								
7.7	Malaria								
7.8	Dengue fever								
7.9	Mental Health Problem								
7.10	Injury								
7.11	Death								
7.12	Skin Diseases								
7.13	Viral diseases of the eye								
7.14	Others (please specify)…………….								

Person 4: Age: Gender:

No	Diseases/Illness/Injury	Before Sidr		After Sidr		Before Aila		After Aila	
		Yes=1	No=2	Yes=1	No=2	Yes=1	No=2	Yes=1	No=2
7.1	Diarrhoea								
7.2	Typhoid								
7.3	Food poisoning								
7.4	Hepatitis (jaundice)								
7.5	Respiratory infections								
7.6	Pneumonia								
7.7	Malaria								
7.8	Dengue fever								
7.9	Mental Health Problem								
7.10	Injury								
7.11	Death								
7.12	Skin Diseases								
7.13	Viral diseases of the eye								
7.14	Others (please specify)…………….								

The End

Thanks for your cooperation

Appendice III

FGD Interview Guide

For Knowledgable people and community people:

Climate change and its impact on human health

[Hint: Is there any significant changes to general and mental health and injury of the local people after and during Sidr/Aila, What make you to say that the health impacts are due to climate change, what was overall health condition of the local people before Sidr/Aila]

Climate change and infectious disease

[Hint: Prevalence of diarrhoea, typhoid and other infectious diseases increased after Sidr/Aila, which one is more common, How many deaths due to this, how many people suffered, is the number high from before Sidr/Aila, what are the main sources of this infectious diseases, what precautions and measurements are taken to prevent it, how many recovered, what is the condition now, hospital admission is high due to which diseases, was that disease highly prevalent before Sidr/Aila]

Climate change and vulnerable population

[Hint: how the children and older adults cope with this climate change, what is their health condition after Sidr/Aila, any illness or injury after Sidr/Aila, what about the immunization program in the locality, all children are immunized, no of children deaths increased after Sidr/Aila, no of older people deaths increased after Sidr/Aila, are they suffering from more diseases now, what are the diseases they had before Sidr/Aila, is climate change aggravating their current health condition]

Climate change and socio-economic situation

[Hint: property damage, lack of food, lack of work etc affecting their lives, what is their current situation and how their condition before Sidr/Aila, are they going through mental trauma for this]

Appendice IV

Research Ethics Approval Form

Middlesex University
Business School London

Supervisor Login
SRCEP Login

RESEARCH ETHICS APPROVAL FORM

Ref: 736-7-4203

NAME OF RESEARCHER: Russell Kabir

STATUS: Postgraduate

PROGRAMME OF STUDY: MPhil Middlesex Business School

NAME OF SUPERVISOR/TUTOR: Dr. Hafiz T. A.Khan

NAMES OF ANY RESEARCH COLLABORATORS:

PROPOSED TITLE OF RESEARCH PROJECT: Climate Change and its impact on the health of the coastal population in Bangladesh

***BRIEF* DESCRIPTION OF THE MAIN AIMS OF THE STUDY:** The purpose of this research is to explore three areas: (i) To what extent climate change can affect human health particularly children and older adults as they are the two most vulnerable groups during climatic disasters; (ii) To investigate the prevalence of rates of disease caused by climatic disasters; (iii) To identify whether or not any evidence of emerging diseases can be found in the worst hit areas.

HAVE YOU READ AND UNDERSTOOD THE UNIVERSITY'S *CODE OF PRACTICE FOR RESEARCH: PRINCIPLES AND PROCEDURES*? Yes

IS THIS STUDY A LITERATURE REVIEW (LIBRARY STUDY) WHICH DOES NOT INVOLVE COLLECTING PRIMARY DATA? No

WILL YOUR RESEARCH INVOLVE:
a) CONDUCTING INTERVIEWS? **Yes**
If Yes, state with whom: **Respondents of this research are climate change affected coastal people from Bangladesh.**
b) PARTICIPANT OBSERVATION? **No**
c) USE OF QUESTIONNAIRE(S) WHICH YOU HAVE DESIGNED? **Yes**
d) FOCUS GROUPS? **Yes**
e) OBSERVATION? **No**

WILL YOU OBTAIN WRITTEN INFORMED CONSENT DIRECTLY FROM RESEARCH PARTICIPANTS? Yes

DO YOU INTEND TO OFFER INCENTIVES TO RESEARCH PARTICIPANTS? No

WILL YOU INFORM PARTICIPANTS OF THEIR RIGHT TO WITHDRAW FROM THE RESEARCH AT ANY TIME? Yes

WILL YOU GUARANTEE CONFIDENTIALITY OF INFORMATION TO PARTICIPANTS? Yes

WILL YOU GUARANTEE ANONYMITY TO PARTICIPANTS? Yes

DOES YOUR RESEARCH METHODOLOGY RAISE ANY SAFETY/LEGAL ISSUES FOR YOU OR YOUR PARTICIPANTS? No

DO YOU HAVE ANY ETHICAL CONCERNS ABOUT THIS RESEARCH PROJECT? No

STUDENT DECLARATION

THE INFORMATION GIVEN ON THIS FORM IS TRUE TO THE BEST OF MY KNOWLEDGE. I WILL USE THESE METHODS IN MY RESEARCH UNLESS I RENEGOTIATE ANY CHANGES WITH MY SUPERVISOR/ TUTOR.

STUDENT SIGNATURE Russell.Kabir **DATE** 12.09.2011

[THE FOLLOWING STATEMENTS ARE FOR THE SUPERVISOR/TUTOR TO TICK AS APPROPRIATE.]
a) I HAVE READ THE INFORMATION SUPPLIED ON THIS FORM AND DO NOT THINK THAT IT RAISES ANY ISSUES THAT NEED TO BE CONSIDERED BY SRCEP. ✓
b) I HAVE READ THE INFORMATION SUPPLIED ON THIS FORM AND HAVE REFERRED/WILL REFER THE PROPOSAL TO SRCEP FOR THEIR CONSIDERATION. ✓
c) THIS PROPOSAL HAS BEEN APPROVED BY SRCEP.
SIGNATURE OF SUPERVISOR/TUTOR .... **DATE** 16/9/2011

Please print this form and complete the declaration above. You may also want to save a copy for your records.

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