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Tropical Cyclone Aila and Its Environmental Impact on Coastal region of Bangladesh

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TROPICAL CYCLONE AILA AND ITS ENVIRONMENTAL IMPACT ON COASTAL REGION OF BANGLADESH

M. Phil. Thesis

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Dedicated
To
My Family

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CERTIFICATE

I hereby recommend and certify that this thesis entitled **"Tropical Cyclone Aila and Its Environmental Impact on Coastal region of Bangladesh"** is a research work carried out by Mst. Monika Sultana for the Degree of Master of Philosophy in the Department of Geography and Environmental studies, University of Rajshahi, under my supervision.

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DECLARATION

I do hereby declare that this thesis entitled **"Tropical Cyclone Aila and Its Environmental Impact on Coastal region of Bangladesh"** submitted to the Department of Geography & Environmental Studies, University of Rajshahi, Bangladesh for the degree of Master of Philosophy is the result of my own research, under the supervision of **Md. Mizanoor Rahman**, Associate Professor, Department of Geography and Environmental studies, University of Rajshahi, Bangladesh.

I further declare that this thesis previously has not been submitted partially or fully previously for any degree or diploma either in this university or any other university or institute.

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Mst. Monika Sultana

Abstract

Bangladesh is among the world's most disaster-prone countries and the frequency of natural disaster has increased in recent years. The coastal morphology of Bangladesh influences the impact of natural hazards on the area. Especially, in the southwestern area, natural hazards like tropical cyclone Aila impacts badly on coastal dwellers and environment and slow down the process of social and economic developments and environmental stability. The purpose of this research is to examine the environmental impact of tropical cyclone Aila in the light of physical and cultural environmental aspect and determine problems created because of environmental impact by underlying environmental, socio-economic and other relevant variables that related to the environmental impact in two remarkable cyclone-prone coastal villages of Bangladesh. Relevant data are collected from two cyclone prone coastal villages of south-western Bangladesh through structured questionnaire survey, key informant interviews and field observations. The questionnaire survey was conducted through simple random sampling procedure, and study villages were selected purposefully considering the severity of environmental impact of cyclone Aila. Both descriptive and inferential statistics are used to identify the factors responsible for environmental impact due to cyclone Aila and storm surge. In physical environmental aspect the study shows that cyclone Aila is cause of large-scale destruction of forest, land erosion, increased saline intrusion of water and soil, air pollution, uneven flood and so on. In cultural environmental aspect it seems that Aila is responsible for widespread deaths, loss of livestock and livelihoods, infrastructural damage, loss of sanitation sector, forced migration etc. All these impacts provoke loss of ecosystem, poverty, malnutrition, appearance of various diseases, school dropout and social unrest. The study also recommends some strategy to recover these problems.

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List of Abbreviations

AP	Associated Press
BBS	Bangladesh Bureau of Statistics
BMD	Bangladesh Meteorological Department
CFS	Child Friendly Space
CPP	Cyclone Preparedness Program
CRF	Coastal Research Foundation
CRG	Calcutta Research Group
CSRL	Common Strategic Rotary Launcher
DDM	Department of Disaster Management
Df	Degree of Freedom
DMB	Disaster Management Bureau
DRR	Disaster Risk Reduction
ECBP	Emergency Capacity Building Project Bangladesh Consortium
FAO	Food & Agricultural Organization
FPP	Forest People Program
Ft	Feet
GIS	Geographical Information System
GoB	Government of Bangladesh
IFRC	International Federation of Red Cross and Red Crescent Societies
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
IRIN	Integrated Regional Information Network
Km	Kilometer
Kmph	Kilometer per Hour
M	Meter
MFDM	Ministry of Flood & Disaster Management
Mi	Mile
Mph	Mile per Hour

NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPDM	National Plan for Disaster Management
PSF	Pond Sand Filter
SPSS	Statistical Package for Social Science
Sq	Square
SVC	Save the Children
Tk	Taka
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
UP	Union Parishad
USD	United States Dollars
WB	World Bank

Glossary

Bazaar **:** Daily market where all types of commodities are available

Gher **:** Shrimp cultivation farm

Golpata **:** Forest leaves

Hat **:** Village local market sets once or twice in a week

Ibid **:** In the same place

Khas **:** Govt. fallow land

Thana **:** Sub-district that consist several unions

Union **:** Smallest electoral unit of rural area, which is comprised of villages.

CHAPTER ONE

INTRODUCTION

CHAPTER ONE

Introduction

1.1 Background

Bangladesh is a low-lying deltaic country in South Asia formed by the Ganges, the Brahmaputra and the Meghna rivers. The geographical location, land characteristics, multiplicity of rivers and the monsoon climate render Bangladesh highly vulnerable to natural hazards. The coastal morphology of Bangladesh influences the impact of natural hazards on the area such as floods, cyclones, tidal surges, tornadoes, earthquakes, infrastructure collapse, high arsenic contents of ground water, water logging, water and soil salinity, epidemic and various forms of pollution are frequent occurrences (GoB, 2010a).

Bangladesh is among the world's most disaster-prone countries and the frequency of natural disasters has increased in recent years. Since independence in 1971, the country has endured almost 200 disaster events – cyclones, storm surges, floods, tornadoes, earthquakes, droughts and other calamities – causing more that 500,000 deaths and leaving serious impacts on quality of life, livelihoods and the economy (ibid). The country was struck by 154 cyclones including 43 severe cyclonic storms, 43 cyclonic storms and 68 tropical depressions during 1877 to 1995. Since 1995, five severe cyclones hit the coast of Bangladesh coast such as on May 1997 (intensity category 4), September 1997 (intensity category 2), May 1998 (intensity category 3), November 2007 (intensity category 4) and May 2009 (intensity category 2) (Dasgupta *et al.*, 2010). A severe cyclone strikes Bangladesh every three years on an average (DDM, 2009).

Especially in the south western area, natural hazards increase the vulnerability of the coastal dwellers and slow down the process of social and economic development & environmental stability. Aila in 2009 is more or less exceptional than the previous natural disaster occurred in Bangladesh. About 2.3 million

people were affected by Aila many of them stranded in flooded villages as they had no alternative to save themselves (Naeem A, 2009).

According to the ministry of flood and disaster management (MFDM), more than 7,103 people were wounded and more than 3,928,238 people were affected. In addition, road networks, water systems and the communication system were damaged. Initial local media reports indicated that the storm surge, heavy rains coupled with gale force winds flattened huge parts of standing crops and washed away numerous fisheries. The availability of safe drinking water was inadequate. Aila affected communities have lost their livelihood productive tools. The main occupation of the south western coastal communities were fishing, collecting honey and wood from Sunderbans; and working on the shrimp cultivation farm. Now, most of the Aila affected people are forced to work as day laborer to earn their living (IFRC, 2010).

Ecosystems such as mangrove forests and wetlands and the respective ecosystem service they provide are critical to sustaining livelihoods. In total, these activities support over 70 livelihood-related activities, including fisheries, aquaculture, livestock grazing and wood collection (Barua *et al.*, 2010). Mangrove forests also protect coastal populations exposed to cyclones (Ibid). During cyclones Aila, the Sundarban mangrove forest acted as a vegetative shield that helped to minimize the adverse impacts of these events by reducing storm surge velocity and stabilizing sedimentation (Barbier, 2006; GoB, 2008).

The storm surges that accompanied cyclone Aila increased soil salinity, leading to a loss of agricultural productivity, and contaminated groundwater sources (Nishat *et al.*, 2013). While saline water intrusion was already a problem in these areas before Aila struck, the cyclone events significantly worsened the problem, particularly in Shyamnagar where vast swaths of agricultural land and aquaculture ponds remain unproductive due to persisting tidal flooding (GoB, 2008; Oxfam, 2012).

1.2 Problem Statement

The coastal zone of Bangladesh is recognized as an extremely vulnerable area. Bangladesh is covered with different types of natural disasters every year. Cyclone is one of them. In latest on May 25, 2009 the cyclone Aila had hit the south-western part of Bangladesh and caused 325 deaths (Roy *et al.*, 2009), affected the residents, homesteads, roads and embankments. In total, over 3.9 million people were affected (UN, 2010) and nearly 350,000 acres of crop land were destroyed. Fishing, agriculture, shrimp farming, salt farming and tourism are the main economic activities of this coastal area. Storm surge of cyclone Aila washed away all the houses, crops and agricultural land. The damage of the infrastructure is enormous, it also destroy the livelihoods of the people.

Aila not only broke down the overall infrastructure but also drop the people into an insecure position of this area. Till now people are struggling to manage minimum basic needs like food, shelter, water and sanitation facilities. Aila have brought different kinds of diseases, injuries and other health problems. It has been observed that people lost everything and they lives in uncertainty, every moments they feels insecurity for their basic needs. Cyclone Aila caused widespread deaths, large-scale destruction of livelihoods and property forcing villagers to migrate. It seems that Aila affects all the sectors of environment. That is why many problems are being created and have already created by this physical and cultural environmental damage. So it is important to identify the damages and losses of environmental sector created by Aila, and the problems created by this damage.

1.3 Research Questions

Based on the stated problems, the formulated research questions are:

- What is tropical cyclone Aila?
- What are the damages and losses of both physical and cultural environmental sector created by Aila?
- What are the problems created by environmental damage?

1.4 Rationale of the Study

Bangladesh is a least-developed, low income food deficit country with 40 percent of the population living below the poverty line (FAO, 2008). Bangladesh is one of the most vulnerable countries to climate change. Vulnerability of Bangladesh to cyclones / storm surges may increase even more as a result of climate change. The trend of tropical cyclones hitting the Bangladesh coast is increasing at the rate of 11.8 per decade from 1950–2000 (Islam and Peterson, 2009). In 2009 cyclone Aila hit the south-western parts of Bangladesh. The Cyclone Aila, which hit the coastal Bangladesh on 25 May 2009, caused huge loss of properties and infrastructure, and displaced a large number of people from their homes (DMB, 2009). As we know the people of affected area faced the problem of safe drinking water availability, sanitation problem, food and nutrition problem, salinity of agricultural land, ecosystem loss, many kinds of diseases etc. The whole region faced a terrible environmental situation and affected by environmental damage which affects every part of coastal people's life. Under the circumstances, this research could be exemplified how severely Aila has affected the environment and the related sectors of the coastal region of Bangladesh. And it may help to consider the steps towards this type of hazards.

1.5 Conceptual Framework

Tropical cyclone Aila has played an inimical role in coastal people's life. It has damaged both physical and cultural part of coastal region's environment. The physical environmental damages have considered fresh water resources damage, loss of ecosystem, land fertility less, increased soil salinity, destruction of forest and biodiversity, heavy rain, uneven flood, coastal land erosion etc. Cultural environmental damages are loss of habitation, road network and communication system damage, property and infrastructural damage, loss of livelihood productive tools, sanitation system damage, loss of education system and social bonding, hampering in tourism, injury and health problem etc. And these damages have caused severe long term and short term problems in various sectors of coastal

people's life and coastal environment. The problems created by these damages are unemployment problem, increase of poverty, forced migration, shelter less, food and nutrition problem, sanitation problem, salinity of land, appearances of various diseases, safe drinking water unavailability, communication problem, hampering clean-up and rescue efforts etc. Finally it seems that tropical cyclone Aila has played in a great role to affect coastal people's life and environment.

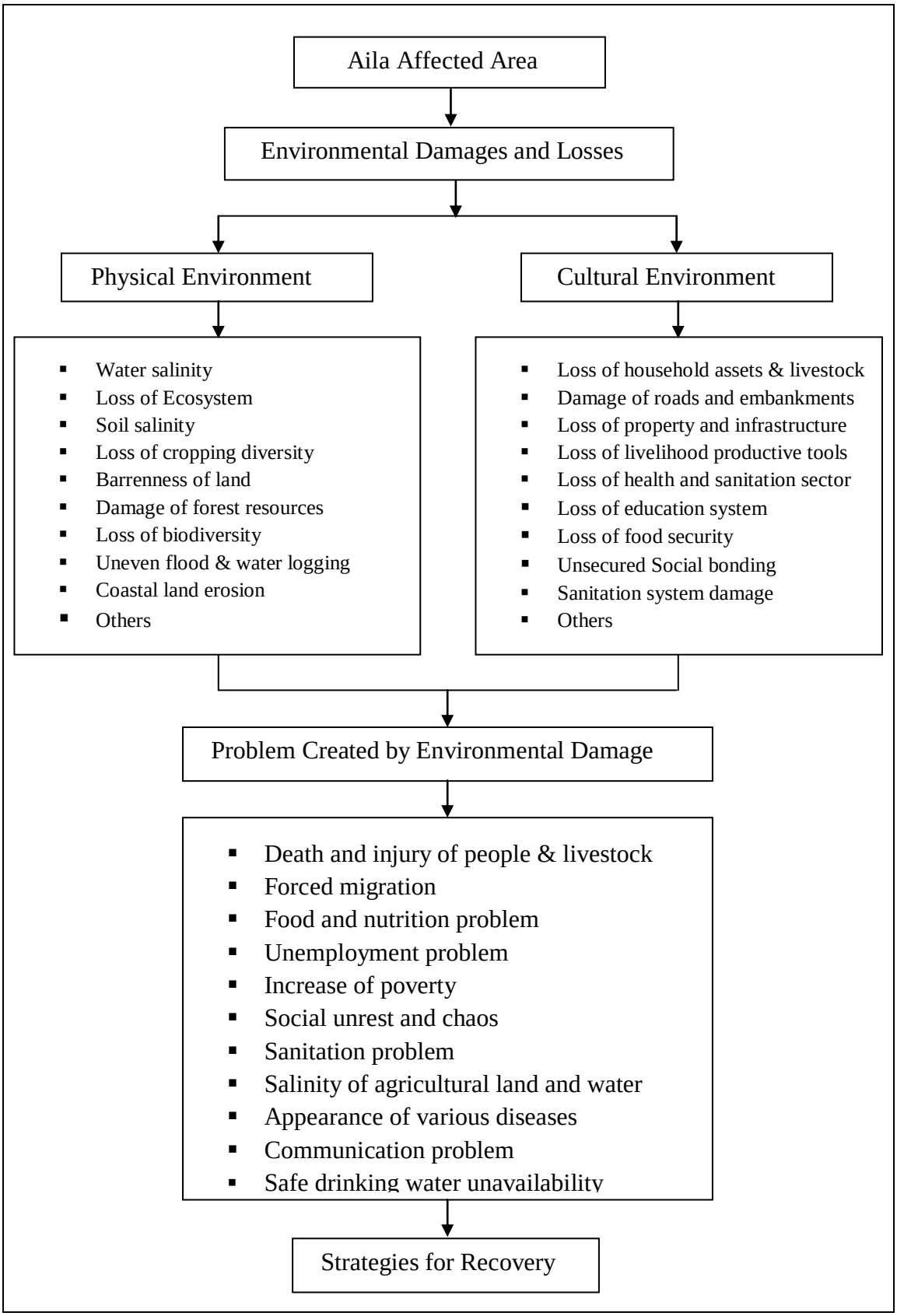


Figure 1.1 Conceptual Framework of the Study.

1.6 Objectives

The general objective of the study is found out the scenario of tropical cyclone Aila and measured the damages and losses of environmental sector of coastal region of Bangladesh. And it's another objective is recommended some strategies for recovering environmental damage.

The specific objectives of the study are as follows:

To identify the damages and losses of environmental sector.

To ascertain the problem created by environmental damage.

To recommend strategies for recovering environmental damage.

1.7 Scope of the Study

The scope of the research is to study about tropical cyclone Aila, its impact on environmental sector and problem created by environmental damage. Tropical cyclone Aila has played as a great shock to nature, environment and people. It has damaged both physical and cultural part of environment equally. In this study it has focused as a major part. Cyclone Aila's environmental damage has created many problems in the life of coastal people. It has affected every sector of their life such as occupation, livelihood, food, shelter, health, sanitation, economic condition, social bonding, recreation, mental peace etc. So the problem created by environmental damages and losses have discussed in the study. And finally on the basis of conclusion, the study has suggested some strategy for recovering the problem.

1.8 Limitation

Environmental impact is a vast concept but the proposed research was intended to see environmental impact of coastal region on the basis of two coastal villages of Satkhira and Khulna district. That is why specific factors have considered finding out the damages and losses of environmental sector due to Aila and problem created by this damage. There had to face several constraints in gathering information from the field. For example, improper information and variation in

people perception about their loss and damage. But using tri-angular method in data analysis this problem has been solved and synthesized the result. Another limitation is though many small and big effective cyclones happening in the coastal region time and again before and after Aila but the proposed research has only focused on the impact of Aila in the study area. Perhaps, comparative study would be more effective. But this research has not considered that matter.

CHAPTER TWO

LITERATURE REVIEW

CHAPTER TWO

Literature Review

This chapter is designed to discuss the relevant literature of the study basically on tropical cyclone Aila, its environmental impact and problem created by environmental damage; and through details investigation of journal articles, reports, documents and books an attempt has been made to conceptualize and explore knowledge gap for problem identification, objective setting and research methodology determination for the study.

2.1 Concept of Tropical Cyclone

A tropical cyclone is a storm system characterized by a low-pressure center and numerous thunderstorms that produce strong winds and flooding rain. A tropical cyclone feeds on heat released when moist air rises, resulting in condensation of water vapour contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as nor'easters, European windstorms, and polar lows, leading to their classification as "warm core" storm systems (Stan Goldenberg, 2004).

The term "tropical" refers to both the geographic origin of these systems, which form almost exclusively in tropical regions of the globe, and their formation in Maritime Tropical air masses. The term "cyclone" refers to such storms' cyclonic nature, with counterclockwise rotation in the Northern Hemisphere and clockwise rotation in the Southern Hemisphere. Depending on their location and strength, tropical cyclones are referred to by other names, such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression, or simply as a cyclone. Tropical cyclones or hurricanes are common within latitude 30^{o} north and south. These intense storms move across shallow shelf seas; the water is being piled-up along the coast as a surge.

While tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and damaging storm surge (James M. Shultz, Jill Russell and Zelde Espinel, 2005). They develop over large bodies of warm water (Chris Landsea, 2009), and lose their strength if they move over land (Sim Aberson, 2009). This is the reason coastal regions can receive significant damage from a tropical cyclone, while inland regions are relatively safe from receiving strong winds. Heavy rains, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 40 kilometers (25 mi) from the coastline. Although their effects on human populations can be devastating, tropical cyclones can also relieve drought conditions (NOAA, 2005). They also carry heat and energy away from the tropics and transport it toward temperate latitudes, which make them an important part of the global atmospheric circulation mechanism. As a result, tropical cyclones help to maintain equilibrium in the Earth's troposphere.

Tropical cyclones from the Bay of Bengal accompanied by storm surges are one of the major disasters in Bangladesh. A tropical cyclone is a rapidly-rotating storm system characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as nor'easters, European windstorms, and polar lows. The strong rotating winds of a tropical cyclone are a result of the (partial) conservation of angular momentum imparted by the Earth's rotation as air flows inwards toward the axis of rotation. As a result, they rarely form within 5° of the equator. Tropical cyclones are typically between 100 and 4,000 km (62 and 2,500 mi) in diameter (Zhang H *et al.*, 1998).

The Bay of Bengal, which forms the southern boundary of Bangladesh, is an ideal breeding ground for tropical cyclones (Rashed–Un–Nabi et al., 2007; Hossain and others, 2012). According to Ali (1996) an estimated 10 percent of the world’s

tropical cyclones form in the Bay of Bengal. In addition to the unique geophysical characteristics of the Bangladesh coast, the socioeconomic characteristics of coastal communities also increase the residents' vulnerability to cyclones (Paul, 2009).

2.2 Tropical Cyclone Aila

Bangladesh is currently ranked as one of the world's most disaster-prone countries, with 97.1 per cent of its total area and 97.7 per cent of the total population at risk of multiple hazards, including cyclones (World Bank, 2005). Bangladesh is well-known for its severe cyclones and storm surges. Geographic location and with its tropical monsoon climate make the country more vulnerable to cyclones (Blaikie *et al*., 1994; Ali, 1999; Paul, 2009).

Aila was the second tropical cyclone to form within the Northern Indian Ocean during 2009. The disturbance that was to become Cyclone Aila formed on 21 May 2009. Over the following days the disturbance slowly intensified into a cyclonic storm, named Aila, located approximately 350 kms offshore (UNDP, 2010).

Cyclone Aila took shape on 23rd May and hit the South-Western coastal zone of Bangladesh on 25th May 2009. The wind speed of the Aila was about 104.6-120.7 km/h (Roy *et. al,* 2009). Almost 2.3 million people were affected by Aila and many people were stranded in flooded villages. The height of the tidal surge was about 10-13m and it washed away the enormous number of households, lives, livestock, crops and all other resources of the affected region. This whole incident happened within a very short period of time, and then people became homeless leaving their assets in the households. During the cyclonic event a very small percentage of the affected people could manage to take shelter in the nearby cyclone shelter and maximum people take shelter on roads and roofs of the schools, colleges, madrashas, mosques and Union Parisahd (local government) buildings.

Tropical Cyclone Aila hit 14 districts on the south-west coast of Bangladesh on the 25th May 2009. The cyclone has had a devastating long-term impact,

particularly because embankments which were breached during the storm remain unrepaired. This means that some homes and schools still flood at high tide. People continue to live on embankments, the only place above water level, without sufficient food, water, shelter or protection. Livelihood options were also severely affected by the cyclone as livestock, shrimp ponds and cropland were washed away or destroyed (UNICEF Bangladesh, 2010).

2.3 Environmental Damages and Losses Caused by Aila

The Cyclone Aila, which hit the coastal Bangladesh on 25 May 2009, caused huge loss of properties and infrastructure, and displaced a large number of people from their homes (DMB, 2009). Khulna and Satkhira District of southwest coastal zone of Bangladesh were hit the hardest by the cyclone Aila although other coastal districts Barisal, Bhola, Pirojpur, Patuakhali, Barguna, Jhalokathi, Bagerhat, Chittagong, Cox's Bazar, Feni, Laxmipur and Noakhali were also affected (Wash Cluste, WaterAid and UNICEF, 2009). It affected both physical and cultural part of environment.

2.3.1 Physical Environmental Damage

The coastal embankments damaged by the cyclone and tidal surges could not be repaired even after one year of the cyclone (Oxfam, 2010). As of August 2010, a large number of displaced people have been living in the makeshift houses of the damaged embankments without adequate food, safe drinking water, proper sanitation facilities, etc. To protect these displaced people, the relevant policies and institutional frameworks should be reviewed on urgent basis to identify key-gaps in protection needs and launch new policy and institutional frameworks (Roy DC, 2010). Poor has become extremely poor and many non-poor have been thrown into poverty and food insecurity by the destruction of Aila (Mallick, 2009).

In addition, the storm surges that accompanied cyclone Aila increased soil salinity, leading to a loss of agricultural productivity, and contaminated groundwater sources (Nishat *et al.*, 2013). As the drinking water sources and

sanitary latrines have been damaged, people are living in unhealthy and unhygienic condition without adequate food, pure drinking water and proper sanitary facilities (Dhaka Mirror, 2010). The cyclone Aila caused huge damages of ponds, where community people used to store sweet water between September and November each year and use that water for the rest of the year. The internally displaced people also faced the problems of physical insecurity, stress due to traumatic experiences, lack of livelihood opportunities, loss of documentation, etc (CRG, 2006).

Natural disasters frequently cause a severe deterioration in the quality and supply of drinking water and disruption of the operation of sanitation facilities. Drinking water sources may become contaminated by the carcasses of domestic animals and dead fish. In the case of cyclones, surface water resources (e.g., ponds, canals, and rivers), generally the main source of drinking water in coastal areas, are often contaminated by saline intrusion (Paul and Routray, 2010a; Paul, 2011; Paul *et al.*, 2012, Caldin and Murray, 2012).

One fisher described the acute crisis of drinking water in Shyamnagar, maintaining that he and his family had to drink harvested rain water for three or four months of the year and buy drinking water for the remaining months as the groundwater had become too salinated to drink (Haque *et al.*, 2013, Interview 81). Based on interview findings, the study estimates that in Shyamnagar, households spent on an average USD 7 per month for drinking water (Ibid).

Various kind of water borne diseases such as Diarrhea and skin disease were the major infectious diseases in Aila-affected areas according to the post-disaster assessment conducted after one month by Save the Children (SVC, 2009). People also got infections for taking baths in ponds (Uttaran, 2010). The incidence of infectious diseases including diarrhea and skin-infection are on the rise and so the conditions for present health service were getting worse. Almost 80 percent people were not getting access to the health facilities. Only 3percent to 4 percent people were able to reach to the clinic or hospitals (ECBP, 2010 and ECBP,

CSRL, 2010). Due to the lack of reconstruction work and still worsen structural situations, people lives without access to the basic health care service (UN, 2010) and about 34% of households (over 108 000 people) have no access to drinking water (AP) (Agenzia Fides, 2011).

Sundarban is one of the largest sources of livelihoods in the Aila affected Khulna and Shatkhira Districts. After Cyclone SIDR, GoB restricted entering the forest. People are only able to access during March-May after taking permission from department of forest of GoB for collecting Golpata, fodder, honey, timber, fish and crab on which the population directly or indirectly dependents.

The Sunderbans, a region which houses 265 of the endangered Bengal Tigers, was inundated with 6.1 m (20 ft) of water. Dozens of the tigers are feared to have drowned in Aila's storm surge along with deer and crocodiles. As of 27 May 2009, one tiger has been found alive; it was found in a waterlogged cowshed following the cyclone's landfall. Additionally the forest remains under an estimated 2.4 m (7.9 ft) of water. On 27 May, conservationists have begun a search for the tigers throughout the forest. The search teams were supplied with fresh drinking water for the tigers as their natural water source was inundated with salt water from Aila's storm surge (The Times of India, 2009).

Ecosystem services from the Sundarban mangrove forest were instrumental in helping affected communities to survive in the aftermath of these disasters. In Shyamnagar, some residents who were interviewed estimated that the number of forest foragers increased tenfold after Cyclone Alia (Ibid). Others adapted by joining food for work programs aimed at building and maintaining coastal embankments, roads, and other physical infrastructures. Women, who were previously relegated to household chores, also participated in different income generating activities in greater numbers to help their households adapt to the impacts of cyclone Alia (Haque *et al.*, 2013:Interview 9).

2.3.2 Cultural Environmental Damage

Some 3.9 million people were affected when Aila slammed into southern Bangladesh on 25 May 2009, killing 190 and injuring more than 7,000. More than 600,000 thatched houses in 11 of the country's 64 districts were damaged or destroyed by the storm, which damaged about 350,000 areas of land, 5,000 educational and other institutions, 8,800km of roads and 157 bridges and culverts. Adding to their troubles are the monsoon rains that have followed Aila. More than 1,400km of levees and dikes constructed in the 1960s to protect agricultural and inhabitable land were washed away in the storm, leaving hundreds of villages and tens of thousands of acres of croplands and shrimp beds exposed to sea water. It enters these areas twice a day with the tide, making them inaccessible and unsuitable for any agricultural work (IRIN Asia, 2009).

After losing livelihood options and having their homes and agricultural plots inundated, many people were forced to migrate – often temporarily, but sometimes permanently – to other areas in search of livelihood opportunities (Kartiki, 2011; Haque *et al*., 2013: Interviews 11, 19). After cyclone Aila, the International Organization for Migration (IOM, 2013) estimated that approximately 120,000 people were displaced from Khulna and the adjacent district of Satkhira. In addition, roughly 40,000 people were displaced from the Koyra Upazilla in Khulna District (IOM, 2010). In some cases, household members migrated to urban centers such as Khulna, Jessore and Dhaka to seek out income-generating opportunities, though many were forced to return due to a lack of jobs and high living costs (Kartiki, 2011). Household surveys identified nine individuals who had moved to Khulna to work in brick fields in order to send remittances home to their households (Haque *et al.*, 2013).

Cyclone Aila destroyed 5,043 educational facilities in all the affected areas (UN, 2010). After Aila, the international NGO, Save the Children-UK created a children education project, called Child Friendly Space (CFS) for 5 months in the two affected areas, Khulna and Satkhira districts. Many children did not come

back to school because they joined their family works, such as collecting relief packages and drinking water (Save the Children, 2009). Even if their schools were not been damaged much, which is almost impossible for the two affected area and almost 90 percent of the students have to use boats to go to the school (Joint Assessment Consortium, 2009).

It also caused considerable infrastructure losses (DDM, 2009; Roy *et al.*, 2009; CRF, 2010; IFRC, 2010; UNDP, 2010). 'Roads and embankments' is one of the worst affected sectors in Aila. The cyclone and tidal surges collapsed the coastal embankments at several points inundating the vast areas (DMB, 2009). The local Roads and Highway authorities confirmed full damage of 367 km of road and partial damage of 1065 km of road only in Khulna District. Locals report about 35 breaches in the embankment system around the district, while the officials of The Disaster Management Information Centre estimated about 597 km of embankment been damaged.

The Fisheries department confirmed a loss of total of 59,045 acres of land under shrimp ghers along with 1,074 acres land under ponds culturing white fish. The official estimates of the economic loss in Dacope, Paikgacha and Batighata is about BDT 900 million. However, locally available reports from many other parts of the affected areas like Koyra give rise to the estimate up to BDT 1.5 billion (Roy *et al.*, 2009).

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

CHAPTER THREE

Research Design and Methodology

This chapter has focused on type of research, research design, selection criteria of the study area, sampling design and procedure, sources of data and its collection and analysis methods.

3.1 Research Types

The research methods applied in the study are both exploratory and descriptive because how, what or why questions are posed (Yin, 1994). In explorative part an attempt is made to find out the environmental impact of tropical cyclone Aila and its upshot in the study area. It has also emphasized to investigate about tropical cyclone Aila and recommended some strategies for recovering environmental damage and problems. Similarly, the study being descriptive has illustrated the problem created by physical and cultural environmental damages and losses such as forced migration, food and nutrition problem, unemployment problem, increase of poverty, sanitation problem, injury and health problem, salinity of agricultural land, appearance of various diseases, communication problem, safe drinking water unavailability etc.

3.2 Research Design

The research design is based on observation including reconnaissance survey, questionnaire survey and key informants discussion of the study area. The questionnaire survey has been carried out at the household level in selected villages while checklist was used for data collection from key informants. Quantitative and qualitative approaches were used to collect data and information, which provide relevant and useful information for identifying the damages and losses of environmental sector and problem created by environmental damage.

3.3 Selection of the Study Area

Selection of the study area is an important step for a research. Necessary data are obtained from the selected area in order to achieve the objectives set for the research. The study concentrates on Patharkhali village of Uttar Bedkashi union of Koyra upazila and Sora village of Gabura union of Shyamnagar upazila. Koyra upazila is in Khulna district and Shyamnagar upazila is in Satkhira district of Bangladesh. Koyra is the largest upazila of Khulna district. And another study area Shyamnagar is regarded as the largest upazila of Satkhira district. The study area has been selected based on following criteria:

- These areas are located in coastal region and regarded as the most cyclone prone area.
- The people and environment of these areas were mostly affected by Aila 2009.
- Koyra and Shyamnagar were the most damaged upazila.
- These areas have the forest area which is the greatest part of physical environment.

Brief History of Study Area: The study area of this research is in Uttar Bedkashi union of Koyra upazila of Khulna district and Gabura union of Shyamnagar upazila of Satkhira district which are in the coastal region of Bangladesh. Uttar Bedkashi union occupies an area of about 22.44 sq. km. The union consists of 13 villages. The total population of this union is 15,195 of which male is 7711 and female is 7484. In the union majority household depends on agriculture.

Another study area Gabura union occupies an area of 33 sq. km. It consists of 15 villages. Out of 38,825 populations of the union 19,307 are male and 19,518 are female. Majority household depends on collecting wood (BBS, 2011).

For the advantage of proper data collection and as the most Aila affected region Patharkhali village of Uttar Bedkashi union of Koyra upazila and Sora village of Gabura union of Shyamnagar upazila has selected as the study area.

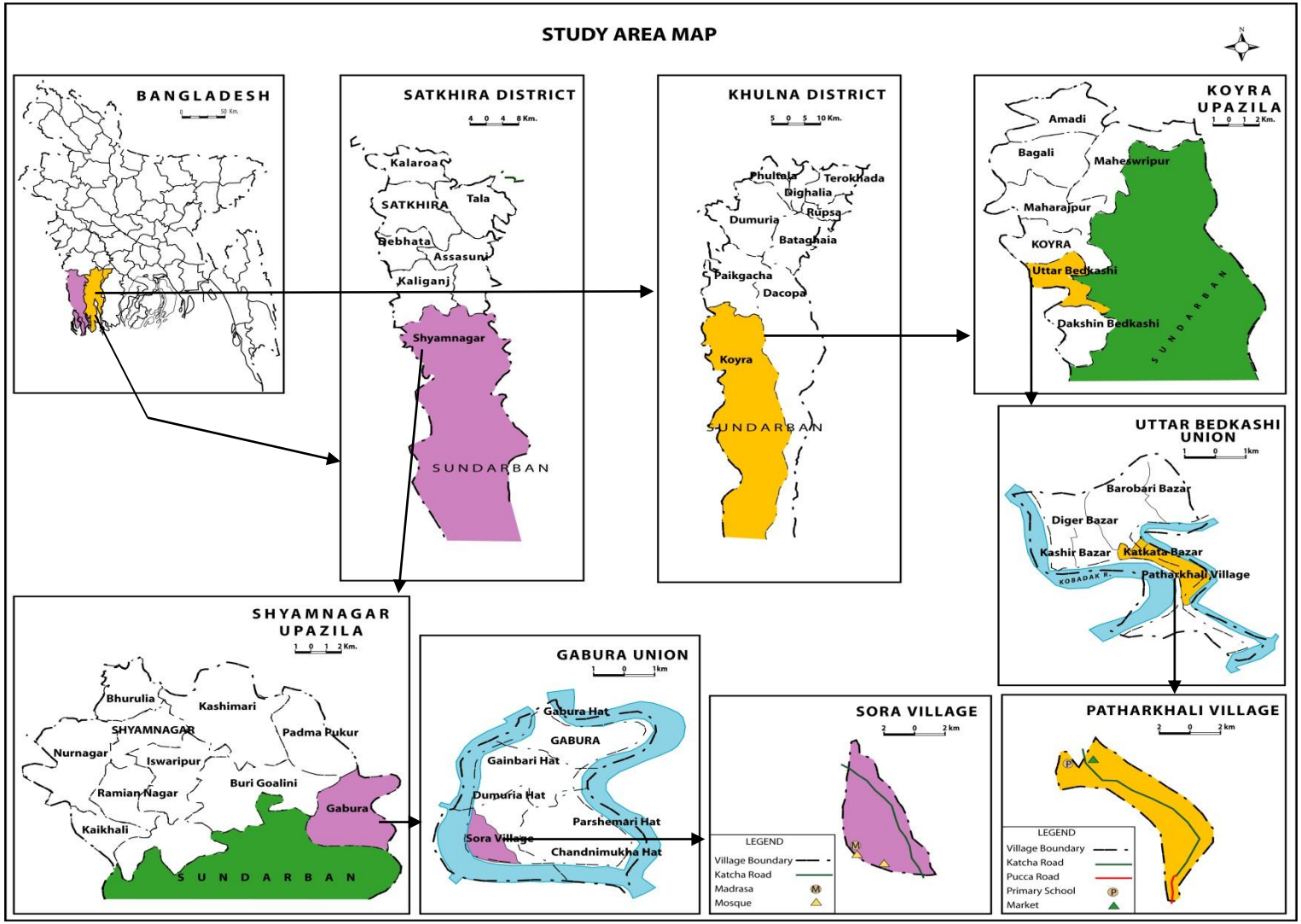


Figure 3.1 Map of the Study Area.

3.4 Sampling Design and Procedure

In previous section, it is mentioned that on the basis of selection criteria the purposive sampling method was used to fix on the study area. The study area is situated in Uttar Bedkashi union of koyra upazila and Gabura union of Shyamnagar upazilla. There are 13 villages in Uttar Bedkashi union and 15 villages in Gabura union. For the advantage of data collection Patharkhali village of Uttar Bedkashi union and Sora village of Gabura union have been selected for the study. However, simple random sampling technique was used to get proportionate of household number for surveying.

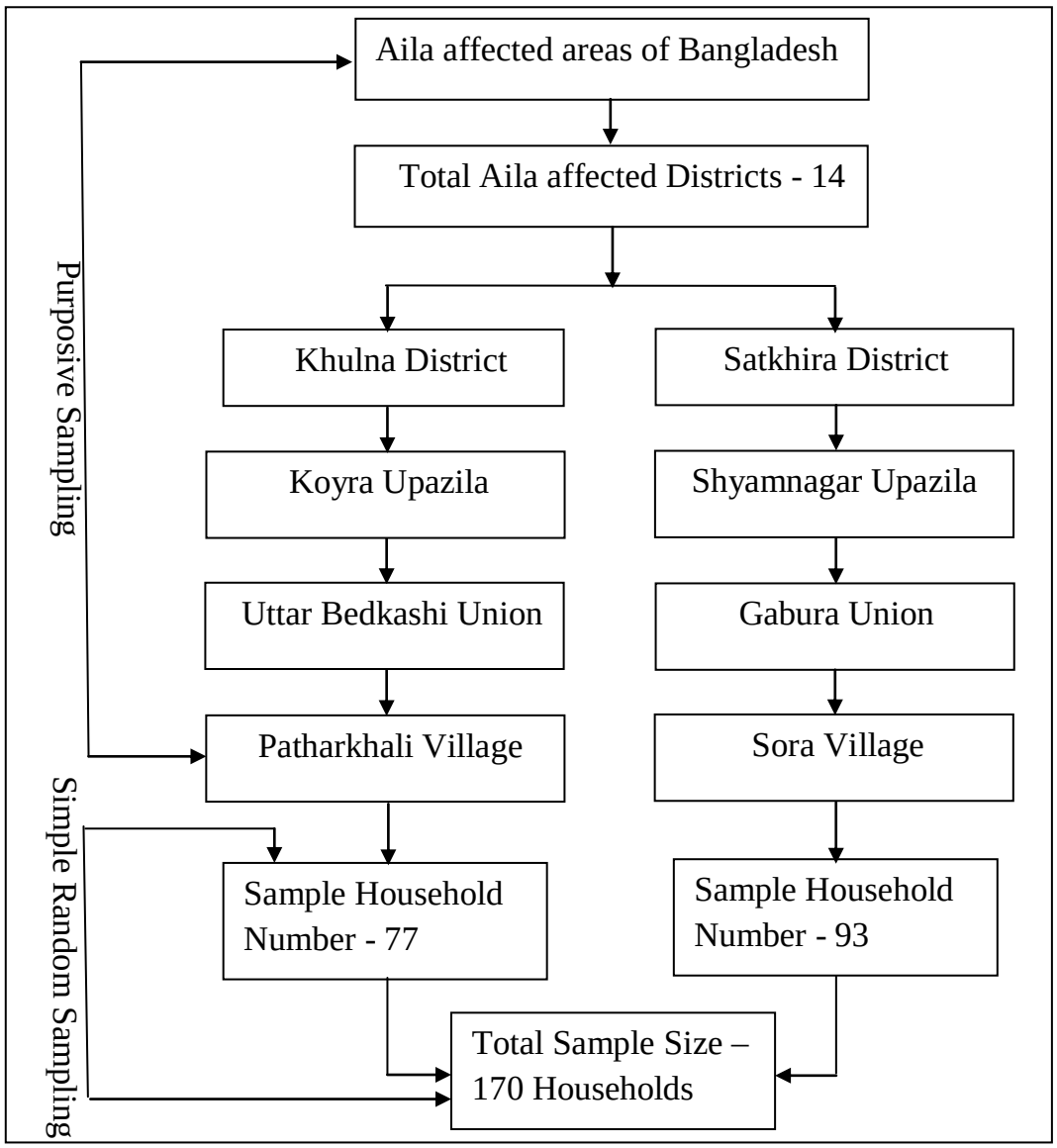


Figure 3.2 Sampling Design and Procedure

To determine the sample size, Yamene's (1967) formula was followed which is following:

$$n = \frac{N}{1 + Ne^2}$$

Where, n = Sample size

N = Total household

e= Level of precision

In the case of village Patharkhali,

$$n = \frac{345}{1 + 345(0.10)^2}$$

Where, n =77

N = 345

e= .10 (10%)

In the case of village Sora,

$$n = \frac{1191}{1 + 1191(0.10)^2}$$

Where, n =93

N = 1191

e= .10 (10%)

Total sample size = 77 (sample size of Patharkhali) + 93 (sample size of Sora) = 170 households.

3.5 Sources of Data and Collection Method

In this study both primary and secondary data has used for analyzing the situation.

3.5.1 Secondary data

The secondary data has collected from various national & international journals and books, coupled with research related published reports, papers, documents, population census, BBS census, MFDM reports, World Bank reports, maps and websites.

3.5.2 Primary Data

The study is also based on primary data that is collected through reconnaissance survey, household questionnaire survey, key informants discussion and field observation.

Reconnaissance Survey: In order to get know about the impact of Aila and identify the possible study area a reconnaissance survey has done that is helpful to

further study area selection, sample size determination and questionnaire finalization.

Questionnaire Survey: A questionnaire survey has conducted at household level to collect detail information regarding environmental impact of Aila in the study area. The main target of this survey is to collect information about physical and cultural environmental damage such as water salinity, soil salinity, land fertility less, loss of biodiversity, destruction of forest, appearance of various diseases, loss of livelihood productive tools, property and infrastructural damage etc.; And the problem created by environmental damage like unemployment problem, forced migration, food and nutrition problem, sanitation problem, communication problem, salinity of agricultural land, safe drinking water unavailability etc. of the study area.

Interview with key informants: Several well-informed persons like NGO worker, village elder, teacher, and local leader has interviewed. The informant's feedback and perception about the impact of Aila has taken into account in the study.

Field observation: During the field survey, observatory procedures has adopted for careful understanding of the factual situation in the area keeping in view the impact of Aila. The parametrical information mainly on physical and cultural environmental damage has observed carefully.

Photographs: Photographs never tell e lie and always picture the reality. Therefore, several photographs were taken for visualizing the situation of after Aila condition. House types, land status, roads status etc were taken in the camera for real information for the study.

3.6 Data Analysis Techniques

The collected data has analyzed first to eliminate the unnecessary and irrelevant information through checking and verification, then EXCELL and SPSS software

have used for tabulation, analysis and graphic presentation. Arc View GIS software has also exercised for preparing study area map.

3.6.1 Quantitative Analysis

Descriptive statistic: Frequency distribution, percentage, regression analysis and cross tabulation etc. descriptive statistics have applied for analyzing data. Various statistical illustrations such as column and bar diagram has used for graphical presentation to elaborate the environmental impact and result in the study area.

3.6.2 Mapping Techniques

Arc View GIS software has applied to prepare the map of study area.

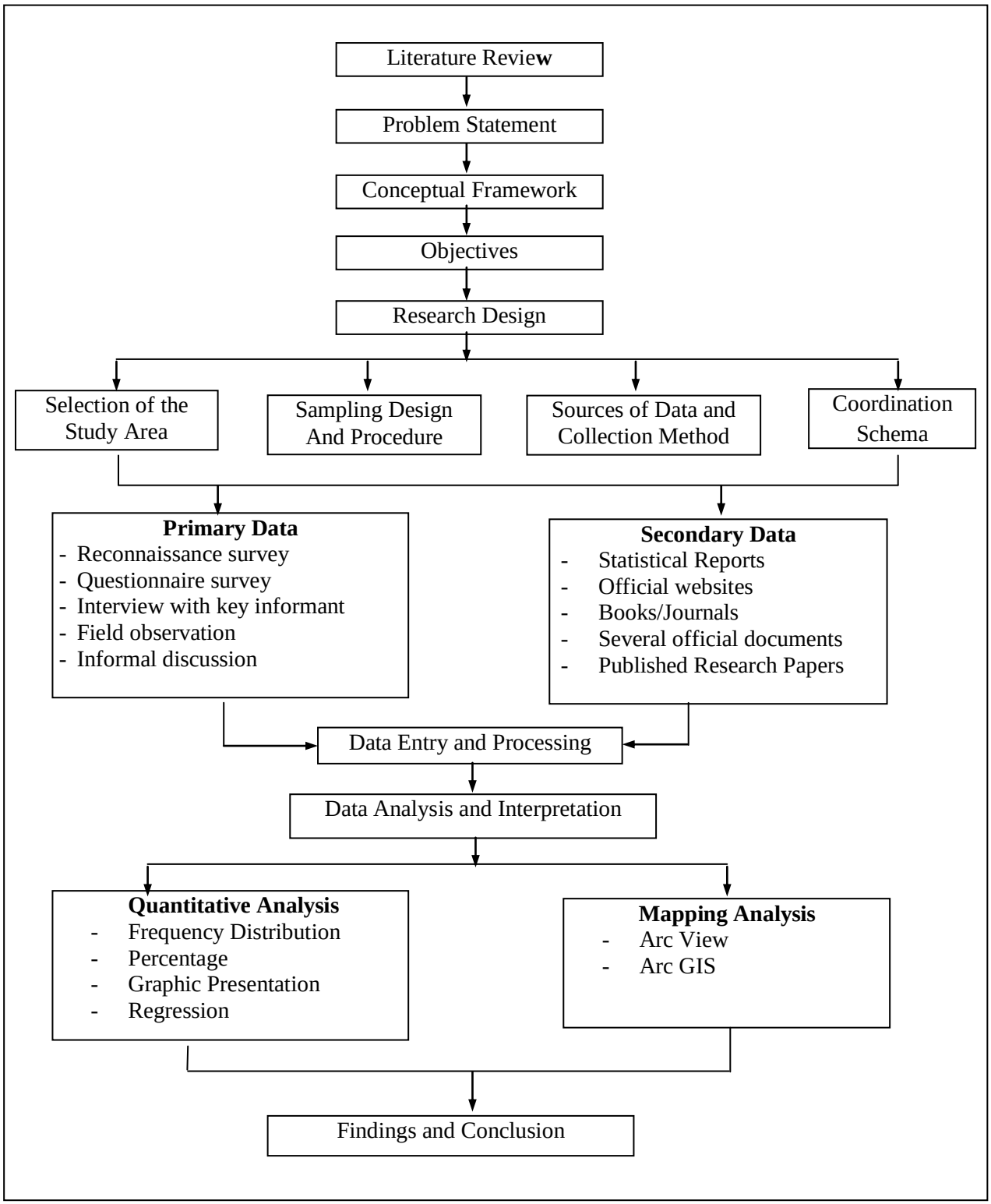


Figure 3.3 Research design.

CHAPTER FOUR

RESPONDENTS PROFILE & SOCIO-ECONOMIC CONDITION

4.1 Age Structure of Respondents

4.2 Ethnicity of the Respondents

4.3 Number of Family Member

4.4 Male Female Ratio

4.5 Death Ratio of Male and Female Due to Aila

4.6 Educational Status

4.7 Occupation of the People of Study Area

4.8 Number of Earning Member of Respondents Family

4.9 Types of Family

4.10 Housing Pattern Changes

4.11 Economic Condition of Respondents Family

CHAPTER FOUR

Respondents Profile & Socio-economic Information

This chapter outlines the respondents profile, their family information and information on socio-economic aspect of both two villages of Shyamnagar and Koyra upazila. The state of socio-economic condition before and after Aila shows the Aila effect on the study area.

4.1 Age Structure of Respondents

Ages of respondents are classified into five categories. Among the respondents most are in the age group of 31-40 years. Whereas, 34.4 percent and 37.6 percent respondents fall in this age group in Sora and Patharkhali village respectively. Besides, second dominant age group is 41-50 years. In Sora and Patharkhali village it is 24.4 percent and 26 percent respectively in this age group. Third dominant age group is 21-30 years.

Whereas, 27.9 percent and 18.2 percent of respondents fall in this age group from Sora and Patharkhali village respectively. There is no respondent under the age of 15 years.

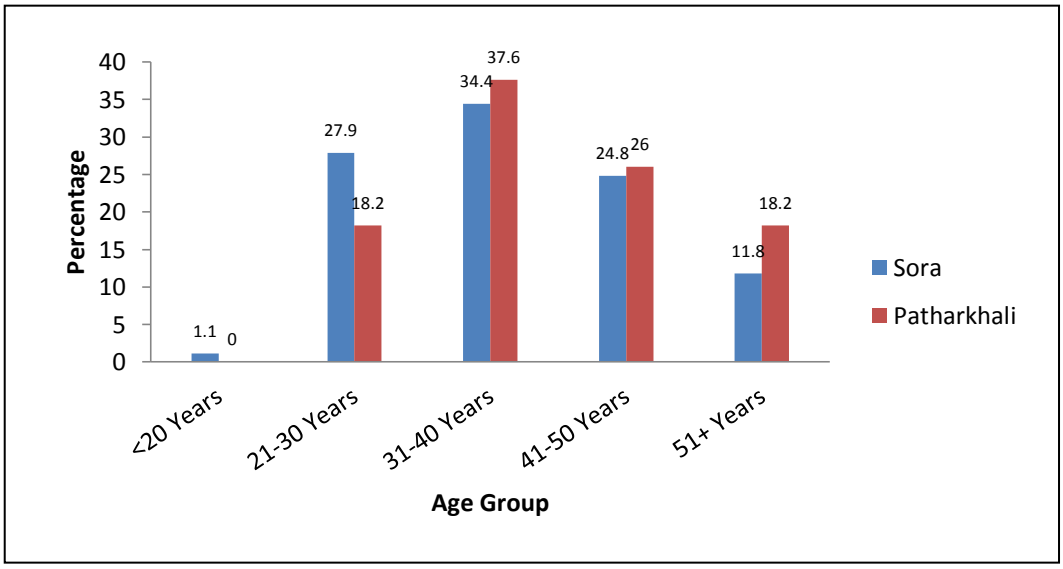


Figure 4.1: Age Structure of Respondents

Source: Field Survey, 2014.

4.2 Ethnicity of the Respondents

Most of the people of both villages are Muslim. However, 100 percent of the respondents are Muslim in both Sora and Patharkhali village (Table 4.1).

Table 4.1: Ethnicity of the Respondents

Religion	Sora (%)	Patharkhali (%)
Muslim	100	100
Hindu	0.0	0.0
Total	100	100

Source: Field Survey, 2014.

4.3 Number of Family Member

The diagram 4.2 demonstrates the number of the respondent's family member. It shows that 72 percent and 62.3 percent of the respondent's family is consisted of 3-5 members, 23.7 percent and 24.7 percent of respondent's family is consisted of 6-8 members, 3.2 percent and 7.8 percent of respondent's family is consisted of <3 members in Sora and Patharkhali village respectively. Besides, in total 6.3 percent of respondent's family is of 9+ members.

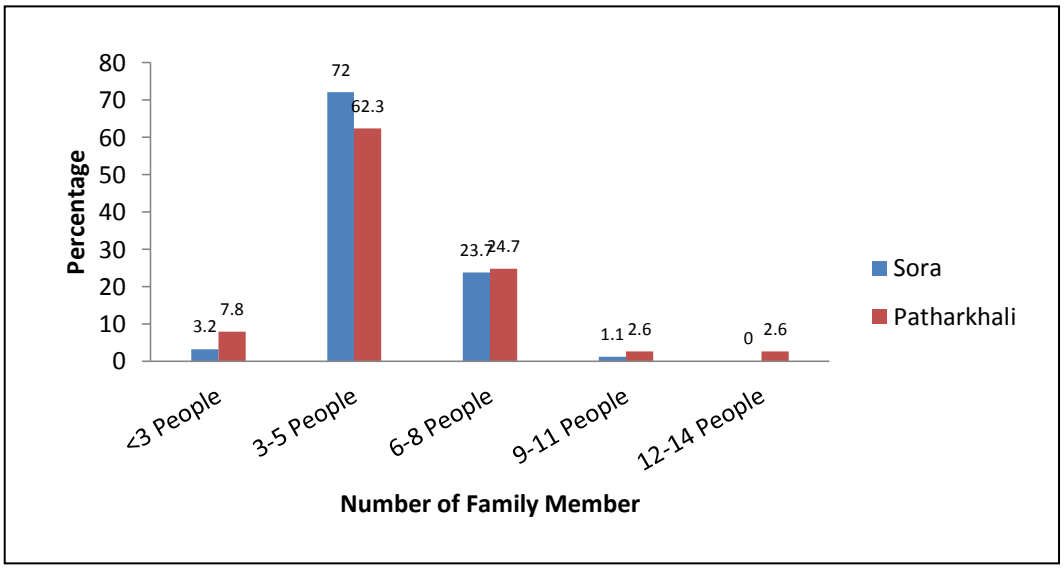


Figure 4.2: Number of Respondent's Family Member
Source: Field Survey, 2014

4.4 Male Female Ratio

Male-female ratio is an important demographic factor of an area. Here, in the study area Sora, male is 52.08 percent and female is 47.92 percent of the total surveyed people. Whereas, in another study area Patharkhali, it is 49.07 percent and 50.93 percent respectively. It shows that male and female are close in number. It is a productive ratio.

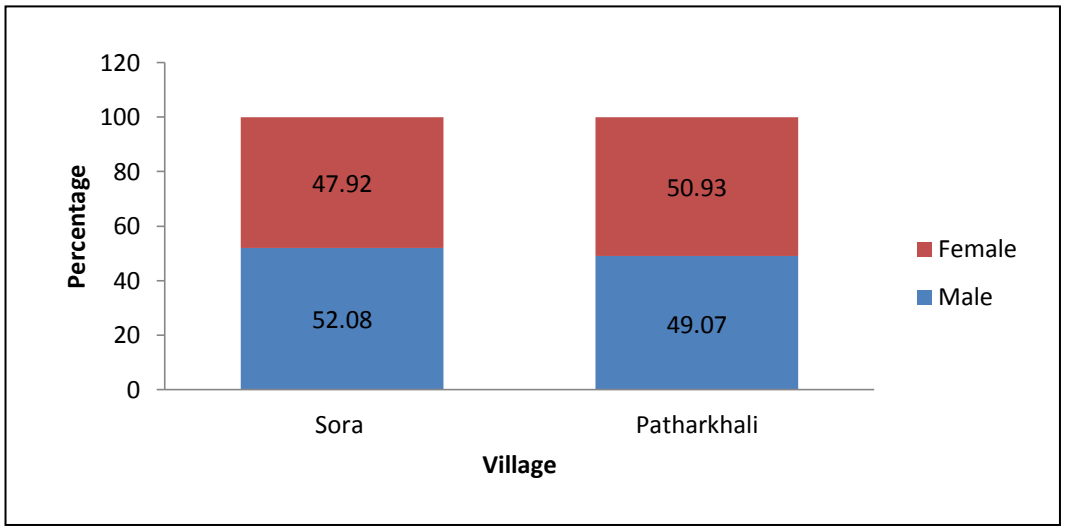


Figure 4.3: Male Female Ratio of the Study Area

Source: Field Survey, 2014.

4.5 Death Ratio of Male and Female due to Aila

On 25 May 2009, cyclone Aila struck the south-west coast of Bangladesh, killing 190, injuring 7,103, and rendering more than half a million people homeless (UN, 2010). Women and children are in worst situation and become more vulnerable because the male earning members of the family were out of home. They either died or migrated to manage their family needs and livelihoods.

According to table 4.2 it seems that, 11 people died from tropical cyclone Aila in Sora village. Whereas the number of male is 6 and female is 5 which show 54.55 percent and 45.45 percent respectively.

In the case of Patharkhali village, the survey report shows, no people died here from Aila. It seems that people of village Patharkhali were less affected by Aila than village Sora.

Table 4.2: Death Ratio of Male and Female Because of Aila

Gender	Sora		Patharkhali	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Male	06	54.55	0	0
Female	05	45.45	0	0
Total	11	100	0	0

Source: Field Survey, 2014.

4.6 Educational Status

The figure (4.4) reveals the educational status of the study area. It shows a comparison between two villages and also male's and female's education status. As can be seen in village Sora illiterate male member is 71.11 percent whereas illiterate female member is 78.26 percent.

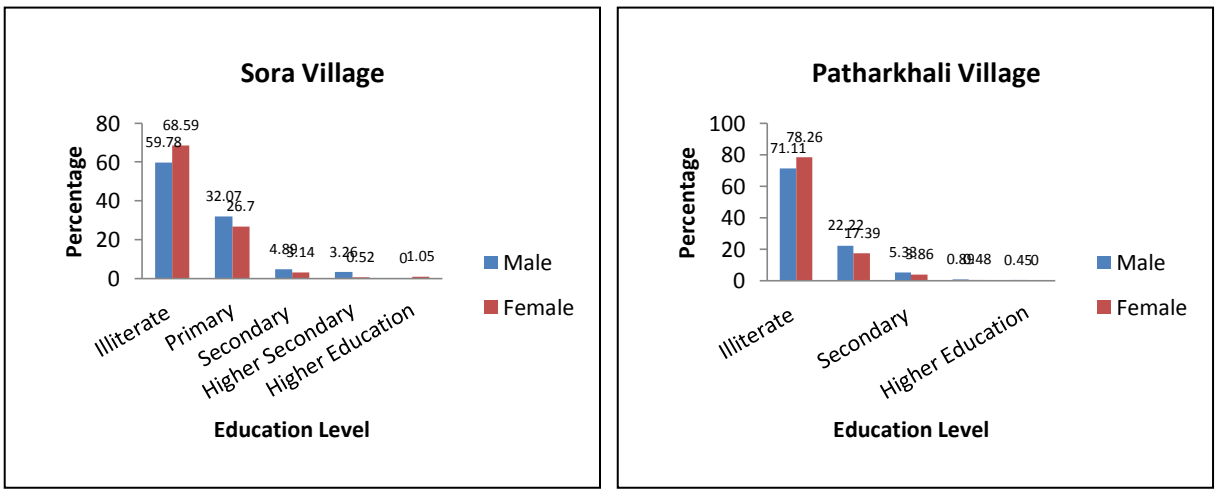


Figure 4.4: Educational Status of the People

Source: Field Survey, 2014.

On the other hand 22.22 percent of male member and 17.39 percent of female member have primary education. It is seen that 5.33 percent of male have passed secondary level of education and among female member it is 3.86 percent.

Similarly only 0.89 percent of male have passed higher secondary examination where as female member is 0.48 percent. And in higher education it is no more.

In the case of village Patharkhali, 59.78 percent of male and 68.59 percent of female are illiterate. Besides, 32.07 percent of male member and 26.7 percent of female member have crossed the level of primary education. In higher secondary and higher education the portion is so less for both male and female.

So in comparative view of two villages it seems that literacy rate of village Patharkhali is much than village Sora. They consume more facilities than village Sora.

4.7 Occupation of the People of Study Area

The most devastating impact of the cyclones reported by respondents in this study was the loss of livelihood opportunities. Loss of boats and fishing equipment continues to limit fishers' capacity to harvest marine resources in more productive coastal waters in adjacent areas. Many people had to leave their villages and migrate to urban areas to search for new income-generating activities, such as working in brick fields or as day laborers.

As rich agricultural land in the villages of Gabura union has been inundated by saline water after cyclone Aila hit. It was difficult for the people at the affected area to farm. In this scenario people were frantically searching for alternative sources of income to maintain their livelihood. Most people mentioned that their livelihood varies from season to season and they are not consistent with one livelihood option even in one season (IFRC, 2010).

It is seen in the case of village Sora (figure 4.6) the number of day labor has increased from 16.1 percent to 33.3 percent after Aila, whereas fisherman has decreased from 34.4 percent to 22.6 percent. The number of woodman also decreased from 36.6 percent to 31.2 percent.

In these areas, the people used to go deep into the forest and collect resources such as leaves, honey, timber, fish and crab both for their own use and for selling,

but after Cyclone Sidr in 2007, the GoB decided to restrict their entrance to the forest only during March to May with a prior permission from the GoB (UN, 2010). For this reason, people of working ages either migrated to the other region in search of job or struggle to survive locally after cyclone Aila. Boatman, service holder and other occupation have in unchanged situation.

On the other hand the scenario of village Patharkhali shows that day labor has increased but not like as village Sora. Here fisherman has decreased from 48.1 percent to 38 percent. The number of woodman, boatman and service holder has increased slightly.

So the majority of households are dependent on the Sundarbans mangrove forest for their livelihoods, which included collecting wood and harvesting crab, white fish and shrimp. Others were daily laborers on shrimp farms, as farmhands, or worked in brick fields.

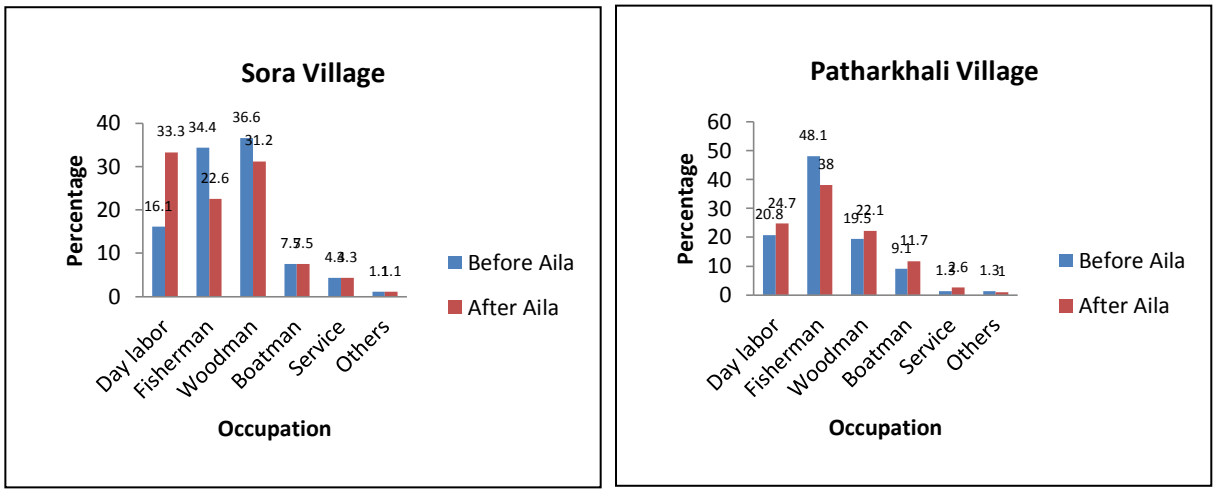


Figure 4.5: Occupation of the People of the Study Area

Source: Field Survey, 2014.

The whole scenario demonstrates that coastal people's livelihood was highly affected by tropical cyclone Aila and still its impacts exist.

4.8 Number of Earning Member of Respondents Family

The loss and damage inflicted as a result of cyclone Aila had long lasting effects. Because destroyed embankments were not repaired in a timely manner, houses, schools and other buildings as well as shrimp farms and crop land were submerged, which had significant implications for livelihoods and severely decreased household incomes (Nishat *et al.*, 2013).

The cyclones had long-term implications on food security as rice harvests significantly decreased, fisheries were greatly affected and freshwater supplies diminished in the wake of increased salinity. In response to the adverse impacts of the cyclones, affected communities adopted a variety of coping strategies, some of which led them to be worse off than before. For instance, children in some households were taken out of school so that they could contribute to income generating activities and help to sustain the livelihood of their families, an erosive coping strategy that could cause an intergenerational transfer of poverty and vulnerability (UNICEF, 2009).

Table 4.3: Number of Earning Member of Respondents Family

Nb. Of Earning Member	Sora Village		Patharkhali Village	
	Before Aila (%)	After Aila (%)	Before Aila (%)	After Aila (%)
1 member	75.26	64.52	76.62	64.93
2 members	10.75	17.20	15.58	22.1
3 members	8.60	10.75	6.49	9.1
4 members	5.38	7.53	1.3	3.87
Total	100	100	100	100

Source: Field Survey, 2014.

So after Aila, the decreased availability of food led to malnutrition and school dropout rates increased as children were forced to take jobs in order to contribute

to the household income. As a result we can see that after Aila the number of earning member has increased in many families (table 4.3).

As is observed from the table in both villages the number of earning member of respondents family has increased after Aila.

4.9 Types of Family

The following diagram shows the types of family of the study area. As is observed from the bar diagram in case of village Sora, 78.3 percent family was single and 21.7 percent family was joint before Aila. But single family portion has increased to 87.1 percent and joint family has decreased to 12.9 percent. It seems a huge change.

On the other hand, in case of village Patharkhali, 68.4 percent family was single type and other 31.6 percent family was joint. Similarly after Aila single family has increased and joint family has decreased here also (Figure 4.6).

It is seen that joint families are being divided into nuclear and single families due to social and economical change of the study area.

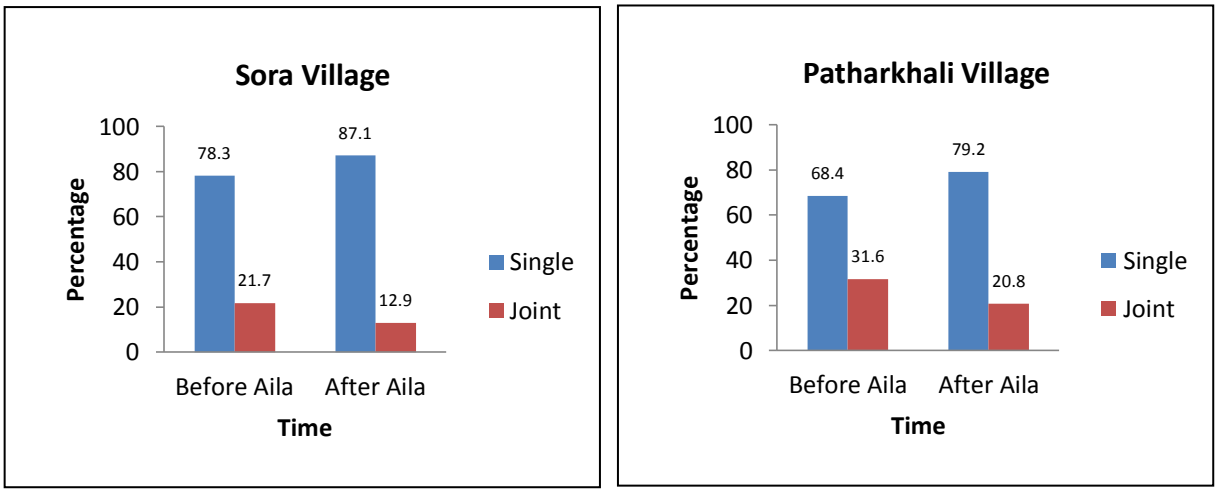


Figure 4.6: Family Types of the Study Area

Source: Field Survey, 2014.

4.10 Housing Pattern Changes

Housing is on the highest demand among the affected people. Because of Cyclone Aila and for water logging situation, infrastructures have been collapsed. Almost all the shelters including safe sanitation system has been demolished which raised the vulnerability for people's livelihood. Majority of the Aila affected people were forced to relocate their houses on embankments or high land due to abolition of their houses by tidal surge and subsequent water logging.

As is observed in the figure 4.7 housing pattern is about similar in both Sora and Patharkhali village. In village Sora, 31.2 percent house was made by golpata-mud, 26.9 percent house was made by golpata-wood, 24.7 percent house was made by tin-mud and other 17.2 percent house was made by tin-wood element before Aila. But after the destruction of Aila there come huge changes. Golpata-mud house and tin-wood house have decreased after Aila but golpata-wood and tin-mud house have increased.

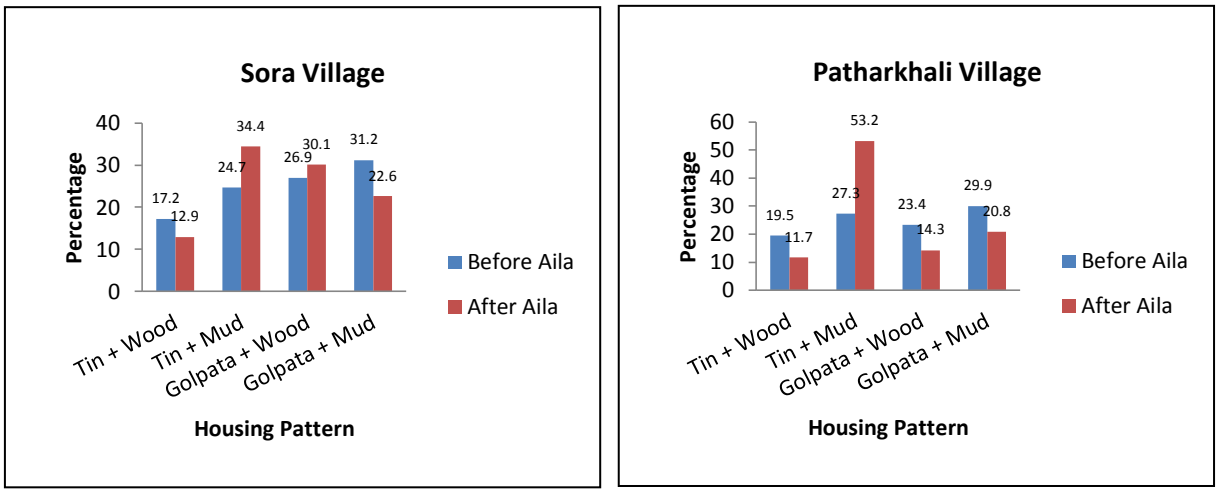


Figure 4.7: Housing Pattern of the Study Area

Source: Field Survey, 2014.

In case of village Patharkhali the scenario is quite same. Here, before Aila 29.9 percent house was made by golpata-mud, 27.3 percent house was made by tin-mud and 23.4 percent house was made by golpata-wood. After Aila tin-mud

house has increased in alarming rate and it is 53.2 percent. But other types of house have decreased proportionately.

It seems that after Aila the flow of golpata and wood from sundarban has decreased. People make tin shade house with the help of NGO or Govt.

4.11 Economic Condition of Respondents Family

People of the study area of this research are generally insolvent because they face various natural disasters every year. According to the statistics a tropical cyclone hits Bangladesh, on average, every 3 years. They are accompanied by high winds of over 150/kph and can result in storm surges up to seven meters high, resulting in extensive damage to houses and high loss of life to humans and livestock in coastal communities.

The figure 4.8 demonstrates the economic condition of respondent's family. It indicates the financial solvency. It shows a comparison. As can be seen in village Sora, before Aila 57 percent family was in insolvent economic condition and 43 percent family was in solvent. But after Aila 64.5 percent family move to insolvent economic condition and rest 35.5 percent family hold solvency.

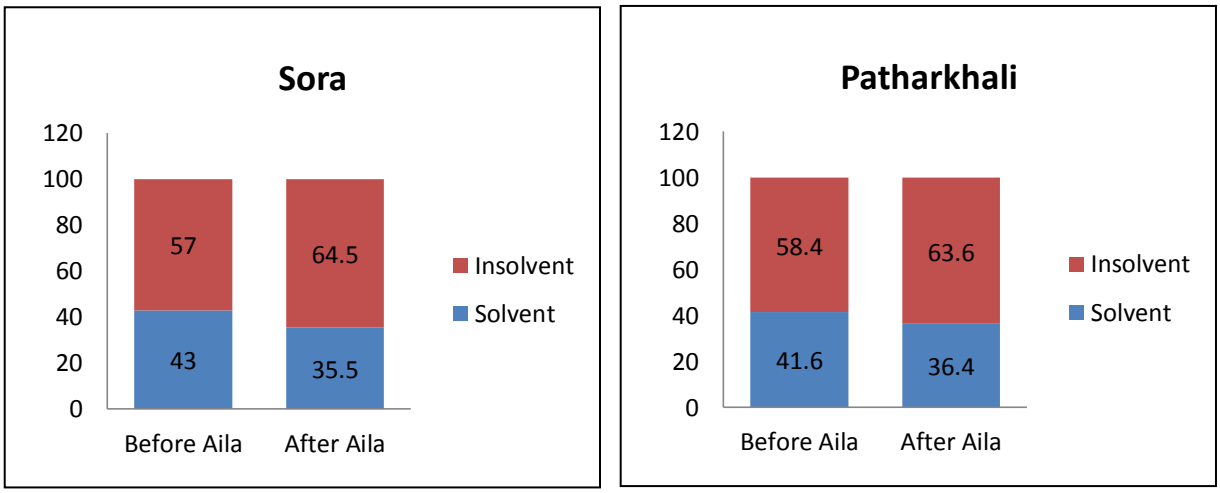


Figure 4.8: Economic Condition of Respondents Family
Source: Field Survey, 2014.

On the other hand, before Aila 58.4 percent family was insolvent and 41.6 percent family was solvent in village Patharkhali. But, after Aila solvent family has decreased to 36.4 percent and insolvent family has increased to 63.6 percent. It seems people suffered how much from Aila and still they are.

CHAPTER FIVE

ANALYSIS, RESULT AND DISCUSSION

5.1 Impact of Aila on Physical Environment

- 5.1.1 Distances from the Coast Line & the River Bank
- 5.1.2 Presence of Polder & the Closest Cyclone Shelter
- 5.1.3 Ecosystem & the Mangrove Forest
- 5.1.4 Sources of Water: Purity & Availability
- 5.1.5 Salinity Level of Water
- 5.1.6 Regression analysis between Distances from Coast, Mangrove Forest, Embankment, Polder and Salinity of Water (Village Sora)
- 5.1.7 Regression analysis between the Distances from Coast, Mangrove Forest, Embankment, Polder and Salinity of Water (Village Patharkhali)
- 5.1.8 Appearance of Water-borne Diseases
- 5.1.9 Tests for Determining Association between Salinity of Water and Waterborne Disease (Village Patharkhali)
- 5.1.10 State of Water Logging & Flood Frequency
- 5.1.11 Air Pollution
- 5.1.12 Airborne Diseases
- 5.1.13 Soil Salinity
- 5.1.14 Land Erosion Status

CHAPTER FIVE

Analysis, Result and Discussion

This chapter has focused on analysis, result and discussion of the study.

5.1 Impact of Aila on Physical Environment

Cyclones hit the coastal regions of Bangladesh almost every year, in early summer (April- May) or late rainy season (October-November). The coastal areas and off-shore islands of Bangladesh are low lying and very flat. The height above mean sea level of the coastal zone is less than 3m. In case of 'Aila' storm surge (up to 22 feet) was the major cause of devastation rather than wind speed. Sea water over topped and breached the polder at 4 points and flooded a vast region of the study area. Storm water destroyed the existing crops, shrimp farm, vegetation, livestock etc and increased the salinity of the land and interior water bodies. The affected people have taken their shelter on the polders. So the effects of a natural disaster may be direct loss of life, and certainly damage to physical properties.

5.1.1 Distances from the Coast Line & the River Bank

The geographical setting of Bangladesh makes the country vulnerable to natural disasters. Its physiography and river morphology also contribute to recurring disasters. So distances from coast line and river are two important phenomena. The village which is situated near to coast and river bank is comparatively more vulnerable prone area due to wind speed, high surge, instant flooding etc.

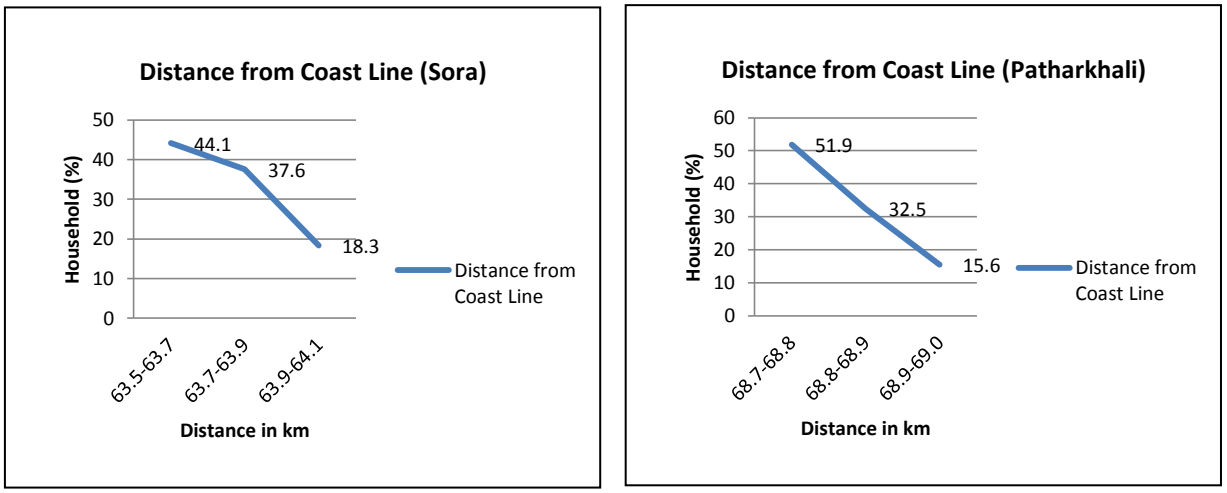


Figure 5.1: Distances from the Coast Line

Source: Field Survey, 2014.

In the figure 5.1, it is observed that the highest distance between the coast line and the village Sora is 64km and it is 69km in case of the village Patharkhali. In village Sora, 44.1 percent of households live in 63.5-63.7 kilometer distance from coast, 37.6 percent of households live in 63.7-63.9 kilometer distance from coast and rest 18.3 percent of households live in 63.9-64.1 kilometer distance from coast.

On the other hand, in case of village Patharkhali, 51.9 percent of households live in 68.7-68.8 kilometer distance from coast, 32.5 percent of households live in 68.8-68.9 kilometer distance from coast and rest 15.6 percent of households live in 68.9-69.0 kilometer distance from coast.

So it seems that village Sora is more vulnerable comparatively between two villages. As we know the wind speed of cyclone Aila was 120 kmph (74 mph) at 25th May, 2009. So these villages were affected most and still now they are suffering.

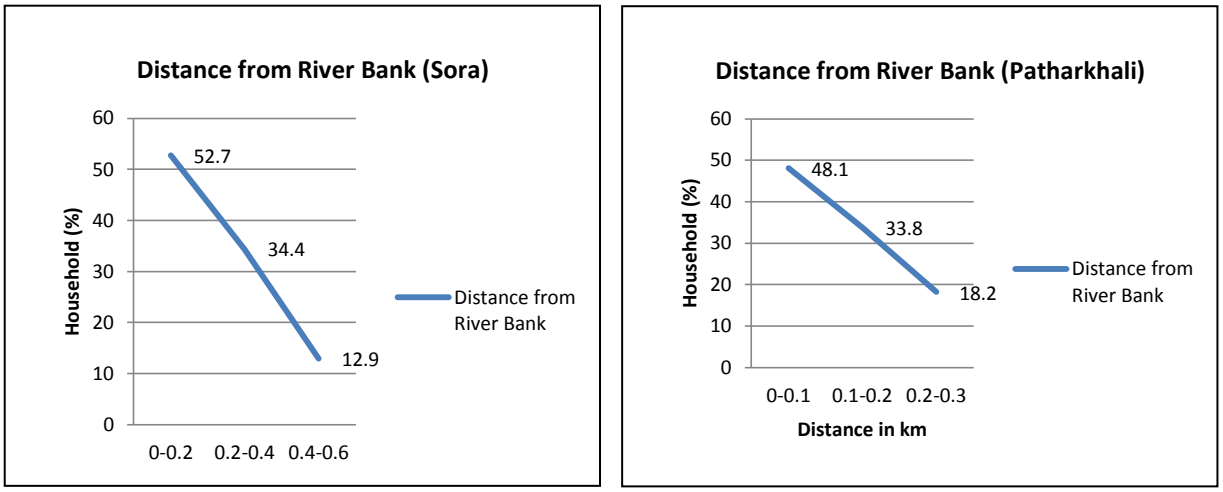


Figure 5.2: Distances from the River Bank

Source: Field Survey, 2014.

In figure 5.2 it is seen that 52.7 percent of households live in 0-0.2 kilometer distance from river bank, 34.4 percent of households live in 0.2-0.4 kilometer distance from river bank and rest 12.9 percent of households live in 0.4-0.6 kilometer distance from river bank. On the other hand, in village Patharkhali, 48.1 percent of households live in 0-0.1 kilometer distance from river bank, 33.8 percent of households live in 0.1-0.2 kilometer distance from river bank and rest 18.2 percent of households live in 0.2-0.3 kilometer distance from river bank. These distances are too less and it shows the clear cause of much vulnerability to cyclone Aila of both two villages. So, the wind speed and high surge easily affects the study area.

5.1.2 Presence of Polder & the Closest Cyclone Shelter

Polder and cyclone shelter are the two major life saving place during disaster. Affected people instantly take place on polder more than cyclone shelter because the closest cyclone shelter is quite far from village whereas the polder is adjacent to village. Another cause is the capacity of cyclone shelter.

Over 1,700 km of flood embankments were damaged by the cyclone and tidal surges. The people, who lost everything, left their homesteads and took shelter in the makeshift houses on roads, damaged embankments, in markets, schools, or even in the open (Sarawat, 2009).

From figure 5.3 it seems that both two villages were adjacent to polder and still now it is. In case of village Sora, 57 percent of households live in 0-0.2 kilometer distance from polder, 31.2 percent of households live in 0.2-0.4 kilometer distance from polder and rest 11.8 percent of households live in 0.4-0.6 kilometer distance from polder. On the other hand in village Patharkhali, 46.8 percent of households live in 0-0.1 kilometer distance from polder, 44.2 percent of households live in 0.1-0.2 kilometer distance from polder and rest 9.1 percent of households live in 0.2-0.3 kilometer distance from polder.

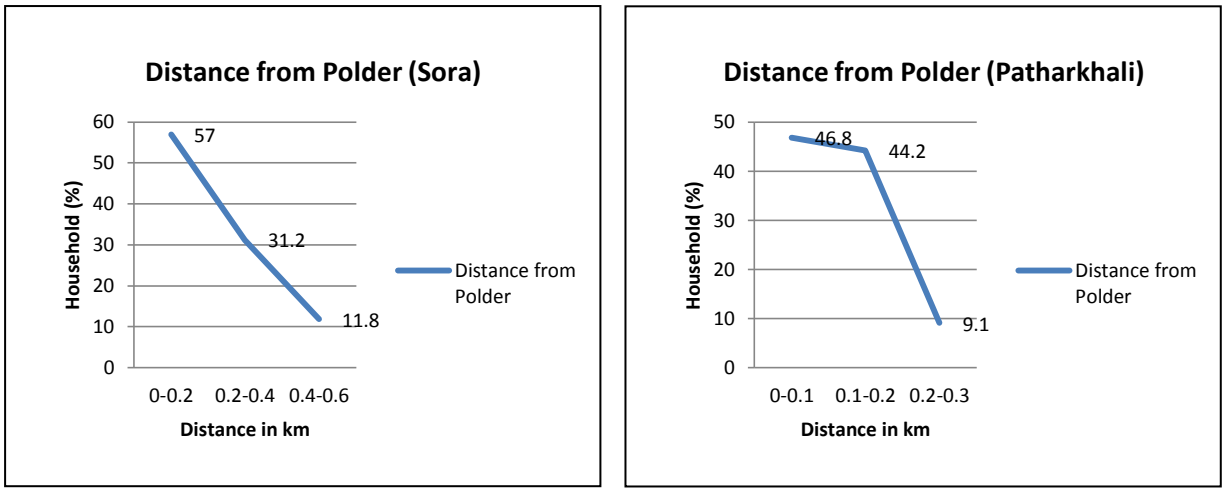


Figure 5.3: Distances from the Polder

Source: Field Survey, 2014.

It implies that people of the village Patharkhali gets more opportunity from polder during cyclonic disaster.

From figure 5.4 we can see that cyclone shelter was in quite far comparing polder. In case of village Sora the closest cyclone shelter was in about 2km distant place. From village Patharkhali it was in about 2.5km distant. It seems that there is not enough cyclone shelter for the affected people. But it is a common matter that early warning systems and access to cyclone shelters can reduce the number of deaths from cyclones.

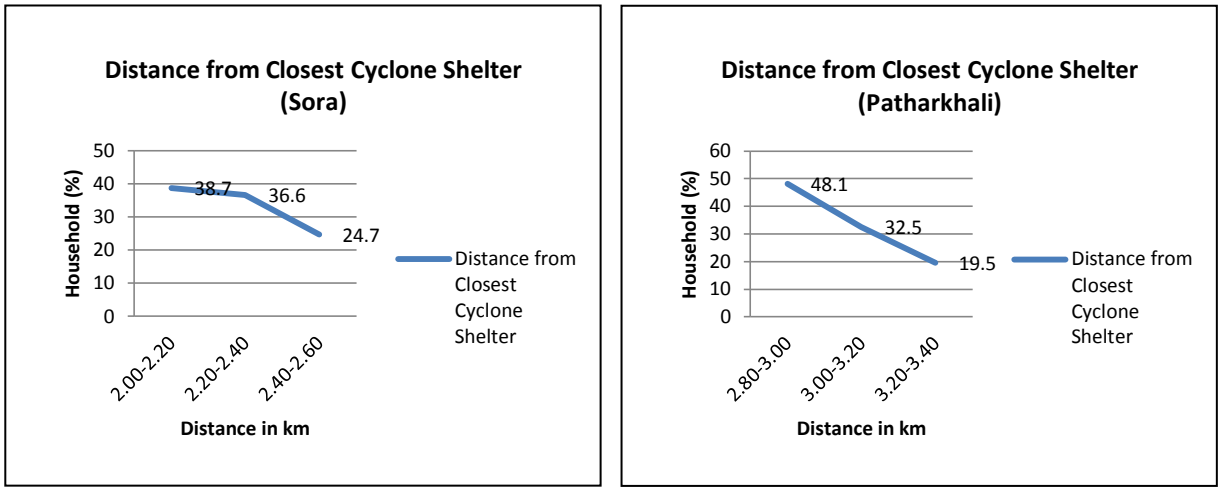


Figure 5.4: Distances from the Closest Cyclone Shelter

Source: Field Survey, 2014.

The above figure also shows that only 38.7 percent of households live in 2.00-2.20 kilometer distance, 36.6 percent of households live in 2.20-2.40 kilometer distance and rest 24.7 percent of households live in 2.40-2.60 kilometer distance from closest cyclone shelter.

On the other hand in village Patharkhali, 48.1 percent of households live in 2.80-3.00 kilometer distance, 32.5 percent of households live in 3.00-3.20 kilometer distance and other 19.5 percent of households live in 3.20-3.40 kilometer distance from closest cyclone shelter.

It implies that in the same village all people do not get same facilities and all are not equally vulnerable.

5.1.3 Ecosystem & the Mangrove Forest

During cyclone Aila, the Sundarban mangrove forest acted as a vegetative shield that helped to minimize the adverse impacts of these events by reducing storm surge velocity and stabilizing sedimentation (Barbier, 2006; GoB, 2008). Past cyclone events, such as the devastating 1991 cyclone Gurky that struck the south-eastern district of Chittagong, have shown that the absence of mangrove forests can result in a greater number of lives lost and more extensive loss and damage to property (Barua *et al.*, 2010). Ecosystem services from the Sundarban mangrove

forest were instrumental in helping affected communities to survive in the aftermath of these disasters. But cyclone Aila impacts negatively on coastal ecosystem.

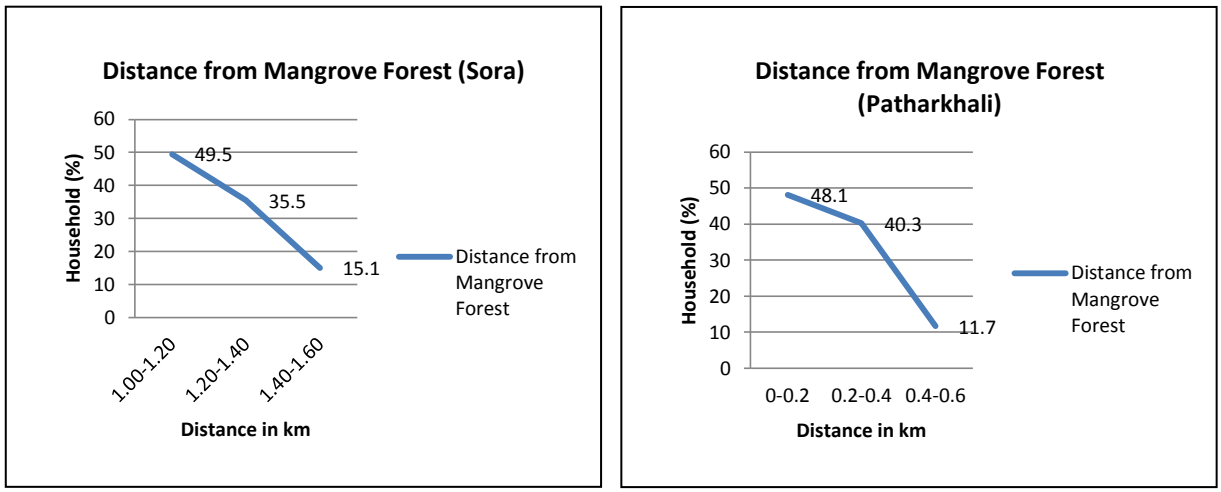


Figure 5.5: Distances from the Mangrove Forest

Source: Field Survey, 2014.

From figure 5.5 it is seen that village Sora is 1km far from mangrove forest Sundarban and village Patharkhali is 0.2km far from same forest. In village Sora, 49.5 percent of households live in 1.00-1.20 kilometer distance, 35.5 percent of households live in 1.20-1.40 kilometer distance and rest 15.1 percent of households live in 1.40-1.60 kilometer distance from mangrove forest.

On the other hand in village Patharkhali, 48.1 percent of households live in 0-0.2 kilometer distance, 40.3 percent of households live in 0.2-0.4 kilometer distance and other 11.7 percent of households live in 0.4-0.6 kilometer distance from mangrove forest.

That is why, village Sora was affected much. Maximum interviewees reported that before Aila their village Sora was covered with mango, jackfruit, date-palm, sisoo etc trees. But now the village is like a desert. People started family forestation since 2years. Though village Patharkhali was less damaged than Sora but they also have started tree plantation.

5.1.4 Sources of Water: Purity & Availability

Cyclone Aila caused significant damage to water sources, particularly in the severely affected. Respondent reported that before Aila, they used pond-sand-filter (PSF) water, tube well water and rain water as their primary sources for drinking water. After Aila, 100% of affected areas contaminated with saline water.

Approximately 10% of ponds have been de-watered. Women spend an average 2-3 hours a day collecting water, often walking 2-3 km to reach the nearest safe water sources/collection point. People are forced to drink pollutant water or spend their limited financial resources on traveling to other water sources or purchasing water. So access to safe water is the key demand of the affected population.

Figure 5.6 reveals the present situation clearly. In village Sora, there is no availability of safe drinking water. Usually ponds are largely used by households as a major source of drinking water. No deep tube well is available in this village. In rainy season rain water acts as a source of drinking water. But it is for few days only. The whole year people drink pond's water which called sweet pond and especially caring for drinking water. They use normal pond water and river water for daily household works.

On the other hand, in village Patharkhali, 75.3 percent of households drink tube well water and other 24.7 percent drink pond water. It seems that they have safe sources of drinking water. For household and other works they also use pond and river water.

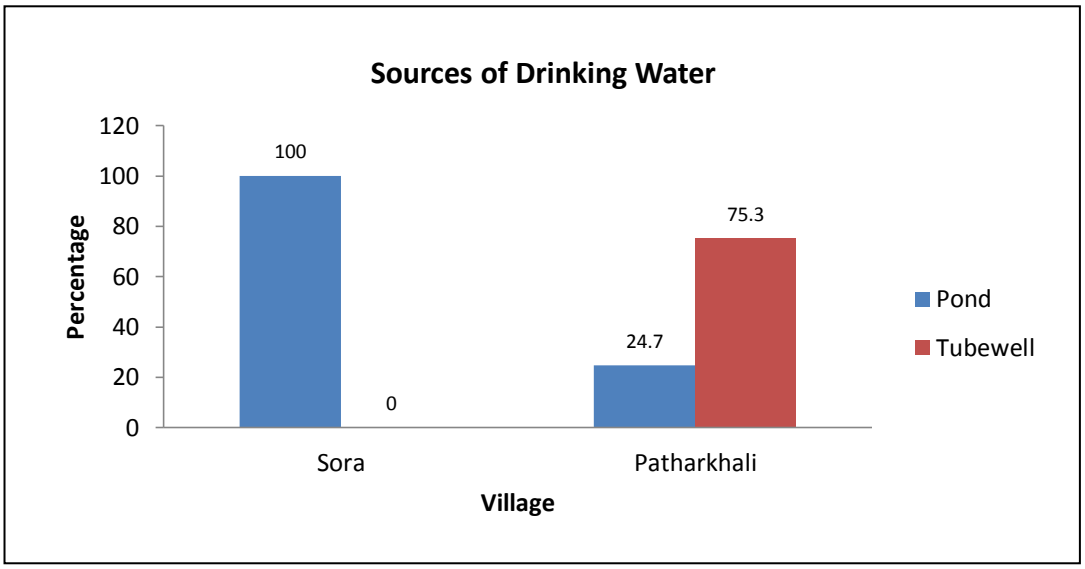


Figure 5.6: Sources of Water (Before & After Aila)

Source: Field Survey, 2014.

In addition, the UP member named Ashraf Ali of village Patharkhali says us whole year 75.3 percent households who drink tube well water, buy it from deep tube well of Sundarban which is for forest guards and officers. The rate is 5tk per plastic drum. A medium family can maintain one month by 5-7 drums of water. They carry it by boat.

5.1.5 Salinity Level of Water

While saline water intrusion was already a problem in these areas before Aila and Sidr struck, the cyclone events significantly worsened the problem, particularly in Shyamnagar where vast swaths of agricultural land and aquaculture ponds remain unproductive due to persisting tidal flooding (GoB, 2008; Oxfam. 2012).

In the following figure 5.7 it also seems that in case of both village salinity of water was less but after Aila it has increased significantly. According to household survey, 59.1 percent household of village Sora and 50.6 percent household of village Patharkhali has answered about increased of water salinity. The adverse effect of salt-water intrusion observed significant in agriculture and fresh water fish production.

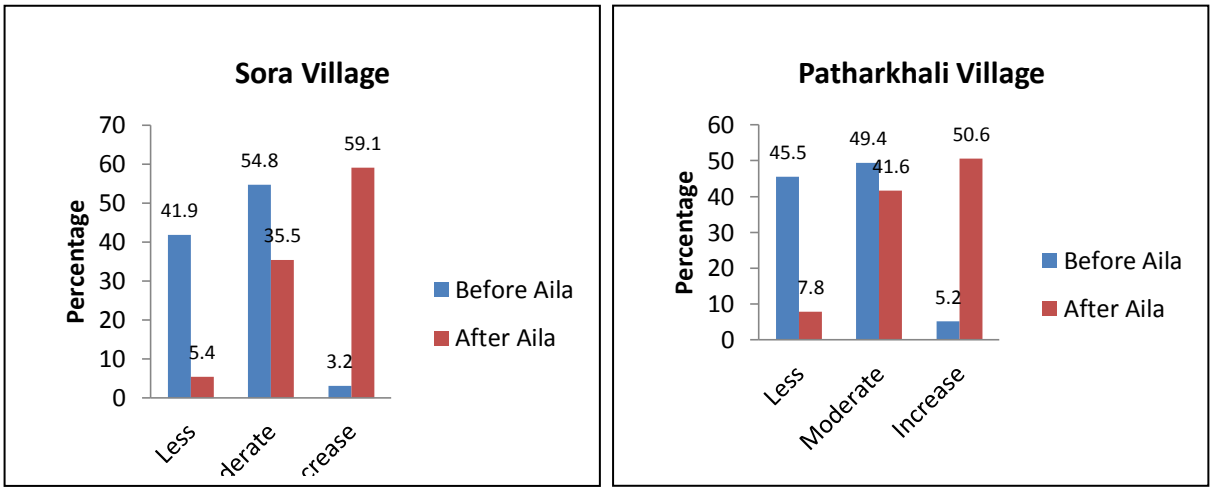


Figure 5.7: Salinity of Water

Source: Field Survey, 2014.

5.1.6 Regression analysis between Distance from Coast, Mangrove Forest, Embankment, Polder and Salinity of Water (Village Sora)

Considering the following regression line,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + U$$

Where,

Y = Salinity of Water

X_1 = Distance from Coast

X_2 = Distance from Mangrove Forest

X_3 = Distance from Embankment

X_4 = Distance from Polder

β_0 = Constant term

β_1, β_2, β_3, and β_4 = Regression co-efficient

U = Random error

Table 5.1 Results of coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	. 542	.148		15.276	.000	2.254	.148
Distance from Coast	.420	.120	.026	.166	.169	.020	.120
Distance from Mangrove Forest	.377	.164	.227	1.079	.284	.177	.164
Distance from Embankment	. 266	.286	.082	.230	.219	.066	.286
Distance from Polder	.124	.269	.153	.461	.246	.124	.269

Finally the fitted model is,

$\hat{Y} = 0.542 + 0.420X_1 + 0.377\ X_2 + 0.266\ X_3 + 0.124\ X_4$

Where,

$$R^2 = 0.725$$

$$\text{Adjusted } R^2 = 0.703$$

Comment: From the above fitted model it is observed that the effect of Salinity of Water on the Distance from Coast, Mangrove Forest, Embankment and Polder are positive. And from the information obtained the value of R^2 is 0.72, so it may concluded that the model explains only 76% of the total variation. The rest (100-72) =28% depends on other factors.

Test of regression co-efficient:

Hypothesis:

$\boldsymbol{H_0}$**:** $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

$\boldsymbol{H_1}$**:** H_0 is not true.

Test statistics is,

$$F = \{SSR/ (k-1)\}/ \{SSE/(n-k)\}$$

Which is {(k-1), (n-k)} degree of freedom and follow F-distribution.

Table 5.2 Results of ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	5.326	4	1.331	4.833	.001[a]
Residual	24.244	88	.276		
Total	29.570	92			

Comment: At 5% level of significance the calculated value of **F** is 4.833 with degrees of freedom is (4, 88) and tabulated value is 2.480. Calculated value is greater than tabulated value. So it may reject the null hypothesis (H_0). Therefore the test is significant. Hence, Salinity of Water depends on the Distance from Coast, Mangrove Forest, Embankment and Polder.

5.1.7 Regression analysis between the Distance from Coast, Mangrove Forest, Embankment, Polder and Salinity of Water (Village Patharkhali)

Considering the following regression line,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + U$$

Where,

Y = Salinity of Water

X_1 = Distance from Coast

X_2 = Distance from Mangrove Forest

X_3 = Distance from Embankment

X_4= Distance from Polder

β_0 = Constant term

β_1, β_2, β_3 and β_4 = Regression co-efficient

U = Random error

Table 5.3 Results of coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	.798	.221		3.618	.001	.357	1.240
Distance from Coast	.328	.052	.034	.538	.093	.132	.076
Distance from Mangrove Forest	.378	.142	.429	2.669	.010	.095	.661
Distance from Embankment	.431	.144	.473	2.981	.004	.142	.719
Distance from Polder	.903	.056	.904	16.779	.000	..652	.91

Finally the fitted model is,

$\hat{Y} = 0.798 + 0.328\ X_1 + 0.378\ X_2 + 0.431X_3 + 0.903X_4$

Where,

$$R^2 = 0.7605$$

$$\text{Adjusted } R^2 = 0.753$$

Comment: From the above fitted model it is observed that the effect of Salinity of Water on the Distance from Coast, Mangrove Forest, Embankment and Polder are positive. And from the information obtained the value of R^2 is 0.76, so it may concluded that the model explains only 76% of the total variation. The rest (100-76) =24% depends on other factors.

Test of regression co-efficient:

Hypothesis:

$\boldsymbol{H_0}$**:** $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

$\boldsymbol{H_1}$**:** H_0 is not true.

Test statistics is,

$$F = \{SSR/ (k-1)\}/ \{SSE/(n-k)\}$$

Which is {(k-1), (n-k)} degree of freedom and follow F-distribution.

Table 5.4 Results of ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	56.618	4	18.873	16.921	.000[a]
Residual	16.521	72	.271		
Total	73.138	76			

Comment: At 5% level of significance the calculated value of **F** is 16.921 with degrees of freedom is (4, 72) and tabulated value is 2.50. Calculated value is greater than tabulated value. So it may reject the null hypothesis (H_0). Therefore the test is significant. Hence, Salinity of Water depends on the Distance from Coast, Mangrove Forest, Embankment and Polder.

5.1.8 Appearance of Water-borne Diseases

Almost 5 years have passed after cyclone Aila, saline water intrusion could not be stopped as the wrecked embankments were not reconstructed everywhere yet. PSF was under the water and caused drinking water scarcity. For this reason water-borne diseases were broken out i.e. dysentery, cholera, diarrheal diseases, skin diseases and fever. However, access to medical facilities for the people of the area is very limited. More than two-third of the respondent did not have the ability to consult with doctors or to buy medicines due to their economic conditions. There were several medical camps during Aila organized by relief organizations, which was running with very limited resources – only few oral saline and water purification tablets. But now they are saying they get no help from government or others.

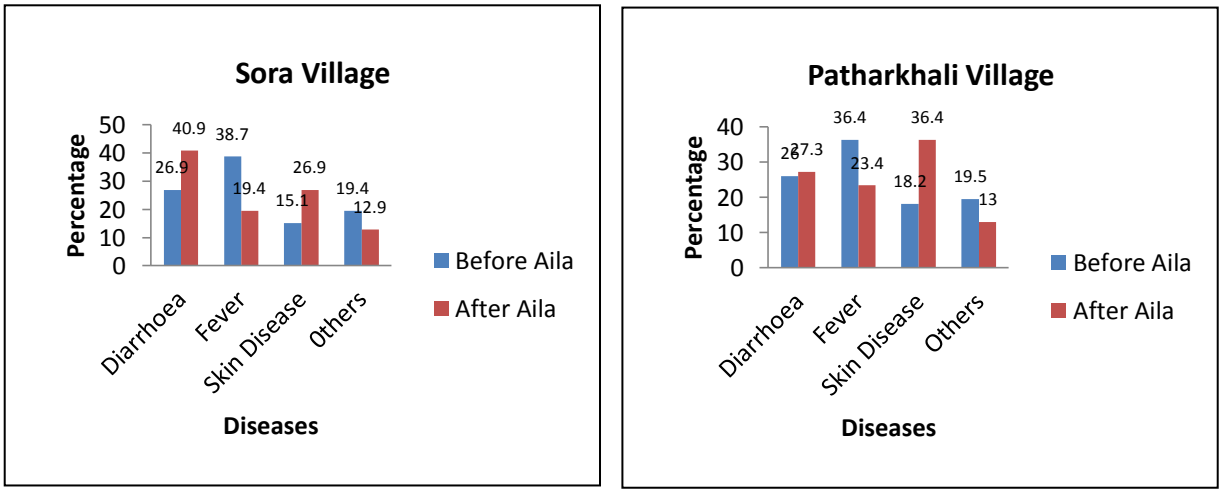


Figure 5.8: Water-borne Diseases (Before & After Aila)

Source: Field Survey, 2014.

The above figure (5.8) demonstrates the comparative study of water-borne diseases of both two villages in before and after Aila situation. In village Sora, fever (38.7 percent) was the most happening disease, second was diarrhoea and then skin disease and others. Here others include cold, cough, cholera etc. But after Aila diarrhoea has increased at alarming rate and it is 40.9 percent. Skin disease has also increased. These all show us the pollution of water resource.

In case of village Patharkhali, before Aila fever was the main disease. But after Aila skin disease has increased significantly and it is 36.4 percent. Diarrhoea is almost unchangeable. Cause in this village maximum people drink safe water by buying water from local forest tube well. But they used unsafe water. That's why they affected by skin disease and others mostly.

5.1.9 Test for Determining Association between Salinity of Water and Waterborne Disease (Village Patharkhali)

H_0: There is no Association between water salinity and waterborne disease

H_1: There exists association between water salinity and waterborne disease

Table 5.5: Bivariate table by Water Salinity and Waterborne Disease

Water Diseases (After Aila)	Salanity of Water (After Aila)			Total
	Moderate	Increase	Less	
Diarrhoea	10 (12.98)	8 (10.38)	3 (3.89)	21 (27.27)
Cough	0 (0.00)	9 (11.68)	1 (1.29)	10 (12.98)
Fever	7 (9.09)	11 (14.28)	0 (0.00)	18 (23.37)
Skin Diseases	15 (19.48)	11 (14.28)	2 (2.59)	28 (36.36)
Total	32 (41.55)	39 (50.64)	6 (7.79)	77 (100)

From table 5.5 it is clear that majority percent of respondents (36.36%) have suffered from skin disease among them 19.48 percent answered that water salinity is moderate, 14.28 percent answered that water salinity is increased and 2.59

percent answered that water salinity is less. Besides, 27.27 percent of respondents have suffered from diarrhea among them 12.98 percent answered that water salinity is moderate, 10.38 percent answered that water salinity is increased and 3.89 percent answered that water salinity is less.

On the other hand 23.37 percent of respondents have suffered from fever among them 9.09 percent answered that water salinity is moderate and 14.28 percent answered that water salinity is increased. Finally 12.98 percent of respondents have suffered from cough among them 11.68 percent answered that water salinity is increased and 1.29 percent answered that water salinity is less.

It also implies that majority (50.64) percent of respondents have answered that water salinity is increased following 41.55 percent and 7.79 percent of respondents have answered that water salinity is moderate and less respectively.

Chi-square test by using SPSS-16.0

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.775[a]	6	.047
Likelihood Ratio	17.530	6	.008

Comment: At 5% level of significance Pearson Chi-Square for 6 df at asymptotic significant is .047 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between water salinity and waterborne disease.

5.1.10 State of Water Logging & Flood Frequency

In Shyamnagar, water logging halted agriculture and aquaculture production for more than two years (Haque *et al.*, 2013, Interview 73). Flooding due to tropical cyclones is one of the most devastating natural hazards in Bangladesh. The coastal region of Bangladesh is particularly vulnerable to cyclonic storm surge floods due

to its location in the path of tropical cyclones, wide and shallow continental shelf and the funnelling shape of the coast (Das, 1972).

According to the field survey report it is observed that water logging has damaged agriculture, fisheries, poultry, shrimp firm and others sector. The following table 5.1 shows that before Aila water logging was medium in both village and after Aila it has increased significantly. And 31.2 percent of village Sora and 45.5 percent household of village Patharkhali have said that after Aila water logging has increased. Village Patharkhali is a low flood plain. That is why water logging is higher there.

Table 5.6: State of Water Logging (Before & After Aila)

State of Water Logging	Sora Village		Patharkhali Village	
	Before Aila (%)	After Aila (%)	Before Aila (%)	After Aila (%)
Less	57.0	6.4	55.8	13.0
Moderate	37.6	62.4	37.7	41.5
Increase	5.4	31.2	6.5	45.5
Total	100	100	100	100

Source: Field Survey, 2014.

Focus group discussion reveals that village Sora was flooded two times after Aila and village Patharkhali was flooded one time. It has renewed the soil and water salinity of the study area.

5.1.11 Air Pollution

Air is an important element of physical environment. We cannot live without it. Cyclone Aila is responsible for air pollution also like other sectors destruction. It has damaged mangrove forest Sundarban, ecosystem of Sundarban and the study area, vegetation, water resources, agriculture and man-made infrastructure. All are indirectly or directly affect the air also.

Table 5.2 reveals that, before Aila in village Sora air pollution was almost less and 71 percent household answered that. But after Aila it has changed less to moderate.

On the other hand in village Patharkhali the situation is quite same. And after Aila the majority 66.2 percent household has answered that the state of air pollution has upgraded from less to moderate state.

It shows that the damage of Sundarban and village trees is responsible for air pollution.

Table 5.7: State of Air Pollution (Before & After Aila)

State of Air Pollution	Sora Village		Patharkhali Village	
	Before Aila (%)	After Aila (%)	Before Aila (%)	After Aila (%)
Less	71.0	6.5	75.3	9.1
Moderate	24.7	71.0	20.8	66.2
Increase	4.3	22.5	3.9	24.7
Total	100	100	100	100

Source: Field Survey, 2014.

5.1.12 Airborne Diseases

Pollutant air is responsible for some diseases and it is called airborne disease. In Aila affected region influenza, mumps, cough and other some airborne diseases are common. Before Aila in village Sora 39.8 percent household faced influenza, 46.2 percent household faced mumps and 14 percent household faced other airborne diseases. After Aila the portion has changed slightly.

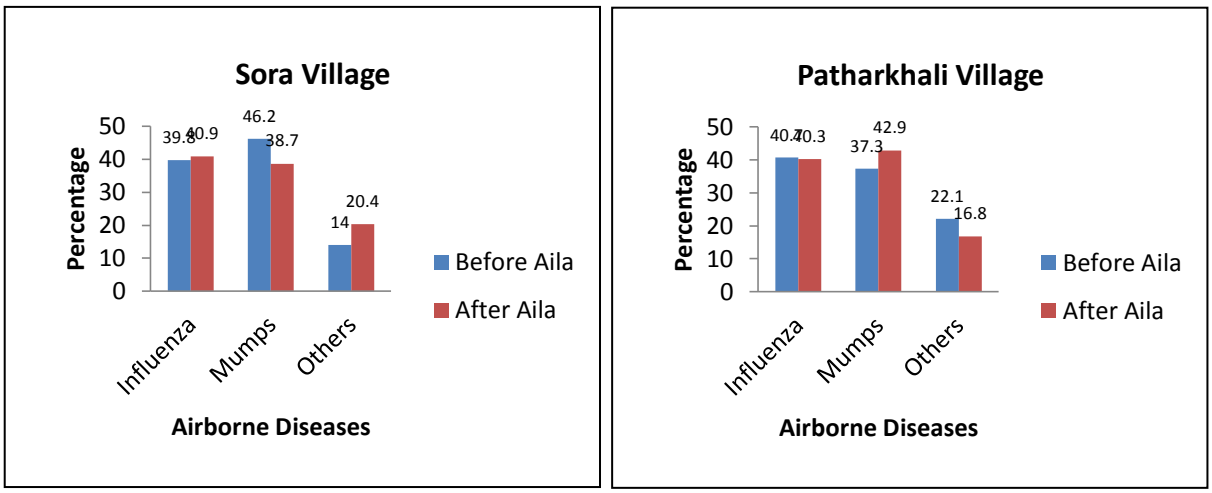


Figure 5.9: Airborne Diseases (Before & After Aila)

Source: Field Survey, 2014.

In case of village Patharkhali, before Aila 40.7 percent household faced influenza, 37.3 percent household faced mumps and 22 percent household faced other airborne diseases. But after Aila influenza affected household has decreased slightly and mumps affected household has increased to 42.9 percent. It seems that Aila has not so exposed impact on airborne diseases. Polluted air affects people badly.

5.1.13 Soil Salinity

The storm surges that accompanied cyclone Aila increased soil salinity, leading to a loss of agricultural productivity, and contaminated groundwater sources (Nishat *et al.*, 2013). Flooding after Aila also increased soil salinity.

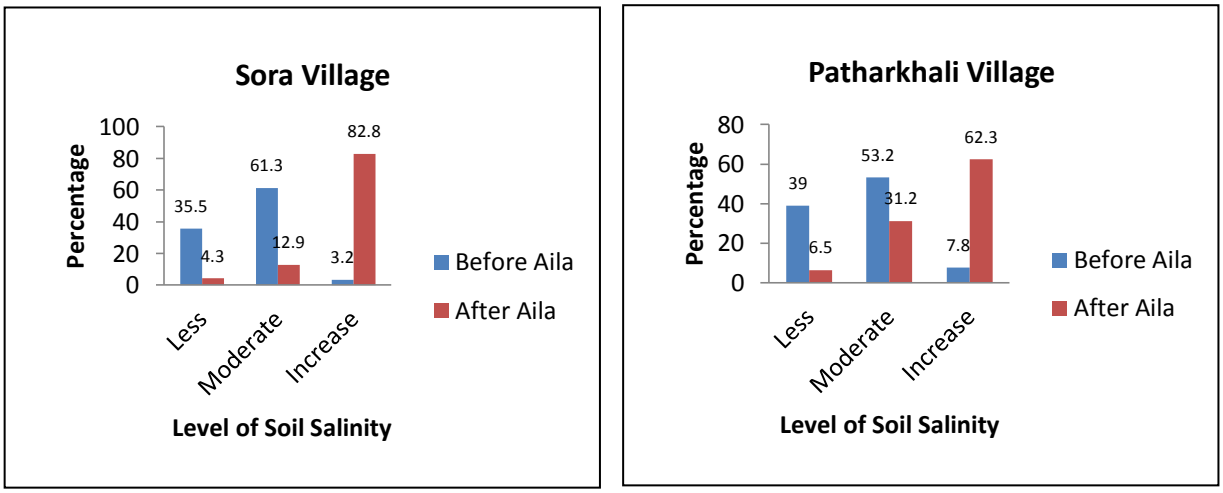


Figure 5.10: Level of Soil Salinity (Before & After Aila)

Source: Field Survey, 2014.

In the above figure (5.10), according to household survey 35.5 percent interviewee says that before Aila soil salinity was less, 61.3 percent says that it was moderate and only 3.2 percent says that it was increase in village Sora. But the majority (82.8 percent) interviewee says that soil salinity has increased significantly after Aila.

In case of village Patharkhali, 53.2 percent interviewee says that soil salinity was moderate before Aila and 62.3 percent interviewee says that soil salinity has increased after Aila. These two are majority portion.

So overall it seems that cyclone Aila has a significant impact on increasing soil salinity. And salinity has a significant impact on agriculture, fisheries and related sectors.

5.1.14 Land Erosion Status

Land erosion is an important issue. River bank erosion and polder damage due to Aila indicates the feature of land erosion. Storm surge and flooding is two important factor of land erosion. In both villages maximum interviewee (table 5.3: Sora 50.5 percent, Patharkhali 46.8 percent) reported that land erosion status has increased due to Aila. Proper management of river bank erosion and reconstruction of polder can less it.

Table 5.8: Land Erosion Status of the Study Area

Land Erosion Status	Sora Village		Patharkhali Village	
	Before Aila (%)	After Aila (%)	Before Aila (%)	After Aila (%)
Less	40.9	11.8	57.1	9.1
Moderate	54.8	36.6	33.1	44.2
Increase	4.3	50.5	9.8	46.8
Total	100	100	100	100

Source: Field Survey, 2014.

5.1.15 Loss of Biodiversity

Apart from agriculture and fisheries, floral and faunal diversity had the least attractive point of news in the Medias covering Aila. But they are most important considering their contribution in the local peoples' livelihoods. The loss of faunal diversity is difficult to assess. However focus group discussion reveals that many numerous dead frogs, snakes and ground hogs floating on water in the study area.

Table 5.9: Loss of Biodiversity

Loss of Bio-diversity	Sora Village		Patharkhali Village	
	Before Aila (%)	After Aila (%)	Before Aila (%)	After Aila (%)
Less	39.8	13.98	48.1	22.1
Moderate	51.6	26.9	35.1	32.5
Increase	8.6	59.14	16.8	45.4
Total	100	100	100	100

Source: Field Survey, 2014.

It can be assumed that because of the saline waterlogged conditions, an anoxic condition was prevailing in the affected areas might cause a colossal loss of the soil living organisms. This has affected the fertility of soil.

The hallmark of plant diversity loss is the dying trees in the waterlogged areas. Mostly Jackfruit, Mango, Litchi and Sissoo trees are dying in the areas. Many other verities of trees are also on the verge of death in Sora and Patharkhali village. Locals say at least 80 percent of the local trees in the affected areas had died in the process. Biodiversity of Sundarban has also been damaged.

5.1.16 Loss of Homesteads

In many cases, losses experienced also included homesteads and farmland, which were inundated with saline water for prolonged periods – an impact with profound consequences for soil fertility and drinking water. In my study areas nearly 90% of the agriculture land and 70% of the homestead gardens were swamped (Jahan I, 2012). It is impossible to produce vegetables in the salinity polluted land before two years. To produce fruit species people have to wait for 6 years (Uthpal Kumar et. al, 2010).

People of the study area said that before Aila they could plant various vegetables like Brinjal, Chillies, the Bean, the Bottle-ground and Tomato on their ground. But after Aila till now they can't do it because of soil salinity and less fertility of soil. Fruit trees also have destroyed. Since last two years they were trying to plant fruit trees again.

5.1.17 Taken Measures against All Kind of Pollution (Water, Soil & Air)

Aila has drawn disastrous effect in all sectors of life and nature. Water, soil and air are three important parts of them. So some measures should be taken to recover them. It is a part of coping strategy. Here 'coping is the manner in which people act within the limits of existing resources and range of expectations to achieve various ends. In general this involves no more than "managing resources", but usually it means how it is done in unusual, abnormal and adverse

situations' (Wisner *et al.*, 2004, p. 113). 'Thus coping can include defense mechanisms, active ways of solving problems and methods for handling stress' (Murphy and Moriarty, 1976, quoted in Wisner *et al.*, 2004, p. 113).

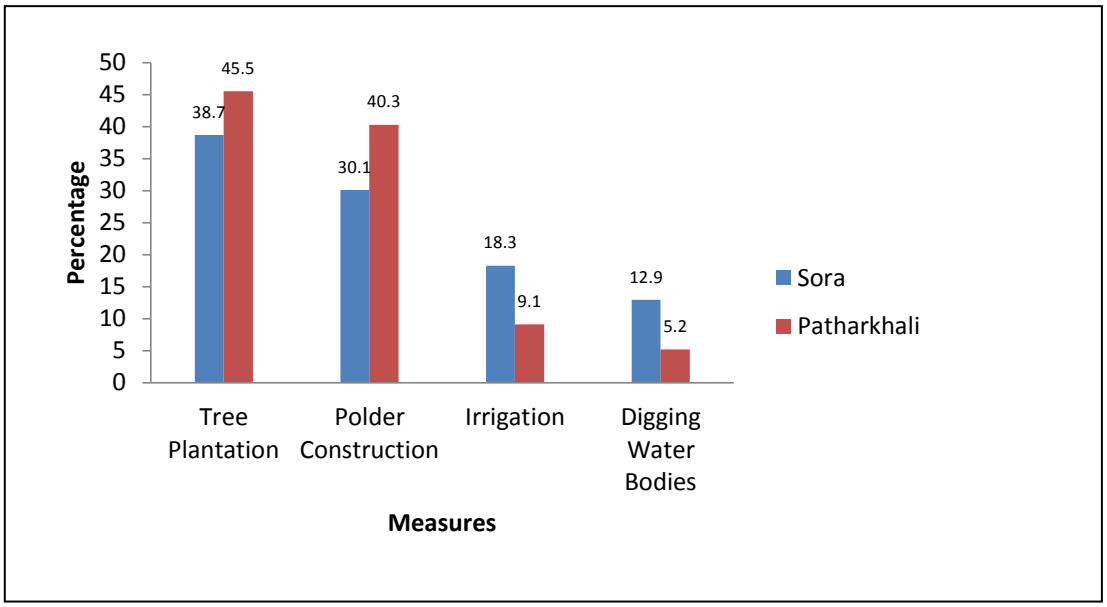


Figure 5.11: Taken Measures against All Kind of Pollution

Source: Field Survey, 2014.

Figure 5.9 shows the measures which have taken to cope up water, soil and air pollution by the people of the study area after Aila. In village Sora 38.7 percent household are related with tree plantation, 30.1 percent household are related with polder construction, 18.3 percent household are trying to irrigation and rest 12.9 percent household are related with digging water bodies.

On the other hand in village Patharkhali, 45.5percent household are planting trees, 40.3percent household are related with polder construction, 9.1percent household are related with irrigation and other 5.2 percent household are digging water bodies.

5.2 Impact of Aila on Cultural Environment

Koyra and Shymnagar upazila of southwest coastal belt of Bangladesh were hit the hardest by the cyclone Aila. Storm surge washed away almost all the houses, crops and agro-land, homestead garden and livestock and there by the area experienced huge toll damages to lives and livelihoods. Aila not only broke down the overall social harmonization but also resulted into a chaotic situation in those areas. People, in the affected region, are now struggling to manage minimum life sustaining requirements like adequate food, shelter, water and sanitation facilities. So it is clear that cyclone Aila effects badly on cultural environmental elements too.

5.2.1 Sanitation Sector

Good sanitation system is now an essential for safe and healthy life of the people. Peoples started to settle down on the embankment and had no permanent sanitation facilities (Wash Cluste, WaterAid and Unicef, 2009).

According to the following figure in village Sora, 5.4 percent of households had sanitary latrines before cyclone Aila, whereas after Aila 58.1 percent of households have sanitary latrines. On the other hand 41.4 percent of households have non-sanitary latrines most of them are now using the temporary hanging latrine provided by relief organizations.

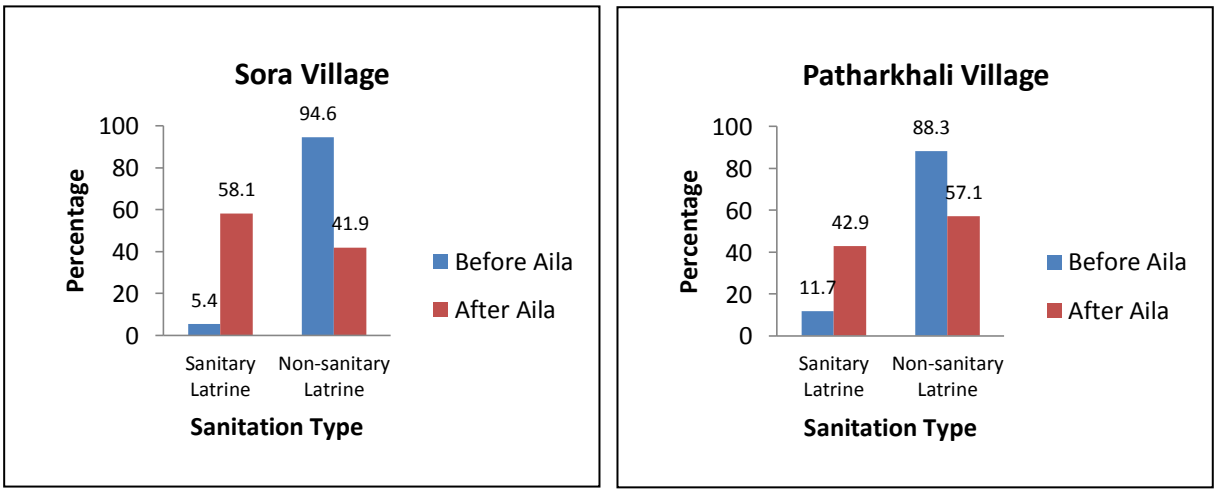


Figure 5.12: Sanitation Facility
Source: Field Survey, 2014.

In case of village Patharkhali, 11.7 percent of households had sanitary latrines before cyclone Aila and after Aila it has increased to 42.9 percent. The people of both villages say that after 6 years of cyclone Aila they are using sanitary latrine because of various NGO's aid. But village Sora has got more aid than village Patharkhali because Sora had more affected.

5.2.2 Lightening/Energy/Power Source

In the study area there is no electric connection. It is a strange matter. The whole area is dependent on either solar energy or oil. Figure 5.13 reveals the comparison of having solar plate as energy source in the study area between before and after Aila period.

As can be seen in village Sora, people started using solar energy after Aila and now 48.4 percent of households have a solar panel as their energy source. But before Aila 100 percent of households were used kerosene lamp. It is a great positive change. Similarly in village Patharkhali, 1.3 percent of households had solar panel before Aila. And it has decreased to 68.8 percent after Aila.

According to this report one can think that after Aila people are in good economic condition and they have escaped the effect of Aila. But the real scenario is totally different. The focus group discussion reveals that people are having benefitted by using solar plate than lamp because of increasing price of kerosene oil. They say if they use kerosene oil it takes minimum 15tk per day but if they buy solar plate it gives unlimited energy. So they buy solar panel in installment and collect money from NGO.

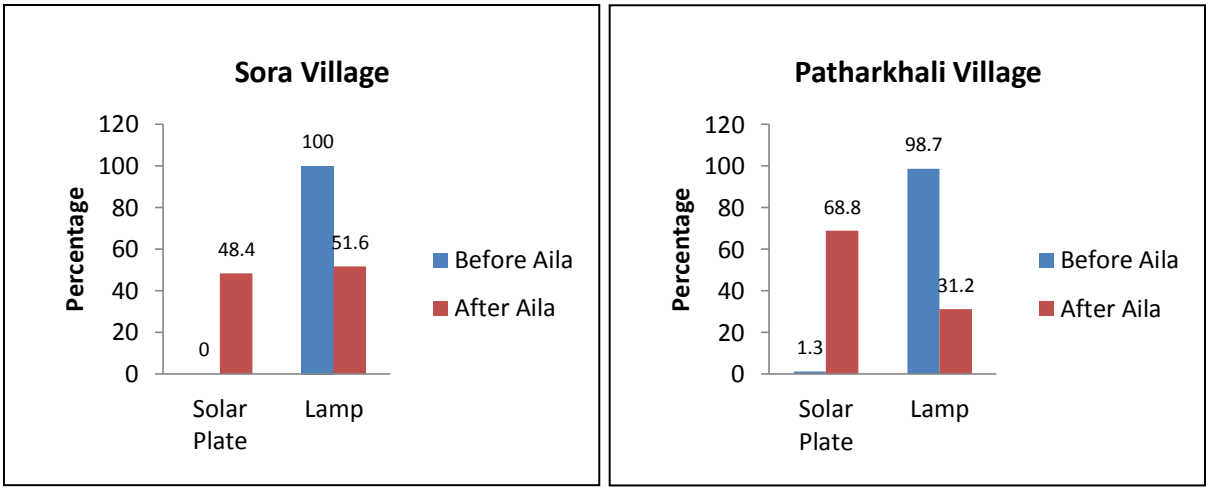


Figure 5.13: Access to Energy Source

Source: Field Survey, 2014.

5.2.3 Household Goods

Loss and damage to a wide range of infrastructure and livelihood-related assets was incurred as a result of Aila in the affected communities. Besides the accounted damage, a large number of households and small infrastructures were damaged. An estimated 243,000 houses were fully destroyed and over 373,000 were partially damaged. Thousands of people took shelter in different cyclone shelters, schools, and makeshift shelters on embankments (IFRC, 2009). Figure 5.14 depicts the damage of household goods and other assets of affected households. It shows that in village Sora purchase of mobile has remarkably increased from 3.2 percent to 78.5 percent after Aila and most damaging household goods are furniture. On the other hand, in village Patharkhali, purchase of television, motorcycle, bicycle, furniture and mobile have increased after Aila.

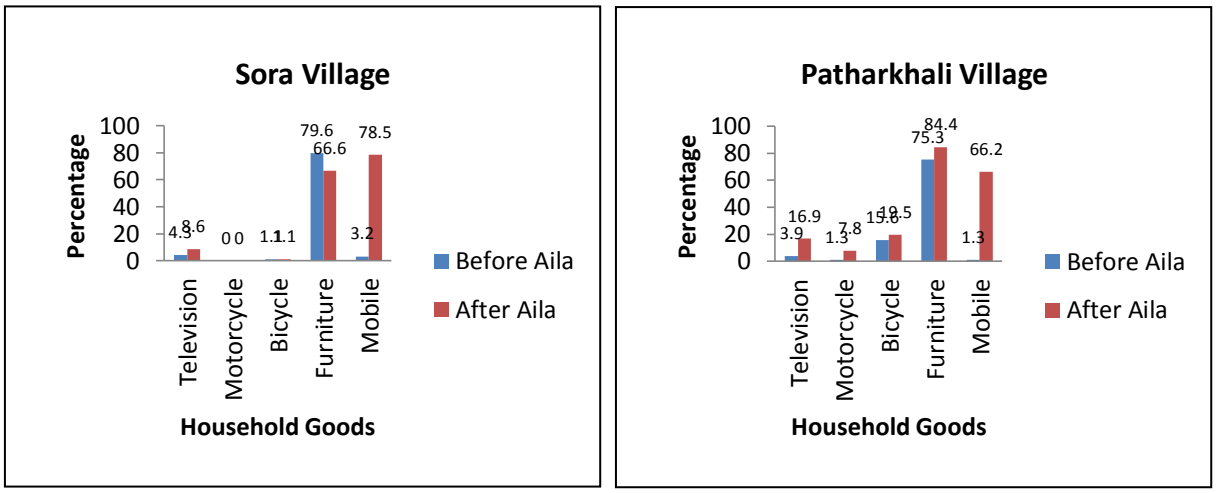


Figure 5.14: Damages of Household Goods

Source: Field Survey, 2014.

It shows that after Aila village Patharkhali has recovered quickly than Aila.

5.2.4 Infrastructural Damage

In terms of infrastructure-related impacts, the transport sector accounted for the majority of additional loss and damage – an estimated USD 141 million, primarily incurred on roads and inland water navigation systems (GoB, 2008). Other losses included the destruction of household goods, agricultural tools (e.g. ploughs), and fishing tools (e.g. boats, nets, etc.), which inhibited effective participation in important livelihood activities (Haque *et al.*, 2013).

In the study area people said about the damage of bridge, culvert, school, madrasa, mosque, road, polder and mostly houses. In village Sora 95.6 percent households had damaged their house and in Patharkhali it was 92.37 percent.

Aila caused a huge damage to infrastructures including households, education institutes, religious institutions, roads and embankments at Koyra. The study reveals that 140 km of roads and 125 km of embankment was fully and 90 km of roads and 61 km of embankment was partially affected. Moreover, 23820 households were damaged fully; whereas 18620 households were damaged partially.

5.2.5 Loss of Livestock Resource

Eighty five percent respondents reported that Aila damaged their 95 percent livestock resources. The livestock and poultry death was continuing even after Aila due to food and drinking water shortage. Now most of the houses are devoid of livestock and poultry resources in the affected area (Mallick *et al.*, 2011).

Large numbers of animals were killed in the cyclone, mainly by the tidal wave surge**.** Not only does this represent a major loss of assets, and loss of purchasing power for the affected families, but it also leads to an expected and protracted decline in the consumption of meat, milk, and eggs in the diets of affected people, plus further loss of income from the use or sale of such products (GoB, 2008).

Figure 5.15 reveals the loss of livestock in the study area. In village Sora and Patharkhali, the percentage of having cow, goat, buffalo, chicken and duck have decreased after Aila. But the number of goat has decreased in significant number in both villages. It seems that livestock resources were affected mostly by Aila and its impact still exists. It affects negatively in the economy of the study area people.

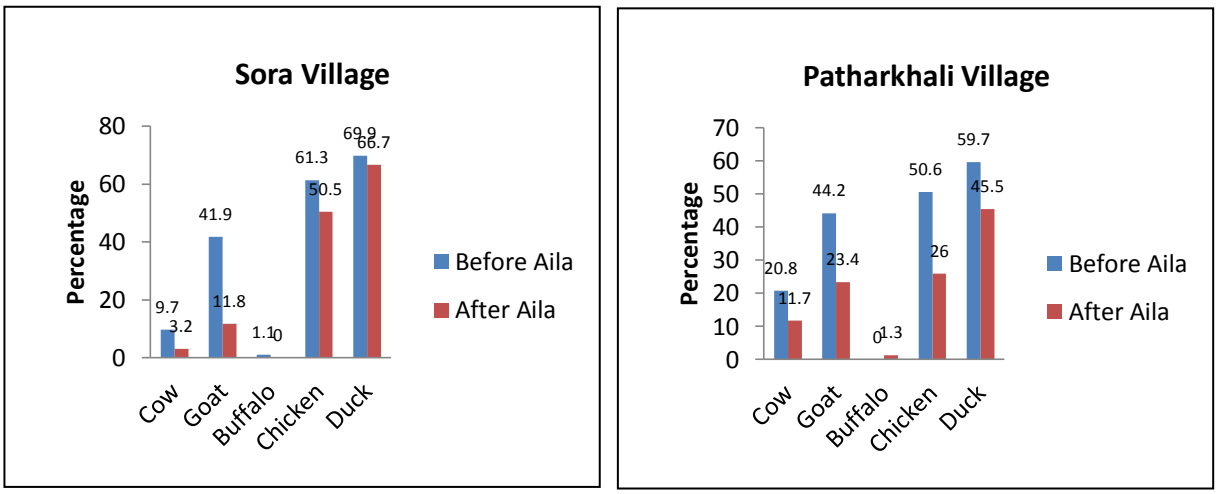


Figure 5.15: Loss of Livestock Resources

Source: Field Survey, 2014.

5.2.6. Land Ownership

Land is an important factor. Mainly the economic structure of Bangladesh is based on land. Landholding pattern in Bangladesh is based on a system of very unevenly distribution. This distribution along with the increasing scarcity of land and increasing growing of population causes a change in the ownership pattern of land.

But in the study area people live in *khas* land. They have no land of their own whether it housing or agricultural land.

a. Housing Land

The table 5.10 presents the data of the amount of housing land of households. House as well as housing land is counted as basic needs. The amount of housing land has no change before and after Aila.

But the amount is so less. The majority of households (Sora 65.6 percent, Patharkhali 66.21 percent) have 3-5 decimal housing land. Others are as usual whether only 4.3 percent households of village Sora and 3.9 percent households of village Patharkhali have more than 9 decimals housing land.

Table 5.10: Housing Land Ownership

Housing land Ownership (in decimal)	Sora Village (%)	Patharkhali Village (%)
<3	11.8	13
3-5	65.6	66.21
5-7	9.7	10.4
7-9	8.60	6.49
>9	4.30	3.9
Total	100	100

Source: Field Survey, 2014.

b. Agricultural Land

Table 5.11 depicts the amount of agricultural land at household level in the study area. From this table it is seen that the amount of agricultural land is not so high. As can be seen in village Sora, 79.6 percent of households have no agricultural land and only 4.3 percent of households have more than 50 decimals agricultural land.

Table 5.11: Agricultural Land Ownership

Cultivated land Ownership (in decimal)	Sora Village (%)	Patharkhali Village (%)
Landless	79.6	83.1
<10	6.5	1.3
10-20	6.5	1.3
20-30	1.1	2.6
30-40	1.1	1.3
40-50	1.1	2.6
>50	4.3	7.8
Total	100	100

Source: Field Survey, 2014.

On the other hand in village Patharkhali, 83.1 percent of households have no agricultural land and only 7.8 percent of households have more than 50 decimals agricultural land. To sum up the landlessness is the major cause of poverty in this region. This cause affects other sectors also.

5.2.7 Average Monthly Income

After five year of Aila's attack, the condition of the Aila affected areas is still not fully improved. Till now the people are struggling to get their basic needs such as food, pure drinking water and shelter.

In the following figure (5.16) it seems that before Aila maximum people of village Sora were in income range 4001-6000 taka which is 51.6 percent of total population. Then 26.9 percent of them were in income range 2001-4000 taka. A few of them were in range above 8000 taka. But after Aila situation maximum of them are in range 6000-8000 taka and it is 49.5 percent of total population. Then second dominant portion is 30.1 percent and they are in range 4001-6000 taka. Whereas, the third dominant portion is 10.8 percent who are in income range 8001-10000 taka.

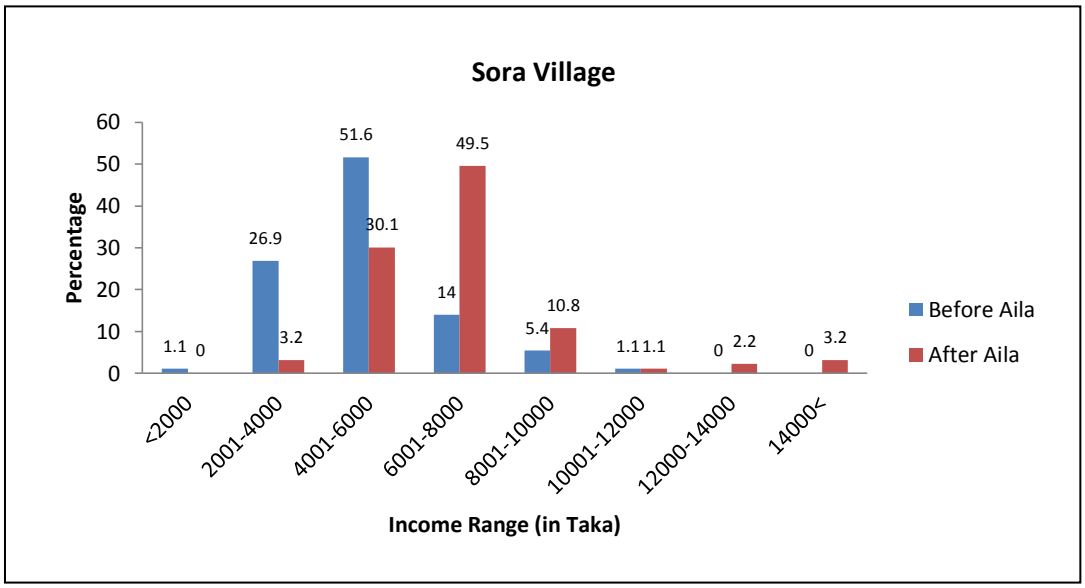


Figure 5.16: Average Monthly Income (Sora)

Source: Field Survey, 2014.

In case of village Patharkhali (figure 5.17) the scenario is quite same. Before Aila 44.2 percent people earned 2001-4000 taka. Then 29.9 percent people's income range was 4001-6000 taka. These groups represent the majority portion. And after Aila maximum 46.75 percent people earn 6001-8000 taka. The second dominant portion is 19.48 percent and they are in income range 4001-6000 taka. The third is 14.3 percent and their income range is 8001-10000 taka. And the total figure demonstrates that overall income has increased in the study area.

At present livelihood cost has increased all over the country and world. But with this phenomena income does not reach at expected level. So in general view thus we can see the income range has increased in the study area but it is too less than their need. That's why they led poor live.

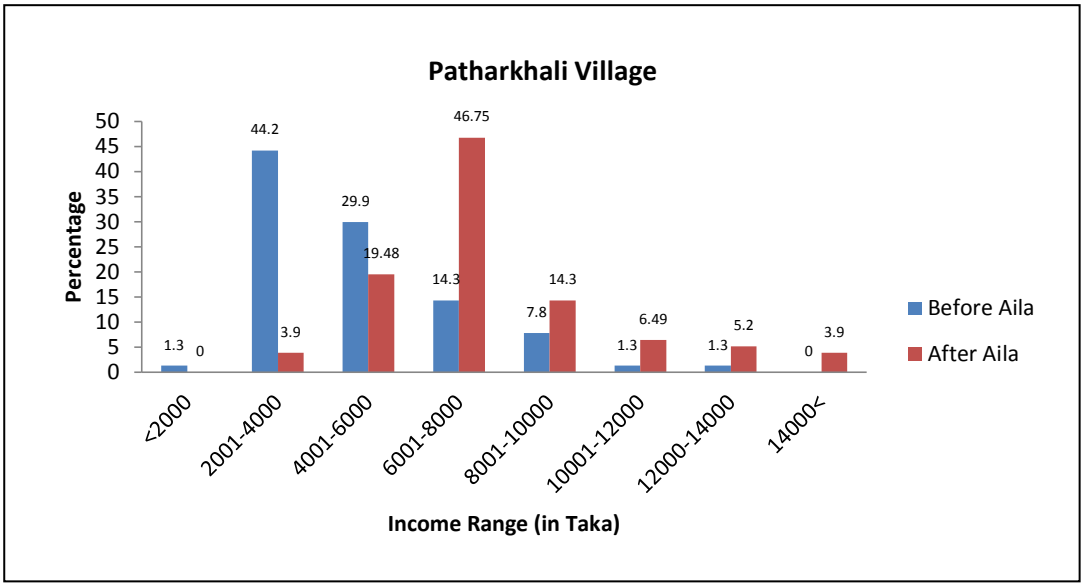


Figure 5.17: Average Monthly Income (Patharkhali)

Source: Field Survey, 2014.

5.2.8 Test for Determining Association between Income Level and Occupation (Village Patharkhali)

H_0: There is no Association between income level and occupation.

H_1: There exists association between income level and occupation.

Table 5.12: Bivariate table by Income Level and Occupation

Average Monthly Income (After Aila)	Occupation of the family members (After Aila)					Total
	Day Labor	Fishing	Woodman	Business	Service	
2001-4000	2 (2.59)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.29)	3 (3.89)
4001-6000	5 (6.49)	6 (7.79)	4 (5.19)	0 (0.00)	0 (0.00)	15 (19.48)
6001-8000	6 (7.79)	17 (22.07)	12 (15.58)	1 (1.29)	0 (0.00)	36 (46.75)
8001-10000	4 (5.19)	5 (6.49)	0 (0.00)	2 (2.59)	0 (0.00)	11 (14.28)
10001-12000	2 (2.59)	0 (0.00)	1 (1.29)	2 (2.59)	0 (0.00)	5 (6.49)
12001-14000	0 (0.00)	2 (2.59)	0 (0.00)	2 (2.59)	0 (0.00)	4 (5.19)
14000<	0 (0.00)	0 (0.00)	0 (0.00)	2 (2.59)	1 (1.29)	3 (3.89)
Total	19 (24.67)	30 (38.96)	17 (22.07)	9 (11.68)	2 (2.59)	77 (100)

From this table it is observed that majority percent of respondents (46.75%) monthly income level is in the range (6001-8000 tk.) who were involved in fishing (22.07%) followed by 7.79 percent, 6.49 percent and 2.59 percent is in range (4001-6000 tk.), (8001-10000 tk.) and (12001-14000 tk.) respectively. Besides, 24.67 percent of respondents are day labor, 22.07 percent of respondents are woodman, 11.68 percent of respondents are involved in business and only 2.59 percent of respondents are involved in Service.

It also implies that only 3.89 percent respondent's income level is very high (<14000 tk.) who were involved in business (2.59%) and service (1.29%). Further 5.19 percent respondent's income level is in income range (12001-14000 tk.) who is involved in fishing (2.59%) and business. Besides it shows that 3.89 percent of respondent's income range is (2001-4000 tk.) who are mostly day labor (2.59%).

Chi-square test by using SPSS-16.0

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	63.190[a]	24	.000
Likelihood Ratio	54.704	24	.000

Comment: At 5% level of significance Pearson Chi-Square for 24 df at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between income level and occupation.

5.2.9 Having Loan

In total, 72 percent of interviewees reported that they were forced to borrow money from relatives or money lenders after the cyclones hit in order to meet their immediate survival needs (Haque *et al.*, 2013). In order to repay their loans, many people had to leave their villages and migrate to urban areas to search for new income-generating activities, such as working in brick fields or as day laborers (Ibid: Interview 11, 19).

The following figure 5.18 shows the percentage of people having loan from various NGO's. In village Sora, 37.63 percent households had taken loan before Aila and after Aila it has increased to 48.38 percent. In case of village Patharkhali, before Aila 41.56 percent households took loan and now the percentage is 50.6.

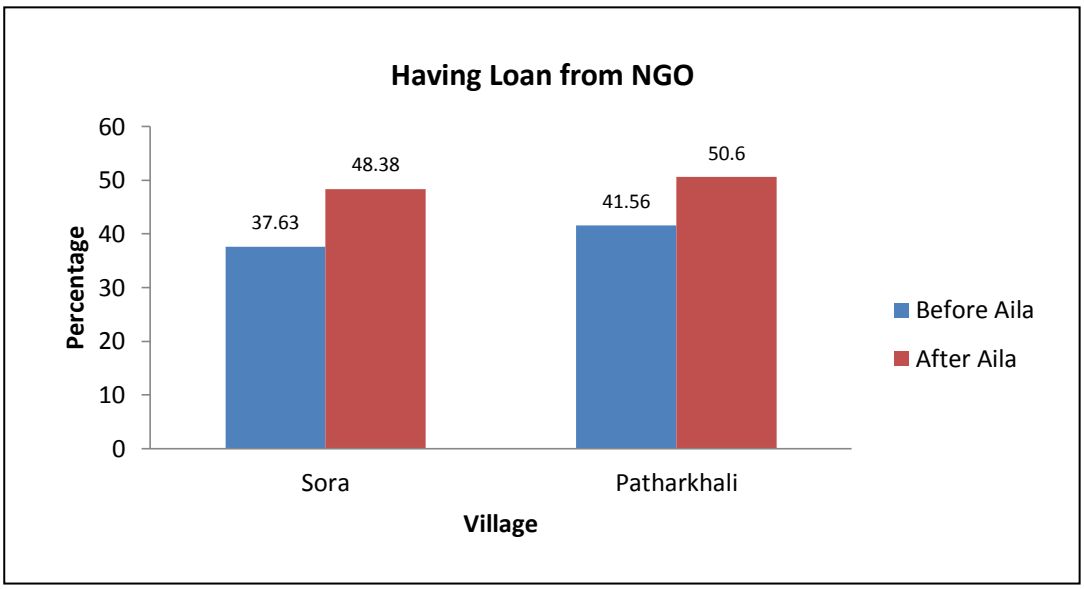


Figure 5.18: Having Loan

Source: Field Survey, 2014.

Focus group discussion reveals that people take loan for repairing house, buying livelihood tools, accessing solar plate and other causes. But one different cause they say some of them takes loan for paying money to rovers. After Aila the violence of rovers has increased at alarming rate. People who go to work in Sundarban and the adjacent river are being harassed by the rover.

5.2.10 Food & Nutrition Intake

Food and nutrition intake is a major indicator of human poverty measurement. Natural disasters such as tropical cyclones or hurricanes severely affect the nutritional status of the impacted population, which is a crucial determinant of household health outcomes (Del Ninno and Dorosh 2002; O'Donnell *et al.*, 2002). Disasters frequently damage or destroy standing crops, vegetables, and fruit trees. In addition, some natural disasters, such as cyclones and associated storm surge, damage, wash away, or spoil stored food. Rural residents also often experience loss of livestock due to natural disasters. All these factors are responsible for acute shortage of food at the household level, particularly for poor households (Del Ninno and Dorosh, 2002; Paul and Routray, 2010a, b).

During this study people were asked about their usual food habit before and after Aila. All the respondents in the study areas used to take food 3 times a day before Aila. However, Aila reversed the situation and now many people have to content with 2 time food intake or hardly 3 times in a day.

In Sora and Patharkhali village respectively 96 percent and 98 percent respondents said that after Aila they are still with insufficient food and so, suffering from malnutrition. About 75 percent respondents identified reduced family income as the major cause of their insufficient food taking. On the other hand, 25 percent respondents blamed increase of the food prices as the primary cause. However, all the respondents agreed that salinity ingress in their crop fields is impeding crop and vegetable production and it is lessening their daily food intake share.

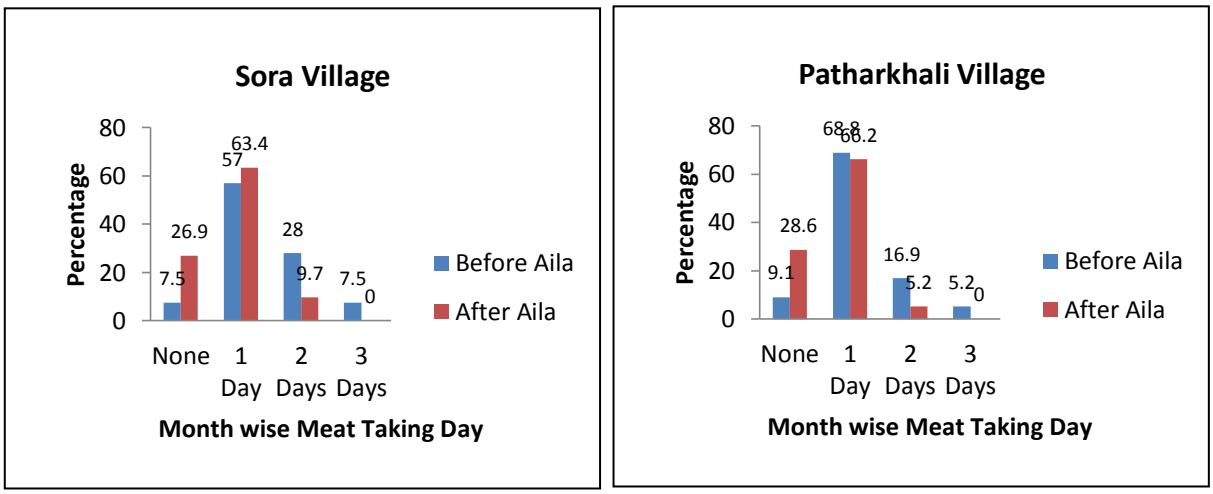


Figure 5.19 (a. Meat): Food Habit Pattern of Respondents Family (month per day)

Source: Field Survey, 2014.

Food habit pattern of Aila affected communities have changed. The following five sub-figures are showing food habit pattern of the study area people. According to the figure 5.19 (a), (b), (c), (d) and (e) it are observed that Aila effects on their food habit pattern. They are taking lower food than before. It effects negatively on their health.

In both villages intake of meat is so rare. Maximum families take meat only one day in a month. In Sora and Patharkhali village respectively 26.9 percent and 28.6 percent households cannot take meat a single day of a month for their insolvency but before Aila it was 7.5 percent and 9.1 percent respectively in Sora and Patharkhali. Huge losses of livestock resources are also responsible for this.

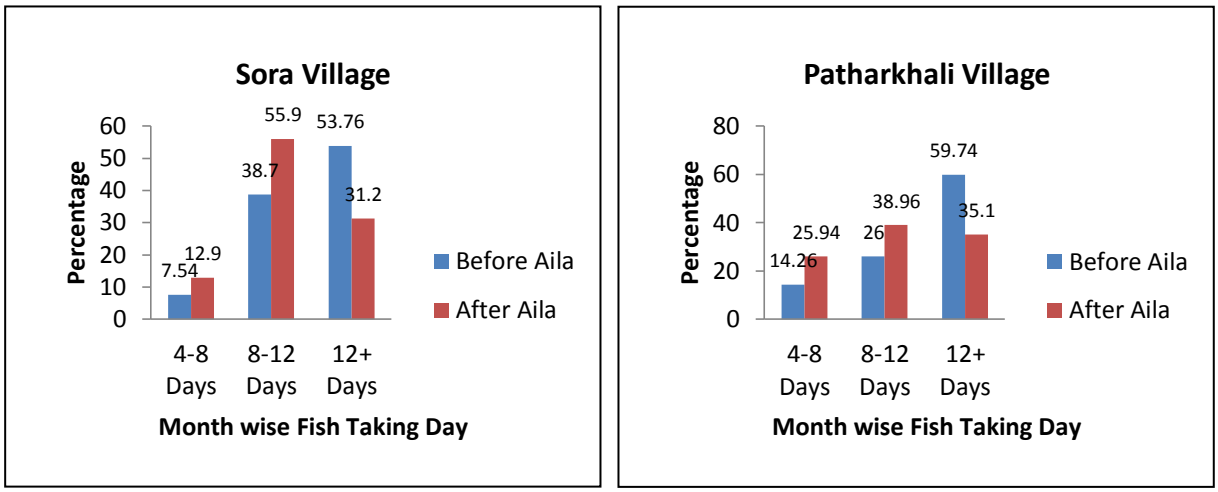


Figure 5.19 (b. Fish): Food Habit Pattern of Respondents Family (month per day)

Source: Field Survey, 2014.

Fishing is the major occupation of the study area people. That is why they take fish maximum days. But due to Aila the pattern has changed.

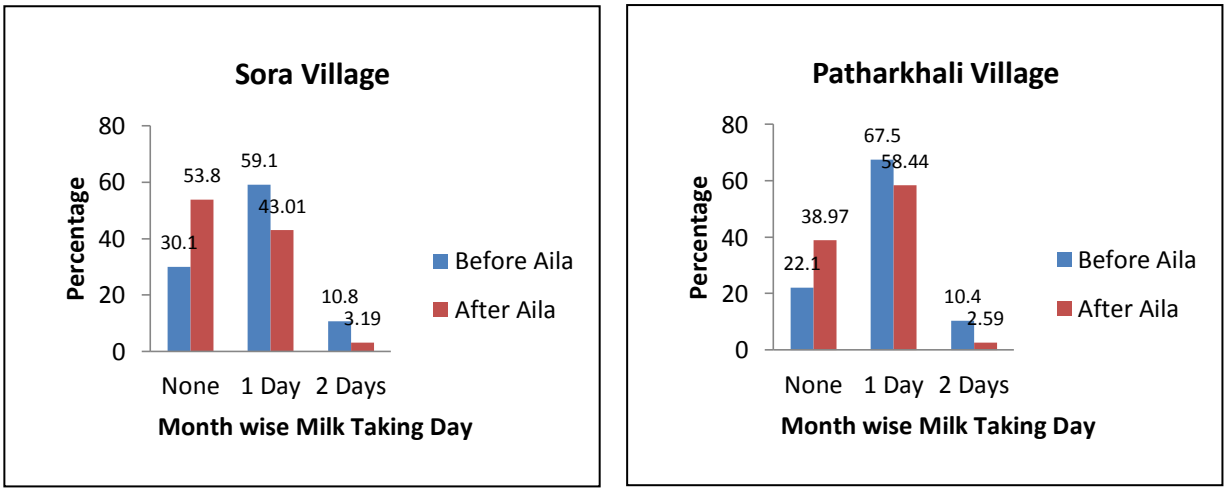


Figure 5.19 (c. Milk): Food Habit Pattern of Respondents Family (month per day)

Source: Field Survey, 2014.

Milk is so rare to intake in the food habit pattern of study area people. In Sora and Patharkhali village respectively 53.8 percent and 38.97 percent households cannot take milk a single day of a month but before Aila it was 30.1 percent and 22.1 percent respectively in Sora and Patharkhali. Before Aila in Sora and Patharkhali village respectively 59.1 percent and 67.5 percent households take milk only one day in a month but after Aila the percentage has decreased to 43.01 percent and 58.44 percent respectively in Sora and Patharkhali village.

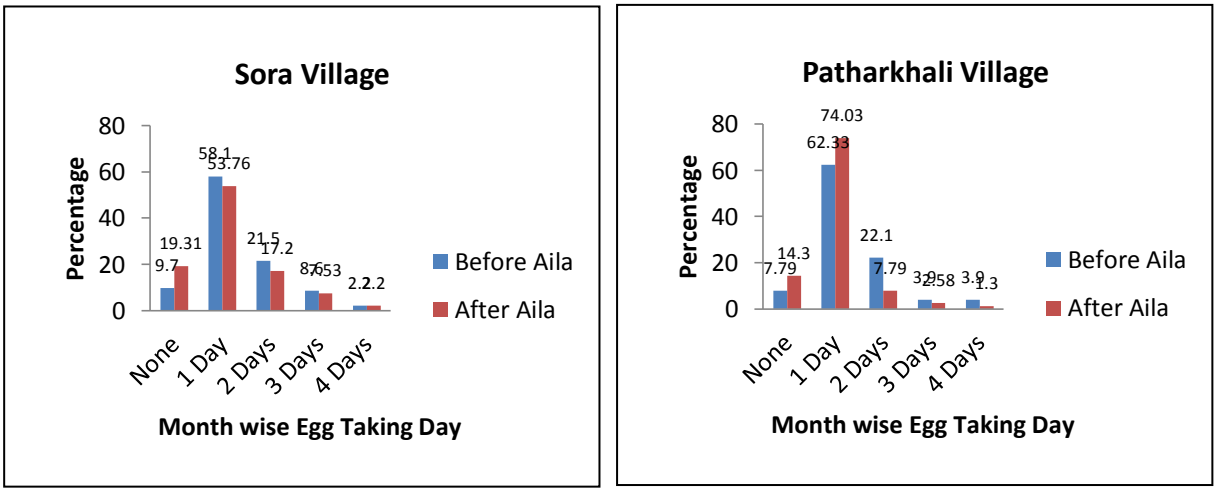


Figure 5.19 (d. Egg): Food Habit Pattern of Respondents Family (month per day)
Source: Field Survey, 2014.

Aila washed away and killed many duck and chicken. So intake of egg has also decreased significantly.

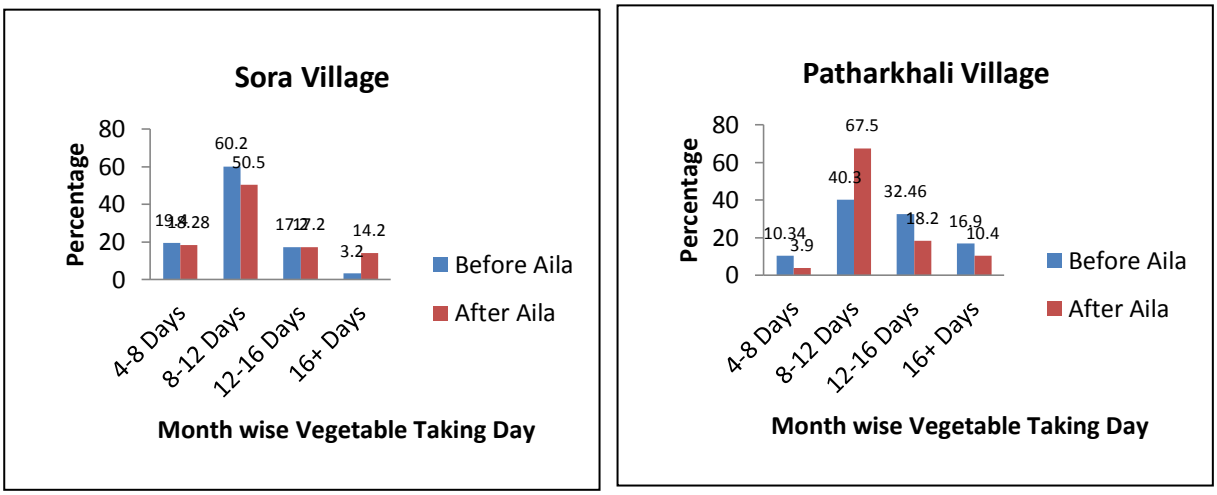


Figure 5.19 (e. Vegetable): Food Habit Pattern of Respondents Family (month per day)
Source: Field Survey, 2014.

Vegetable is a common food for the poor. But Aila damaged the homestead sector also. So intake of vegetable has also changed due to Aila.

Finally it shows that Aila has a severe negative impact also on food and nutrition intake of the study area people.

5.2.11 Shrimp Cultivation

Shrimp farming is one of the major occupations in South-western coastal region of Bangladesh. Aila affected region also follows similar occupational pattern and shrimp farming alone constitutes 40 percent of the total occupation. Rest of the employed people engaged with small holding agriculture (30 percent) and wage labour activities (30 percent) (Mallick *et al.*, 2011).

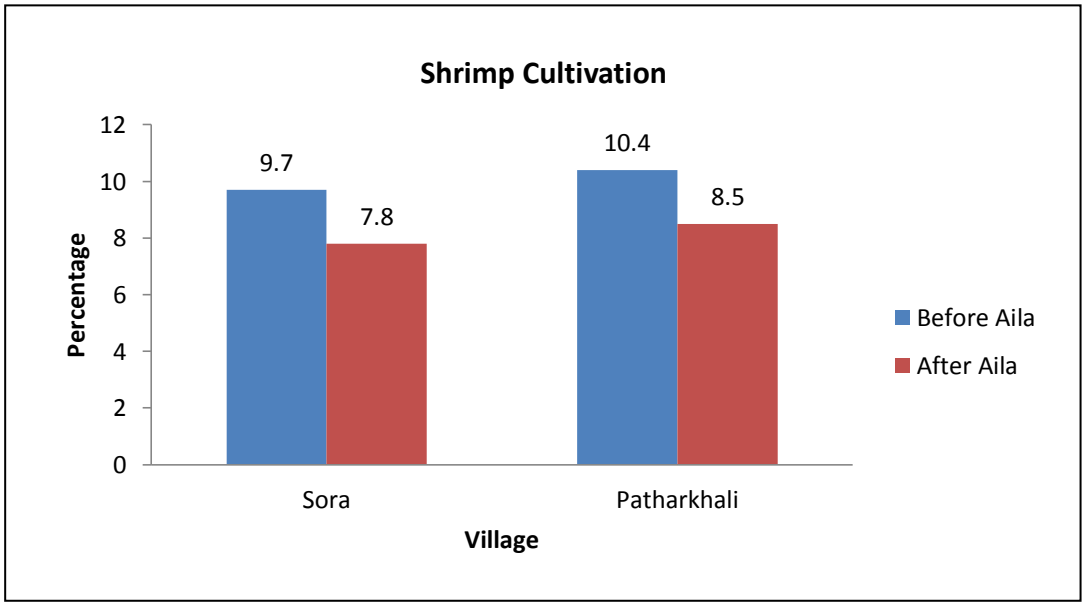


Figure 5.20: Shrimp Cultivation

Source: Field Survey, 2014.

The above figure 5.20 shows that before Aila 9.7 percent households of village Sora and 10.4 percent households of village Patharkhali had shrimp firm but after Aila it has decreased to 7.8 percent and 8.5 percent respectively in both villages. It recognized the worst effect of Aila on shrimp firming.

However, the study reveals that 96 percent of the livelihood bases were devastated by Aila. Most unfortunate thing is that till now most of the affected people could not be able to recover the damages. More than 80 percent of the respondents in all the two villages are struggling to maintain a subsistence living.

5.2.12 Cropping Intensity

In the agricultural sector, most direct losses (95 percent) were incurred as a result of high winds and storm surges that destroyed or damaged more than 6400 sq. km of cropland (World Bank, 2012). At the community level, residents of Shyamnagar and Koyra who were interviewed recalled having their fields flattened by torrential winds and also noted significant loss and damage to aquaculture as a result of tidal surges (Haque *et al.*, 2013).

Though short term impacts on agricultural crops were not severe in the study area, the long-term residual impacts are far-reaching and cause profound negative impacts on local food security (Warner *et al.*, 2012). For instance, rice harvests significantly decreased in consecutive years following cyclone Alia due to the sudden and drastic increase in soil salinity that resulted from in-land storm surges.

Table 5.13: Cropping Intensity

Cropping Intensity	Sora Village		Patharkhali Village	
	Before Aila (%)	After Aila (%)	Before Aila (%)	After Aila (%)
Single	0	100	0	100
Double	100	0	100	0

Source: Field Survey, 2014.

Table 5.13 shows the cropping intensity of the study area before and after Aila. In both villages it is seen that before Aila the cropping intensity was in double form and now it is single. Increase of soil and water salinity is responsible for it.

5.2.13 Migration

Disasters like Aila (2009) and Sidr (2007) have forced more than a million people to be made homeless and to migrate from their regions. Bangladesh's lack of preparedness and its diminishing strength to combat calamities, combined with peoples' lack of ability to cope with disasters may have contributed to the massive destruction. However, there is concern that global climate change may also be contributing to the severity of the weather, multiplying the suffering of the people (FPP, 2009).

Consequently, in the wake of both Sidr and Aila, many areas experienced significant out-migration – predominantly cyclical and seasonal, but sometimes permanent – as people left their households in search of employment (Kartiki, 2011). Aila resulted into significant migration from the affected areas of Satkhira and Khulna district. Most of them have migrated to Khulna, Satkhira, Bagerhat, Pirojpur, Borishal, Potuakhali, Gopalganj, Faridpur, Jessore and Narail (Mallick *et al.*, 2011).

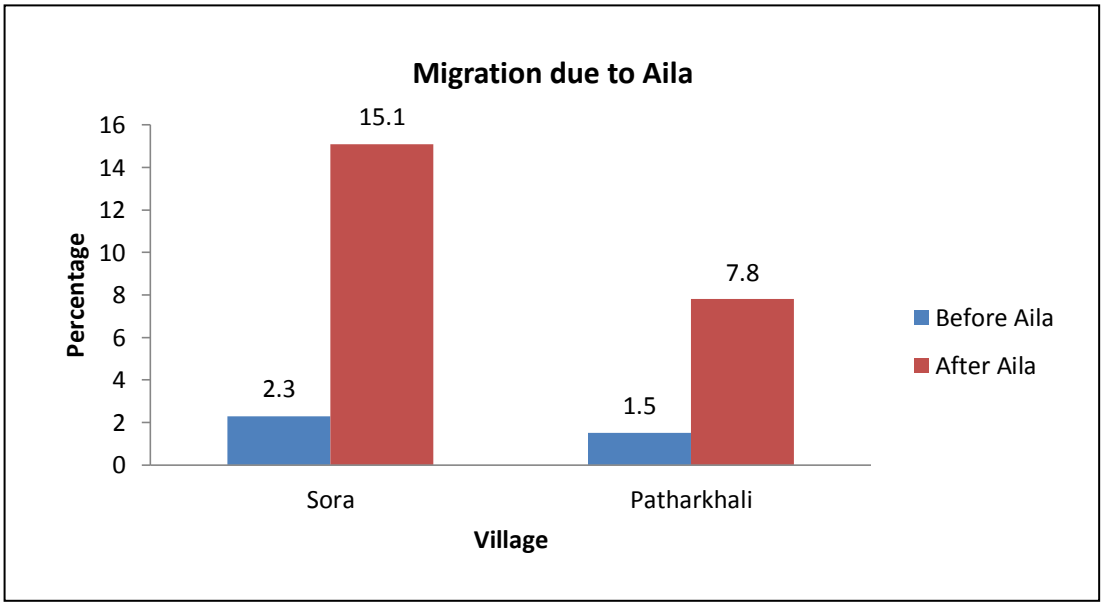


Figure 5.21: Migration Due to Aila

Source: Field Survey, 2014.

Figure 5.21 reveals that from Sora 15.1 percent families have permanently migrated after Aila, whereas from Patharkhali it is 7.8 percent. Most of people have migrated to Khulna, Satkhira, Rangamati, Dumuria, Doulatpur, Jessore and Kesobpur areas for looking jobs. Some people have also migrated to West Bengal of India in search of jobs. Whether, some families have migrated temporarily from Sora and Patharkhali village. The trend is continuing.

5.2.14 Social Unrest

In Patharkhali, all respondents reported that law and order situation is relatively better than other part of the Aila affected regions. In Sora, about 15 percent respondents said that law and order situation is well at their locality. However, 85 percent reported that robbery activities have increased in Sundarbans region. These respondents claimed that fishermen and forest dependent people are facing problem from robbery demand in Sundarbans. On the other hand, conflict between the agriculture and shrimp owners has been reported in both villages. The shrimp farmers and firm owners are now very much aggressive to start the shrimp farming activities at their fields.

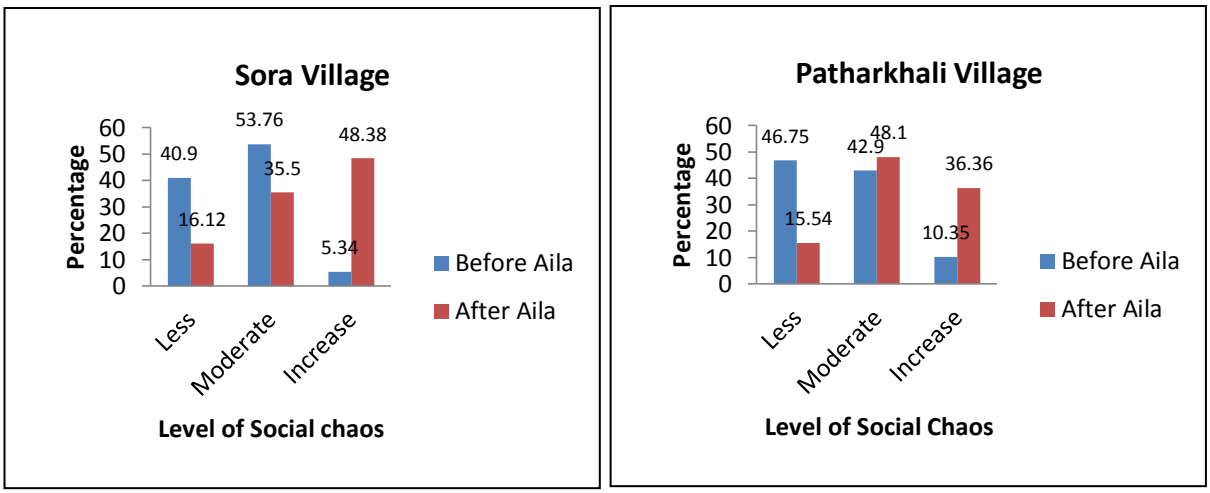


Figure 5.22: Social Chaos

Source: Field Survey, 2014.

Figure 5.22 present the state of social chaos and unrest in the study area. It shows that social chaos and unrest has increased after Aila in both villages.

However, local farmers are against the shrimp farming activity by arguing that salinity intrusion in agro-fields as a consequence of widespread shrimp farming is hampering their production. Local people claimed that the administration and local elites are favoring shrimp farming. As a result local farmers have been suffering from reduced agricultural production and sometimes receive administration harassment in case of their positioning against the shrimp owners. About 25 percent respondents wished to go for social movement against shrimp farming activities at their sites and protest the activities at any cost.

5.3 Empirical Findings of the Study

The study has mainly focused on the environmental impact assessment of Aila in the affected locality. And on the basis of analysis, the study has identified some important findings. The major looks of those are reflected below:

- In this study it is observed that there is two kind of environmental impact due to Aila. Such as physical environmental impact and cultural environmental impact (figure 5.23).

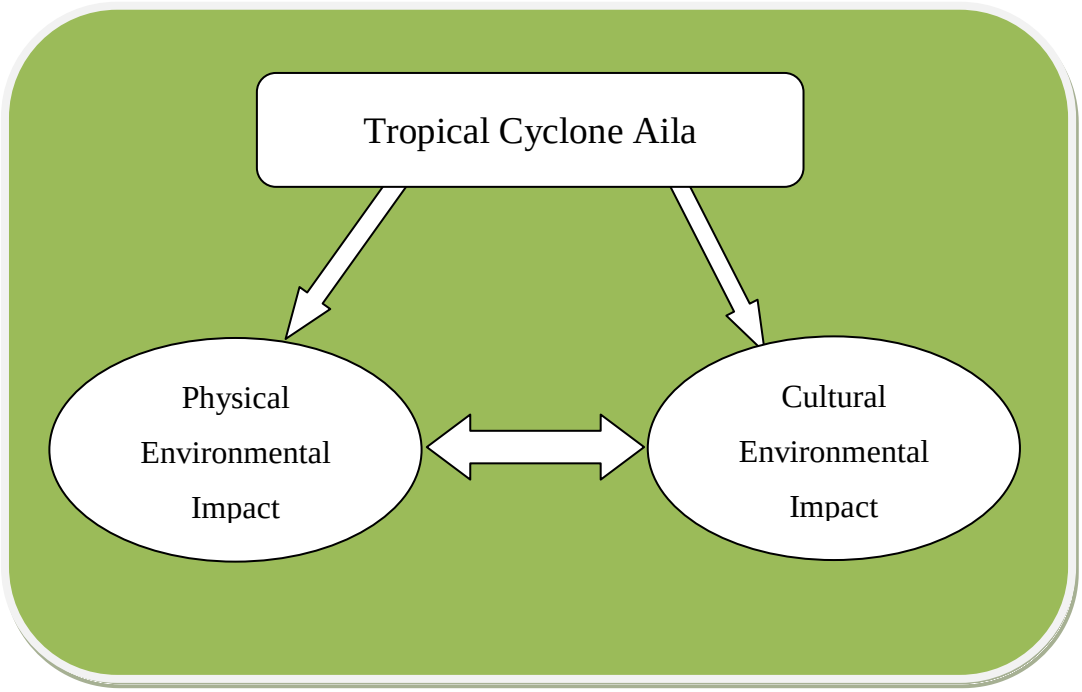


Figure 5.23: Impact of Cyclone Aila

- Physical environmental impact consist salinity of soil, salinity of water, air pollution, waterborne disease, airborne disease, destruction of forest, loss of biodiversity, loss of homesteads, water logging and uneven flood, land erosion etc (figure 5.24).

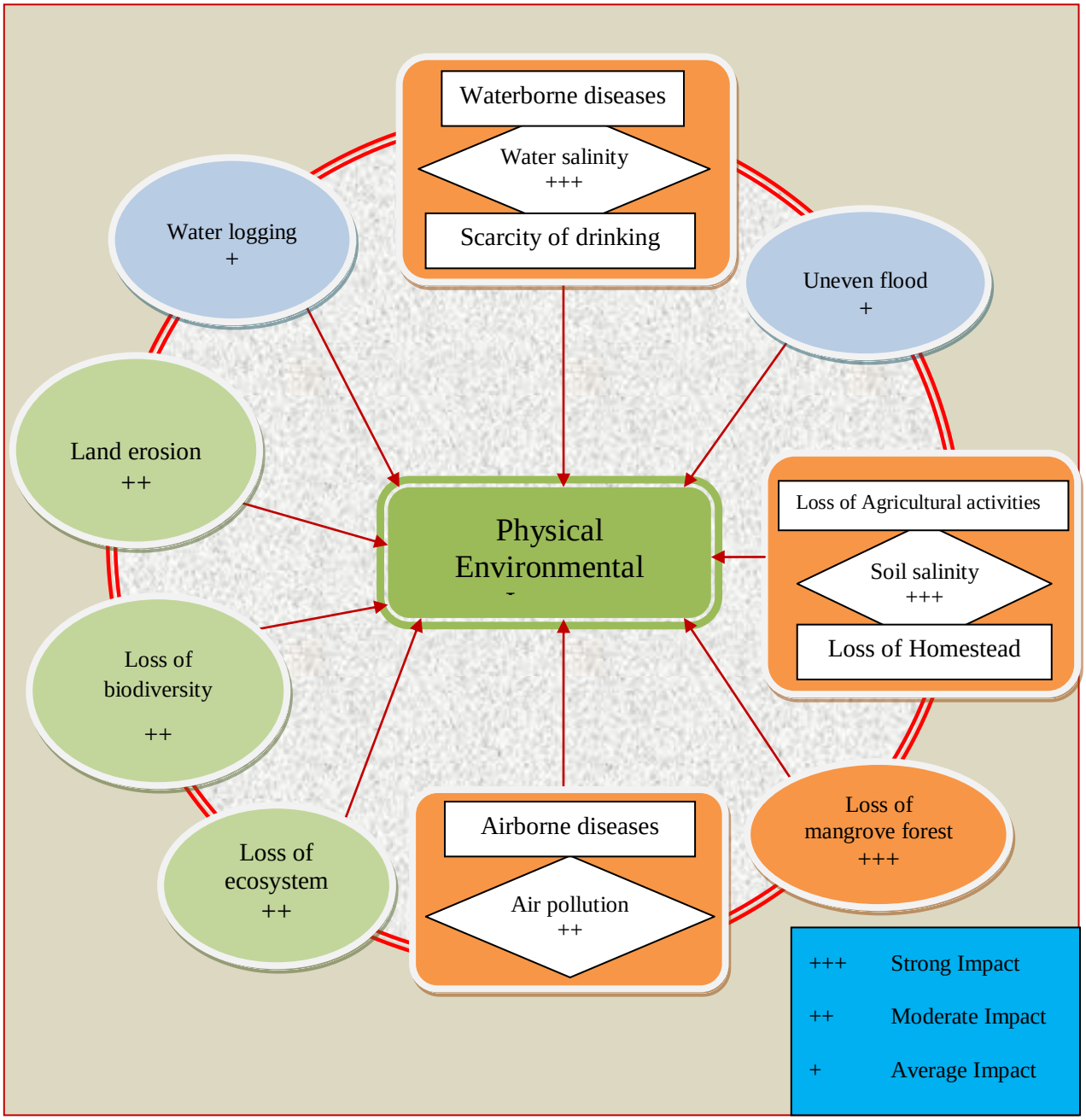
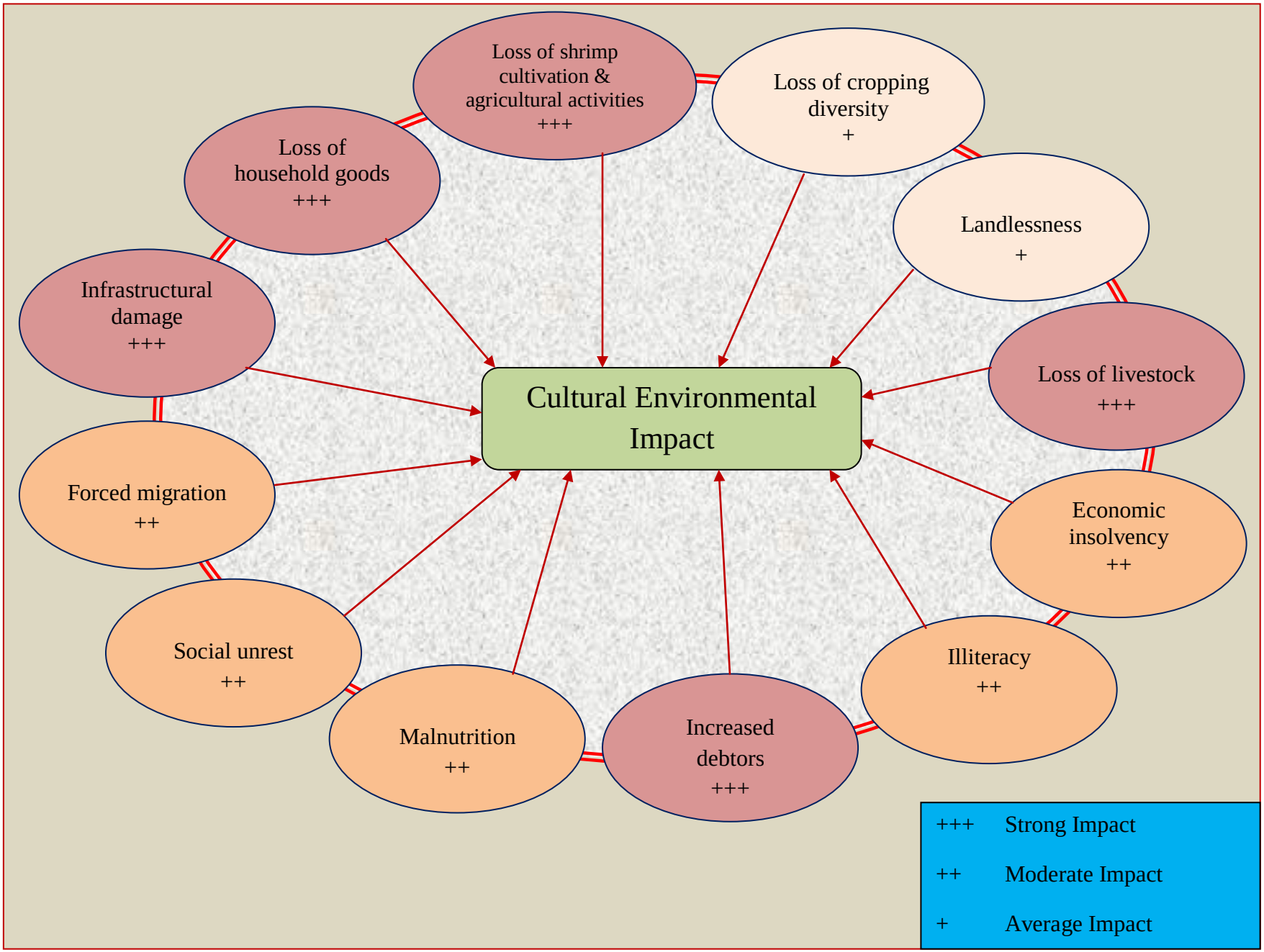


Figure 5.24: Flow Chart of Physical Environmental Impact.

Figure 5.25: Flow Chart of Cultural Environmental Impact



- Cultural environmental impact consist illiteracy, low income, economic insolvency, change of occupation, loss of household goods, loss of livestock, loss of shrimp cultivation, damage of infrastructure and house, loss of cropping diversity, forced migration, social unrest etc (figure 5.25).
- All impacts are interrelated and affect each other. Some impacts are strong and all strong impacts have sub impact.

Table 5.14: Overall Environmental Impact Due to Aila in the Study Area

Items	Status	Level of concern	Remarks
Physical Environmental Impact			
Salinity of soil	Increased	Very high	Due to tidal flood & storm surge accompanied by Aila
Salinity of water	Increased	Very high	Due to tidal flood & Aila intrusion water
Air pollution	Exist	Low	Aila has damaged mangrove forest Sundarban, ecosystem of Sundarban and the study area, vegetation, water resources, agriculture and man-made infrastructure. All are indirectly or directly happened air pollution.
Waterborne disease	Increased	High	Due to pure drinking water scarcity
Airborne disease	Increased	Moderate	Due to air pollution
Mangrove forest coverage	Decreased	Moderate	Due to the extreme speedy wind and inundate with salt water from Aila's storm surge.
Loss of biodiversity	Increased	Moderate	Due to storm surge & saline waterlogged condition
Loss of homesteads	Exist	High	Due to inundate with salt water from Aila's storm surge.
Water logging	Increased	Moderate	After Aila flood frequency has increased. So water logging has also increased.
Land erosion	Mild erosion	Moderate	Storm surge of Aila and flooding is two important factor of land erosion

Items	Status	Level of concern	Remarks
Cultural Environmental Impact			
Literacy rate	Decreased	Moderate	Because of poverty
Non-agricultural occupation	Increased	High	Due to soil & water pollution agricultural activities has decreased
Economic solvency	Decreased	Moderate	Due to loss of assets & occupation
Sanitation facility	Increased	Moderate	After Aila the help of relief organization and NGO has increased in this sector
Loss of livestock	Increased	Very high	Due to sudden storm surge of Aila and flooding
Loss of household goods	Increased	High	Due to sudden storm surge of Aila and flooding
Cropping diversity	Decreased	High	Due to soil and water pollution
Shrimp cultivation	Decreased	Moderate	Due to lack of capital
Loan acceptor	Increased	Very high	Due to various problem
Social unrest	Exist	High	Due to various social problem
Migration	Increased	Moderate	Due to loss of house, poverty & to search work

Source: Author

From the findings of the study it is seen that tropical cyclone has straight and important effect on coastal region including man and environment; and it also plays an important role in their livelihood as well as country economy and environment directly and indirectly.

5.4 SWOT Analysis

SWOT analysis is done to answer the questions, such as:

- What are the internal strengths of the study area based on which an attractive strategy can be built for reduce environmental damage?
- Which weakness does the strategy need to correct?
- Does the study area weakness disqualify it from pursuing certain opportunities?
- What are the opportunities the study area can pursue with a chance of success?
- What threats should be this area worry about?

The analysis is based on interactions with the study area people, group discussion and household survey. The analysis findings are summarized in Table 5.15 below.

Table 5.15: SWOT Analysis for Coping up Environmental Damage in the Study Area

SOWT ANALYSIS	
Strengths	***Weaknesses***
▪ Part of the biggest mangrove forest Sundarban is located in the study area. ▪ The soil and climatic condition of the study area are very suitable for mangrove forest and shrimp cultivation. ▪ People are attracted by social forestation. ▪ Shrimp cultivation is very familiar and profitable in the study area. ▪ Solar energy is the main energy source in the study area & it is highly favorable to environment. ▪ Huge water resource ▪ Healthy environment	▪ Salinity of soil & water is the main problem in the study area. ▪ Agricultural activities are very poor. ▪ Literacy rate is very low. ▪ Most of the people have lack of technical knowledge in development of environment and agricultural work. ▪ There is lack of pure drinking water. ▪ Most of the people depend on forest for their livelihood and cutting trees for sell. ▪ Lack of awareness system and enough cyclone shelter in the study area.
Opportunities	***Threats***
▪ By exaggerating social forestation in the area the damage and frequency of tropical cyclone can be less. ▪ It is expected that in the near future the awareness system will be improve and it will help people. ▪ Building enough cyclone shelter can save people and govt. has already taken that steps. ▪ Building enough and potent polder can save soil and water from extreme salinity. ▪ There is possibility of export of shrimp to the world markets from Bangladesh.	▪ The coastal morphology of Bangladesh influences the impact of natural hazards on the area such as floods, cyclones, tidal surges, water logging, water and soil salinity, epidemic and various forms of pollution are frequent occurrences. ▪ The trend of tropical cyclones hitting the Bangladesh coast is increasing at the rate of 11.8 per decade from 1950–2000. ▪ Tropical cyclones can also relive drought conditions. They also carry heat and energy away from the tropics. ▪ Tropical cyclone can damage both physical (ex. Sundarban) and cultural (ex. infrastructure) environment deadly.

CHAPTER SIX

SUMMARY & CONCLUSION

CHAPTER SIX

Summary and Conclusion

This chapter intends to present sum mary of the findings, recommendations and conclusion.

6.1 Summary of the Findings

The study examines the environmental impact of Aila in the light of physical and cultural environmental aspect such as water salinity, soil salinity, destruction of forest and infrastructure, destruction of livestock, damage of roads and embankment, loss of sanitation system, loss of livelihood productive tools etc. This study also discusses the problem created by environmental damage.

6.1.1 Tropical Cyclone Aila

The cyclone Aila was a category-1 cyclonic storm. It hit the southwest coastal region of Bangladesh on 25 May 2009. The highest wind speed was recorded as 120 km per hour. Though the speed of cyclone Aila was not denoted as a severe one, the consequences of it were very long sustained. One of the main reasons was the breaches in the coastal embankment, which consequently submerged villages. These similar villages were also affected by Sidr, category 4 cyclone on 15 November 2007 just 18 months before of Aila. However, the loss of infrastructure, houses, institutions, cultivable land and crops, the livelihoods of the survivors were simply destroyed.

The worst two affected districts are Satkhira and Khulna followed by Bagerhat, Pirojpur, Barisal, Patuakhali, Bhola, Laksmipur, Noakhali, Feni, Chittagong and Cox’s Bazar. This study is prepared focusing on two villages named Patharkhali and Sora of Khulna and Satkhira district repectively.

6.1.2 Physical Environmental Impact

Aila features a mammoth damage on physical structures. The main damage was done by the flooding of water breached through the damaged embankments all round the area. It was found that there is a one-to-one relationship between the damage of the embankment and breaching activities by the shrimp farmers near the particular embankment. Affected communities reported that, frequent breaching of the embankments to lift saline water in *ghers* made the half-century old embankments quite weak and led it break down during the tidal surge inflicted by cyclone Aila. Negligence in properly repairing the embankments with a buffer zone in a place has also contributed to the damage of the embankment. Moreover, silting up of the river beds in region has also forced the tidal surge and usual river flow to put immense continuous pressure on the embankments to make them even weaker. It is clear that the study area is riverine area and near from the coast also. Both two villages are bound by polder. So after breaching embankment and polder villages were being affected much.

From the study findings it is seen that major physical environmental impact is increased water salinity, soil salinity, riverbank erosion, air pollution, destruction of forest, loss of biodiversity, loss of homesteads, water logging, loss of agricultural diversity and so on. These major impacts have some sub impacts such as water pollution or saline intrusion of water is responsible for waterborne disease, air pollution is responsible for airborne disease, barrenness of land etc.

The affected population was vulnerable to outbreaks of many waterborne diseases were broken out i.e. dysentery, cholera, diarrheal diseases, skin diseases and fever. In village Sora 40.9 percent of households are suffering from diarrhoea and in village Patharkhali it is 27.3 percent while before Aila it was 26.9 percent and 26 percent in village Sora and Patharkhali respectively. On the other hand, in village Sora 26.9 percent of households are suffering from skin disease and in village Patharkhali it is 36.4 percent while before Aila it was 15.1 percent and 18.2 percent in village Sora and Patharkhali respectively.

Drinking water sources in many communities had been contaminated by saline and debris. In village Sora 59.1 percent of households are agreed about increased water salinity and in village Patharkhali it is 50.6 percent. However, access to medical facilities for the people of the area is very limited. More than two-third of the respondent did not have the ability to consult with doctors or to buy medicines due to their economic conditions.

Apart from agriculture and fisheries, floral and faunal diversity has been the least attractive point of news in the Medias covering Aila. But they are most important considering their contribution in the local peoples' livelihoods and environment. In village Sora 59.14 percent of households are agreed about huge loss of biodiversity due to Aila and in village Patharkhali it is 45.4 percent. The loss of floral and faunal diversity is difficult to assess.

6.1.3 Cultural Environmental Impact

The study implies that the major cultural environmental impacts are destruction of roads, embankments and polders; loss of livelihood productive tools, loss of sanitation system, damages of house and infrastructure, loss of livestock etc.

This study indicates that, despite being a Cat-1 cyclone, Aila took a heavy toll on the coastal people's livelihoods. In coastal areas fish were a key source of food and animal protein. During the near term period fish consumption in the diet was declined, as catches were reduced due to either damage to boats and nets and/or the unavailability of labor which was diverted to other critical activities such as housing repairs and reconstruction. Fish production from household ponds and shrimp fisheries was also declined, as many ponds and shrimp cultivation areas were badly damaged and littered with storm wreckage and debris. As a result poverty has increased. Children are dropped out from school and starting work.

Many households lost their food stocks as a result of severe damage to housing. Large numbers of cattle, buffalos, goats and poultry have been killed. The government of Bangladesh estimated that nearly 382,000 livestock animals were killed; the large majority of these were believed to be cattle. The study shows that

many people had livestock before Aila and every household of them lost some of them. Now they are not interested about keeping livestock for lack of pastureland and feeding. Livestock losses represent not only a loss of critical household assets, with an associated loss to wealth and income, but also a loss in milk production for own consumption. And it's a major cause of malnutrition in this area because they cannot buy nutritious food but they consume if they have. After Aila it is seen that by the study, people are taking less food. Meat, egg and milk are rare in their food habit.

Damage to sanitation facilities and infrastructure was significant. But now after 6 years of Aila sanitation facility is quite improved. In village Sora 58.1 percent people are using sanitary latrine and in village Patharkhali it is 42.9 percent while before Aila it was 5.4 percent and 11.7 percent in village Sora and Patharkhali respectively. It has come to true because of government help and NGO's activities.

Aila caused a huge damage to infrastructures including households, education institutes, religious institutions, roads and embankments in the study area. Housing damages were the most visible and tangible damages associated with cyclone. Piles of damaged housing and construction materials were common within the hardest hit residential areas. The total number of houses damaged was nearly 1.2 million, approximately 30% of those were reported as fully damaged and the remaining 70% partially damaged. A high proportion of wood framed houses with corrugated iron roofs had been destroyed or severely damaged in coastal areas. Less extensive damage was observed at locations further in land or north of the coast.

There was widespread damage to transport and communications networks. Rural roads and many of the embankments protecting such roads were extensively damaged. Most of the road damage was associated with the tidal surges in coastal areas. Large uprooted trees on roadsides also account for some of the damages, as

trees were uprooted segments of tarmac or earthen roads became cracked or fragmented.

6.2 Recommendation

Based on the research outcome, the followings are recommended in order to reduce environmental impact of tropical cyclone.

- **Implementation of Disaster Management Plan:** Proper implementation of disaster management plan can help people of coastal region to reduce damages and losses of tropical cyclone. Such as construction of adequate cyclone shelter for protection of lives and properties from cyclone and tidal surge, coastal forestation program, improvement of early warning system and forecasting, advance preparedness, implementation of DRR strategy etc.
- **Decentralization of Planning:** Gathering evidence of cyclone impact at the local level, placing emphasis on local ecological knowledge and traditional innovation, and analyzing community-level preparedness are essential components of the planning necessary to combat the impacts of tropical cyclone. It is vital that local people fully participate in policy making and programs dealing with climate change impacts, mitigation and adaptation. Community-based adaptation should, therefore, be a central tenet of action on impact of tropical cyclone in Bangladesh. Work with communities, civil society, and government to bring basic services to scale (with a focus on disaster resilience).
- **Development of Infrastructure:** Construction of cyclone resilience house such as brick-built houses with concrete roofs (on stilts, if needed) in accordance with appropriate building codes, high and wide polder, bridge, culvert, roads, local food storage system and multistoried educational institutions can save people from extreme damage and loss.
- **Construction of Adequate Number of Cyclone Shelter:** At present, number of cyclone shelter is not enough to protect maximum number of

people at the study sites. In Gabura union there are only 9 cyclone shelters for 38,825 people. It means each cyclone shelter goes for 4,314 people and the number is more than the capacity of a cyclone shelter. On the other hand in Uttar Bedkashi union, total population is 20,528 and the number of cyclone shelter is only 7. Therefore, sufficient number of cyclone shelters should be constructed at the sites before any other cyclone attack.

- **Construct Coastal Embankments:** There is a need to protect vulnerable areas by renovating the existing embankments and creating new ones. Along the coast lines of Sora and Patharkhali village, coastal embankment should be constructed in such a way so that this can be cyclone resistant, all weather serviceable and durable.
- **Enhancement of Plantation Program:** Beside of village Sora and Patharkhali there was a part of mangrove forest but cyclone Aila has destructed the part. Shelter belts are barriers of trees or shrubs that are planted to reduce wind velocities and as a result, reduce transpiration and prevent wind erosion. In coastal areas, shelterbelt plantation of Casuarinas as a main specie is the most suitable and effective alternative to minimize the impacts of wind velocity and saline ingress. They also provide direct benefits to agricultural crops, resulting in higher yields, and provide shelter to livestock, grazing lands and farms. On the other hand, plantation, regeneration and protection of Mangroves act as a bulwark against the natural hazard like cyclone and provide natural shelter as well as protective shield for the lives and property against this hazard and other hazards. They also help in prevention of soil erosion and provide ecological and economic benefits to the coastal community including livelihood and employment opportunities. Extra care should be taken immediately to Sundarban which can be called as “Safeguard of Bangladesh” from cyclonic hazard.
- **Development of Agricultural Sector:** Introduce salinity tolerant varieties of rice and review coastal land use and housing policy to grow

environment friendly agriculture and shrimp firm and promote cyclone resilient housing practice can help people.

- **Preparation of Land Use Plan:** Preparation and proper implementation of a land use plan can reduce the socio-economic impacts of any disaster including cyclone. So an effective land use plan should be formulated and at the same time proper implementation of it should also be ensured in the study area.
- **Remove Drinking Water Scarcity:** In coastal region the major problem of the affected area is scarcity of drinking water. Therefore, a sufficient number of tube-well should be erected through a soft loan scheme or non refundable donation. NGOs can help the local communities to pump-out saline water from the affected pond. Alternatively, Pond Sand Filter (PSF) could be introduced to the affected area. Besides this the main natural source of pure drinking water of the study area is rain water. They use preserve rain water next 4-5 months. So it is important to take initiatives to collect and preserve more rain water as they can use it more time.
- **Poverty Reduction Program:** Since the entire livelihood option in the affected area was destroyed by Aila and the affected people became workless. So alternative livelihood opportunities should be created by using locally available natural resources. In long term, small scale job opportunities may be introduced from the local investors, government and NGOs. Training on craft, tailoring, poultry and fish feed firming, ice factory, umbrellas' bat factory, match factory, cold storage and other small and medium scale industries may be introduced to alleviate the poverty and reduce vulnerability of the local people.
- **Improve Law and Order System:** According to the respondents perception after Aila people are being blackmailed by pirates when they go for fishing or forest. It harasses them economically. So law and order system even security system in the coastal region should be improved.

6.3 Conclusion

The study has examined the extent of environmental impact of tropical cyclone Aila on coastal region of Bangladesh. There were five deadliest storms since 1970 in the Bay of Bengal and Aila was the recent cyclone that had hit the coastal region of Bangladesh in just 40 years since 1970. Particular emphasis was given to identify the impact such as number of death of peoples, damages of wealth, flood frequency after Aila, soil salinity, water salinity, damages of infrastructure, damages of forest, loss of livestock etc due to tropical cyclone Aila. Extensive technical reports and news-paper information were taken into account. Along with the literature review, data were collected through people's interview during field visit to cyclone Aila affected area. The data of several factors are analyzed. Results showed that after six years of Aila people are still suffering in several sectors. The natural environment of the study area is also the same suffered. Problems like salinity of soil and water which hampering agricultural work, poverty, joblessness, lack of capital and scarcity of pure drinking water etc are still hanging on the fate of affected people. So it needs to bridge between the problem and their solution. That's why some initial steps should be taken. The most important one is to improve the infrastructural conditions. Damaged embankments and communication system should be repaired properly, and where necessary reconstructed, as priority basis to protect the affected area from further flooding and tidal surges. Height of the embankments should be increased together with proper forestation with suitable tree species at both sides of the embankments. At present, number of cyclone shelter is not enough to protect maximum number of people at the study sites. Therefore, sufficient number of cyclone shelters should be constructed at the sites before any other cyclone attack. Transport networks between settlements and cyclone shelters could also be improved to facilitate the movement of people and goods during disaster events.

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APPENDIX – I

Title: Tropical Cyclone Aila And Its Environmental Impact On Coastal Region Of Bangladesh

(Questionnaire for survey)

1. Respondent's Profile: Village:

1.1 Name of Respondent:

1.2 Age: ..... Years

1.3 Ethnicity: ……..

2. Family & Socio-Economic Information:

2.1 Number of family member.....

2.2 How many members is male/female?

a) Male ..... b) Female.....

2.3 Dead member due to Aila:

Male	Female

2.4 Educational status of the family member:

Stage	Male	Female
Illiterate		
Primary		
Secondary		
Higher Secondary		
Higher education		

2.5 Occupation of family member:

Member	Present occupation	Previous occupation
1.		
2.		
3.		
4.		
5.		
6.		

2.6 Total Number of Earning Member: ……..

2.7 Types of family:

a. Single b. Joint

2.8 housing pattern:

Type	Present	Previous
Pucca		
Semi pucca		
Kancha		
Others		

2.9 Economic Condition:

Type	Before Aila	After Aila
Solvent		
Insolvent		

3. Information about environmental damages and losses:

3.1 Physical Environment:

3.1.1 Distance from the coast line: ……km
3.1.2 Distance from the river bank: ……km
3.1.3 Distance from the polder: ……..km
3.1.4 Distance from the closest cyclone centre: ……..km
3.1.5 Distance from the mangrove forest: ……km
3.1.6 Availability of safe drinking water:

After Aila	Before Aila
Yes/No	Yes/No

3.1.7 Sources of water:
a. Tube-well b. Pond c. River d. Public tank e. Others
3.1.8 Salinity of your water: normal/less/increase
3.1.9 Appearances of waterborne diseases:
a. Diarrhoea b. Fever c. Skin disease d. Others
3.1.10 State of water logging:
a. Less b. Moderate c. Increase
3.1.11 Flood frequency: ……../……../…… times
3.1.12 Air pollution:
a. Less b. Moderate c. Increase
3.1.13 Air-borne diseases:
a. Influenza b. Mumps c. Others
3.1.14 Soil salinity:
a. Less b. Moderate c. Increase
3.1.15 Land erosion status:
a. Less b. Moderate c. Increase
3.1.16 Loss of biodiversity:
a. Less b. Moderate c. Increase
3.1.17 Loss of homesteads:
a. Less b. Moderate c. Increase
3.1.18 Taken measures against all kind of pollution:
a. Tree plantation b. Polder construction c. Irrigation d. Digging water bodies

3.2 Cultural Environment:

3.2.1 Sanitation facility:

After Aila	Before Aila
Yes/No	Yes/No

3.2.2 Energy source:

After Aila	Before Aila
Solar panel/Lamp	Solar panel/Lamp

3.2.3 Household assets:

Items	After Aila	Before Aila
T.V.		
Bicycle		
Motorcycle		
Furniture		
Mobile		

3.2.4 Infrastructural damage seen by you in your locality:

Items	During Aila
Bridge	
Culvert	
School	
Mosque	
Madrasa	
House	
Others	

3.2.5 Loss of livestocks:

Items	After Aila (nb.)	Before Aila (nb.)
Buffalo		
Cattle/cow		
Goats		
Chicken		
Duck		

3.2.6 Land ownership:

Type	After Aila (decimal)	Before Aila (decimal)
Housing land		
Cultivated land		

3.2.7 Average Monthly income:

After Aila	Before Aila

3.2.8 Did you have any kind of loan?

After Aila	Before Aila
Yes/No	Yes/No

3.2.9 Food habit pattern (month wise, before Aila):

a) Meat ---------- day b) fish---------- day

c) Milk---------- day d) Egg---------- day

3.2.10 Present situation of these items in food table (month wise):

a) Meat ---------- day b) Fish---------- day

c) Egg---------- day d) Milk---------- day

3.2.11 Having shrimp cultivation farm:

After Aila	Before Aila
Yes/No	Yes/No

3.2.12 Present cropping intensity:

a. Single crop b. Double crop c. treble crop

3.1.13 Migration status:

After Aila	Before Aila
Yes/No	Yes/No

3.1.14 Social chaos after Aila:

a. Less b. Moderate c. Increase

_____

Signature of Researcher

Date:

(The researcher will ensure the privacy of data the of the respondent)

APPENDIX – II

List of Interviews Cited

Interview no.	Upzila	Interview Form	Notes on subject	Date
Interview 9	Shyamnagar	Face to face	Female	26.12.12
Interview 11	Shyamnagar	Face to face	Male, laborer	26.12.12
Interview 19	Koyra	Face to face	Male, working in fisheries	27.12.12
Interview 73	Shyamnagar	Face to face	Male, farmer	26.12.12
Interview 81	Koyra	Face to face	Female, working in fisheries	04.01.13

Source: Haque et al., 2013.

APPENDIX – III

Some Photographs of the Study Area after Five Years of Cyclone Aila Attack

Housing Pattern (Photograph No. 1, 2)

Photograph-1

Photograph-2

Roads & Polders (Photograph No. 3, 4, 5)

Photograph-3

Photograph-4

Photograph-5

Wooden Bridge & Stair (Photograph No. 6, 7)

Photograph-6

Photograph-7

Fishing Element (Photograph No. 8, 9, 10)

Photograph-8

Photograph-9

Photograph-10

Shrimp Cultivation Farm (Photograph No. 11, 12)

Photograph-11

Photograph-12

Mangrove Forest (Photograph No. 13, 14)

Photograph-13

Photograph-14

Dry Land (Photograph No. 15, 16)

Photograph-15

Photograph-16

Water Logging in Low Land (Photograph No. 17, 18)

Photograph-17

Photograph-18