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Climate Change Induced Economic Transformation, Vulnerability and Adaptation in the Aila (Tropical Cyclone) Susceptible Areas of Bangladesh

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University of Rajshahi

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This thesis is submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Geography and Environmental Studies

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CERTIFICATE

This is to certify that the study entitled ***"Climate Change Induced Economic Transformation, Vulnerability and Adaptation in the Aila (Tropical Cyclone) Susceptible Areas of Bangladesh"*** *is a research work carried out by Md. Mizanoor Rahman. All the discussions, analysis, explanations and representations of this research have conducted under my direct guidance and supervision.*

It is also recommended that the research is too satisfactory for submission to the Department of Geography and Environmental Studies, University of Rajshahi as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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DECLARATION

*I hereby declare that this thesis entitled "**Climate Change Induced Economic Transformation, Vulnerability and Adaptation in the Aila (Tropical Cyclone) Susceptible Areas of Bangladesh"** is the result of my own research, under the supervision of Dr. Md. Zahidul Hassan, Professor, Department of Geography & Environmental Studies, University of Rajshahi, Bangladesh.*

In addition I want to declare that this thesis paper has not submitted for any degree, diploma or other qualification neither in the universities of Bangladesh nor any other foreign universities.

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(Md. Mizanoor Rahman)

Abstract

Bangladesh is a land of natural calamities. Due to locational disadvantage, especially situated at the tip of the funnel shaped Bay of Bengal on the south and at the foot of Himalayas on the north, every year it experiences a number of different types of natural calamities, such as flood, cyclone, river bank erosion, and drought etc. Literatures indicate that recently, frequency of these events has been increased due to climate change. As per spatial distribution of natural calamities, northern part is prone to flood, western part prone to drought, eastern part basically hilly region prone to flash flood and southern part prone to cyclone. The Southern part, along the coast of Bangladesh is the worst affected area to cyclone and its ultimate effects. Basically, economic sector is the hard hited among all other sectors. Tropical cyclone Aila tore the area in 2009 affected the livelihood of people. The study is an effort to discuss the vulnerability and adaptation strategy of the inhabitants in the light of economic change like occupation, income, expenditure capacity, savings, housing structures, general and agricultural land use etc. that taken place due to Aila. Necessary data and information were collected from both primary and secondary sources for the study, and to analysis and representation of collected data both quantitative and qualitative analysis and mapping techniques have been applied. For statistical analysis SPSS, image processing IRDAS IMAGIN 9.2, and mapping analysis ArcMap-ArcInfo software have been used. The research findings indicate that because of cyclone Aila, economy of the area have been taken down turn. Most of people were engaged with agriculture allied activities, but after Aila agricultural land has been converted into aquaculture. Consequently, people had to change less earning occupation such as daily labour, rickshaw puller, brickfield worker etc. As a result, people had to reduce all sorts of consumptions to cope with the changing situation. GOs and NGOs extended hand through limited opportunity to rebuilding house, dam, road, reforestation but not any income generate activities. So, the livelihood of the people is still vulnerable in terms of economy. This following research recommends to recover the vulnerable situation through creation of income opportunity in the study area.

Key words: Cyclone Aila, Economic transformation, Land use change, Vulnerability, Adaptation

Acronyms

Aila: Tropical cyclone which affects coastal region of Bangladesh on 27 May 2009.

BDT: Bangladeshi Taka

Bigha: One third portion of an acre basically uses to measure an area.

Gher: Shallow water marshy land which use for shrimp cultivation.

Jhupri: All through of the house are made by thatched.

Katcha: The house which wall and floor are made by mud and roof is made by tin or thatched.

Macha: Made by bamboo and rope about 5 to 8 feet height from ground which stands on four to six bamboo pillars. Mostly situated inside house for taking shelter and put goods during cyclone/cyclonic surges/flood.

Pucca: The house which wall, floor and roof are made by brick and concrete.

Pata: Made by bamboo stick and rope which put on the boundary of ghare to protect fishes. It allows water to go in and outside during high and low tide.

Semi-Pucca: The house which wall and floor are made by brick and roof is made by tin or thatched.

Abbreviations

AD	**:**	Anno Domini
AFP	**:**	Annual Financial Plan
BISIC	**:**	Bangladesh Small and Cottage Industries Corporation
BRTA	**:**	Bangladesh Road Transport Authority
BTCL	**:**	Bangladesh Telecommunication Company Limited
CCDB	**:**	Christian Commission for Development in Bangladesh
CCEC	**:**	Center for Coastal Environment Conservation
CDP	**:**	Carbon Disclosure Project
CEGIS	**:**	Center for Environment and Geographic Information Services
CNRS:		Center for Natural Resource Studies
DDM	**:**	Department of Disaster Management
DFID	**:**	Department for International Development
DMB	**:**	Disaster Management Bureau
DMRD	**:**	Disaster Management and Relief Division
EC	**:**	European Council
EPWAPDA	**:**	East Pakistan Water and Power Development Authority
GDP	**:**	Gross Domestic Product
GOs	**:**	Government Organizations
GR	**:**	Gratuitous Relief
IMDMCC	**:**	Inter-Ministerial Disaster Management Coordination Committee
IMF	**:**	International Monetary Fund
IPCC	**:**	Intergovernmental Panel on Climate Change
LGED	**:**	Local Government Engineering Department
MoFDM	**:**	Ministry of Food and Disaster Management
NDMC	**:**	National Disaster Management Council
NGOs	**:**	Non-Government Organizations

OCHA	**:**	Office for the Coordination of Humanitarian Affairs
SAP	**:**	Structural Adjustment Programs
SPARRSO	**:**	Space Research and Remote Sensing Organization
SST	**:**	Sea Surface Temperature
TR	**:**	Test Relief
UDMC	**:**	Union Disaster Management Committee
UN	**:**	United Nations
UNDP	**:**	United Nation Development Programme
UNDRO	**:**	United Nations Disaster Relief Organization
UNFCCC		United Nations Framework Convention on Climate Change
UNISDR	**:**	United Nations. International Strategy for Disaster Reduction
VGD	**:**	Vulnerable Group Development
VGF	**:**	Vulnerable Group Feeding
VEP	**:**	Vulnerability as Expected Poverty
VEU	**:**	Vulnerability as low Expected Utility
VRIM	**:**	Vulnerability-Resilience Indicator Models
WAPDA	**:**	Water and Power Development Authority
WB	**:**	World Bank
WCED	**:**	World Commission on Environment and Development
WDB	**:**	World Development Bank

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Chapter 1
Introduction

1.1 Background

Bangladesh is at grave risk to climate change affiliated events and it is extremely vulnerable to various natural disasters like cyclones, floods, tidal surges, riverbank and coastal erosion, drought etc. It is currently ranked as the most climatically vulnerable country in the world (EC, 2008, IPCC, 2007). The country is trapped between the Himalayas in the north and the encroaching Bay of Bengal to the south with 711 km coastline (CDP, 2006). Due to geographical location and funnel shaped coastline it is susceptible to frequent extreme climatic events and that is why almost every year, the country experiences disasters of one kind or another- such as tropical cyclones, storm surges, coastal erosion, floods, and droughts. And among them flood and cyclone are the most frequent and most vulnerable to the livelihood, property and jeopardizing the development activities (Ali, 1999). Evidences indicate that world's topical cyclones with death tolls in excess of 5000 are considered; it is found that 16 out of 35 such disasters occurred in Bangladesh. About 53% of the world deaths from these cyclones took place in Bangladesh. The casualty has been shown in the following table:

Table 1.1: Deaths/lost due to cyclone in Bangladesh.

Year	Deaths/lost	Year	Deaths/lost
1584	200000	1965	19270
1822	40000	1965	12000
1876	400000	1970	300000
1897	175000	1991	145000
1911	120000	2007	10000*
1917	70000	2009	8528*
1962	50000		

Source: Damen and Westen, 2015

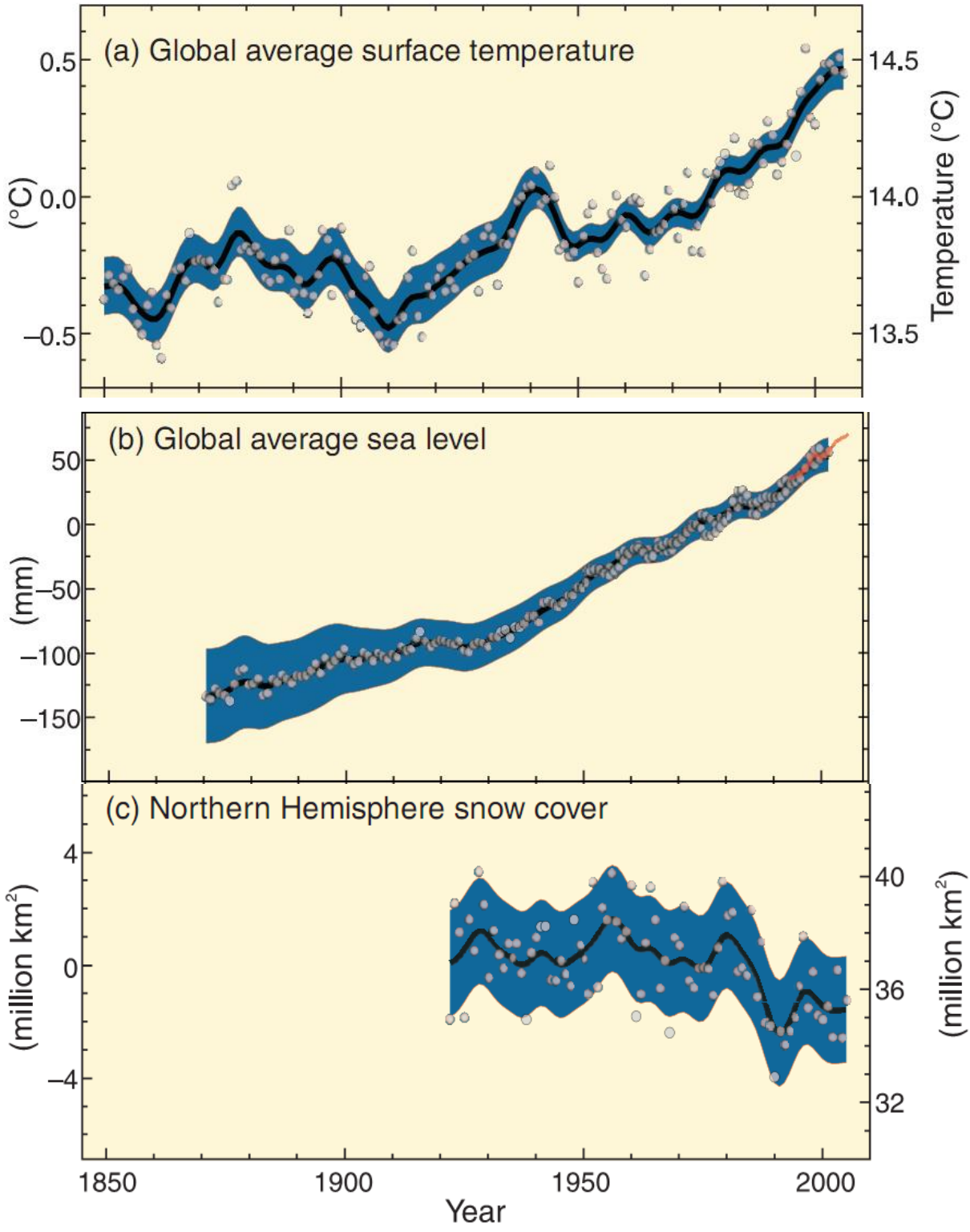
* Red Crescent Society (Wikipedia)

On an average each of every three years Bangladesh experiences by a sever cyclone strike (DDM, 2009). According to Dasgupta et.al.(2010) between1877and 1995 Bangladesh was hit by 154 cyclones (including 43 severe cyclonic storms, 43 cyclonic storms, 68

tropical depressions). Since 1995, five severe cyclones hit the coast of Bangladesh in May 1997, September 1997, May 1998, November 2007 and May 2009. Moreover, the frequency of natural disasters such as floods, cyclones etc. have increased significantly over the last decades, particularly in the coastal line of Bangladesh which is asserted as the impact of climate change (Karim and Mimura, 2008).

For tropical cyclone formation the Sea Surface Temperature (SST) should have a minimum of about 26 to 27^0C. It could be speculate that any rise in SST due to climate change is likely to be accompanied by an increase in cyclone frequency. The highest number of tropical cyclones, about 33% of the world total, form in the Western North Pacific, which is a vast area of very warm waters, with some about 30^0C (Frank 1985). On the other hand, the East Pacific, just west of Central America has the highest frequency of tropical cyclone genesis per unit area in the world; its average SST is about 29^0C. Same correlation between tropical cyclone formation and SST has been established in the North East Atlantic ocean. So, it is very natural that any SST rise due to climate change in the Bay of Bengal may increase the tropical cyclone frequency of which Bangladesh will have the most vulnerable experienced.

According to IPCC (2007) global temperature has increased by 0.74^0c during 1906 to 2006. Rising sea level is consistent with warming. Global average sea level has risen since 1961 at an average rate of 1.8 mm/year and since 1993 at 3.1 mm/year, with contributions from thermal expansion, melting glaciers and ice caps, and polar ice sheets (figure 1.1). So, it could be assumed that due to sea level rising low coastal area may go under water.



Source: IPCC, 2007

Figure1.1 Change in Global average surface temperature, sea level and snow cover of northern hemisphere

Biermann and Boas (2008) estimate that by 2050 more than 200 million people could lose their homes due to climate change; by 2080 increased storm surges could affect 103 million additional people; and floods, droughts, and storm surges could all hurt water availability and quality and affect 1.5 billion people. Because of climate change, a sea level rise of .05 meter over the last 100 years has already eroded 65 percent landmass of 250 square kilometers of Kutubdia, 227 square kilometers of Bhola and 180 square kilometers of Sandwip islands. In case of any sea level rise, islands like these and the entire coastal area would be hit hard resulting in billions of dollars of losses in GDP, economic downturn, ecological damage and livelihood assets and options (DFID, 2007). Cyclone Aila has caused substantial damage across areas of southern Bangladesh and West Bengal of India. Massive flooding caused much of the damages, which has contaminated drinking water sources with sea water and killed the fishes that people rear in the freshwater ponds. This will affect people's livelihoods in the long run (Oxfam). Cyclone Aila tore through southern Bangladesh in May 2009 killed 300 people and destroyed 2,500 miles of roads and embankments. All most all the dwelling houses of the affected area have lost their livelihood, 80% of the population being dependent on agriculture and rest 20% on fish firming, wage labour and other small business. Aid organizations are reporting that two years later, 200,000 people are still living in inhuman conditions or have been displaced (AFP). According to UN Office for the Coordination of Humanitarian Affairs (OCHA, 2009) report, approximately 350,000 people remained displaced and unable to return to affected villages. Notable work has begun yet to rehabilitate the damaged embankment areas, which flooded twice daily that contaminates drinking water by salinity and make farming difficult due to saline water. Families in these areas depend on emergency food and water distribution. Still now, most of the people homeless and workless and the economy of the area transforms to a new dimension which is vulnerable to their livelihood.

1.2 Objectives of the study

The general objective of the study is to discuss the changing economy and livelihood due to Aila and how the dwellers and different GOs and NGOs are trying to recover the situation. On the basis of analysis, the study will also present recommendation and

strategies in order to enhance preventive measure and adaptive capacity of the victims. The specific objectives are as following:

- -To discuss the changing economic circumstances that occurred due to Aila in the study area;
- -To discuss the changing livelihood in the context of vulnerability of the area;
- -To discuss the role of stakeholders and organizations (both national and international) to recover the situation;
- -To examine the policies and programs of Bangladesh government and NGOs that have taken to overcome the situation and
- -To recommend strategy for rapid improvement of the situation.

1.3 Statement of Significance

It is proved that climate change could have devastating impact on agriculture of Bangladesh. Agriculture is a key economic driver in Bangladesh, accounting for nearly 20 percent of the GDP and 65 percent of the labor force depend on it. The performance of this sector has considerable influence on overall growth, the trade balance, and the level and structure of poverty and malnutrition. Moreover, much of the rural population, especially the poor, is depended on the agriculture as a critical source of livelihoods and employment. Due to Aila, a massive area has gone under water and flooding by sea water. This is how, the farming of coastal belt region has been demolished results the economy of the areas has been transformed and threatens the livelihood of the dwellers. Beside that infrastructure such as buildings, roads, shops, homestead areas, healthcare centers, markets etc also badly affected which has brought severe change in the daily life standard of the dwellers. Still now people of this area are living in measurable conditions. So, intensive research is necessary and time demanding for developing strategy in order to improve the situation.

1.4 Conceptual Framework

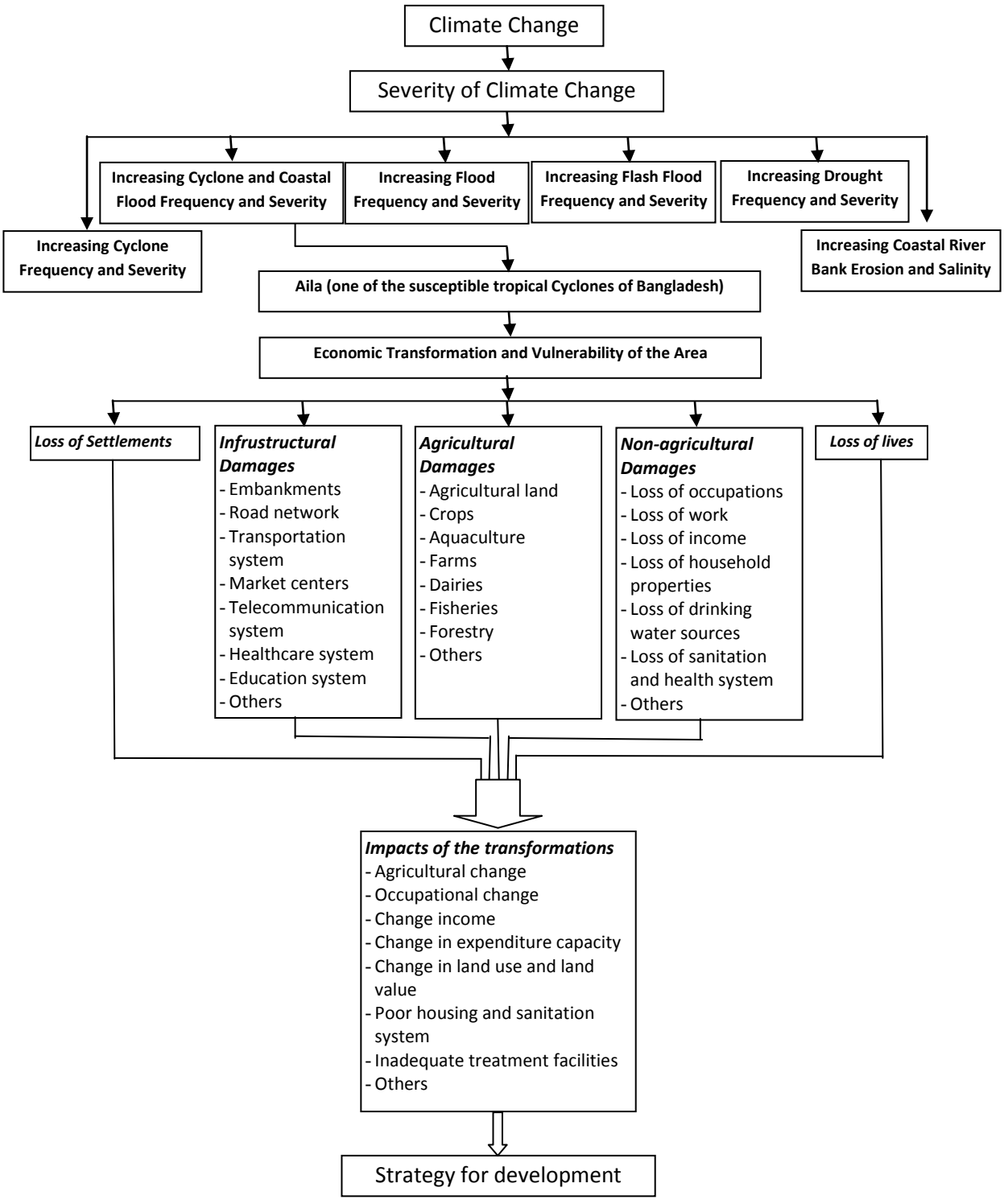


Figure 1.2 Conceptual framework

1.5 Scope of the study

The scope of the research is to study the present economic situation of the Aila affected area. It will also discuss how the total economy of the area has taken turn down due to cyclone Aila in the light of changing situation of income, expenditure capacity, food, shelter, clothing, education, sanitation, treatment, loss of income source, agricultural land and so on.

Moreover, in the study, livelihood of the stakeholder will be discussed in the context of measuring vulnerability. Review of relevant literatures indicate that the inhabitant of the area is severely suffering by different diseases due to lack of safe drinking water; lack of sufficient food due to lack of work as well as insufficient income which is fuel of food, education, treatment, housing as well as all sorts of life supporting essentials will be discussed in the study.

Since 2009, it is long time that the affected area past away, different GOs and NGOs tried to improve the situation through formulating number of policies and programmes. How the programmes are working and how much the policies and programmes are effective for the betterment and recover the situation also will be discussed in the study.

On the basis of situation analysis, need-based analysis, and effectiveness and short fault of taken policy and programmes analysis the study will recommend strategy for the rapid recovery from economic vulnerability of cyclone Aila.

1.6 Limitation of the study

- In some cases like number of population, household etc. the study is made on secondary data of population census of 2001 and 2011 which are not just before and after of cyclone Aila. As a result, the result of analysis may be little bit deviated from accurate situation.

-Land use change detection was made on satellite image analysis categorizing into water bodies, aquaculture, agricultural land, vegetation, settlement, bare land and tidal land. But in Patakhali village, it was not possible to distinguish vegetation and settlement separately. Because, houses are covered by canopy of trees.

For land use change analysis satellite images of 2004 and 2014 were collected and used. Images of 2004 were considered as before Aila and 2014 were considered as after Aila. Because, satellite image of 2008 is not available. This may bring short fault in land use information of the study.

-Literatures on economic transformation indicate that economic transformation is hierarchical in terms of time and space. But this study has only considered the change of economic situation of the stakeholders on the basis of a set of indicators.

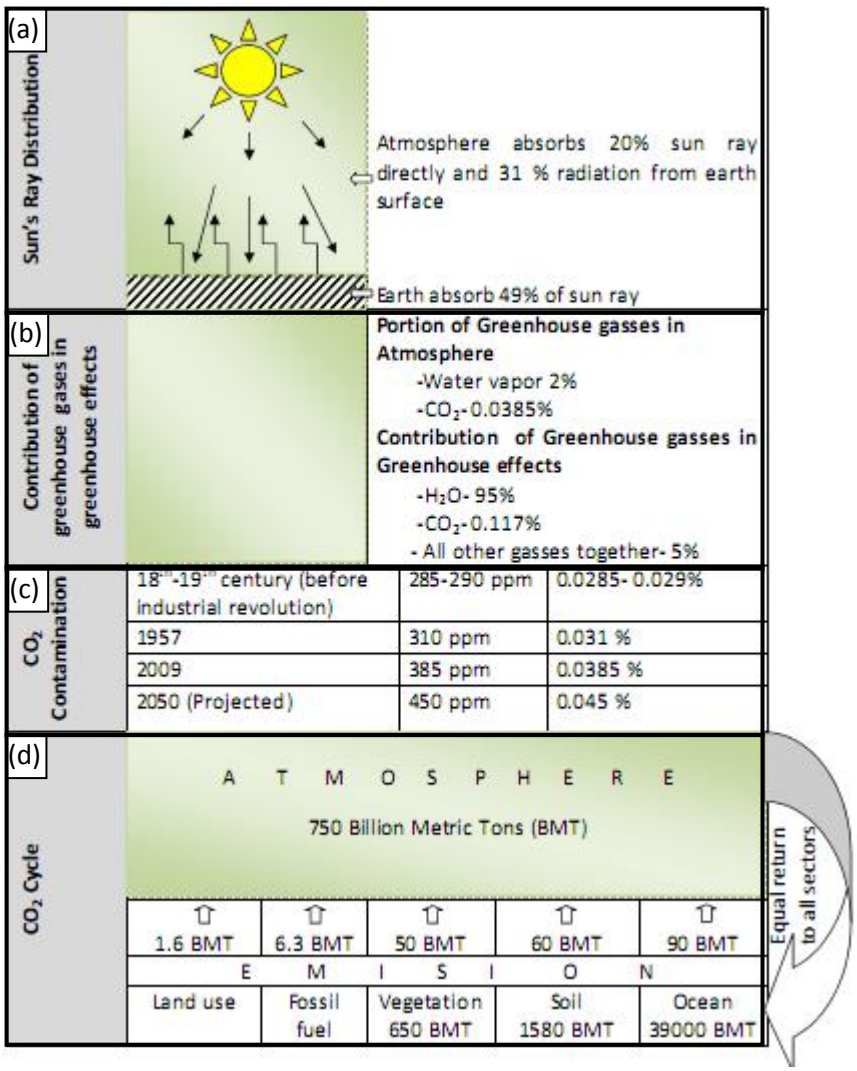
Chapter 2

Literature Review

Climate change and variation have impact on every sector of economy of coastal belt of Bangladesh. The review includes the literature relevant to the impacts of climate change and variation emphasizing economic transformation, vulnerability and suggestive adaptation. Successive sections discuss the understanding climate change, impact of climate change, economic transformation, vulnerability, adaptation and brief history of cyclone of the study area.

2.1 Understanding Climate change

The average weather condition in a place for long time is called climate. It includes patterns of temperature, precipitation (rain and snow), humidity, wind and seasons. Climate of a certain place depends on its geographical settings. Climate patterns play a vital role in shaping natural ecosystems, and the human economics and cultures that depend on them. Rising levels of carbon dioxide (CO_2) and other heat-trapping gases in the atmosphere have warmed the Earth and are causing wide ranging impacts, including rising sea levels; melting snow and ice; more extreme heat events, fires and drought; and more extreme storms, rainfall and floods. It is predicted that these trends will continue and in some cases accelerate, posing significant risks to human health, forests, agriculture, freshwater supplies, coastlines, and other natural resources that are vital to economy, environment, and quality of life of a country.



Source: Calculated from Ahmed, 2011

Figure 2.1 Understanding Climate Change

The first part (a) of the above figure shows energy source for the heating of the earth's surface and atmosphere. Of the total solar radiation that reaches the top of the atmosphere, 49% reaches the earth's surface, 31% is reflected back to space from the earth's surface and the atmosphere, and 20% is absorbed by the atmosphere. That means earth's surface is the major source of heating atmosphere. Part (b) provides information about the contribution of greenhouse gasses to the greenhouse effects. Atmosphere contains 2% water vapor and 0.0358% CO_2 and contribution of these two gasses to the greenhouse effect is 95% and 0.117% respectively. So, water vapor is more liable than CO_2 to the greenhouse effect. Part (c) of the figure includes information on changing rate

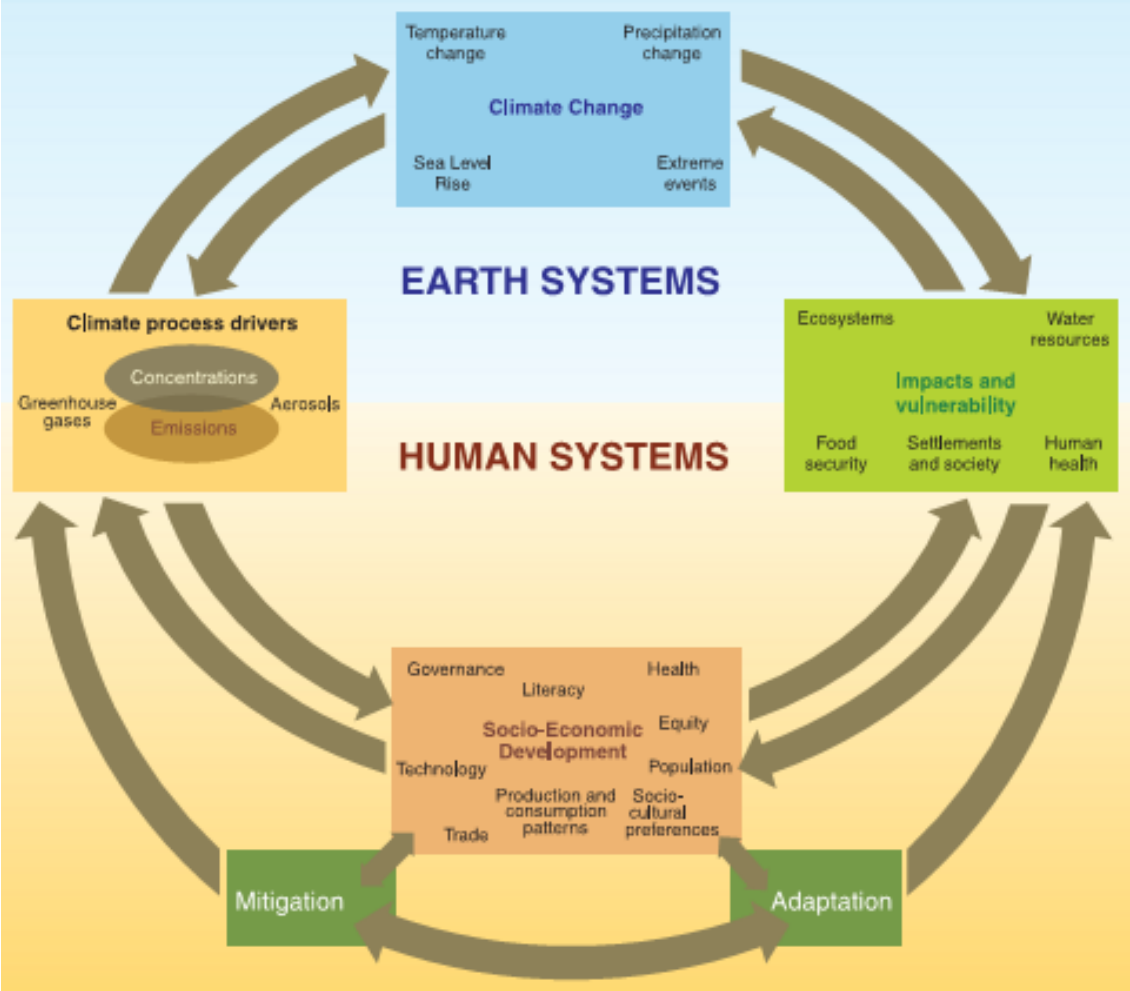
of CO_2 in atmosphere. Before industrial revolution (18^{th}-19^{th} centuries) the contamination of CO_2 was 280-290 ppm which is 0.0285-0.029 % of the total atmosphere. It was reached 310 ppm in 1957 and 385 ppm in 2009 which are 0.031 and 0.0385% of the total atmosphere. If the trend continues, it is expected that it would be 385 ppm in 2050 which is 0.045% of the total atmosphere. Last part (d) of the figure shows exchange information of CO_2 among atmosphere and different surface sources. On a long term basis, the flux of CO_2 from the earth's surface to the atmosphere (upward flux) is equal to its return flux from the atmosphere to the surface (downward flux). On a global/annual basis the total CO_2 exchange is 207.9 billion metric ton and fossil fuel contributes only 6.3 billion metric tons which is 2.32% of total upward flux.

According to the study of Professor Jorgen Pender Steffensen of the University of Copenhagen, the Little Ice Age marked the lowest temperature in the last 8000 years of earth's history. In the Medieval Age temperature was almost 3^0C higher than Little Ice Age. On the other hand recent temperature is 1.5^0C higher than Little Ice Age. Warmer climate during the Medieval Warm Period cannot be attributed to anthropogenic CO_2 due to fossil fuel burning. Although large-scale coal burning began since the beginning of the industrial Revolution (18^{th} to 19^{th} century), earth's climate deteriorated during the Little Ice Age (1400-1900 AD). This cyclical change in earth's climate is attributed to the natural cycle of earth's climate (Ahmed, 2011).

2.2 Impact of climate change

Climate change involves to multifarious impact of physical and cultural environment. Physical environment basically temperature, precipitation, sea level rise, and climate induced extreme events effect the other physical components like ecosystem, water resources etc. and cultural environment such as human health, food security, settlements and society. IPCC in Third Assessment Report of 2001 represents a schematic framework of anthropogenic climate change drivers, impacts and response. The framework provides information mainly to describe the linkages clockwise, i.e. to derive climatic changes and impacts from socio-economic information and emissions. With increased understanding of these linkages, it is now possible to assess the linkages also counterclockwise, i.e. to

evaluate possible development pathways and global emissions constraints that would reduce the risk of future impacts that society may wish to avoid.



Source: IPCC, 2007

Figure 2.2 Impact of climate change

From the view of the framework, it can be said that Bangladesh is both physically and culturally affected. Due to physiographical distribution, its coastal region is vulnerable to any potential adverse impact of sea level rising. At the same, due to geographical location it is fertile breeding zone of cyclone effects frequently by severe cyclone.

Source: Geo Consult, 2004

Figure 2.3 Inundated areas if sea level rises

Huq et al. (1995) estimated that 11% of the country's population lives in the area threatened by a 1 meter sea level rise. The area around Dhaka is quite dense, but there are also pockets of population density in the Khulna region, which is most vulnerable to sea level rise. More people would be at risk from flooding from coastal storms. In addition, the major port of Mongla would be at risk, as would one-eighth of the country's agricultural land and 8,000 km of roads.

Aila, the devastating cyclone hit the southern Bangladesh in May 2009, destroyed the whole economic system of the area. Almost all the houses destroyed, whole agriculture system demolished, transportation and communication system damaged and majority portion land have gone under water. Inundation of such a large portion of the country could present major challenges in terms of loss of income and displaced populations.

As Nicchollas (2002) notes, the impacts of sea-level rise are likely to be felt disproportionately in certain areas, reflecting both natural and socio-economic factors that lead to higher vulnerability. He suggests that, in absolute terms, the most vulnerable locations are found around Africa and, most particularly, South and South-East Asia, with lesser impacts in East Asia. The Intergovernmental Panel on Climate Change (IPCC) has argued that by 2050, sea levels could rise by an additional 1 meter due to anthropogenic global warming. As a result, Bangladesh could lose up to 20% of its land area with the concomitant displacement of up to 20 million refugees and loss of 32% of its production of rice and 8% of its wheat (Cruz et al. 2007). At present, Bangladesh is too poor to adapt to such a rise in sea level. The costs of protection would be substantial. Huq et al. (1995) estimate that 4,800 km of existing coastal defences would need upgrading and an additional 4,000 km of new defences would be needed and these protection measures would cost up to 1 billion US$. The most vulnerable part of Bangladesh, the Khulna region, lies along the country's southwestern coast. With the exception of the hilly Chittagong area and the northwestern part of the country, most of the country is less than 10 m above sea level. In the long run, sea level rise could displace tens of millions of people. To resettle 13 million people, as per an estimate it would cost US$ 13 billion (Debove, 2003).

According to IPCC in their recently published Fourth Assessment, the following changes have been observed in climate trends, variability and extreme events.

- In Bangladesh, average temperature has registered an increasing trend of about 1^0C in May and $.5^0$C in November during the 14 year period from 1985 to 1998.
- The annual mean rainfall exhibits increasing trends in Bangladesh. Decadal rain anomalies are above long term averages since 1960s.
- Serious and recurring floods have taken place during 1987, 1988, 2002, 2003 and 2004. Cyclones originating from the Bay of Bengal have been noted to decrease since 1970 but the intensity has increased.
- Frequency of monsoon depressions and cyclones formation in Bay of Bengal has increased.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season.
- The precipitation decline and droughts has resulted in the drying up of wetlands and severe degradation of ecosystem.

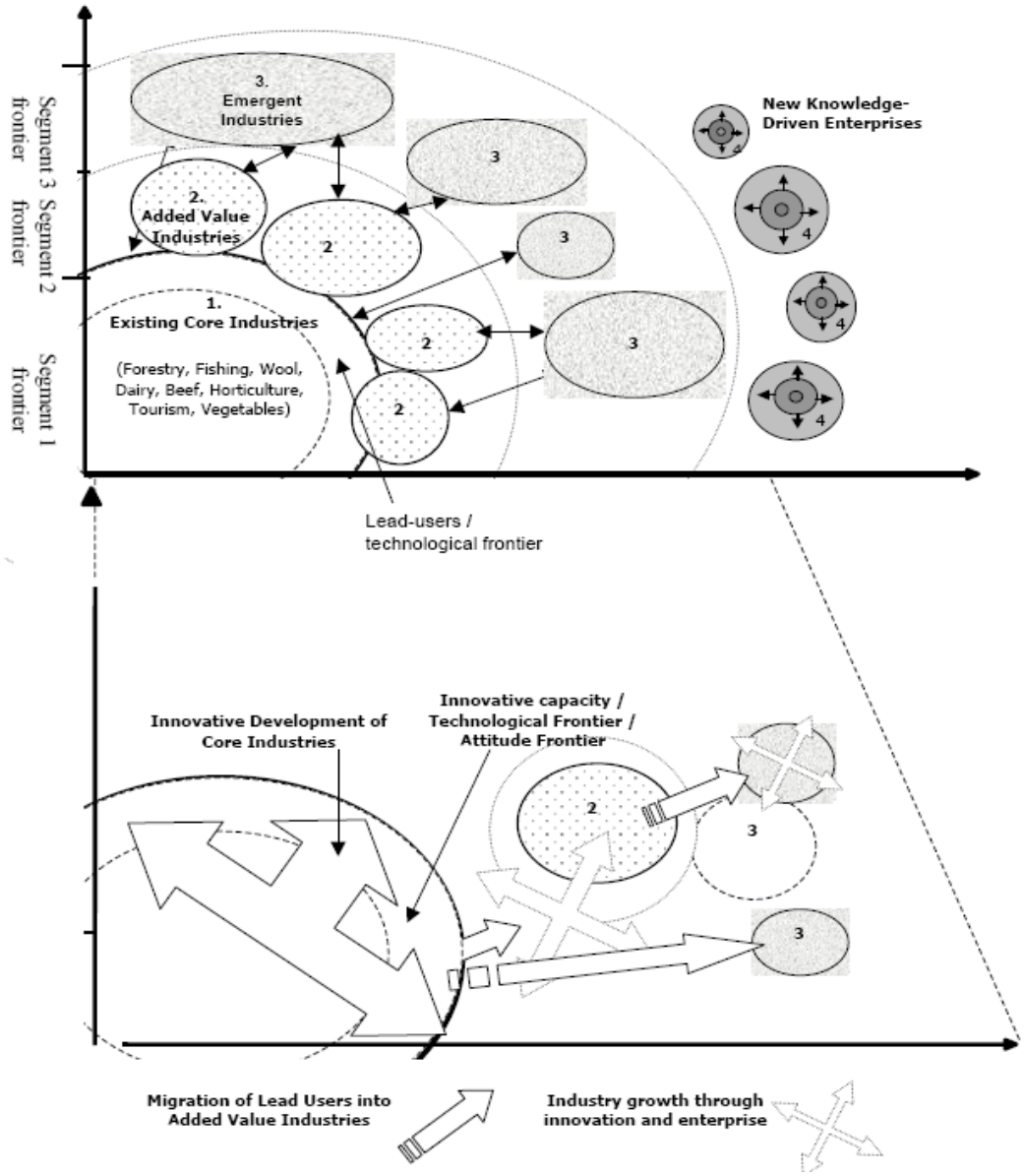
The above discussion indicates that Bangladesh is vulnerable in term of economic settings such as occupation, income, settlement, housing etc

2.3 Economic Transformation

Economic transformation can be defined as a process that makes changes the relative contribution of economic sector to GDP and employment over time. This process emerges through two main directions: first, reallocation of factors of production from less productive sectors to more productive ones; and second, diversification of the economy away from primary commodity sectors (agriculture and others) into industry and services (Berthelemy and Soderling 2001).

Jim Anderton (2006) stated, "Economic transformation is about ensuring that the economy can continuously evolve in order to create and capitalize on new opportunities, and respond to threats such as increased global competition and climate change. It is also about hastening the pace of change in our economy."

Webb and Grant (2003) consider the economy transforms in four segments based around recognition of the key competitive drivers for different types of firm these are below:



Source: Webb and Grant (2003)

Figure 2.4 Economic transformations through migrating market structure

Segment 1: Existing Core industries — representing most of the existing export economy and largely based around products that are mostly commodities.

Segment 2: Value-adding existing industries — representing the higher value firms that already exist or are emerging from core industries in segment 1.

Segment 3: Emergent industries — representing industries that have migrated into very different and high value markets removed from their original sectors, or businesses that were originally focused on servicing the industries in

segments 1 and 2, but are now established as high value industries in their own right.

Segment 4: New knowledge-driven enterprises — representing the seeding and development of technology-intensive or highly creative enterprises those are new.

This framework provides a way of thinking about transforming process of an economy though the transform process of economy in the study area is due to different reason.

2.3.1 Stylized Facts of Transformation

Despite the lack of a general theory, however, it is commonly agreed that the process of economic development is characterized by a period of rapid per capita growth combined with structural change. While structural change can be defined as an alteration in the relative importance of economic sectors, the interrelated processes of structural change that accompany economic development are jointly referred to as economic transformation (Syrquin 1988).

Although no single theory fully describes the transformation process, it can generally be described by several stylized facts that almost universally characterize the outcome of this process. These transformation patterns can be observed in newly industrializing countries in Asia and Latin America, yet also relate to the experiences of European countries during the 19th and early 20 centuries, and are as follows. First, economic structure changes significantly during the transformation period, when industrialization triggers a rapid increase in the share of manufacturing in the economy, and a concomitant decline in agriculture's share (Chenery 1960, Kuznets 1966). Second, the share of the total labor force employed in the agricultural sector falls, while that in other economic sectors rises. However, that does not imply an absolute decline in the number of laborers employed in the agricultural sector, as the share of agricultural employment in the total labor force can decline relatively slowly compared with declines in the agricultural sector's GDP share in the economy (Fisher 1939, Hayami and Ruttan 1985). Third, within this process, the

center of the country's economy shifts from rural areas to cities, and the degree of urbanization significantly increases (Kuznets 1966, Stern et al. 2005).

2.3.2 Sources of Transformation

Lewis' dual economy theory was the first seminal contribution to understanding how technology-led productivity growth in the industrial sector leads to economic transformation (Lewis 1954).

The Green Revolution not only reinforced the view that technology-led productivity growth can transform traditional agriculture into a modern sector, but also showed that agriculture helps accelerate the economy-wide transformation process. Evidence suggests that the rapid agricultural growth in many Asian and Latin American countries in the 1960s and 1970s was driven by the adoption of new farming technologies, including the use of irrigation, high-yield crop varieties, and modern inputs such as fertilizer. Based on empirical evidence from India, Hazell and Ramasamy (1991) argue that one of the attractions of green revolution technologies is that they are, in principle, scale-neutral. However, this scale neutrality is primarily observed in cereal production and mainly occurs in Asia, where adoption of these technologies raised the yields and incomes for both small- and large-scale farmers, thereby helping to alleviate absolute rural poverty. This occurred because productivity increases took place in the existing on-farm resources of land and labor, and required only few scarce resources, such as farm-level capital. A Green Revolution, thus, often involves the majority of farmers in a developing country and significantly increases agricultural productivity over a relatively short period of time. Besides many well known success stories among Asian countries, such as in India and China, Mexico is regarded as an example of an early successful Green Revolution in Latin America. Mexico's average national wheat yield in 1960-61 was 2.5 times higher than the average national yield a decade earlier, and about 98 percent of the annual wheat harvest in the latter time period involved improved wheat varieties (Schultz 1964). The recent World Development Report (WDR), which compares productivity growth in agricultural and non-agricultural sectors over the past 15 years, shows that labor productivity in agriculture grew faster than that in non-agriculture when considering agriculture-based and urbanized developing country groups, whereas labor productivity in

agriculture increased more slowly than that in non-agriculture among transforming countries. However, even in the latter country group, agricultural labor productivity still grew faster than the population, at 2.2 percent annually between 1993 and 2005 (World Bank 2007).

Both agricultural economists and general development economists emphasize the important role played by the public sector in technology development, and the importance of local adaptation for agricultural transformation. The national or international transfer of agricultural technology involves the adaptation of location-specific technology to different environmental conditions (Hayami 1974). This means that public institutions must conduct adaptive research, whereby agricultural experiment stations promote research outcomes and improve the capabilities of regional farming populations. Such public spending should also be combined with conventional public investments in roads, transportation, and irrigation facilities, which together form the most important and successful government interventions in an early Green Revolution. Today, public investments in rural infrastructure, including irrigation, roads, transport, power, telecommunication, market development, rural finance, and research are considered the most important factors for long-term agricultural development (World Bank 2007).

However, recent studies also emphasize the importance of the efficiency and sequencing of public investments. Economic outcomes are often unsatisfactory and many public resources are wasted when public spending and policies are biased towards large-scale production and the estate sector. This sector often constitutes a small share of total production, and such policies ignore the majority of smallholders (as seen in many African countries during the late 1960s and 1970s). For example, large-scale state farms throughout Africa absorbed substantial public resources in the 1960s to 1980s (Meier 1989). Furthermore, the resources spent on agricultural input and other subsidies have often been used inefficiently and ineffectively. In Zambia, for example, until very recently about 80 percent of the non-wage agricultural budget was spent on agricultural subsidies, whereas the spending on research, extension services and rural infrastructure (i.e. investments that have shown high payoffs) accounted for only 15 percent of this share of the budget (WDR 2008). The efficiency of public investment is also constrained

by institutional capacity. For example, there is no doubt about the importance of irrigation for the success of the Green Revolutions in Asia and Latin America, but an important factor in this success was the existence of a relatively complex institutional capacity, along with the management experience to efficiently operate irrigation systems.

Schultz argued that the accumulation of capital is a necessary but not sufficient condition for transformation, especially in the case of agriculture (Schultz 1964). In this view, the profitability in the agricultural sector is low when agriculture employs only traditional factors. Low returns to agricultural investment explain the minimal saving behavior of farmers and the low accumulation rate of traditional factors. However, Schultz proposes that farmers will have an incentive to invest in agriculture as soon as their investments become profitable. This was demonstrated during the Green Revolution, when farmers changed their investment and savings behavior following the introduction of modern technology that were developed by public and non-farm sectors, and supported by with public investments in irrigation and infrastructure.

2.3.3 The Role of Linkages

While productivity growth and capital accumulation are important elements of transformation, together with changes in consumer demand (which are not discussed in detail herein), they also further enhance economic inter-linkages during the transformation process. Hirschman (1958) was among the first development theorists to emphasize the backward and forward linkages created by capital investments in the industrial sector. Johnston and Mellor (1961) thereafter extended this concept by going beyond industrial sectors and explicitly emphasizing the interactions between agricultural and non-agricultural sectors. In this view, agriculture should not be seen merely as a source of surplus to support industrialization, but as a dynamic source of growth, employment and more equal income distribution. Inter-sectoral relations between agriculture and non-agriculture will likely determine the course of transformation in many developing countries. While the share of agriculture in the economy will decline over the longer run as transformation progresses, successful agricultural development in the short- and medium-run is a prerequisite for transformation (Meier 1989). This dynamic role of

agriculture is embodied in the process of transforming traditional agriculture into a modern sector, as this process enhances both consumption and production linkages between agriculture and non-agriculture and between rural and urban areas. The backward linkages occur through increased demand of agriculture for modern inputs, such as fertilizer (produced by the manufacturing sector), and marketing and trade (provided by service sectors). The strongest backward linkages are the consumption linkages, which are especially strong in low-income countries, leading to higher growth multipliers and poverty reduction effects (Delgado et al. 1996, Christiaensen et al. 2006, Diao et al. 2007, World Bank 2007).

The existence of these linkages between a modern agricultural sector and the rest of the economy also poses several transformation challenges. Modern inputs used in agricultural production are often not produced locally. Fertilizers are imported into many developing countries, making these countries' agricultural sectors more import-intensive. In addition, many modern inputs (e.g. improved seeds) are often location-specific, meaning that it is not sufficient to merely import existing varieties. Instead, local research institutions must perform adaptation studies and develop new forms that are appropriate to the given country (Schultz 1964). Finally, supply of modern factors within a country also depends on factors and activities outside of agriculture. Hence, transforming agriculture requires increased efficiency and modernization across the whole economy (Hayami and Ruttan 1985).

2.3.4 The Roles of Market, Institutions, and Governments in Transformation

Institutional change in general and market development in particular are necessary parts of transformation. As stated by Matthews (1986), the choice of technique or institution may affect both institutional change and market development. Most economists agree that the quality of institutions can explain differences in growth and transformation processes by shaping incentives to develop new technologies and innovation (Rodrik et al. 2004, Easterly and Levine 2003). Moreover, by drawing lessons from studies in several countries, Rodrik finds that the onset of the transformation process does not necessarily

require extensive institutional reform, but rather institutional reform should be seen as an endogenous part of the transformation process (Rodrik 2003).

Technology-led productivity change involves the intensive use of modern inputs purchased from markets. The availability of seasonal financing, more developed marketing systems, and supply chains built around smallholder farmers becomes increasingly important in agricultural transformation, requiring simultaneous and complementary investments in all links of the supply chain. However, coordination, opportunism, rent-seeking costs, and risk can all complicate the effectiveness and efficiency of such simultaneous investments (Poulton et al. 2006). The lack of market institution development and investment in infrastructure and information systems results in high transportation and transaction costs, forcing farmers to remain within a traditional, subsistence mode of production. Moreover, increased use of modern inputs and growing agricultural production can significantly increase the market and profitability risk of small farmers in the process of transformation, further lowering their incentive to adopt any new technology.

The active role of the state in transformation during the 1950s and 1960s was based on the optimistic view that transformation or development in general can be accelerated by a defined series of policies and direct public interventions. The pre-World War II economic crisis, the existence of market under-development, and the pervasiveness of market failure in developing countries forced many governments to engage in central planning. Additionally, the apparent initial success of central planning in many Eastern Bloc countries further encouraged governments to rely on the "commanding heights" of the state rather than the market (Yergin and Stanislaw 1998). The core elements of this strategy included planned investment in capital accumulation, utilization of rural surplus labor reserves, adoption of import substitution industrialization (ISI) strategies, and a series of policy interventions in international trade and domestic markets.

To finance state-led industrial development, governments often discriminated against agriculture and other export-oriented sectors. Overvalued exchange rates, high import duties on intermediates and capital goods, and heavy taxation of agricultural exports all

undermined the role of sectors that would otherwise have had comparative advantages for leading growth and structural change (Krueger et al. 1991). Within agriculture, the most important state interventions during the 1960s to 1980s were the direct involvements of governments in market activities. Input and output marketing and processing facilities in many developing countries (especially in Africa) were almost always operated by semiautonomous government or parastatal agencies, or by mostly government-initiated cooperatives on a monopoly basis. However, the operations of most public marketing agencies tended to be costly and inefficient because of overstaffing and inexperienced management. In addition, small-scale private trading, often operating in informal, traditional markets, was discouraged. According to the WDR 2008, public expenditure reviews suggest that a large share of public spending in agriculture has been allocated to providing private goods at high costs in many countries, even in recent years.

Direct government interventions aimed at correcting market failures frequently resulted in extensive "government failures", which inhibited positive market responses and development. Although market failure is often the result of inappropriate incentives rather than the lack of responsiveness (Krueger 1986), 20 years after inception of the World Bank/International Monetary Fund (IMF) structural adjustment programs (SAP), which sought to right prices and correct markets, underdeveloped markets are still a predominant phenomenon in many African countries, particular for staple commodities that are produced by a majority of small farmers. However, in many other developing countries, especially in successfully transforming countries, a great deal of progress has been made, primarily led by the private sector. In Africa, inadequate transport infrastructures and services in rural areas continue to push up marketing costs and undermine local markets and export opportunities. Public market information systems have often yielded disappointing results, and price-risk management through the public sector is still inefficient. There is a general lack of a consistent legal and regulatory framework that encourages free market competition and guides the private sector and farmers, and contract enforcement mechanisms continue to be weak.

A large agenda remains for improving the performance of marketing systems in developing countries. The existence of both market failures and government failures calls

for a better understanding of the interaction between the public and private sectors and the role of institutions in transformation. Such an understanding is often country-specific, and the path to the successful transformation of institutions in general and to market development in particular often requires experimentation, a willingness to depart from orthodoxy, and attention to local conditions (Rodrik 2003). However, recent market developments under globalization and the rapidly growing local and international demand for agricultural products have opened up important new opportunities for developing countries to find their paths to transformation through the joint efforts of private and public sectors.

2.4 Vulnerability

Vulnerability is the extent to which may damage or harm a system. Basically, vulnerability depends to a great extension on its wealth, and the poverty limits adaptive capabilities. It also depends on the economic condition and space. The second assessment report of IPCC argues that socio-economic systems "typically are more vulnerable in developing countries where economic and institutional circumstances are less favorable" (Watson et al. 1996;240). Moreover, vulnerability is highest where there is the greatest sensitivity to climate change and the least adaptability.

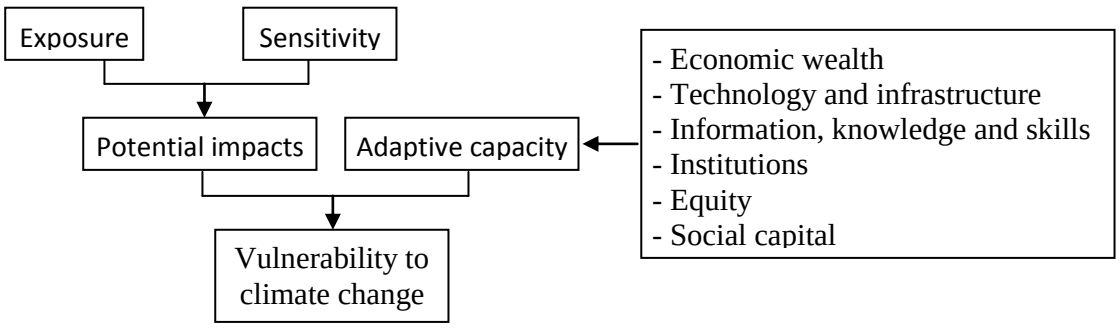


Figure 2.5 Conceptualization of vulnerability to climate change in the IPCC Third Assessment Report

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as the extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to which in

climate and the ability to adapt the system to changes in climate. Wilbanks et al. (2007) noted that the two factors that contribute to vulnerability are largely determined by the development context which has such a strong influence on households' income, education and access to information, on people's exposure to environmental hazards in their homes and workplaces and on the quality and extent of provision for infrastructure and services. But in urban areas, vulnerability is also so much influenced by the extent and quality of infrastructure and public services, especially for vulnerable populations (Satterthwaite, 2007).

However, it is important to ask: "Vulnerable to what?" In other words, hazard and vulnerability are mutually concomitant and lead to risk. If there is no hazard it is not feasible to be vulnerable when seen from the perspective of the potential damage or loss the occurrence of an event might signify. In the same way, no hazard can exist for an element or system if such an element is not 'exposed' and vulnerable to the potential event. A population might be vulnerable to hurricanes, for example, but not to earthquakes or floods.

In other words, vulnerability is the "state of reality" that underlies the concept of risk. It is the causal reality that determines the selective character of the severity of damage when a hazard event occurs. Vulnerability refers to the propensity of exposed elements such as human beings and their livelihoods to suffer damage and loss when impacted by single or diverse hazard events (UNDRO 1980; Timmerman 1981; Maskrey 1984; Cardona 1986, 1990; Liverman 1990; Cannon 1994, 2006; Blaikie et al. 1996; UNISDR 2004, 2009b; Birkmann 2006b; Thywissen 2006). Vulnerability reflects susceptibility, the intrinsic predisposition to being affected; the conditions that favour or facilitate damage. The measurement of vulnerability is a challenge; it is related to the degree of exposure, susceptibility, fragility and lack of resilience or lack of (societal) response capacities of a socio-ecological system that favors adverse effects.

Vulnerability refers to susceptibilities or fragilities of the exposed elements; i.e. to the likelihood to be affected, but also it is related to the lack of resilience or lack of response capacities of the society and environment. Vulnerability is also closely tied to natural and

built environmental degradation at the urban and rural levels and the gradual climate change.

Cardona and Barbat (2000); McCarthy et al. (2001); Birkmann (2006); Carreño et al. (2007a); IPCC (2007) have suggested that vulnerability originates in the following factors (see Figure 2.6):

- *Exposure* is the likelihood of human settlements and environment to be affected by a dangerous phenomenon due to its location in the area of influence of the phenomenon and to a lack of physical resistance.

- *Susceptibility and/or fragility* is the predisposition of society and ecosystems to suffer harm resulting from the levels of susceptibilities or fragilities of human settlements and disadvantageous conditions and relative weaknesses related to physical, ecological, social, economic, cultural, and institutional issues.

-*Lack of resilience* (*or ability to anticipate, cope and recover) or lack of societal response capacities* is/are the limitations in access to and mobilization of the resources of the social-ecological system, and the incapacity to respond in absorbing the impact. The resilience includes the capacity to anticipate, cope and recover in the short term.

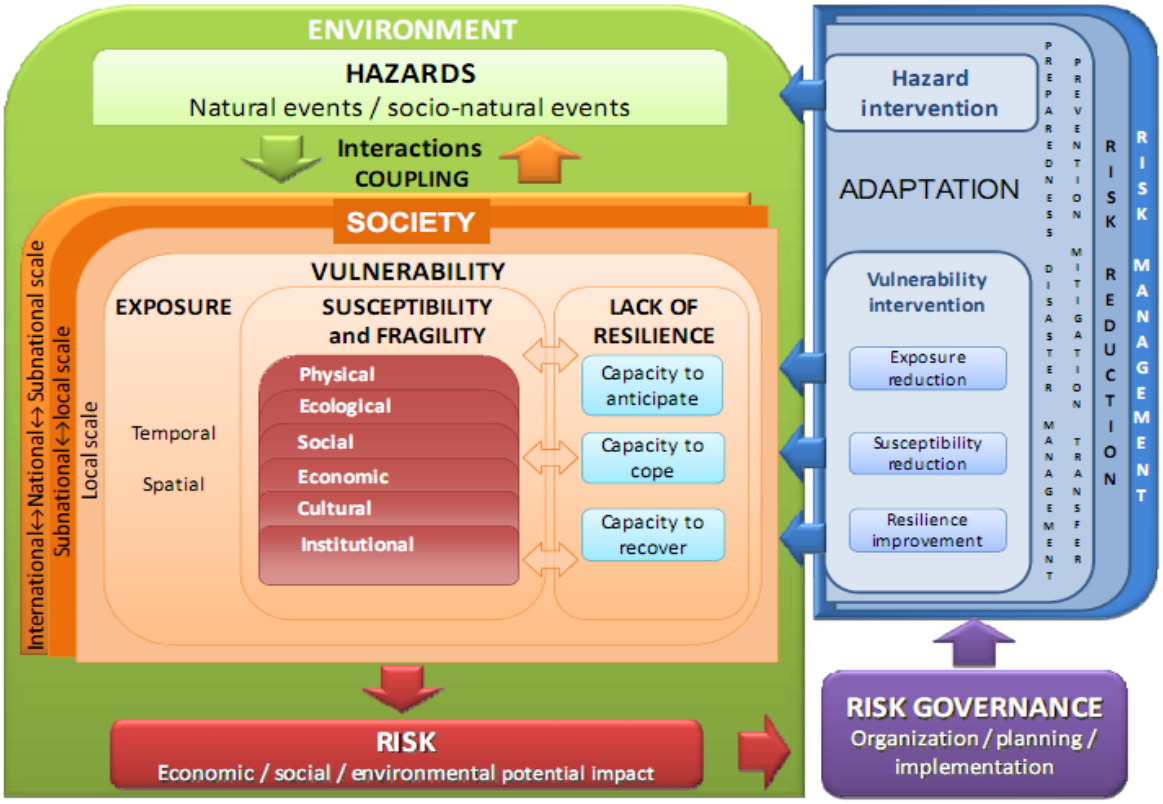


Figure 2.6 Theoretical framework for a holistic approach to disaster risk assessment and management.

As illustrated in Figure 2.6, the 6 thematic dimensions of vulnerability describe different features of the susceptibility/fragility component as well as those of the lack of resilience or the lack of (societal) response capacities, as represented through the arrows linking the two boxes. Measurement of vulnerability should then take into account and integrate these different dimensions.

In contrast to vulnerability - *risk* is defined as the expected probability of harmful consequences or losses resulting from interactions between natural or anthropogenic hazards and vulnerable conditions. It is the potential occurrence of physical, social, economic, and environmental consequences or losses, in a given area and over a period of time, resulting from the vulnerability conditions of a social-ecological system exposed to hazards. In order to face the recognized risk, it is necessary to involve the *risk governance* which includes the totality of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated and management decisions are taken. These risk management decisions include tasks on

risk reduction, prevention, mitigation and transfer and also preparedness and disaster management, which allow implementing measures for hazard intervention or vulnerability intervention that lead to exposure and susceptibility reduction and resilience improvement.

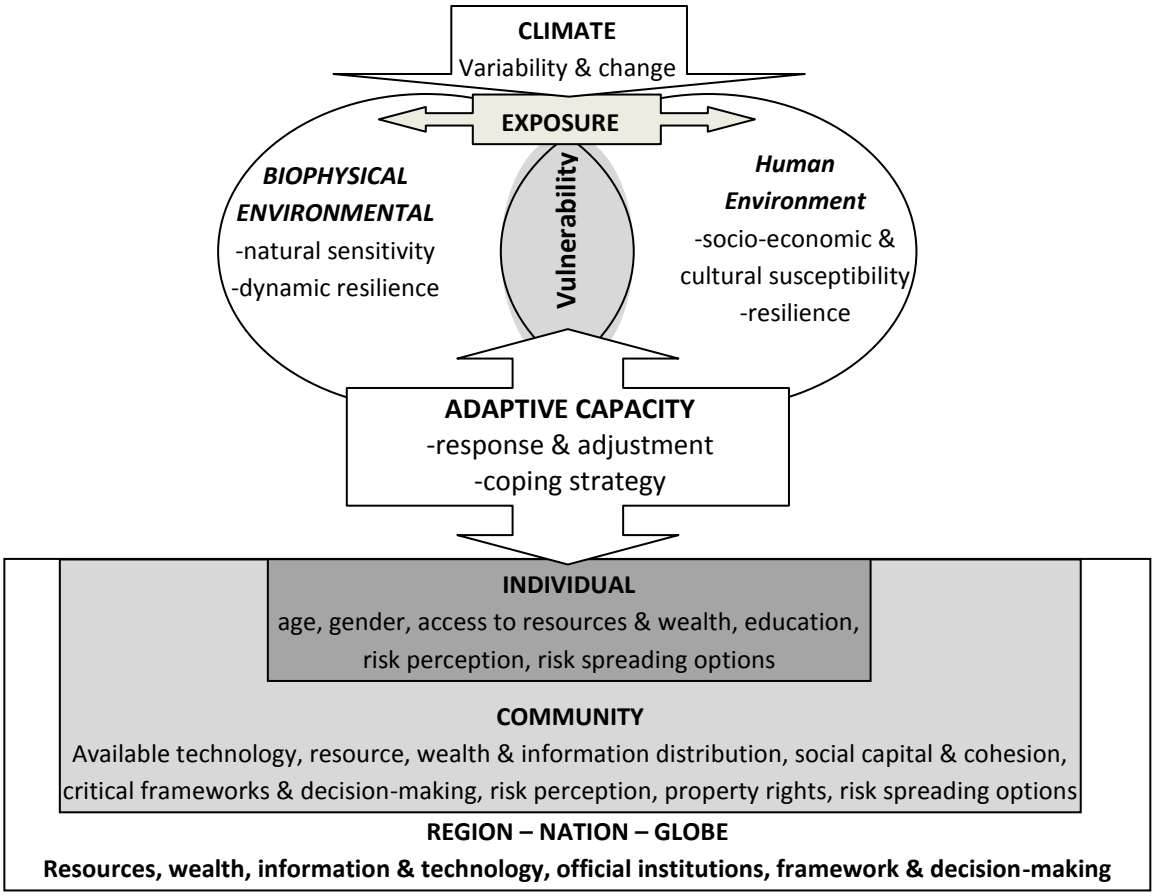


Figure 2.7 Integrated vulnerability framework (Dolan and Walker, 2004)

Vulnerability can be distinguished as pre-adaptation vulnerability and post-adaptation vulnerability (Smit et al., 2000). However, the level of vulnerability is determined by the adverse consequences that remain after the process of adaptation has taken place (Kelly and Adger, 2000)

From the food security point of view vulnerability can be define as the presence of factors that place people at risk of becoming food insecure or malnourished (FAO, 1999).

For better planning to vulnerability assessment due to climatic event can be through three steps are as following:

- A sensitivity analysis for the systems associated with the planning areas;
- An evaluation of the adaptive capacity of the systems associated with each of these planning areas;
- An assessment of how vulnerable the systems in the planning areas are to the effects of climate change.

2.4.1 Measuring Vulnerability

Vulnerability can be measure as:

V = f {E(AC); S(AC)} [as adapted from (Yohe and Tol, 2002), where V is vulnerability, E is exposure, S is sensitivity, and AC is adaptive capacity].

Here, vulnerability of a system is a function of its exposure and sensitivity, which in turn are a function of the system's adaptive capacity and resilience. Although the above model has non-linear, multivariate, and case-specific factors, it is evident that a general increase in adaptive capacity is an integral component to decreasing vulnerability. While some portion of vulnerability is inherently natural and unsolvable, or uncorrectable, it is the responsive nature of humans that makes adaptive capacity such an important research subject to study (Füssel and Klein, 2006).

The ability to measure vulnerability is increasingly being seen as a key step towards effective risk reduction and the promotion of a culture of disaster resilience. In the light of increasing frequency of disasters and continuing environmental degradation, measuring vulnerability is a crucial task if science is to help support the transition to a more sustainable world (Kasperson et al., 2005).

In the final document of the World Conference on Disaster Reduction, '' Hyogo Frame work for Action 2005 – 2 015'', the international community underlined the need to promote strategic and systematic approaches to reducing vulnerabilities and risks to hazards (United Nation s (UN), 2005, preamble). The declaration points out that:

The starting point for reducing disaster risk and for promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic and environmental vulnerabilities to disasters that most societies face, and of the ways in

which hazards and vulnerabilities are changing in the short and long term, followed by action taken on the basis of that knowledge (U N, 2005).
In this context the Hyogo Framework stresses the need to develop indicators of vulnerability as a ‘‘key activity’’:

Develop systems of indicators of disaster risk and vulnerability at national and sub-national scales that will enable decision-makers to assess the impact of disasters on social, economic and environmental conditions and disseminate the results to decision makers, the public and populations at risk (UN , 2005).

Although the international community does not formulate guidelines on how to develop indicators or indicator systems to assess vulnerability, the Hyogo Framework for Action underlines the fact that impacts of disasters on (1) social, (2) economic, and (3) environmental conditions should be examined through such indicators. Since sustainable development is characterised by three pillars – social, economic and environmental (UN, 1993; WCED, 1987) – the formulation used in the Hyogo Framework for Action can be interpreted as implying a link between vulnerability assessment and sustainable development. Moreover, the declaration underlines the necessity to develop methods and indicators which, based on those recommendations, can be used in policy and decision-making processes. Furthermore, it is evident that measuring vulnerability requires, first and foremost, a clear understanding and definition of the concept of vulnerability.

O’Brien et al. (2007) and Kelly and Adger (2007) separate definitions of vulnerability into two categories. Such as contextual or focal point approaches to assessing vulnerability focus on the context that creates vulnerability and view vulnerability as a consequence of social and institutional factors. Vulnerability is thus determined by interaction between social norms, political institution and resource endowments (Adger, 2006). On the other hand, End-point or outcome estimates of vulnerability define vulnerability as what is left after expected impacts and adaptation is accounted for, and can thus be seen as the net impact of climate change (Kelly and Adger, 2000). Typical for the letter category are studies that use impact scenarios and estimates of biophysical climate change impacts in order to assess vulnerability.

The indicator approach

The indicator approach aims to measure vulnerability to climate change through combining indicators of biophysical impacts (exposure) with indicators of socio-economic characteristics (sensitivity and adaptation) in an aggregate indicator of vulnerability (Gbetibouo et al. 2010). The approach has been used both at the global level (Brooks et al. 2005) and national and regional levels (Gbetibouo et al, 2010; O'Brien et al., 2004).

To analysis vulnerability to climate change and variability Gbetibouo et al. (2010) apply this method in South Africa. They use frequency of past climate extremes and predicted changes in rainfall and temperature by 2050 as indicators of exposure to long-term changes in climate and changes in climate variability. The underlying assumption is that the larger the predicted change, the greater the exposure. To capture sensitivity, agricultural characteristics such as irrigation rate, land degradation index, crop diversification index, share of small-scale agriculture and rural population density are used. Finally, adaptive capacity is captured through indices of household assets, such as social capital (share of farmers in farmer organizations), human capital (literacy rate) and a number of socioeconomic characteristics such as farm income, farm size, agricultural share of GDP and access to credit. But the largest exposure to climate change is not always the most vulnerable: rather vulnerability is closely linked to social and economic development.

Some limitations to this method, also noted by the authors in these two studies, are the subjective nature of the indicators chosen, and the fact that the aggregate indicators of vulnerability do not reflect local institutions that may increase or decrease sensitivity and adaptive capacity. A third limitation is that the differential impact of price changes due to trade liberalization and scenarios for agricultural price changes due to climate change are not taken into account. For instance, the vulnerability of the growing group of urban poor cannot be addressed without taking into account food price change that may result from climate change impacts on agriculture.

The econometric approach

A second group of approaches to measuring vulnerability use econometric analysis to estimate either expected poverty measures or expected utility measures of vulnerability to a shock. In general, both the vulnerability as expected poverty (VEP) and the vulnerability as low expected utility (VEU) approaches are based on calculating the probability that as individual or household's welfare falls below some benchmark level as the result of a shock or exposure to risk.

The expected poverty group of measures identifies vulnerable households as those likely to fall below as agreed-upon poverty line in the future with a particular probability (Alwang et al., 2001). Christiaensen and Subbarao (2005) use pseudo panel data or rural households in Kenya to estimate the probability of becoming poor, and find that the households have a 39 percent probability of becoming poor in the future. The authors identify rainfall variability in arid areas, malaria and idiosyncratic shocks as important factors that increase vulnerability, i.e. the probability of becoming poor in the future. Households that own livestock are able to buffer some idiosyncratic shocks, but not covariate shocks.

An application to farmers' vulnerability to climate extremes in Ethiopia is given in by Deressa et al. (2009). They estimate the probability of the income of households falling below a poverty line, and classify vulnerable households as those with more than 50 percent probability of falling below the poverty line. The authors are able to identify the share of vulnerable households in different agro ecological zones, and differentiate between vulnerable households that are poor today and vulnerable household that are not poor today. The results are highly sensitive to which poverty line is used; with a poverty line of 2 USD a day almost all households are poor today and likely to remain poor due to climate extremes.

Ligon and Schechter (2003) showed that this class of vulnerability measures has some unwanted properties. First, a household that will be poor with certainty is judged less vulnerable than if the household's expected consumption level is below the poverty line, but with equal probability of consumption just above or just below the poverty line. Second, using higher order vulnerability as expected poverty measures implies increasing

absolute risk aversion, which is not empirically supported (Hoddinott and Quisumbing, 2008; Ligon and Schechter, 2003). To avoid these properties, the authors suggest defining households as vulnerable if their utility of consumption after a shock is below a certain level. It can be shown that this measure of vulnerability can be decomposed to attribute vulnerability to poverty, idiosyncratic shocks, and covariate shocks. An application using data from Bulgaria shows that poverty and risk play approximately equal roles, and that households headed by employed males are less vulnerable than female-headed households.

There are several limitations to using econometric approaches to measuring vulnerability to climate change. First, methods based on observed data will have to rely on already observed climate variability to measure vulnerability to climate change. Second, Kamanou and Morduch (2005) point to high data requirements and that the form of the utility function must be assumed, as weaknesses of the VEU approach. Finally, we may also say that both the VEP and VEU approaches can be classified as outcome measures of vulnerability. The focus is not on the context that creates vulnerability, but rather on the expected outcome of a shock for household welfare, or the relationship between risk and welfare. Climate change and climate variability will affect many sectors simultaneously and have important general equilibrium effects in developing countries. The impacts of for instance global food price changes or yield changes will be unevenly spread across household groups, thus we need an approach that is able to account for the indirect effects through markets and prices as well as differential access to endowments and markets. This leads us to the more aggregate approaches to measuring vulnerability to climate change.

2.5 Sensitivity

Positive correlation can be found between sensitivity and vulnerability. If sensitivity rises for a certain calamities, the vulnerability also rises. Sensitivity is the degree to which a built, natural or human system is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., sea level rise, increased water temperature). If a system is likely to be affected as a result

of projected climate change, it should be considered sensitive to climate change (Center for Science in the Earth System, 2007).

2.6 Adaptation

In the climate change research very often resilience and adaptation use as synonym. Adaptation of societies and activities is an excellent umbrella concept for those factors that mediate between geophysical conditions and events, on the one hand, and human abilities to cope with, take advantage of, or adapt to those conditions and events, on the other hand (Rayner and Malone, 2000).

Adaptation is a composite concept, incorporating environmental, social, economic, political, demographic, cultural, gender and psychological factors, in describing the capacity to recover and survive, to change and grow. This conceptualization draws attention to the amplifiers or attenuators of the impacts of climate change and points toward characteristics of certain groups, certain institutions, and certain places. It also emphasizes the degree to which the risks of climate catastrophe can be cushioned or ameliorated by adaptive actions that are or can be brought within the reach of populations at risk.

For instance, Yohe and Tol (2002:26) identified eight generalized "determinants of adaptive capacity," many of which are societal in character, although the authors draw on an economic vocabulary and framing:

1. The range of available technological options for adaptation

2. The availability of resources and their distribution across the population

3. The structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed

4. The stock of human capital, including education and personal security

5. The stock of social capital, including the definition of property rights

6. The system's access to risk-spreading processes

7. The ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers themselves

8. The public's perceived attribution of the source of stress and the significance of exposure to its local manifestations.

Table 2.1The sectors and variables used in the Vulnerability-Resilience Indicators Model (VRIM).

Sectoral Indicators	Proxy Variables	Proxy For
Food security	Cereals production/ crop land area Protein consumption/ capita	Degree of modernization in the agriculture sector; access of farmers to inputs to buffer against climate variability and change Access of a population to agricultural markets and other mechanisms (e.g., consumption shift) for compensating for shortfalls in production
Water resource Sensitivity	Renewable supply and inflow of water	Supply of water from internal renewable resources and inflow from rivers divided by withdrawals to meet current or projected needs
Settlement/ infrastructure sensitivity	Population at flood risk from sea level rise Population without access to clean water Population without access to sanitation	Potential extent of disruptions from sea level rise Access of population to basic services to buffer against climate variability and change
Human health Sensitivity	Completed fertility Life expectancy	Composite of conditions that affect human health including nutrition, exposure to disease risks, and access to health services
Ecosystem sensitivity	% Land managed Fertilizer use/ cropland area	Degree of human intrusion into the natural landscape and land fragmentation Nitrogen/phosphorus loading of ecosystems and stresses from pollution
Human and civic resources	Dependency ratio Literacy	Social and economic resources available for adaptation after meeting other present needs Human capital and adaptability of labor force
Economic capacity	GDP(market)/ capita An income equity measure	Distribution of access to markets, technology, and other resources useful for adaptation Realization of the potential contribution of all people
Environmental Capacity	% Land unmanaged SO_2/area Population density	Landscape fragmentation and ease of ecosystem migration Air quality and other stresses on ecosystems Population pressure and stresses on ecosystems

Source: Brenkert and Malone 2005.

The Vulnerability-Resilience Indicators Model identifies 17 factors (listed in the Table below) that together assess the resilience of a society. The VRIM has been used to compare 160 countries, evaluate adaptive capacity at temperature increases of 1.5°C and 4.5°C, analyze India and Indian states under current conditions and future scenarios, and examine resilience in Mexico and Mexican states.

Again, Brooks and Adger (2005) point out that the concept of adaptive capacity only makes sense in the context of what resources and systems would be affected by climate change. Some aspects of adaptive capacity can be generally useful, such as the flexibility that high levels of education brings. Other aspects are very specific, such as the ability to build coastal protection infrastructure or to plant drought-resistant crops. The U.S. Agency for International Development's project Famine Early Warning System (FEWS 1999), for instance, focused its vulnerability assessment guidance on food security.

Downing (2005), at the other end of the aggregation-disaggregation spectrum, advocates a grassroots process in which community stakeholders determine *what* they are vulnerable to (droughts, storms, etc.), *who* is vulnerable, *how* future vulnerability is shaped, and at *what scales*. Thus, a good vulnerability assessment will be unique to the community where it is developed; plans for mitigation and adaptation will be specific to that place and society. Brooks and Adger (2005) discuss a similar bottom-up, place-and-community specific approach to assessing and building adaptive capacity, and Smit and Wandel (2006:288) join the chorus by describing "participatory vulnerability assessments [that] allow for the recognition of multiple stimuli beyond those related to climate, to include political, cultural, economic, institutional and technological forces. Furthermore, the methodologies recognize the interaction of various exposures, sensitivities and adaptive capacities over time."

Adaptive capacity describes the ability of built, natural and human systems associated with a given planning area to accommodate changes in climate with minimum disruption or minimum additional coast. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of change in conditions (Watson et al., 1996). But adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system (Smith et al. 1996)

According to UNFCCC (2000b) adaptation activities can be divided in the following three stages:

- Stage I Adaptation: Planning, which includes studies of possible impacts of climate change, to identify particularly vulnerable countries or regions and policy options for adaptation and appropriate capacity building;
- Stage II Adaptation: Measures, including further capacity building, which may be taken to prepare for adaptation as envisaged in Article 4.1 (e) [Cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa affected by drought an desertification, as well as flood.]
- Stage III Adaptation: Measures to facilitate adequate adaptation, including insurance, and other adaptation measures as envisaged in Articles 4.1 (b) and 4.4 [4.1-b: *Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures…to facilitate adequate adaptation to climate change.* 4.4: *The developed country parties and other develop parties shall also assist the developing country parties that are particularly vulnerable to the adverse effects to climate change in meeting the costs of adaptation to those adverse effects.]*

On the other hand climate change adaptation is any adjustment or action undertaken which brings beneficial opportunities as well as moderates or reduces the adverse consequences of climate change in response to any climate-related changes in the physical and cultural environment.

According to UNFCCC, adaptation is about finding and implementing ways of adjusting to climate change and responding to climate changes risks and vulnerabilities.

Moreover, socio-economic systems in coastal zones also have a capacity to respond autonomously to external pressures, including sea-level rise, People, and their support and lifestyle systems, are in a constant process of coping with environmental variability and change as well as with a range of economic, social and political factors. These coping

processes are reflected in systems of resource use, including agriculture, water consumption, housing styles, settlement locations and the like. It is important to recognize that the coping process is dynamic, since the influences people and communities respond to, and their personal needs and wants, are constantly changing. Autonomous adaptation is likely to become more important as sea level rises, though its effectiveness is likely to decrease with the increase in rate of rise above historic values. Planned adaptation activities should always be undertaken in ways that reinforce coping processes (Hay and Mimura, 2005).

However, the adaptation epistemic community lists the general categories of adaptive capacity determinants as economic resources, technology, information and skills, infrastructure, institutions, and equity (IPCC, 2001). Yohe and Tol (2002) offer a slightly expanded description of the determinants of adaptive capacity; take institutions as an example, where "the structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed" describe the institutional determinant of adaptive capacity. Others highlight networks, collective action, and social capital as expanded definitions of determining factors (Pelling and High, 2005; Adger, 2003). Yet these descriptions remain relatively vague, and are difficult to assess, because they lack indicators at various scales. Moreover, the respective weights to assign to these determinants are uncertain. Researchers continue to work toward a way to operationalize the measurement of adaptive capacity and vulnerability (Adger et al, 2004; O'Brian K. et al, 2004), but the prioritization of determinants, and the development of indicators within each determinant category remain in their infancy.

Table 2.2: Range of Adaptive Capacity Determinants

Determinants of adaptive capacity	
Determinants	Encompasses
Human capital	Knowledge (scientific, "local", technical, political), education levels, health, individual risk perception, labor
Information & Technology	Communication networks, freedom of expression, technology transfer and data exchange, innovation capacity, early warning systems, technological relevance
Material resources and infrastructure	Transport, water infrastructure, buildings, sanitation, energy supply and management, environmental quality
Organizational and social capital	State-civil society relations, local coping networks, social mobilization, density of institutional relationships
Political capital	Modes of governance, leadership legitimacy, participation, decentralization, decision and management capacity, sovereignty
Wealth and financial capital	Income and wealth distribution, economic marginalization, accessibility and availability of financial instruments (insurance, credit), fiscal incentives for risk management
Institutions and entitlements	Informal and formal rules for resource conservation, risk management, regional planning, participation, information dissemination, technological innovation, property rights and risk sharing mechanisms

Source: Eakin and Lemos (2006)

However adaptation can be integrated or categorized into autonomous or planned and short, medium and long term.

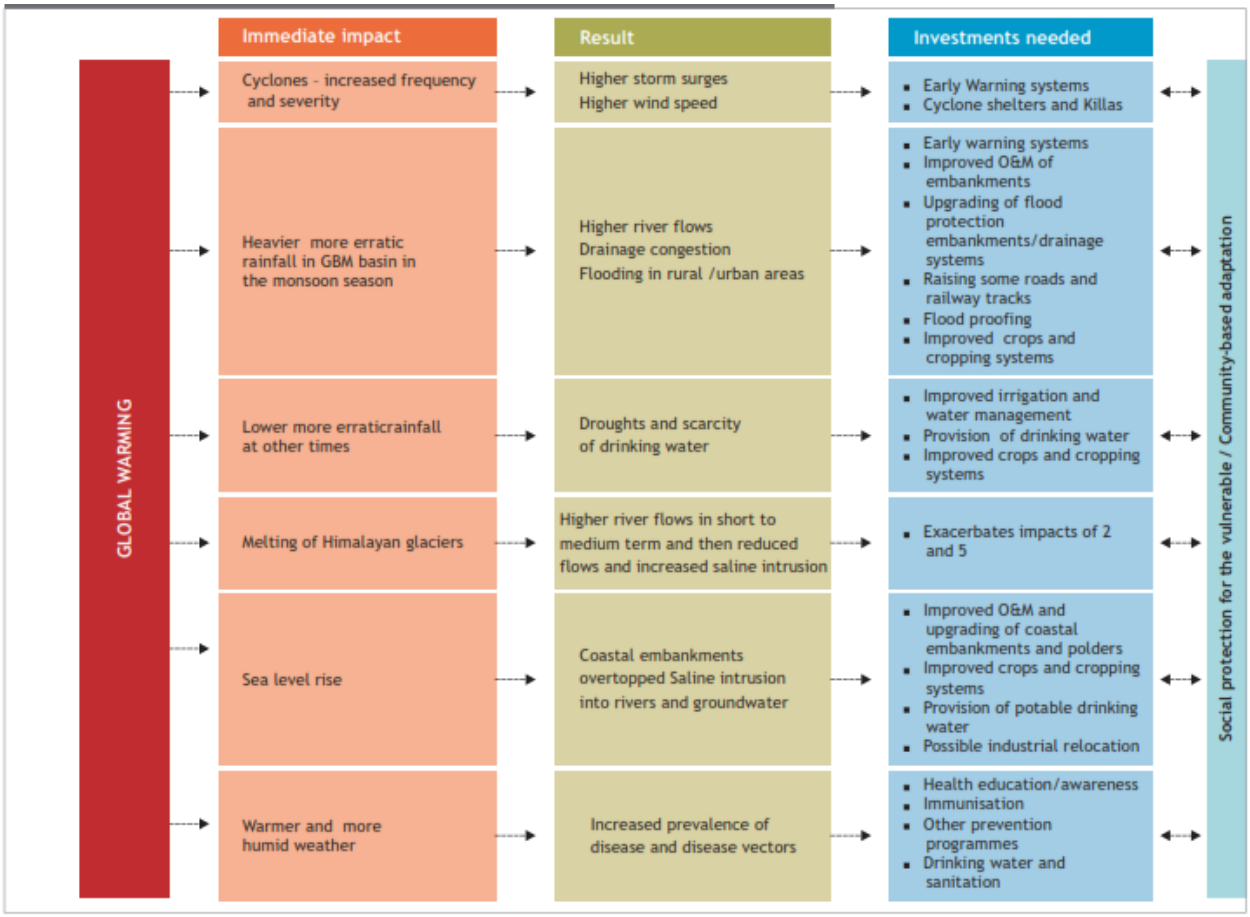
In Bangladesh casualties from tropical cyclones decreased dramatically between the 1970s and late 1990s. This is attributed to deployment of a cyclone detection radar system, supported by early warning using radios and evacuation shelters in villages (Hay and Mimora, 2005)

The likely impacts of global warming on Bangladesh and required types of investment are shown in the schematic diagram below (figure 2.8).

The Government of Bangladesh has taken 10 years programme (2009-2018) named Climate Change Action Plan to build the capacity and resilience of the country to meet the challenges of climate change. Keeping in view, the needs of poor and vulnerable, including women and children the programme comprises six pillars. Such as-

- Food Security, Social Protection and Health
- Comprehensive Disaster Management
- Infrastructure
- Research and Knowledge Management
- Mitigation and Low Carbon Development
- Capacity Building and institutional Strengthening

Under these six themes, a number of programmes have been taken to address the problem related to the climate change impact. Among the programmes Research and Knowledge Management, Capacity Building, Infrastructure development like Embankment, Polder and Cyclone Shelter building, invention of saline water tolerant varieties to ensure the food security.



Source: GOB, 2009

Figure 2.8 Likely impact of global warming on Bangladesh and required investments.

2.7 Brief history of cyclone in the study area

Since 1797 Bangladesh has been hit by 61 severe cyclones, 34 of which were accompanied by storm surges. Table 2.3 below shows a brief account of selected severe cyclones with particular reference to the affected area, type and casualties. The frequency of a wave (surge plus tide) with a height of about 10 meters is approximately once per 20 years. A storm surge of approximately once in 5 years has a height of about 7 meters (surge plus tide). Beside these exceptional surges, wind wave occur, the dimensions of which depend on wind speed and direction, fetch, water depth, and duration. Wave of 3 meters height may occur under unfavorable conditions in the coastal regions (French Engineering Consortium and Bangladesh Water Development Board, 1989).

Table 2.3 Effect of cyclones in the study area

Sl. No.	Year	Affected Area	Nature of the Phenomena	Approximate loss/damage
1	1895	Sunderban	Cyclonic surge	Damage report is not available
2	1901	Western Sunderban	Cyclonic storm	Damage data is not available
3	1917	Sunderban	Cyclonic storm	70000 people killed
4	1960	Sunderban	Cyclonic storm	106 people killed
5	1963	Sunderban	Cyclonic storm	Damage data not available
6	1967	Sundarban-Noakhali coast	Cyclonic storm	Damage data not available
7.	1971	Sundarban coast	Cyclonic storm	11000 people killed
8	1973	Sunderban-Patuakhali coast	Severe cyclonic storm	183 people killed
9	1974	Khulna coast	Cyclonic coast	Damage data not available
10	1975	Suderban-Bhola-Chittagong coast	Severe cyclonic storm	5 people killed
11	1978	Sunderban-Khulna coast	Cyclonic storm	Damage data not available
12	1988	Sunderban	Severe cyclonic storm	5708 people killed and 6000 missing; 65000 cattle were lost
13	1991	Patuakhali-Cox's Bazar coast	Most severe cyclonic storm	145000 people killed, 70000 cattle killed
14	2007	Sunderban	Most severe cyclonic storm	*10000 people killed
15	2009	Sunderban	Most severe storm surges	*8528 people killed

Source: Khan, S. R., 2015

* Wikipedia

From above table it could be said that in last 100 years the study area is affected by more than 5 severe cyclones and other 10 cyclone storms and surges. In 1917 the area was affected by cyclone storm killed 70000 live. 11000 people were lost their life in 1971 due to cyclonic storm. Again 5708 people killed and 6000 missing; 65000 cattle were lost by severe cyclonic storm in 1988. The area also hit by most severe cyclonic storm killed 145000 people and 70000 cattle in 1991. The area also affected by most severe cyclonic storm surges in 2009 killed 8528. The cyclone is known as Aila which devastating adverse effect is still now bearing by the people of the area.

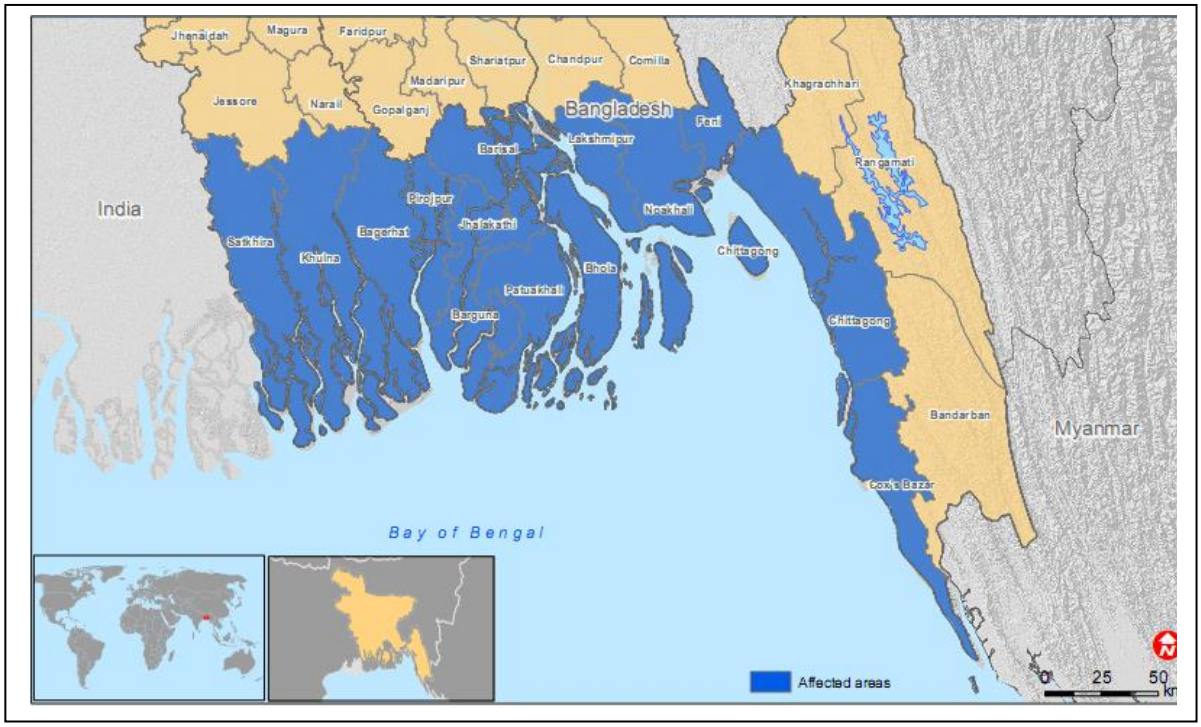


Figure 2.9 Map of study area

Chapter 3
Research Methodology

The chapter is designed to discuss the type of research, research design, selection criteria of the study area, sampling deigns 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. In explorative part an attempt has been made to find out the issues and how they are influencing the economic transformation system in the study area. Upshot of economic transformation in the light of vulnerability analysis and how the stakeholder copes with has also been discussed in this part. Moreover, an emphasized has given to investigate the taken development policy and planning of International Organizations, Government, GOs and NGOs and their impact to the development of the area. Similarly, the study being descriptive has illustrated the economic transformation process and pattern; and to show economic transformation it has described present and past economic situation of the residents, such as occupation, per capita income, expenditure capacity, land use pattern, and mode of transportation as well as infrastructures to analysis the vulnerability. In this part it has also discussed adaptation measures those are taken in order to cope with the fragile situation.

3.2 Research Design

A detail literature survey helps to conceptualized about the research problems and applied research methods. The applied research design is based on observation including questionnaire survey, checklist survey, group discussions with dwellers and key informants of the study area. A questionnaire survey has carried out at the household level in the sampled villages while checklist was used for data collection from group discussion, key informants and relevant institutions. Beside that informal group discussion was made to get information regarding different issues relevant to the research. Quantitative and qualitative approaches were used to collect data and information, which provide relevant and useful information for analysis of the various mode of economic

transformation. After collecting data, both descriptive and analytical statistics have applied for analysis.

A outline of the research design is given in the figure 3.1.

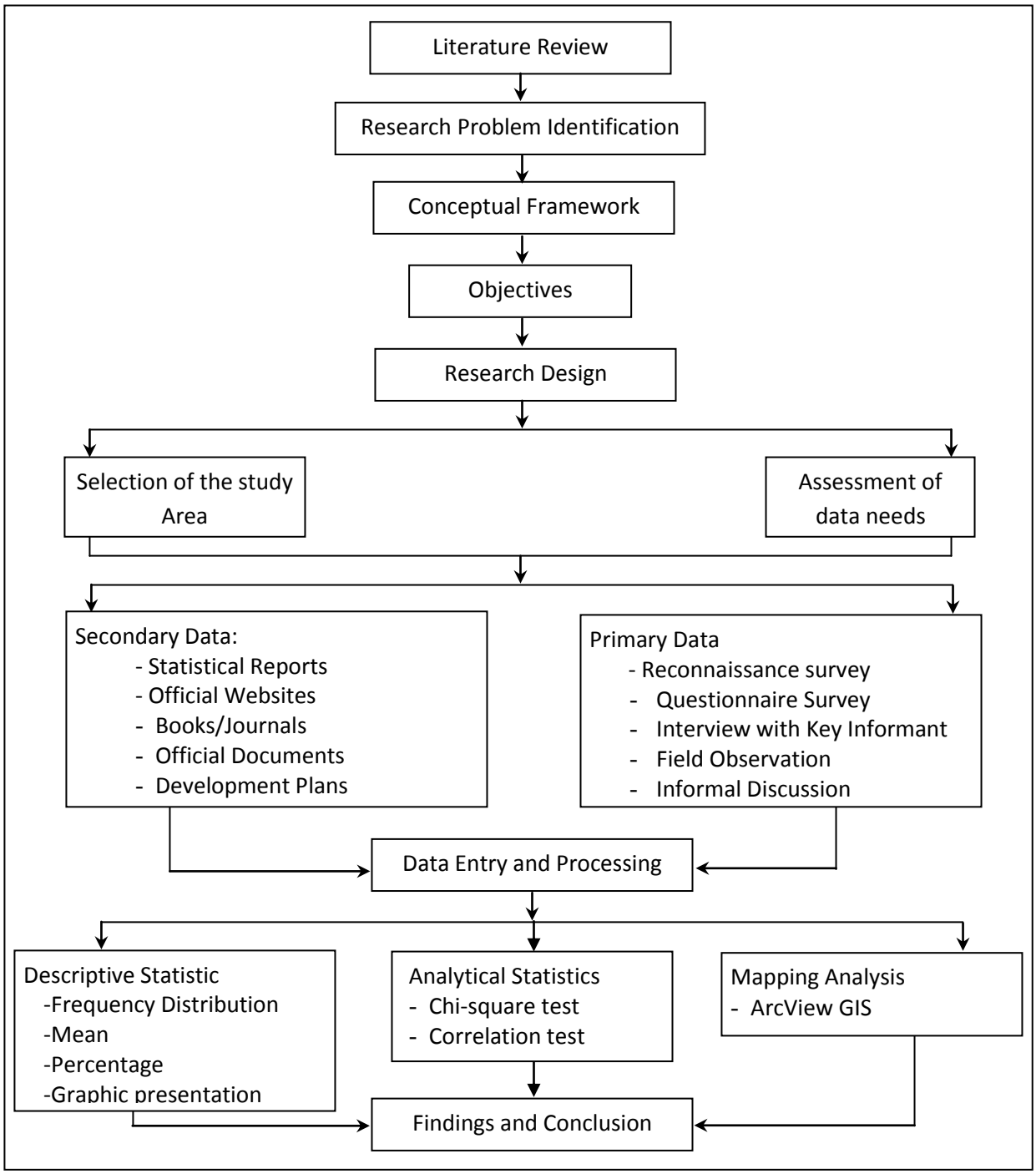


Figure 3.1 Research Design

3.3 Selection of the study area.

South-western part of Bangladesh which is severely affected by tropical cyclone Aila is the focused area for this study. The study area has been selected based on following criteria.

- Coastal region
- Aila affected area.
- Huge infrastructural loss area
- Huge households loss area
- Huge assets loss area
- Huge occupation loss area
- Huge agricultural loss area
- Huge dwellers facilities loss area

Brief description of the study area: The study area is situated in the southern part of Bangladesh, bounded over on the east and north by the Aila free area of Bangladesh, on the west by India and on the south by Bay of Bengal. The area comprises 11 districts in southern Bangladesh; including the most-affected districts Satkhira, Khulna, Bagerhat, Barguna and from them the two worst districts have been selected.

For the study three villages from two upazilas of two districts have been selected purposively. The selected villages are Sora and Chakbara from Shyamnagor upazila of Satkhira district and Patakhali from Koyra upazila of Khulna district.

The topography of the coastal area is flat low-lying land having elevation mostly 3m above the mean sea level (msl). Geologically, the area suffers from subsidence to some extent, and this is due to consolidation of the new deposits of sediments and settlement of the base strata (Hoque: 1992). It is a part of the humid tropics with the Himalayas lying in

the north and the funnel shaped coast touching the Bay of Bengal in the south. This type of geography of the country produces life-giving monsoons but also the catastrophic ravages of disasters.

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. A number of villages of coastal area of Bangladesh have been affected by Aila. Three villages from two upazilas of two districts of Aila affected area have been selected by applying purposive sampling. All of selected villages are severely affected by Aila and still now the measury of the dwellers is rigorous. On the other hand, the simple random sampling technique was used to get proportionate of household number in the villages for questionnaire survey.

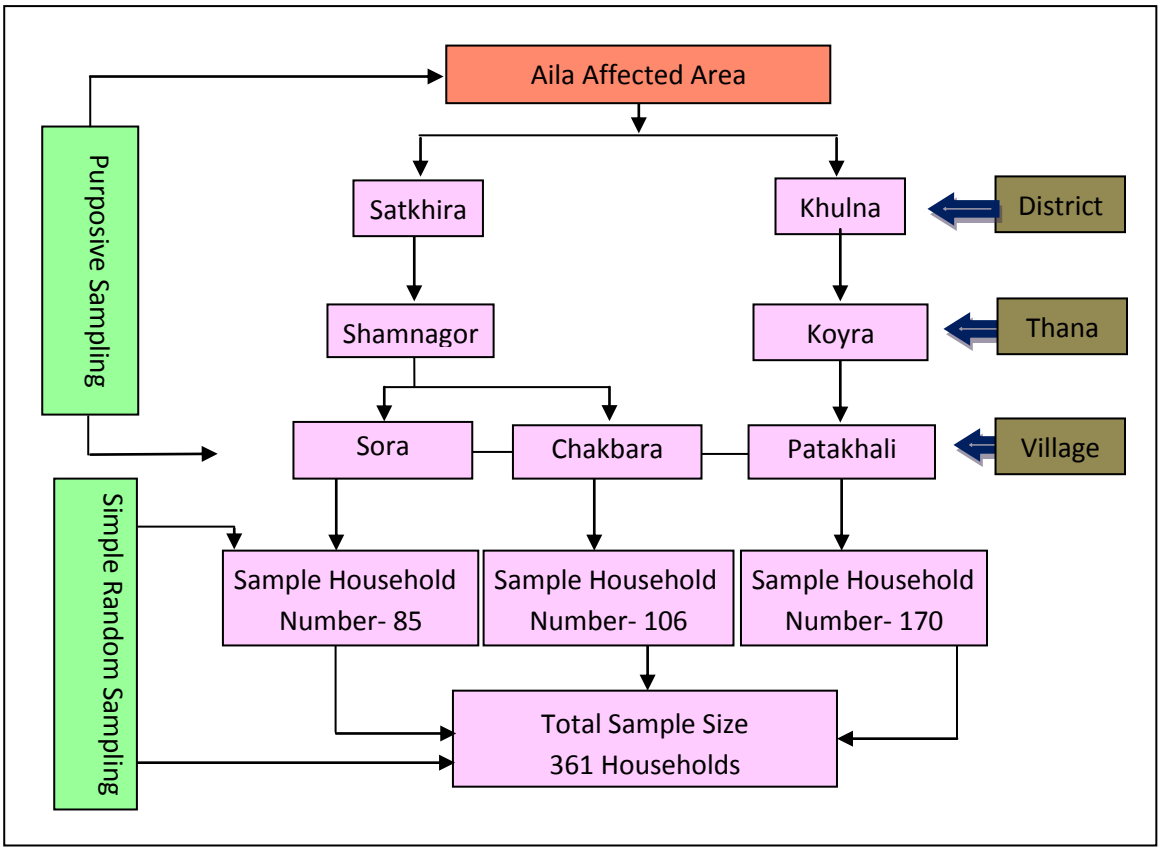


Figure 3.2 Sampling Design and Procedure

To determine the sample size, R.V.Krejcie and D. W. Morgan's (1970) method has been used. As per the determining procedure of them, 361 households out of 6177 have been selected as sample size. Out of 361 sample size 85 from Sora, 106 from Chakbara and 170 from Patakhali have taken for collecting data.

Table 3.1 Guide to minimum sample size

(95% confidence level, +/- 5% margin of error)

Population Size	Sample Size	Population Size	Sample Size
10	10	550	226
20	19	600	234
40	36	700	248
50	44	800	260
75	63	900	269
100	80	1,000	278
150	108	1,200	291
200	132	1,300	297
250	152	1,500	306
300	169	3000	341
350	184	6,000	361
400	196	9,000	368
450	207	50,000	381
500	217	100,000+	385

Source: R. V. Krejcie, and D. W. Morgan, "Determining Sample Size for Research Activities", Educational and Psychological Measurement, Vol. 30: 607-610, 1970

3.5 Sources of Data and Collection Methods

In the study both primary and secondary data are used for analysing the situation.

3.5.1 Secondary Data

By using checklist data was collected from several governmental and non-governmental offices relevant to the research. The list of sources is given in Appendix D.

Besides, coupled with research related published reports, journals, books, papers, documents, and maps have been collected from different library, Local Government Engineering Department (LGED), Dhaka and websites.

3.5.2 Primary Data

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

Reconnaissance Survey: In order to conceptualization about the current economic situations, damages and losses due to cyclone Aila and its background information; and identification the possible study area a reconnaissance survey was conducted which was helped to further study area selection, sample size determination and questionnaire finalization.

Questionnaire Survey: A questionnaire survey was conducted at household level to collect detail information regarding economic activities, its change, vulnerability and adaptation technique in the study area. The main target of this survey was to collect information on demographic characteristics such as total population, male-female ratio, working population; economic characteristics like occupation, per capita income and expenditure capacity; land namely utilization type, agricultural pattern; facilities and services available; and their effects to the development of the area.

Interview with stakeholders/key informants: Several government officials (Block Supervisor), well-informed/unbiased persons like village elder, teacher, local leader and army personnel (retired) were interviewed. The informant's feedback and perception on different economic issues were taken into account in the study.

Field Observation: During the field survey, observation procedures were adopted for careful understanding of the factual situation in the area keeping in view the effectiveness of the available facilities and the government development policies specific to the concerned question in research. The parametrical information mainly on improvement of transport network, housing quality, growth of tertiary sectors and both pull and push factors for adopting agricultural changes, occupational changes and migration were observed carefully.

Informal Discussion: In order to get broad concept and to fulfill the data gap, and to triangulate the information, several informal discussion were conducted with the different kind of recipients.

3.6 Data Analysis Techniques

The collected data is analyzed first to eliminate the unnecessary and irrelevant information through checking and verification before coding process, and then EXCELL and SPSS software was used for tabulation, analysis and graphic presentation. ArcView GIS software was also exercised for mapping analysis.

3.6.1 Quantitative Analysis

Descriptive Statistic: Frequency distribution, percentage, average and cross tabulation etc descriptive statistics are applied for analyzing data. Various statistical illustrations such as pie chart, line and bar diagram are used for graphical presentation to elaborate the economic and development situation and their consequences in the area.

Analytical Statistic: Chi Square test has conducted to find out the significant relation between the factors and indicators, and also among the indicators.

3.6.2 Mapping techniques

ArcView GIS software was applied to show the land use change and others mapping illustrations.

3.6.3 Satellite imageries and maps analysis

For the study Landsat satellite images of 2004 and 2014 are used to identify land cover change. The image of 2004 is 30 meter resolution Thematic Mapper (TM) image which was acquired in 4 November 2004. The image of 2014 is 30 meter resolution Landsat 8 image which was acquired in 26 October 2014. Source of those images are Earth Explorer. On the other hand, map of study area is collected from LGED digital map and cadastral map from local people (Amin). Later on the map is digitized in ArcGIS 9.3.

The satellite imageries and maps that are used in this study are shown in the table 3.2 and 3.3 respectively.

Table 3.2 List of Imageries Used in the study and their Attributes

No	Images	Resolution	Date of Acquisition	Source
1	Landsat 2004	30 meter	4 November 2004	Earth Explorer
2	Landsat 2014	30 meter	26 October 2014	Earth Explorer

Table 3.3 List of Maps Used in the study

No	Maps	Source
1.	District Map of Bangladesh	LGED
2.	Cadastral map of studied villages	Local people

Processing softwares: ERDAS Imagine 2014 software is used to process collected remotely sensed data especially to classify land cover change and spatial analysis. ArcGIS 9.3 used to process data in GIS operation.

Methods: ***Ground Trothing*** - The purpose of the field work for this study is to observe the study area and collect the ground truth data for land cover classification. Field work was carried out in September 2013 by using maps and GPS. An in-depth observation was done and the coordinate points all land cover of the study area was recorded accordingly. In order to take coordinate points in the area, it was stratified first in to stratum based on homogenous shape, pattern, color, etc. For each stratum in the field, random coordinate points were selected and recorded in several places, which are representatives of each stratum. A total 40 sample points were selected for the whole stratum. It was classified into - classes of land cover types which are: forest, agricultural land, settlement, water bodies, aquaculture, and bare land.

Land Cover Change Analysis - A time-series analysis was conducted to detect change using 2 different images from 2004 and 2014. This analysis was done using ERDAS Imagine 2014 and Arc GIs software

3.6.4 Weight measuring techniques

There are many techniques to measure weight of indicators. To assign weight the 0 – 1 or 1 – 0 transformation techniques has been followed here.

Calculation: To calculate transform value following formula has been used:

R = Maximum value of the indicator i – Minimum value of the indicator i,

$= X_{i(max)} - X_{i(min)}$

Transform Value (TV) $= \frac{X_{ij} - X_{i(min)}}{R}$

Here, $X_{ij} = X_i$ value of j district

$\underline{X_{i(min)}}$ = Minimum X_i value among the districts

TV = 0 , when $X_{ij} = X_{i(min)}$

TV = 1 , when $X_{ij} = X_{i(max)}$

Total Transform Value (TV)= (TV_1+TV_2+TV_3+TV_4+TV_5) for each area.

Chapter 4

General Descriptions of the Study Area

This chapter includes general information of the study villages. In the light of objectives of the study population size, households, their occupation, savings, general and agricultural land use, infrastructure etc are discussed.

4.1 Population and household size

In terms of population all the villages are large in size. Among the study villages Sora has highest and Patakhali has lowest number of population. Table 4.1 indicates that in all three villages, female population is higher than the male population, and the difference is the highest in Chakbara. As per population census 2011, male-female ratio of Satkhira district 49:51. Except Sora, male-female ratio is higher than the Satkhira district. It should be kept in mind that literatures related to cyclone vulnerability indicate females and child are more vulnerable than male. On the other hand, in terms of number of households Sora is the largest and Patakhali is the smallest among the study villages.

Table 4.1 Population and household number of the study villages

		Sora		Chakbara		Patakhali	
		Number	Percentage	Number	Percentage	Number	Percentage
Population	Total	5593	100	2428	100	844	100
	Male	2747	49.20	1149	47.32	413	48.93
	Female	2846	50.80	1279	52.68	431	51.07
Household		1191		551		199	

Source: Population census 2011 (Community series)

4.2 Density of population

Bangladesh is one of the most densely populated countries in the world. Its current population density is 1015 person/km^2. On the other hand, population density of Satkhira

and Khulna district is 520 and 528 person/km^2 respectively. Table 4.2 shows that the density of population in Sora and Chakbara villages is much higher than their district (Satkhira) population density. Even it is higher than the national population density (1015 Person/km^2). So, it indicates that the area is more vulnerable to any natural event if taken place there.

Table 4.2 Population density of the study villages

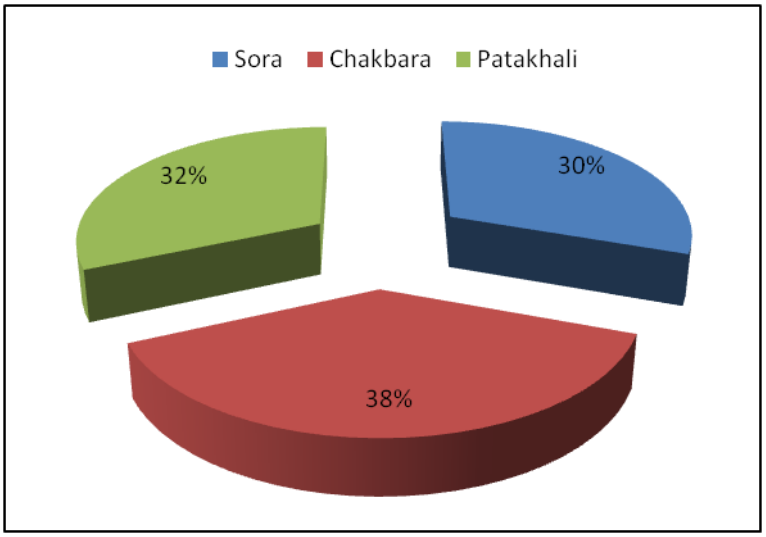
(Density in per square kilometer)

	Sora	Chakbara	Patakhali
Area (Kilometer)	4.42	2.01	2.16
Density (Population/Sq. Km)	1265	1207	390

Source: Population census 2011 (Community series)

On the other hand population density of Patakhali village is close to its district population density (528 Person/km2).

4.3 Literacy



Source: Population census 2011 (Community series)

Figure 4.1 Literacy rate of the study area, 2015

The chart above gives information about the literacy rate of the study villages. Among the study villages literacy rate of Chakbara village is slightly higher than the other two villages. But in all three villages the literacy rate is below the national and their district literacy rate. Hence, the literacy rate of Bangladesh, Satkhira and Khulna district is 51.8 %, 52.1% and 60.1% respectively. So, it can be said that the area is backward in terms of education.

4.4 Occupation

People's economic activities are related to production, exchange and consumption and on the basis of production economic activities can be classified as primary, secondary and tertiary economic activities (Alexander, 1988). Now a day, tertiary economic activities are classified as tertiary and quaternary. Bangladesh is basically rural dominated country. More than 70% of populations live in village area. One of the main characteristics to distinguish rural-urban area is economic activities. The main economic activities of Rural areas is primary economic activities whereas in urban areas secondary and tertiary economic activities predominant.

Table 4.3 Occupation of the inhabitant of the study area

(Figures are in percentage)

Main occupation

	Sora	Chakbara	Patakhali
Fishing	45.30	28.33	28.10
Farmer	15.10	15.00	9.40
Service	3.50	6.70	4.70
Labour	23.30	33.30	37.50
Carpenter	2.30	3.30	3.10
Shopkeeper	2.30	6.70	4.70
Motor cycle driver	3.50	1.70	4.70
Boatman	1.20	1.70	0.00
Poultry	0.00	1.70	0.00
Others	3.50	1.70	7.80
Total	100.00	100.00	100.00

Supplementary occupation

	Sora	Chakbara	Patakhali
Fishing	26.70	33.30	46.90
Farmer	5.80	8.30	15.60
Service	1.20	0.00	0.00
Labour	40.70	18.30	28.10
Carpenter	3.50	1.70	0.00
Poultry	0.00	1.70	0.00
Shopkeeper	2.30	0.00	3.10
Motor cycle driver	3.50	0.00	1.60
Others	16.30	36.70	4.70
Total	100.00	100.00	100.00

Source: Field survey, 2015

Table 4.3 indicates that people of the study area involve both in main and supplementary occupation. It can be said from the table that almost all the people of the study villages involve with primary economic activities. A very few number are involved with tertiary economic activities. In Sora village, 45.30% people accept fishing, 23.30% daily basis work, 15.10% farming, 3.5% service and 3.50% motorcycle driver as main profession. Similarly, 26.70% fishing, 40.70% daily basis work and 5.80% farming are found as supplementary occupation.

On the other hand, majority people of Chakbara village depend on daily labour (33.30%) and fishing (28.33%) as their main occupation. But as supplementary occupation 33.30% involve with fishing, 18.30% with daily basis work and 8.30% with farming.

As like Chakbara, most of the people of Patakhali village involve with daily basis work (37.50%) and fishing (28.10%) as their main occupation. Few (4.70%) depends on grocery shops. If we see the supplementary occupation pattern of Patakhali village, 46.90% people involves with fishing, 28.10 % with daily labour and 15.60 % with agriculture. Moreover, few people of all three villages accept motor cycle service as their main and supplementary occupation.

4.5 Income

It can be seen from the following table that people of the study villages earn money from both main and supplementary sources. Maximum number of people of Sora (52.33%) and Chakbara(48.33%) villages earn 6000-9000 taka per month from their main source of income. Whereas, maximum number of population of Patakhali village (46.88%) earn from 3000 to 6000 taka per month from their main source of income. Moreover, 25.58% and 19.77% population of Sora village earn per month 9000-12000 taka and 3000-6000 taka respectively; 23.33% and 16.67% population of Chakbara village earn per month 3000-6000 taka and 9000-12000 taka respectively; 29.69% and 17.19 % population earn per month 6000-9000 taka and 9000-12000 taka respectively from their main source of income. If we see the supplementary income most of the three study villages earn less than 2000 taka per month. Also a remarkable percentage of people of the areas earn 2000-4000 taka per month.

Table 4.4 Income pattern of the study villages, 2015

(Figures are in percentage)

		Sora	Chakbara	Patakhali
Income from main sources	<3000 tk.	1.16	1.67	0.00
	3000-6000 tk.	19.77	23.33	46.88
	6000-9000 tk.	52.33	48.33	29.69
	9000-12000 tk.	25.58	16.67	17.19
	12000< tk.	1.16	10.00	6.25
	Total	100.00	100.00	100.00
Income from supplementary sources	<2000 tk.	50.00	66.67	60.94
	2000-4000 tk.	38.37	23.33	32.81
	4000-6000 tk.	10.47	3.33	6.25
	6000-8000 tk.	1.16	3.33	0.00
	8000< tk.	0.00	3.33	0.00
	Total	100.00	100.00	100.00
Total income	<5000 tk.	0.00	0.00	0.00
	5000-10000 tk.	46.51	25.00	54.69
	10000-15000 tk.	40.70	46.67	43.75
	15000-20000 tk.	11.63	18.33	1.56
	20000< tk.	1.16	10.00	0.00
	Total	100.00	100.00	100.00

Source: Field survey, 2015

The table also provides information on total income. It is found that income of most of the respondents is from 5000-10000 and 10000-15000 taka range. A remarkable percentage of respondents are from 15000- 20000 taka in Sora and Chakbara villages. Whereas in Patakhali village 15000 taka and above classes are very limited. Again, 1.16% people of Sora and 10% people of Chakbara income is more than 20000 taka. So, it can be said that in term of income Chakbara is better than other two villages.

4.6 Expenditure

Expenditure pattern of the study villages is discussed on the basis of monthly expenditure for cloth, food, treatment, drinking water, and others. Most of the respondents monthly cost for cloth is 300-600 taka. Besides, more than 30 percent respondents of Sora and

Chakbara monthly cost for cloth is 600-900 taka whereas 20.31 percent respondents of Patakhali cost for cloth is less than 300 taka.

Again, majority respondent of Sora (30.23%) and Chakbara (31.67%) monthly cost for food is 4000-5000 taka whereas majority respondents of Patakhali village monthly cost for food is 2000-3000 taka.

Almost one-third of respondents of Sora pay per month 300-400 taka 40% people of Chakbara pay per month 200-300 taka and 48.44 percent respondents of Patakhali pay per month 100-200 taka for treatment purpose. The information provided in the table 4.5 indicates that expenditure for treatment purpose in Sora is higher than other two villages.

The study area is a water scarcity area in terms of drinking and households use water. Though the underground water of Patakhali village is available and suitable for drinking and daily uses, and the inhabitant have no need to pay. But the ground water of Sora and Chakbara villages is contaminated by saline and people use pond water for drinking and cooking purpose. Almost all the people of these two villages get pond water free of cost. There is a water purification plant in Chakbara village and about 18% people of this village pay 200-400 taka per month for getting the purified water of this plant. Besides, very few people of Sora village pay 300-400 taka per month for this purpose.

From the table 4.5 it can be said that the expenditure for other purpose of Chakbara village is higher than the other two villages.

In case of total expenditure, most of the people of all three villages' people spend 6000-9000 taka per month and second highest portion people spend 3000-6000 taka per month as total monthly expenditure in these villages. However, more people of Chakbara village spend 9000-12000 taka which is more than other two villages.

Table 4.5 Expenditure pattern of the study villages, 2015

		Sora	Chakbara	Patakhali
Cloth	<300 tk.	1.16	8.33	20.31
	300-600 tk.	55.81	53.33	68.75
	600-900 tk.	33.72	30.00	9.38
	900-1200 tk.	6.98	5.00	1.56
	1200-1500 tk.	2.33	3.33	0.00
	Total	100.00	100.00	100.00
Food	<2000 tk.	1.16	0.00	3.13
	2000-3000 tk.	16.28	15.00	67.19
	3000-4000 tk.	23.26	30.00	25.00
	4000-5000 tk.	30.23	31.67	3.13
	5000< tk.	29.07	23.33	1.56
	Total	100.00	100.00	100.00
Treatment	<100 tk.	1.16	0.00	4.69
	100-200 tk.	4.65	26.67	48.44
	200-300 tk.	27.91	41.67	4.69
	300-400 tk.	33.72	15.00	25.00
	400-500 tk.	16.28	10.00	6.25
	500< tk.	16.28	6.67	10.94
	Total	100.00	100.00	100.00
Drinking water	0 tk.	98.84	65.00	100.00
	100-200 tk.	0.00	15.00	0.00
	200-300 tk.	0.00	15.00	0.00
	300-400 tk.	1.16	3.33	0.00
	400< tk.	0.00	1.67	0.00
	Total	100.00	100.00	100.00
Others	<500 tk.	17.44	5.00	93.75
	500-1000 tk.	19.77	28.33	0.00
	1000-1500 tk.	34.88	36.67	0.00
	1500-2000 tk.	22.09	23.33	0.00
	2000< tk.	5.81	6.67	0.00
	Total	100.00	100.00	100.00
Total expenditure	<3000 tk.	3.49	1.67	3.13
	3000-6000 tk.	34.88	31.67	26.56
	6000-9000 tk.	60.47	53.33	65.63
	9000-12000 tk.	1.16	11.67	4.69
	12000< tk.	0.00	1.67	0.00
	Total	100.00	100.00	100.00

Source: Field survey, 2015

4.7 Saving

Saving of the people of the study area is very small in amount. Most of the people of the study villages monthly saving is 1000-2000 taka per month. Moreover, a remarkable percent people of these villages monthly saving is less than 1000 taka. Saving of 18.60%, 18.33% and 17.19% people of Sora, Chakbara and Patakhali villages respectively is range from 2000 to 3000 taka. It can be said from the table 4.6 that in terms of more than 3000 taka per month saving Chakbara is in better position than other two villages.

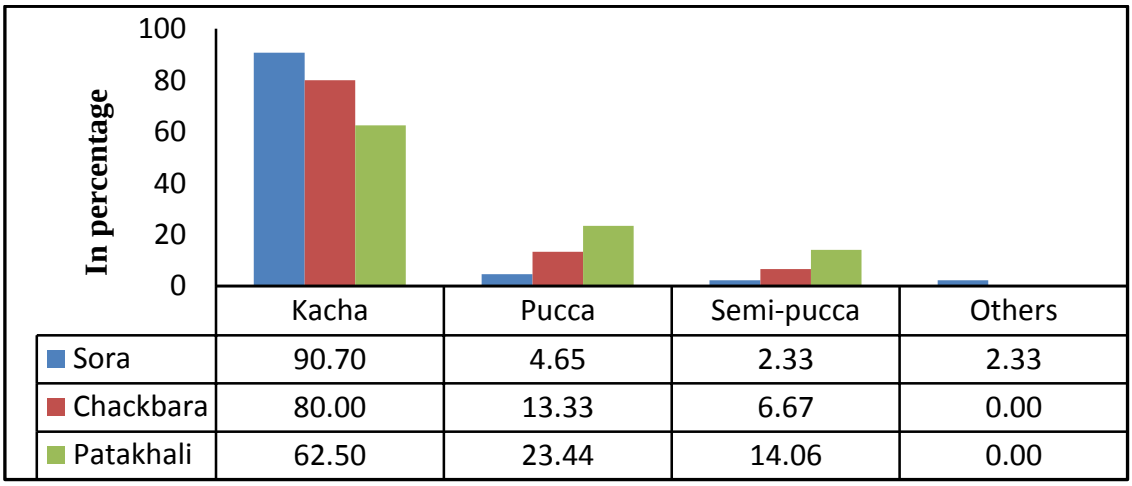
Table 4.6 Saving pattern of the study villages, 2015

	Sora	Chakbara	Patakhali
<1000 tk.	36.05	21.67	32.81
1000-2000 tk.	41.86	46.67	42.19
2000-3000 tk.	18.60	18.33	17.19
3000-4000 tk.	2.33	8.33	6.25
4000< tk.	1.16	5.00	1.56
Total	100.00	100.00	100.00

Source: Field survey, 2015

4.8 Housing status

Urban and rural areas of Bangladesh can be identified on the basis of the housing structure. Almost all the urban houses are pucca and semi-pucca whereas rural houses are kacha or semi-pucca.



Source: Field Survey, 2015

Figure 4.2 Housing structure of the study area, 2015

Figure 4.2 indicates that in all three villages more than 75% houses are kacha, 4 to 22% pucca and 2 to 7% semi-pucca. In Sora village 90.70, 4.65, 2.33 and 2.33 % houses are kacha, pucca, semi-pucca and others respectively. On the other hand, 80% house kacha, 13.33% house pucca and 6.67% house semi-pucca are found in Chakbara village. Majority portion houses are kacha in Patakhali village also. But in term of pucca house Patakhali village is better than other two villages.

4.9 Toilet facilities

Table 4.7 provides information about on toilet facilities of the study villages. It can be seen from the table that only Sora village has Sanitary (water sealed) toilet and it is also only 2.33 percent. Most of the residence use unhygienic toilet. There are 62.79, 70.00 and 79.69 percent Non-sanitary toilet in Sora, Chakbara and Patakhali respectively. Moreover, a condiderable portion inhabitant use Sanitary (non-water sealed) toilet and it is 13.95, 30.00 and 20.31 percent in Sora, Chakbara and Patakhali village respectively. Still now a number of population (20.93%) of Sora village use open space.

Table 4.7 Toilet facilities of the study villages, 2015

(Figures are in percentage)

	Sora	Chakbara	Patakhali
Sanitary (water sealed)	2.33	0.00	0.00
Sanitary (without-water sealed)	13.95	30.00	20.31
Non-sanitary/unhygienic	62.79	70.00	79.69
Others/ open space	20.93	0.00	0.00
Total	100.00	100.00	100.00

Source: Field Survey, 2015

4.10 Sources of drinking water

Pure drinking water is an important element for lives. But a drinking water scarcity is found in all the study villages except Patakhali. In Sora village, 94.19 percent people use pond water and 5.18 percent people use rain water for drinking purpose. Besides, people

of Chakbara village use rain water for few months on the basis of reserve and rest of the months use pond water for drinking purpose. People of these two villages are suffering severely for pure drinking water because underground water is highly contaminated by salinity. On the other hand 100 percent inhabitants of Patakhali village use tube-well water for drinking purpose.

Table 4.8 Sources of drinking water of the study villages, 2015

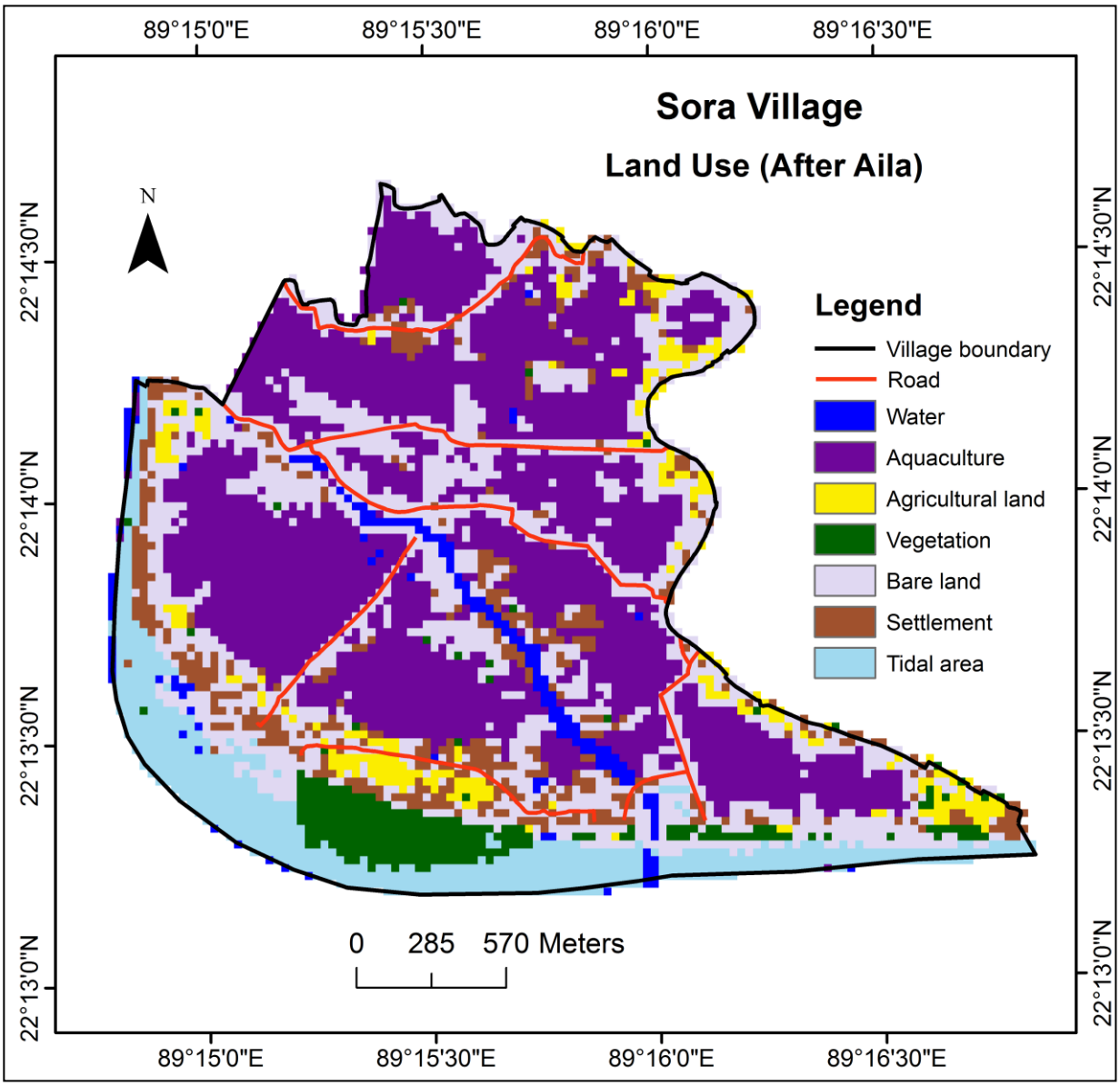
(Figures are in percentage)

	Sora	Chakbara	Patakhali
Pond	94.19	0.00	0.00
Rain water	5.81	0.00	0.00
Pond and rain water	0.00	100	0.00
Tube-well	0.00	0.00	100
Total	100	100	100

Source: Field Survey, 2015

4.11 Land use

World land use trend indicates that rural land use is mainly dominated by the agriculture, while the urban land use is dominated by the non-agriculture basically homestead use (Rahman, 2009). The study area is a rural area. For this reason most of the land is devoted to agriculture and its allied use. The following figure and table indicate recent land use pattern and information of Sora village. Aquaculture, particularly shrimp cultivation is the prominent land use pattern of the village. 41.11 % land is engaged with shrimp cultivation followed by settlement 8.39%, bare land 28.65%, tidal area 10.67%, vegetation 4.31% and water bodies 2.70% land.



Source: Image processing, 2014

Figure 4.3 Land use pattern of Sora village, 2014

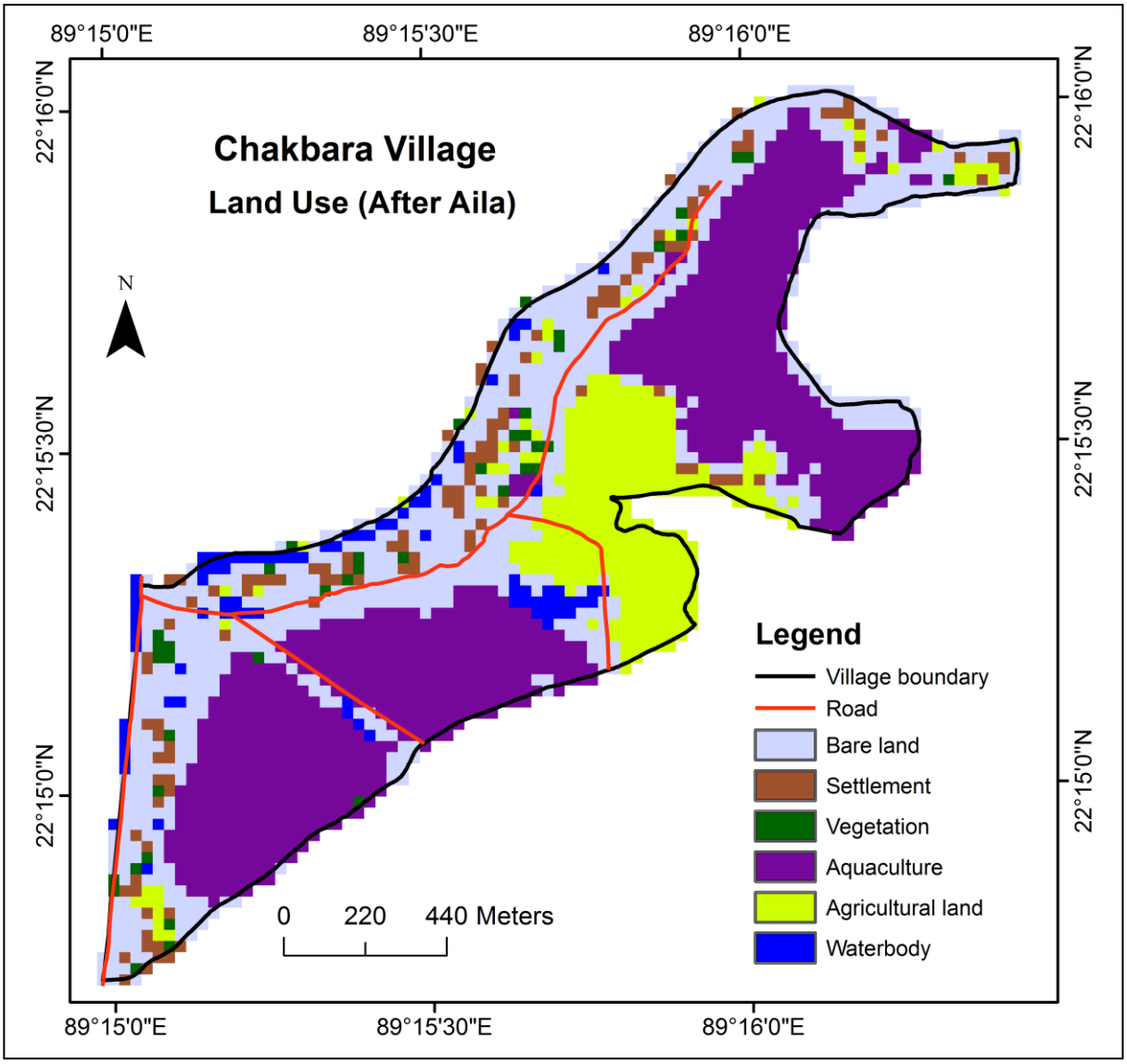
Table 4.9 Land use pattern of Sora village, 2014

(Figures are in percentage)

	Water bodies	Aquaculture	Agricultural land	Vegetation	Settlement	Bare land	Tidal area	Total
Area (acres)	37.58	573.11	58.27	60.05	116.98	399.42	148.78	1394.19
Percentage	2.70	41.11	4.18	4.31	8.39	28.65	10.67	100

Source: Image processing, 2014

Like Sora, prominent land use in Chakbara is aquaculture (shrimp cultivation). The highest amount (40.27%) of land devotes for shrimp cultivation. Second highest category is agriculture which occupies 13.90% land. Settlement covers 5.28%, water bodies3.63%, and vegetation1.80% of total land.



Source: Image processing, 2014

Figure 4.4 Land use pattern of Chakbara village, 2014

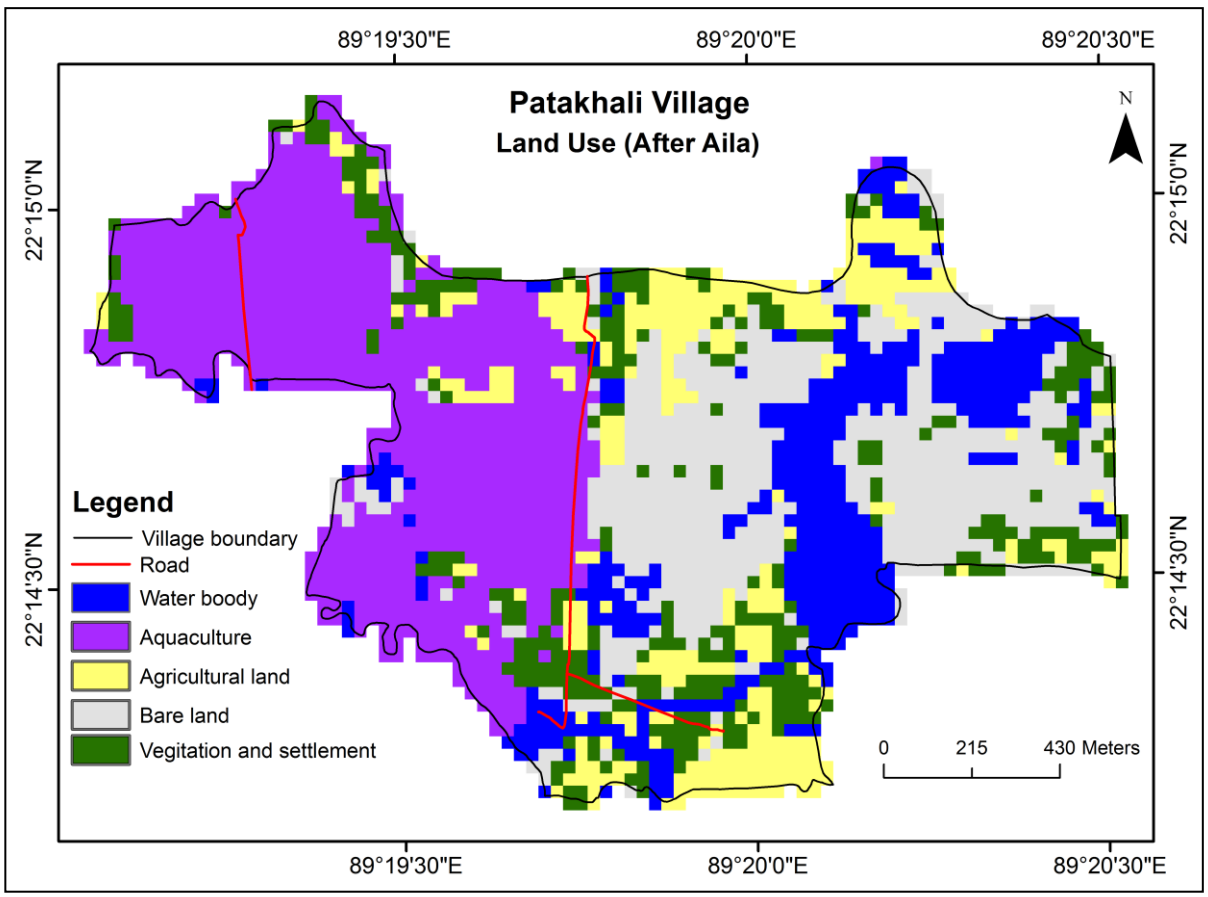
Table 4.10 Land use pattern of Chakbara village, 2014

(Figures are in percentage)

	Water bodies	Aquaculture	Agricultural land	Vegetation	Settlement	Bare land	Total
Area (acres)	18.68	207.50	71.61	9.3	27.80	180.36	515.25
Percentage	3.63	40.27	13.90	1.80	5.40	35.00	100.00

Source: Image processing, 2014

From figure 4.5 and table 4.11, it is found that the highest percent land (33.04%) of Patakhali village is engaged with aquaculture (shrimp cultivation). 16.36 percentage of land is under water body which is fully unproductive. 13.21 % land uses as homestead vegetation and settlement. Only 13.40 % land cultivates for agricultural purpose.



Source: Image processing, 2014

Figure 4.5 Land use pattern of Patakhali village, 2014

Table 4.11 Land use pattern of Patakhali village, 2014

(Figures are in percentage)

	Water bodies	Aquaculture	Agricultural land	Vegetation and settlement	Bare land	Total
Area (acres)	93.40	188.60	76.50	75.40	136.98	570.88
Percentage	16.36	33.04	13.40	13.21	23.99	100

Source: Image processing, 2014

About one-fourth of land is bare which is either fallow or few portion of it using as kaccha road.

Agricultural land use

Agricultural land uses are discussed under four categories such as aquaculture, crops, vegetables & fruits and others. From table 4.12 it can be said that in all the study villages except few exceptions more than 80% people are not involved with any one type of cultivation. Those are involved with agriculture most of them are shrimp cultivator also. In Sora 6.98 % people have either 0-.333 acres or .333-.666 acres shrimp firm. But in Chakbara 8.3 % respondents have more than 1.666 acres of aquatic land. Besides, few respondents have other sizes of land in both Sora and Chakbara villages. On the other hand in Patakhali village only 1.56% respondents have less than .333 acres shrimp firm.

In case of crop cultivation more land of Chakbara is devoted than other two villages. In both Sora and Chakbara villages, different types of crops land are exist but in Patakhali only small crop land can be seen.

On the other hand vegetables and fruits cultivation was found in Chakbara.

Table 4.12 Agricultural land use pattern of the study area, 2015

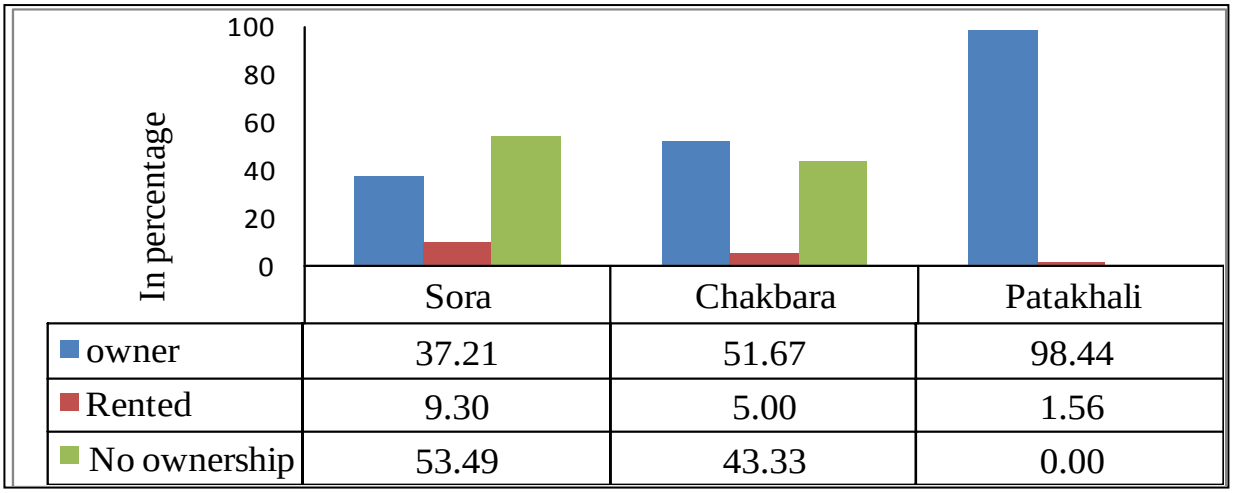
(Figures are in percentage)

	Aquaculture			Crops			Vegetables and fruits			Others		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Not cultivating	82.56	80.00	98.44	87.21	63.33	92.19	100.00	96.67	100.00	97.67	98.33	100.00
0-.333 acres	6.98	1.67	1.56	6.98	5.00	6.25	0.00	3.33	0.00	2.33	1.67	0.00
.333-.666 acres	6.98	1.67	0.00	1.16	10.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00
.666-1 acres	1.16	6.67	0.00	3.49	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-1.333 acres	1.16	1.67	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.666 + acres	1.16	8.33	0.00	1.16	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: Field survey, 2015

4.12 Land ownership

Land is an essential ingredient of economic activities. All the economic activities take place on land. So, land ownership has a positive co-relation with the livelihood pattern of an area. From the figure 4.6, it can be said that inhabitant of Patakhali have almost cent percent (98.44%), Chakbara almost fifty percent (51.67%) and Sora almost one-third (37.21%) land ownership. So, in terms of land ownership both Sora and Chakbara are in lag behind.



Source: Field Survey, 2015

Figure 4.6 Land ownership pattern of the study area, 2015

Table 4.13 provides homestead and agricultural land ownership pattern of the study villages. In case of homestead land most of the people of all three villages have small patch of homestead land. 69.77% population of Sora, 46.67% population of Chakbara and 62.50% population of Patakhali village have less than 5 decimals homestead land. While 19.77 % land owners of Sora village have more than 20 decimals, 21.67% land owners of Chakbara village have more than 20 decimals and 23.44% land owners of Patakhali village have 5-10 decimals homestead land. Few land owners of all three villages have 10-15 or 15-20 decimals homestead land.

In case of agricultural land most of respondents have no agricultural land. 12.79% of Sora, 13.33% of Chakbara and 15.63% of Patakhali respondents have less than 1 bigha agricultural land. Few people have more than 5 bighas agricultural land in all the study villages except Patakhali. Again, 5.81% of Sora, 8.33% of Chakbara and 1.56% of Patakhali land owners have 1-2 bighas land. Moreover, small percent of land owners of all villages have 3-5 bghas land.

Table 4.13 Homestead and agricultural land ownership pattern of the study area, 2015

(Figures are in percentage)

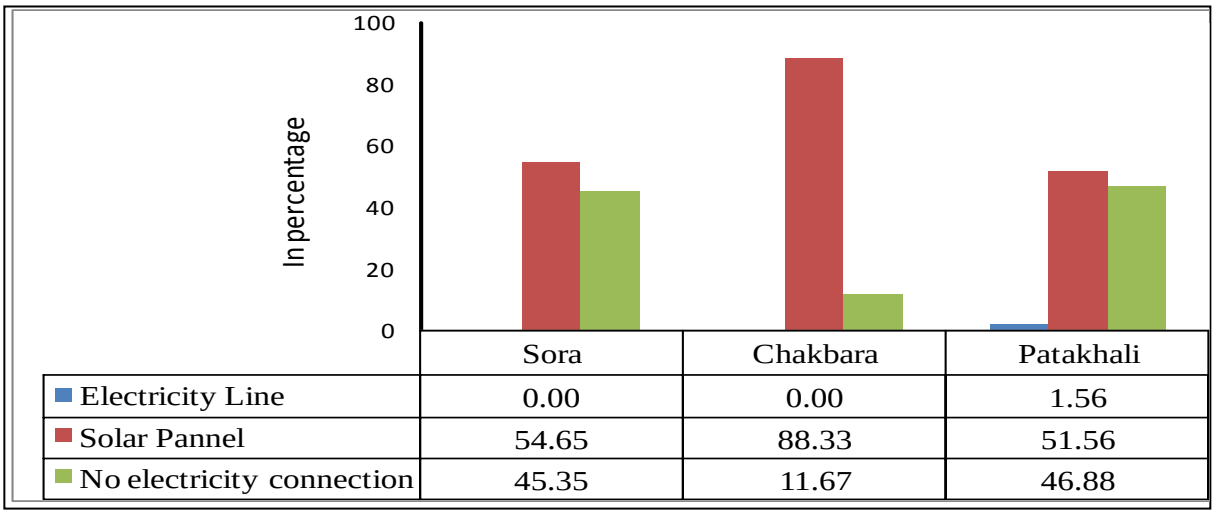
		Sora	Chakbara	Patakhali
Homestead land	< 5 decimals	69.77	46.67	62.50
	5-10 decimals	3.49	13.33	23.44
	10-15 decimals	4.65	13.33	3.13
	15-20 decimals	2.33	5.00	4.69
	20< decimals	19.77	21.67	6.25
	Total	100.00	100.00	100.00
Agricultural land	0 Bigha	69.77	53.33	81.25
	0-1 Bigha	12.79	13.33	15.63
	1-2 Bigha	5.81	8.33	1.56
	2-3 Bigha	2.33	6.67	0.00
	3-4 Bigha	2.33	0.00	0.00
	4-5 Bigha	2.33	3.33	1.56
	5+ Bigha	4.65	15.00	0.00
	Total	100.00	100.00	100.00

Source: Field survey, 2015

4.13 Household equipments

4.13.1 Power connection

From figure 4.7 it can be said that in all three villages have no electricity. But the villages are facilitated by solar power. In Sora 54.65%, in Chakbara 88.33% and in Patakhali 51.56% households have solar power. Rest has no either electricity or solar power connection.



	Sora	Chakbara	Patakhali
Electricity Line	0.00	0.00	1.56
Solar Pannel	54.65	88.33	51.56
No electricity connection	45.35	11.67	46.88

Source: Field Survey, 2015

Figure 4.7 Power connection pattern of the study area, 2015

Hence, the villages are not facilitated by electricity connection and have small solar panel only for light, the people have no other electricity operated equipments like fridge, fan, television, rice cooker etc.

4.13.2 Cell phone

In case of mobile phone, 67.44% of Sora, 73.33% of Chakbara and 78.13% of Patakhali respondents have 1 cell phone. But a remarkable percent of people of three villages do not have any cell phone. On the other hand few people of Sora village have 2 cell phones and Chakbara have 2 to 4 cell phones.

Table 4.14 Number of cell phone of the study villages, 2015

	Sora	Chakbara	Patakhali
No cell phone	31.40	11.67	21.88
1 cell phone	67.44	73.33	78.13
2 cell phone	1.16	10.00	0.00
3 cell phone	0.00	1.67	0.00
4 or more cell phone	0.00	3.33	0.00
Total	100.00	100.00	100.00

Source: Field Survey, 2015

4.13.4 Other resources

In all three villages, most of the respondents have less than 1000 taka equivalent household resource. 15.12% respondents of Sora, 18.33% respondents of Chakbara and 26.56% respondents of Patakhali have 1000-4000 taka equivalent household resources. Again, in Sora 6.98%, Chakbara 13.33% and Patakhali 1.56% respondents have more than 14000 taka equivalent household resources. While, few respondents of all villages have 4000-14000 taka equivalent household resources.

Table 4.15 Other resources in the study area, 2015

(Figures are in percentage)

	Sora	Chakbara	Patakhali
<1000 tk.	61.63	45.00	54.69
1000-4000 tk.	15.12	18.33	26.56
4000-7000 tk.	4.65	10.00	7.81
7000-10000 tk.	6.98	8.33	6.25
10000-14000 tk.	4.65	5.00	3.13
14000< tk.	6.98	13.33	1.56
Total	100.00	100.00	100.00

Source: Field Survey, 2015

Chapter 5

Change Analysis

The following chapter furnishes some information of changes that has taken places in the study villages. Here emphasis are given on socio-economic indicators such as dependent-independent population, occupation, income, expenditure capacity, land ownership, general and agricultural land use, household resources, infrastructures etc.

5.1 Change in number of population and household

Cyclone Aila has brought change in number of population and household of the affected area. Though the number of population has increased in Sora and Chakbara village but it has decreased in Patakhali. It is found that in Sora male, female and total population have increased. In Chakbara though an increasing trend found in total and female population but a decreasing trend is found in male population. On the other hand, in Patakhali, total, male and female population have decreased by 1.26, 1.11 and 1.39 percent per year respectively. Change in male and female population indicates that male migrate for the earning is the main cause of decreasing population.

Table 5.1 Change in number of population and households of the study villages

(Figures are in percentage)

		Sora			Chakbara			Patakhali		
		Before Aila	After Aila	Change (%/year)	Before Aila	After Aila	Change (%/year)	Before Aila	After Aila	Change (%/year)
Population	Total	5267	5593	.61	2322	2428	.45	966	844	-1.26
	Male	2629	2747	.44	1177	1149	-2.37	465	413	-1.11
	Female	2538	2846	1.21	1145	1279	1.17	501	431	-1.39
Household		993	1191	1.99	459	551	2.00	183	199	.87

Source: Calculated from population census 2001 and 2011 (Community series)

Though both positive and negative change are found in number of population but only positive change can be seen in household number in all three villages. The national growth rate of household number per year is 2.33% (BBS, 2011). It is observed that

household growth rate in all three villages is lower than the national growth rate. This trend indicates that Sora, Chakbara and Patakhali are the most Aila affected villages.

5.2 Change in density of population

Followed by the change in number of population of the study area the population density has been increased in Sora and Chakbara village and has been decreased in Patakhali village. The national population density was 964 persons/sq. km in 2011, and 834 persons/sq. km in 2001. During this period the annual growth rate was 1.55 person/sq. km. The low increasing rate and negative trend in change of population density of the study area indicate that people have migrated to any another safe place for their shelter and better earning opportunity.

Table 5.2 Change in population density of the study villages

(Density in per square kilometer. Change indicates percent per year)

	Sora			Chakbara			Patakhali		
	Before Aila	After Aila	Change (%)	Before Aila	After Aila	Change (%)	Before Aila	After Aila	Change (%)
Area (Kilometer)	4.42	4.42	0	2.01	2.01	0	2.16	2.16	0
Density (Population/Sq. Km)	1191	1265	.62	1155	1207	.45	447	390	-1.2

Source: Population census 2001 and 2011 (Community series)

5.3 Change in literacy rate

The literacy rate of Bangladesh in 2011 was 56.09 percent and growth rate was 1.39 percent per year. In term of literacy the Aila affected area is backward area. Among the study villages both literacy rate and its growth rate in Patakhali are higher than the other two villages. Yearly growth rate of literacy in Sora, Chakbara and Patakhali was 0.97, 0.39 and 1.29 percent respectively.

Table 5.3 Change in literacy rate of the study villages

(Figures are in percentage. Change indicates per year)

Sora			Chakbara			Patakhali		
Before Aila	After Aila	Change	Before Aila	After Aila	Change	Before Aila	After Aila	Change
22.90	32.6	0.97	36.88	40.8	.392	20.90	33.8	1.29

Source: Population census 2001 and 2011 (Community series)

5.4 Change in Occupation

Cyclone Aila has an unpleasant impact on occupational of the study area. With the land use change it has brought massive change in people's earning sources. Change in occupation is discussed here on the basis main and supplementary occupation.

5.4.1 Main occupation

On the basis of the provided information on the table 5.4 it can be said that after Aila people has diverted their occupation mainly from fishing and farming to service and day labour. In Sora, before Aila 53.50% people was involved with fishing which is 45.30% after Aila; before Aila 20.90% was involved with farming which is 15.10% after Aila; before Aila 14% was involved with day labour which is 23.30% after Aila and 1.20% was involved with motor cycle driving which is 3.50% after Aila.

In Chakbara, before Aila 48.30%, 18.30%, 11.70% and 1.67 % people was involved with fishing, farming, labour and motorcycle driving respectively which are 28.33%, 15.00%, 33.33% and 1.70% respectively after Aila.

In Patakhali village, before Aila 34.40% people was involved with fishing which is 28.10% after Aila; before Aila 12.50% people was involved with farming which is 9.40% after Aila; before Aila 39.10% people was involved with day labour which is 37.50% after Aila; before Aila 1.6% people was involved with motorcycle driving which is 4.70%

after Ail. Besides, change in other occupation such as service, carpenter, shopkeeper etc is very limited.

Table 5.4 Change in main occupation of the study villages

(Figures are in percentage)

	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Fishing	53.50	48.30	34.40	45.30	28.33	28.10
Farmer	20.90	18.30	12.50	15.10	15.00	9.40
Service	2.30	6.70	3.10	3.50	6.70	4.70
Labour	14.00	11.70	39.10	23.30	33.30	37.50
Carpenter	2.30	3.33	1.60	2.30	3.30	3.10
Shopkeeper	1.20	6.67	3.10	2.30	6.70	4.70
Motor cycle driver	1.20	1.67	1.60	3.50	1.70	4.70
Boatman	2.30	1.67	0.00	1.20	1.70	0.00
Poultry	0.00	0.00	0.00	0.00	1.70	0.00
Others	2.30	1.67	4.60	3.50	1.70	7.80
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.4.2 Supplementary occupation

As like main occupation, most of the people are evolved with either fishing or working as day labour or working as agricultural day labour or driving motorcycle as their supplementary occupation. In Sora, before Aila 30.20% people was involved with fishing, 41.90% was involved with day labour, 2.30% was involved with motorcycle driving whereas after Aila 26.70% was involved with fishing, 8.30% was involved with farming, 40.70% was involved with daily labour and 3.50% was involved with motorcycle driving as their supplementary occupation.

In Chakbara village 33.30%, 8.30% and 18.30% people are involved with fishing, farming and day labour respectively as their supplementary occupation. But before Aila 15.00%, 10.00%, 31.70% and 1.67% people was involved with fishing, farming, daily laboring and motorcycle driving as their supplementary occupation.

Table 5.5 Change in supplementary occupation of the study area

(Figures are in percentage)

	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Fishing	30.20	15.00	39.10	26.70	33.30	46.90
Farmer	4.70	10.00	14.10	5.80	8.30	15.60
Service	0.00	0.00	0.00	1.20	0.00	0.00
Labour	41.90	31.70	32.80	40.70	18.30	28.10
Carpenter	3.50	3.33	1.60	3.50	1.70	0.00
Shopkeeper	1.20	0.00	4.70	0.00	1.70	0.00
Boatman	3.50	0.00	0.00	2.30	0.00	3.10
Motor cycle driver	2.30	1.67	1.60	3.50	0.00	1.60
Others	12.70	38.30	6.10	16.30	36.70	4.70
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

In Patakhali village, fishing provides supplementary occupation to 39.10% and 46.90% people before and after Aila respectively, agriculture provides 14.10% and 15.60% people after and before Aila respectively, daily labour sector provides 32.80% and 28.10% people after and before Aila and motorcycle driving provides 0.00% and 1.60% people before and after Aila respectively.

5.5 Change in income

Change in income is discussed here on the basis of monthly income from main and supplementary sources.

5.5.1 Income from main source

Monthly income level is classified into five classes such as less than 3000 tk., 3000-6000 tk., 6000-9000 tk., 9000-12000 tk. and more than 12000 taka. Though the change in classes less than3000 taka and more than 12000< taka is not notable but in class 3000-6000 taka a negative and classes 6000-9000 and 9000-12000 taka a positive change is found. In Sora village, 19.77% people income is 3000-6000 taka which was 70.93% before Aila. 22.09% people belongs to 6000-9000 taka income group of this village has reached to 52.33% and 2.33% people of 9000-12000 taka group has reached to 25.58%.

Table 5.6 Change in main income of inhabitants of the study area

(Figures are in percentage)

Monthly income in BDT	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Less than 3000	3.49	1.67	3.13	1.16	1.67	0.00
3000-6000	70.93	58.33	59.38	19.77	23.33	46.88
6000-9000	22.09	21.67	25.00	52.33	48.33	29.69
9000-12000	2.33	11.67	9.38	25.58	16.67	17.19
More than 12000	1.16	6.67	3.13	1.16	10.00	6.25
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

In Chakbara village, change in 3000-6000 taka class is from 58.33% to 23.33%; change in 6000-9000 taka class is from 21.67% to 48.33% and change in 9000-12000 taka class is from 11.67% to 16.67%.

In Patakhali village, before Aila 59.38%, 25.00% and 9.38% people income were 3000-6000 taka, 6000-9000 taka and 9000-12000 taka group respectively which are after Aila 46.88%, 29.69% and 17.19% respectively.

5.5.2 Income from supplementary source

In case of monthly supplementary income more than 80% people income was less than 2000 taka before Aila whereas after Aila it is between 50-70%. Before Aila 80.23%, 80.00% and 90.63% people of Sora, Chakbara and Patakhali village respectively supplementary income was less than 2000 taka. People of this range have changed to 50.00%, 66.67% and 60.94% in Sora, Chakbara and Patakhali respectively after Aila. On the other hand, in Patakhali village 60.94% people's supplementary income is less than 2000 taka which was 90.63% before Aila and 32.81% people supplementary income is 2000-4000 taka which was 7.81% after Aila.

Table 5.7 Change in supplementary income of inhabitants of the study area

(Figures are in percentage)

Monthly income in BDT	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Less than 2000	80.23	80.00	90.63	50.00	66.67	60.94
2000-4000	19.77	13.33	7.81	38.37	23.33	32.81
4000-6000	0.00	5.00	1.56	10.47	3.33	6.25
6000-8000	0.00	1.67	0.00	1.16	3.33	0.00
More than 8000	0.00	0.00	0.00	0.00	3.33	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.5.3 Total income

On the basis of the provided information in the following table it can be said that monthly income level of all three villages have been increased. Whereas income of most of the people was from 5000-10000 taka but now it is from 5000-15000 taka. Moreover, people of income class 15000-20000 taka have been increased in all three villages. But in case of more than 20000 taka class increase in Chakbara village is higher than other two villages. So, economically Chakbara is more solvent than other two villages. It is to be noted that, inflation rate is not considered here. So, it can be said that this limited positive change in income does not indicate the positive economical solvency of the people.

Table 5.8 Change in total income of inhabitants of the study area

(Figures are in percentage)

Monthly income in BDT	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Less than 5000	4.65	0.00	3.13	0.00	0.00	0.00
5000-10000	80.23	68.33	85.94	46.51	25.00	54.69
10000-15000	13.95	20.00	10.94	40.70	46.67	43.75
15000-20000	1.16	10.00	0.00	11.63	18.33	1.56
More than 20000	0.00	1.67	0.00	1.16	10.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.6 Change in expenditures

Expenditures of the respondents of the study villages are discussed here by classifying expenditure for some basic needs such as cloth, food, treatment, drinking water, others and total expenditure. Most of the people of the study villages paid 300-600 taka/ per month for cloths before and after Aila. But After Aila number of people of 300-600 taka range has reduced while 600-900 taka range has gone up.

Expenditure of money for food has increased in all study villages. In Sora village, 8.14% people paid 4000-5000 taka before Aila but 30.23% people pay 4000-5000 taka after Aila. A negative change is found in 2000-3000 and 3000-4000 taka range in this village. On the other hand in Chakbara village a reducing change is found in 2000-3000 and 3000-4000 taka range while a increasing change is found in 4000-5000 and more than 5000 taka range. Expenditure capacity for food has changed from lower limit to consecutive upper limit in Patakhali village.

Expenditure for treatment in all three villages has been increased after Aila. While most of the people of Sora village paid 100-400 taka before Aila, now they are paying 200-500 taka per month for this purpose. But in Chakbara village most of the people was paid up to 600 taka but after Aila they are paying up to 900 taka for this reason. In Patakhali village, most of the people were paid up to 600 taka per month but after Aila they are paying up to 900 taka per month.

Almost all the people of three villages have no need to pay for drinking water purpose. A very few people of Chakbara village pay maximum 100 to 200 taka after and before Aila respectively.

Expenditure for other resources in both Sora and Chakbara villages has been increased whereas in Patakhali village it remains almost same.

As like income, expenditure levels of people of all villages have been increased. Monthly total expenditure of most of the people of the study villages were from 3000- 9000 taka before Aila but now it is needed from 6000- 12000 taka per month. Accordingly, 12000 taka and more monthly spend capable people have also been increased in all three villages.

Table 5.9 Change in expenditure of the inhabitants of the study area

(Figures are in percentage)

	Monthly expenditure in BDT	Before Aila			After Aila		
		Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Cloths	Less than 300	23.26	21.67	82.81	1.16	8.33	20.31
	300-600	70.93	68.33	17.19	55.81	53.33	68.75
	600-900	4.65	6.67	0.00	33.72	30.00	9.38
	900-1200	1.16	3.33	0.00	6.98	5.00	1.56
	1200-1500	0.00	0.00	0.00	2.33	3.33	0.00
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Food	Less than 2000	10.47	1.67	56.25	1.16	0.00	3.13
	2000-3000	31.40	31.67	39.06	16.28	15.00	67.19
	3000-4000	39.53	43.33	3.13	23.26	30.00	25.00
	4000-5000	8.14	21.67	1.56	30.23	31.67	3.13
	More than 5000	10.47	1.67	0.00	29.07	23.33	1.56
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Treatment	Less than 100	5.81	21.67	43.75	1.16	0.00	4.69
	100-200	34.88	48.33	35.94	4.65	26.67	48.44
	200-300	30.23	16.67	7.81	27.91	41.67	4.69
	300-400	17.44	8.33	1.56	33.72	15.00	25.00
	400-500	8.14	5.00	10.94	16.28	10.00	6.25
	More than 500	3.49	0.00	0.00	16.28	6.67	10.94
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Drinking water	No pay	98.84	73.33	100.00	98.84	65.00	100.00
	100-200	1.16	25.00	0.00	0.00	15.00	0.00
	200-300	0.00	1.67	0.00	0.00	15.00	0.00
	300-400	0.00	0.00	0.00	1.16	3.33	0.00
	More than 400	0.00	0.00	0.00	0.00	1.67	0.00
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Others	Less than 500	33.72	16.67	98.44	17.44	5.00	93.75
	500-1000	38.37	55.00	1.56	19.77	28.33	0.00
	1000-1500	27.91	23.33	0.00	34.88	36.67	0.00
	1500-2000	0.00	5.00	0.00	22.09	23.33	0.00
	More than 2000	0.00	0.00	0.00	5.81	6.67	0.00
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Total expenditure	Less than3000	3.49	1.67	3.13	0.00	0.00	0.00
	3000-6000	34.88	31.67	26.56	9.30	5.00	7.81
	6000-9000	60.47	53.33	65.63	61.63	66.67	59.38
	9000-12000	1.16	11.67	4.69	27.91	20.00	29.69
	More than 12000	0.00	1.67	0.00	1.16	8.33	3.13
	Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.7 Change in saving

As like income and expenditure monthly saving of the respondents of the study villages has also been increased. Per month saving of most of the people was 1000-2000 taka before Aila but after Aila it is from 1000-3000 taka. Moreover, people of both 3000-4000 and more than 4000 taka per month saving of all three villages have been increased. It can be also marked from the table that saving in Chakbara village is more than other two villages.

Table 5.10 Change in saving of the inhabitants of the study area

(Figures are in percentage)

Monthly Saving in BDT	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Less than 1000	59.30	53.33	53.13	36.05	21.67	32.81
1000-2000	38.37	35.00	40.63	41.86	46.67	42.19
2000-3000	2.33	6.67	4.69	18.60	18.33	17.19
3000-4000	0.00	3.33	1.56	2.33	8.33	6.25
More than 4000	0.00	1.67	0.00	1.16	5.00	1.56
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.8 Change in housing structure

From the following table it can be seen that housing structure has been changed in all three village. Pucca house in all the study villages have been increased but in Patakhali village changing rate is higher than other two villages. At the same a growth trend is found in semi-pucca houses in the villages. On the other hand, Katcha and Jhupri houses have been decreased during this time. From the discussion it can be said that in term of housing structure the situation is better than previous time.

Table 5.11 Change in housing structure of the study area

(Figures are in percentage)

Housing structure	Sora		Chakbara		Patakhali	
	Before Aila	After Aila	Before Aila	After Aila	Before Aila	After Aila
Pucca	2.5	4.65	2.9	13.33	1.95	21.87
Semi-pucca	2.51	2.33	2.55	6.67	1.99	3.13
Katcha	92.26	90.69	92.26	80	94.68	75
Jhupri	2.73	2.33	2.29	0	1.38	0
Total	100	100	100	100	100	100

Source: After Aila: Field survey, 2015

Before Aila: Population census, 2001

5.9 Change in toilet facilities

Table 5.12 provides information on toilet facilities of the study villages. Majority people of the study villages use non-sanitary toilet. In, Sora, before Aila 4.65%, 18.60% and 60.47% people were used sanitary (water sealed), sanitary (non-water sealed and non-sanitary toilet respectively. But after Aila 2.33%, 13.95% and 62.93% people use sanitary (water sealed), sanitary (non-water sealed and non-sanitary toilet respectively. But in Chakbara, 30% and 70% people use sanitary (non-water sealed) and non-sanitary toilet respectively which were 23.33% and 75% before Aila respectively. Hence, there is no sanitary latrine in Chakbara village.

In Patakhali village, most of the people (79.69%) use non-sanitary and few people (20.31%) use sanitary (non-water sealed) toilet. But before Aila all the people of this village were used non-sanitary latrine.

Table 5.12 Change in toilet facilities of the study area

(Figures are in percentage)

Types of toilet	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Sanitary (water sealed)	4.65	0.00	0.00	2.33	0.00	0.00
Sanitary (non-water sealed)	18.60	23.33	0.00	13.95	30.00	20.31
Non-sanitary	60.47	75.00	100.00	62.79	70.00	79.69
Others	16.28	1.67	0.00	20.93	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

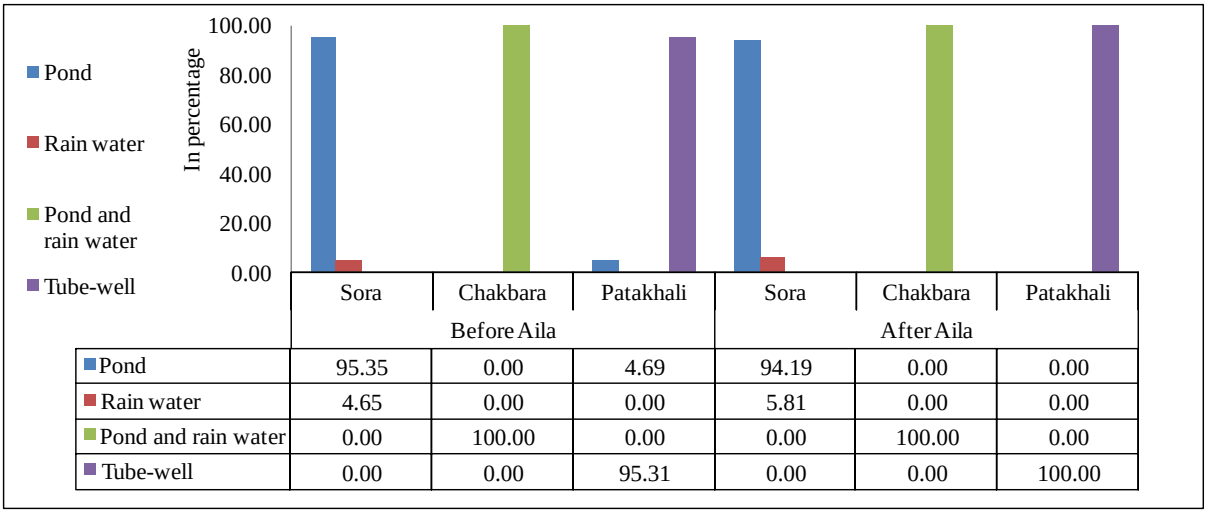
Source: Field survey, 2015

However, still now a remarkable portion people of Sora village use open space for this purpose.

5.10 Change in Sources of drinking water

From figure 5.1it can be said that almost same pattern of drinking water sources was found in all three villages before and after Aila.

In case of Chakbara village 100% people use ponds water for few months and rain water for few months. Same information was found before Aila. In Patakhali village 100% people use tube-well water for drinking purpose but before Aila 95.31% and 4.69% people were used tube-well and pond water respectively.



	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Pond	95.35	0.00	4.69	94.19	0.00	0.00
Rain water	4.65	0.00	0.00	5.81	0.00	0.00
Pond and rain water	0.00	100.00	0.00	0.00	100.00	0.00
Tube-well	0.00	0.00	95.31	0.00	0.00	100.00

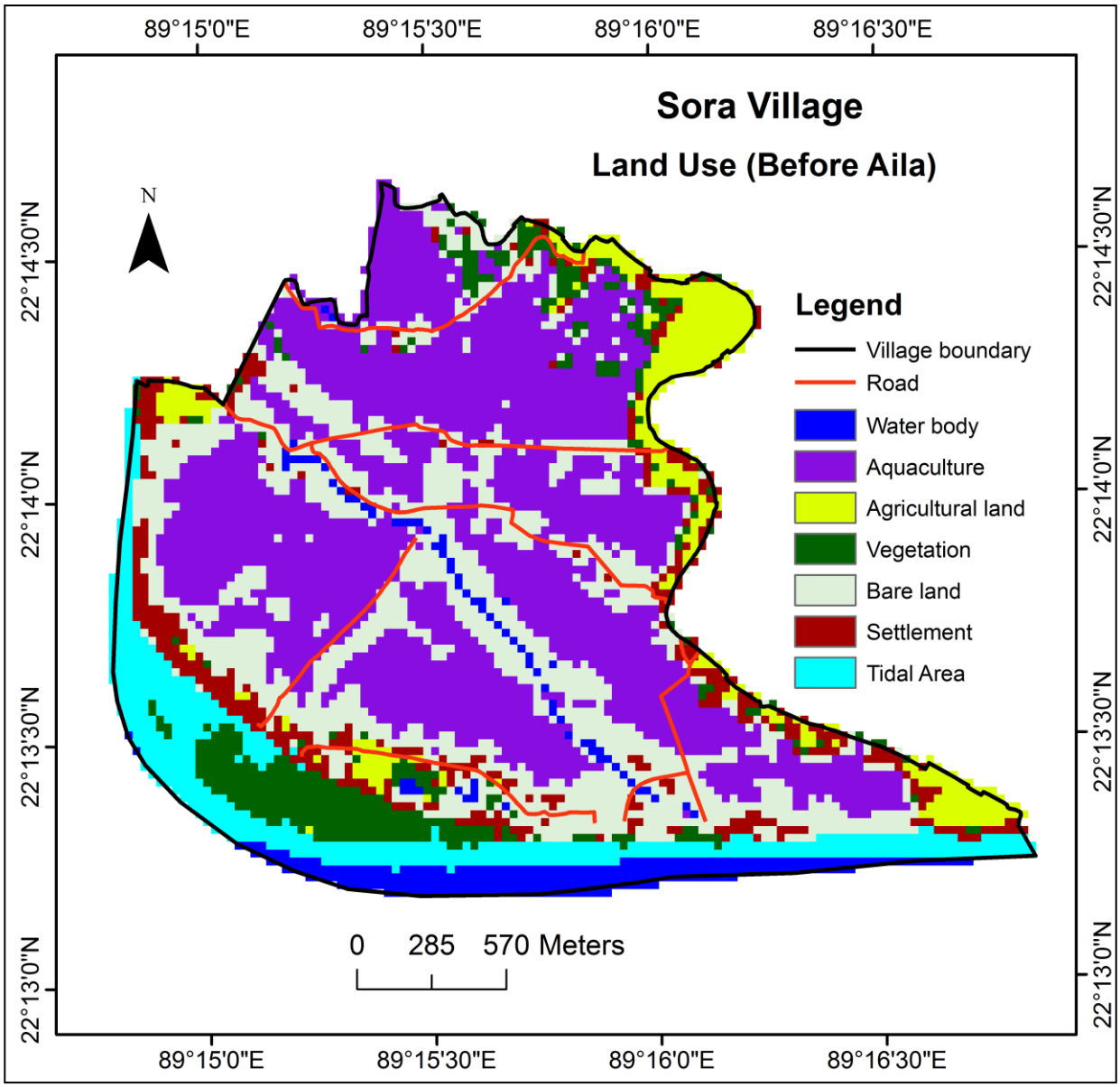
Source: Field Survey, 2015

Figure 5.1 Change in sources of drinking water of the study area, 2015

5.11Change in land use pattern

Land use change is discussed here under general and agricultural land use categories.

5.11.1 General land use



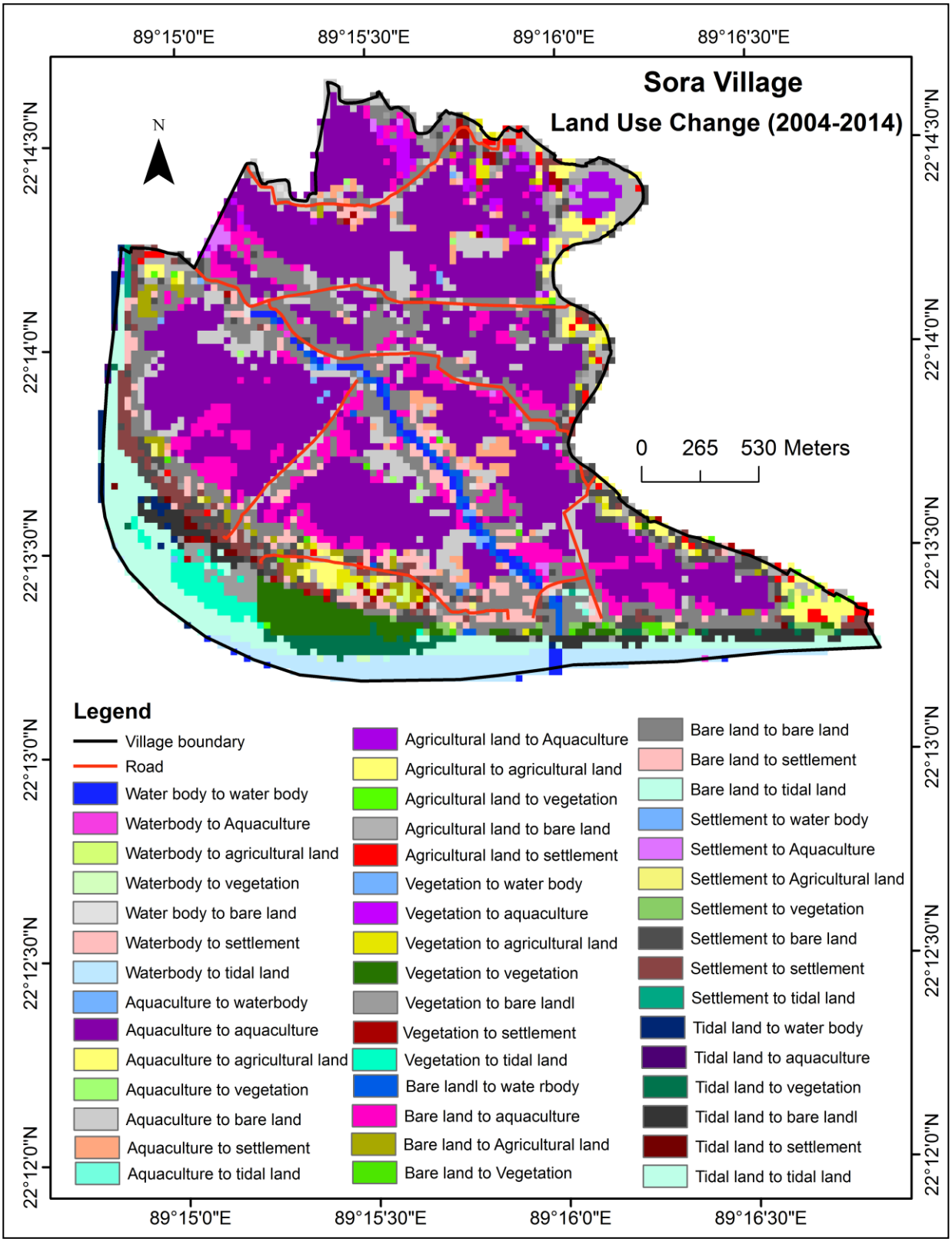
Source: Image processing, 2004

Figure 5.2 Land use pattern of Sora village, 2004

Table 5.13 Land use pattern of Sora village, 2004

	Water bodies	Aquaculture	Agricultural land	Vegetation	Settlement	Bare land	Tidal area	Total
Area (acres)	74.28	565.33	88.29	95.85	100.30	345.16	124.99	1394.19
Percentage	5.33	40.55	6.33	6.88	7.19	24.76	8.96	100

Source: Image processing, 2004



Source: Calculated from image processing (2004-2014)

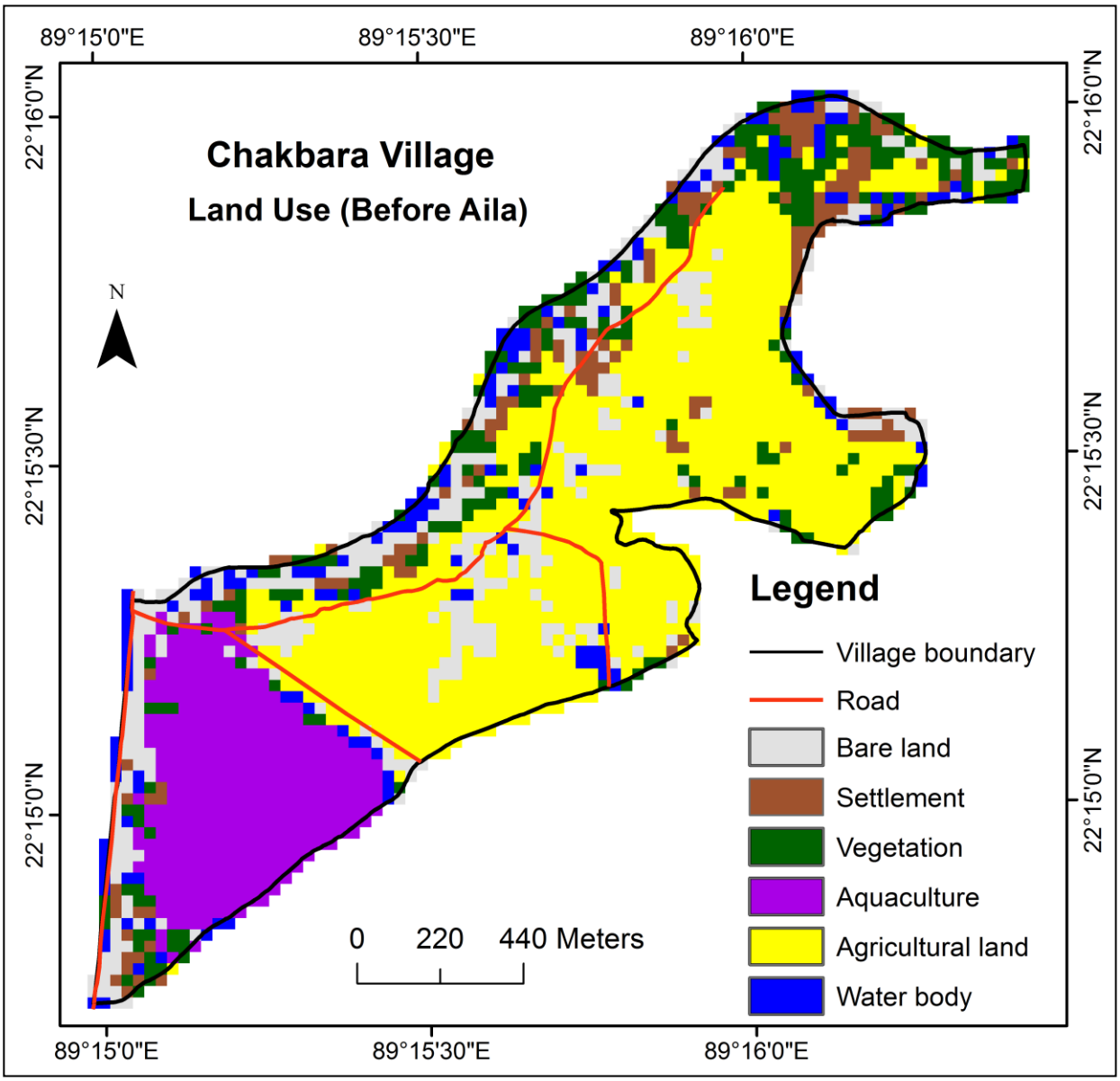
Figure 5.3 Land use change of Sora village (2004-2014)

Aila has brought both negative and positive change in land use pattern of the study area. Negative change means conversion of productive land into unproductive land and positive change means conversion of unproductive land into productive land. Table 5.14 and figure 5.3 indicate that in Sora village water bodies has been reduced from 5.33% to 2.7%, agricultural land from 6.33% to 4.18%, vegetation from 6.88% to 4.31% while aquaculture area has increased from 40.55% to 41.11%, settlement from 7.19 to 8.39%, bare land from 24.76% to 28.65% and tidal area 8.96% to 10.67%. (detail information included in table- E1 , appendix-E).

Table 5.14 Land use change pattern of Sora village (2004-2014)

Before								
	Water bodies	Aquaculture	Agricultural land	Vegetation	Settlement	Bare land	Tidal area	Total
Area (acres)	74.28	565.33	88.29	95.85	100.3	345.16	124.99	1394.19
Percentage	5.33	40.55	6.33	6.88	7.19	24.76	8.96	100
After Aila								
Area (acres)	37.58	573.11	58.27	60.05	116.98	399.42	148.78	1394.2
Percentage	2.7	41.11	4.18	4.31	8.39	28.65	10.67	100

Source: Calculated from image processing (2004-2014)



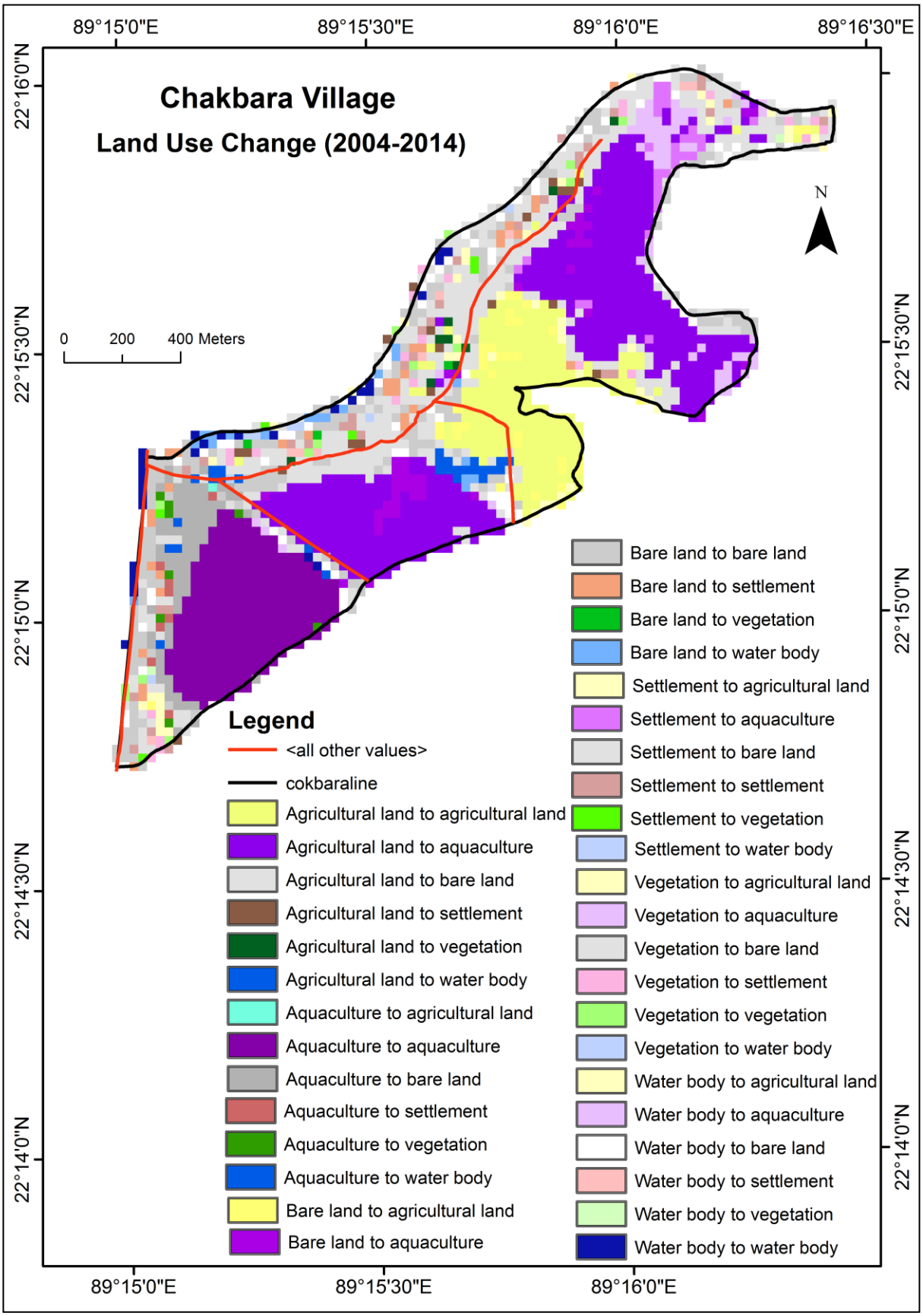
Source: Image processing, 2004

Figure 5.4 Land use pattern of Chakbara village, 2004

Table 5.15 Land use pattern of Chakbara village, 2004

	Water bodies	Aquaculture	Agricultural land	Vegetation	Settlement	Bare land	Total
Area (acres)	37.36	84.95	224.62	55.82	35.36	77.17	515.25
Percentage	7.25	16.49	43.59	10.83	6.86	14.98	100.00

Source: Image processing, 2004



Source: Calculated from image processing (2004-2014)

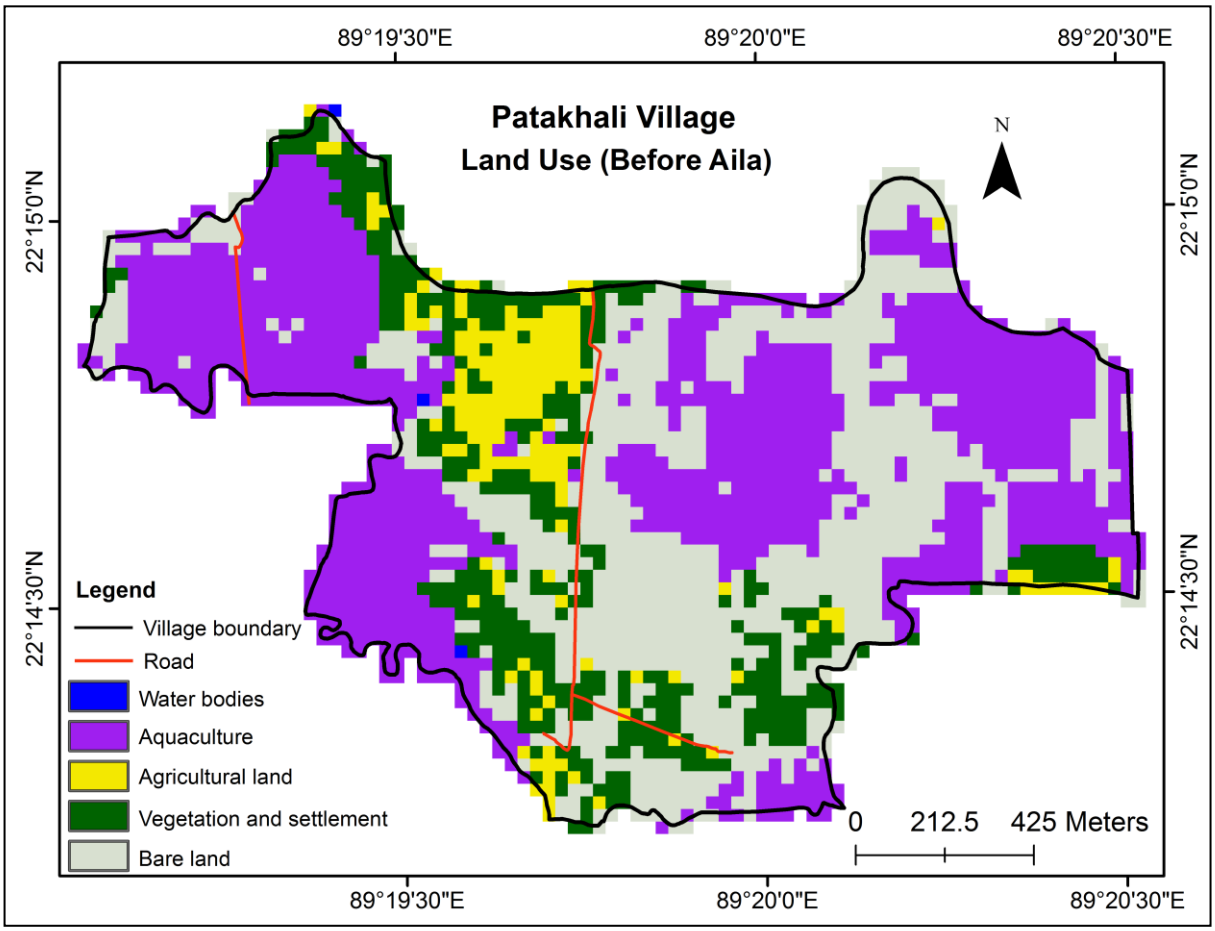
Figure 5.5 Land use change of Chakbara village (2004-2014)

In Chakbara village water body, agricultural land, vegetation and settlement has converted into either aquaculture or bare land. Due to Aila water bodies have reduced from 7.25% to 3.63%, agricultural land from 43.59% to 13.9%, vegetation from 10.83% to 1.8% and settlement from 6.86% to 5.4% of total land. On the other hand, shrimp cultivation (aquaculture) and bare land have reduced at 40.27% and 35% from 16.49% and 14.98% of total land respectively.

Table 5.16 Land use change of Chakbara village (2004-2014)

Before Aila							
	Water bodies	Aquaculture	Agricultural land	Vegetation	Settlement	Bare land	Total
Area (acres)	37.36	84.95	224.62	55.82	35.36	77.17	515.25
Percentage	7.25	16.49	43.59	10.83	6.86	14.98	100
After Aila							
Area (acres)	18.68	207.5	71.61	9.3	27.8	180.36	515.25
Percentage	3.63	40.27	13.9	1.8	5.4	35	100

Source: Calculated from satellite image 2004 and 2014



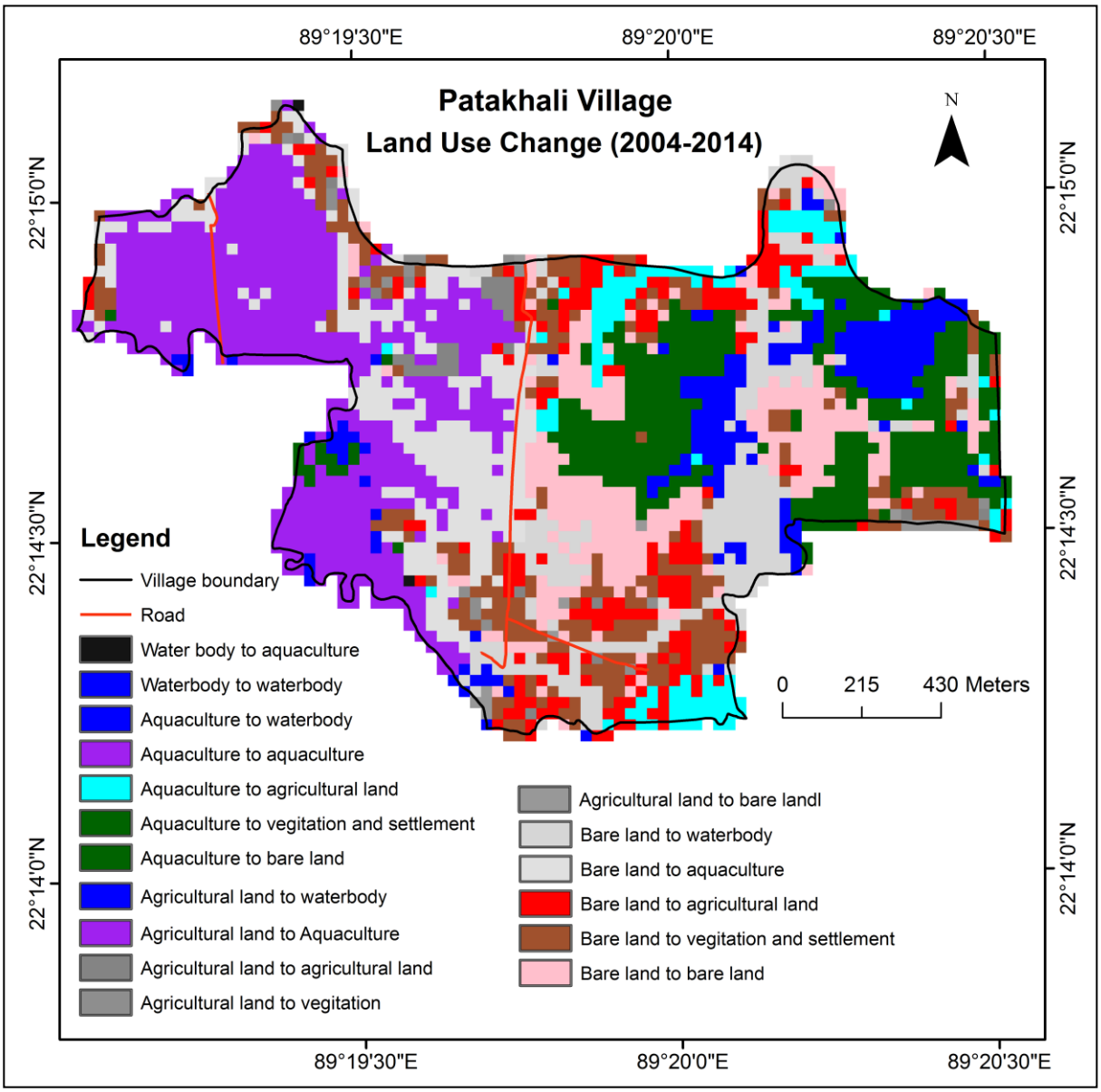
Source: Image processing, 2004

Figure 5.6 Land use pattern of Patakhali village, 2004

Table 5.17 Land use pattern of Patakhali village, 2004

	Water bodies	Aquaculture	Agricultural land	Vegetation and Settlement	Bare land	Total
Area (acres)	0.67	251.31	38.03	85.39	195.48	570.88
Percentage	0.12	44.02	6.66	14.96	34.24	100

Source: Calculated from satellite image 2004



Source: Calculated from image processing (2004-2014)

Figure 5.7 Land use pattern change of Patakhali village (2004-2014)

Table 5.18 Land use change of Patakhali village (2004- 2014)

		Before Aila				
	Water bodies	Aquaculture	Agricultural land	Vegetation and Settlement	Bare land	Total
Area (acres)	0.67	251.31	38.03	85.39	195.48	570.88
Percentage	0.12	44.02	6.66	14.96	34.24	100
After Aila						
Area (acres)	93.4	188.6	76.5	75.4	136.98	570.88
Percentage	16.36	33.04	13.4	13.21	23.99	100

Source: Calculated from satellite image 2004 and 2014

In terms of land use, in Patakhali village major change have taken place in water bodies, aquaculture and agricultural land sectors. Water bodies have gained 16.24%, agricultural land gained 6.74% of total land. On the other hand, aquaculture has lost by 10.94%, vegetation and settlement lost by 1.75% and bare land lost by 10.25% of land (detail sector wise land use change information has included in appendix-E, Table-E3)

5.11.2 Change in Agricultural land use

Agricultural land use changes are discussed here on the basis of land area under aquaculture, crops, vegetable and fruits. From table 5.19 it can be said that in Sora all sized aquaculture have been increased; in Chakbara large sized aquaculture have been increased but in Patakhali aquaculture have been decreased.

In case of crop area, in all three villages have been decreased but in Sora this change is higher than the other two villages. And in Patakhali village large sized crop cultivator have converted into small cultivator.

Table 5.19 Change in agricultural land use of the study area (2004-2014)

(Figures are in percentage)

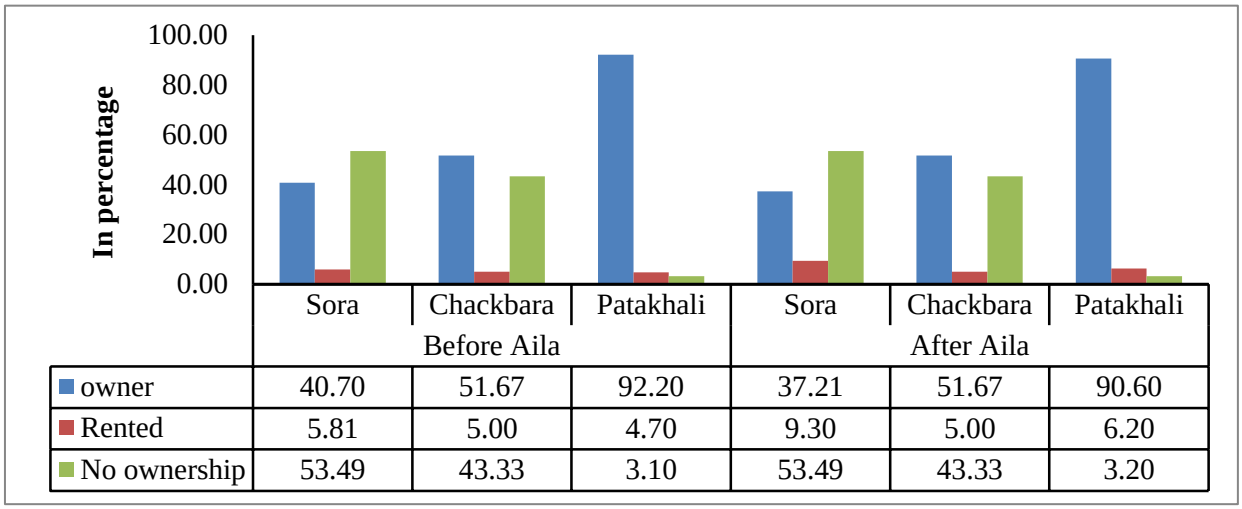
	Aquaculture			Crops			Vegetables and fruits			Others		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
Before Aila												
0 acre	87.21	85.00	96.88	80.23	61.67	92.19	0.00	95.00	100	98.84	100	100
0-.33 acres	5.81	1.67	3.13	10.47	6.67	3.13	0.00	1.67	0.00	0.00	0.00	0.00
.33-.66 acres	4.65	0.00	0.00	2.33	6.67	1.56	0.00	1.67	0.00	0.00	0.00	0.00
.66-1acres	1.16	6.67	0.00	3.49	3.33	1.56	0.00	0.00	0.00	0.00	0.00	0.00
1-1.33 acres	1.16	0.00	0.00	2.33	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.33-1.66 acres	0.00	3.33	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.66+ acres	0.00	3.33	0.00	1.16	13.33	1.56	0.00	1.67	0.00	0.00	0.00	0.00
Total	100	100	100	100	100	100	0.00	100	100	100	100	100
After Aila												
0 acre	82.56	80.00	98.44	87.21	63.33	92.19	100.00	96.67	100.00	97.67	98.33	100
0-.33 acres	6.98	1.67	1.56	6.98	5.00	6.25	0.00	3.33	0.00	2.33	1.67	0.00
.33-.66 acres	6.98	1.67	0.00	1.16	10.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00
.66-1acres	1.16	6.67	0.00	3.49	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-1.33 acres	1.16	1.67	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.33-1.66 acres	1.16	8.33	0.00	1.16	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: Field survey, 2015

On the other hand vegetables and fruits cultivation area only found in Chakbara village. Though the number of less than .33 acres cultivators has been increased but the number of .33-.66 acres cultivator have been decreased.

5.12 Change in land ownership

Figure 5.8 provides information on change in land ownership of the inhabitant of the study area. Due to Aila land ownership has reduced from 40.70% to 37.21% in Sora village and from 92.20% to 90.60% in Patakhali village but in Chakbara village it is found unchanged. At the same time rented owner has increased in Sora and Patakhali village while Chakbara has remained unchanged.



	Before Aila			After Aila		
	Sora	Chackbara	Patakhali	Sora	Chackbara	Patakhali
owner	40.70	51.67	92.20	37.21	51.67	90.60
Rented	5.81	5.00	4.70	9.30	5.00	6.20
No ownership	53.49	43.33	3.10	53.49	43.33	3.20

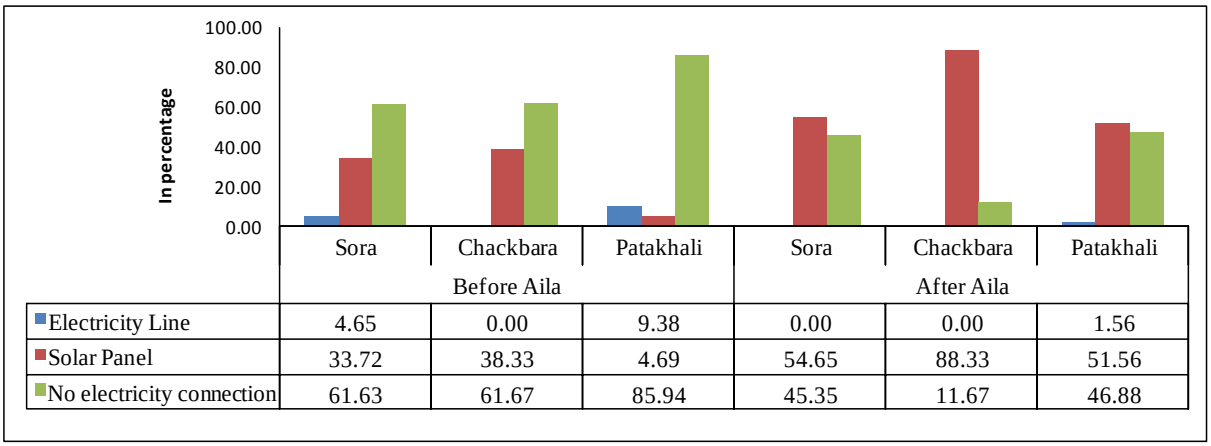
Source: Field survey, 2015

Figure 5.8 Land ownership pattern change of the study area (2004-2014)

5.13 Change in household equipments

5.13.1 Change in power connection

From the figure 5.9 it can be said that all the study villages are not facilitated by electricity. But before Aila, only Patakhali village was facilitated with electricity and only 9.38% respondents had electricity connection. In order to provide light and other power purpose people of all villages use solar panel and number of solar panel users have been increased after Aila. In Sora 54.65% people use solar panel which was 33.72% before Aila. In Chakbara 88.33% people use solar panel which was 38.33% before Aila. In Patakhali village solar panel users have reached to 51.56% after Aila which was only 4.69% before Aila. Still now a considerable proportion of people have no electricity or solar power connection.



	Before Aila			After Aila		
Electricity Line	4.65	0.00	9.38	0.00	0.00	1.56
Solar Panel	33.72	38.33	4.69	54.65	88.33	51.56
No electricity connection	61.63	61.67	85.94	45.35	11.67	46.88

Source: Field survey, 2015

Figure 5.9 Change in power connection (2004-2014)

5.13.2 Change in number of cell phone users

Table 5.20 indicates that cell phone users in the study area have been increased by two times after Aila. More than one mobile user have also found in Sora and Chakbara village during this time. 67.44%, 73.33% and 78.13% respondents of Sora, Chakbara and Patakhali village respectively use 1 cell phone whereas before Aila it was 32.56%, 46.67% and 34.38% respectively. In Chakbara village 10% people use 2 cell phones and few people use more than two cell phones. Again in Sora villages a limited number of people use more than one cell phone. Though the number of no cell phone users has been decreased but still now a remarkable percent people have no cell phone.

Table 5.20 Change in number of cell phone users

(Figures are in percentage)

	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
No cell phone	67.44	51.67	65.63	31.40	11.67	21.88
1 cell phone	32.56	46.67	34.38	67.44	73.33	78.13
2 cell phones	0.00	1.67	0.00	1.16	10.00	0.00
3 cell phones	0.00	0.00	0.00	0.00	1.67	0.00
4 or more cell phones	0.00	0.00	0.00	0.00	3.33	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.13.3 Change in other resources

Household resources are measured by money value (taka). From table 5.21 it can be said that household resources have been lost due to Aila and people is not yet able to recover it. The number of people those had more than 14000 taka worth household resources have been reduced. After Aila, 6.98%, 13.33% and 1.56% people of Sora, Chakbara and Patakhali villages respectively have more than 14000 taka household resources but before Aila 28.24%, 51.67% and 17.19% people of Sora, Chakbara and Patakhali respectively had household resources worth more than 14000 taka. On the other hand lower classes such as less than 1000 taka and 1000-4000 taka have been increased in all three villages which indicate economic down turn of the area.

Table 5.21 Change in other resources

(Figures are in percentage)

	Before Aila			After Aila		
	Sora	Chakbara	Patakhali	Sora	Chakbara	Patakhali
<1000 tk.	55.29	28.33	40.63	61.63	45.00	54.69
1000-4000 tk.	7.06	3.33	10.94	15.12	18.33	26.56
4000-7000 tk.	5.88	5.00	14.06	4.65	10.00	7.81
7000-10000 tk.	3.53	10.00	15.63	6.98	8.33	6.25
10000-14000 tk.	0.00	1.67	1.56	4.65	5.00	3.13
14000< tk.	28.24	51.67	17.19	6.98	13.33	1.56
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

5.14 Change in over all development

To measure the development level of the study villages 0-1 transformation procedure is used. A detail transformation processes was discussed in research methodology chapter. As per composite index of the following table-5.22 it can be said that Chakbara is more developed than other two villages and Patakhali is more develop than Sora. Before Aila though the ranking of Chakbara village was same among the villages but reverse position was found between Sora and Patakhali village.

Table 5.22 Change in overall development

Indicators		After Aila									Before								
		Sora		Chakbara		Patakhali		Highest value	Lowest value	Range	Sora		Chakbara		Patakhali		Highest value	Lowest value	Range
		V1	TV1	V2	TV2	V3	TV3				V1	TV1	V2	TV2	V3	TV3			
Literacy		32.60	0.00	40.80	1.00	33.80	0.15	40.80	32.60	8.20	22.90	0.13	36.88	1.00	20.90	0.00	36.88	20.90	15.98
Total income	5000-10000	46.51	0.85	25.00	0.46	54.69	1.00	54.69	0.00	54.69	80.23	0.68	68.33	0.00	85.94	1.00	85.94	68.33	17.61
	10000-15000	40.70	0.93	46.67	1.07	43.75	1.00	43.75	0.00	43.75	13.95	0.33	20	1.00	10.94	0.00	20.00	10.94	9.06
	15000-20000	11.63	0.60	18.33	1.00	1.53	0.00	18.33	1.53	16.80	1.16	0.12	10	1.00	0.00	0.00	10.00	0.00	10.00
Expenditure	3000-6000 tk.	9.30	1.00	5.00	0.00	7.81	0.65	9.30	5.00	4.30	34.88	1.00	31.67	0.61	26.56	0.00	34.88	26.56	8.32
	6000-9000 tk.	61.63	0.31	66.67	1.00	59.38	0.00	66.67	59.38	7.29	60.47	0.58	53.33	0.00	65.63	1.00	65.63	53.33	12.30
	9000-12000 tk.	27.91	0.82	20.00	0.00	29.69	1.00	29.69	20.00	9.69	1.16	0.00	11.67	1.00	4.69	0.34	11.67	1.16	10.51
Saving	1000-2000 tk.	41.86	0.00	46.67	1.00	42.19	0.07	46.67	41.86	4.81	38.37	0.60	35	0.00	40.63	1.00	40.63	35.00	5.63
	2000-3000 tk.	18.60	1.24	18.33	1.00	17.19	0.00	18.33	17.19	1.14	2.33	0.00	6.67	1.00	4.69	0.54	6.67	2.33	4.34
	3000-4000 tk.	2.33	0.00	8.33	1.00	6.25	0.65	8.33	2.33	6.00	0	0.00	3.33	1.00	1.56	0.47	3.33	0.00	3.33
Pacca house		4.65	0.21	13.33	1.00	2.33	0.00	13.33	2.33	11.00	2.5	0.58	2.9	1.00	1.95	0.00	2.90	1.95	0.95
Semi-pacca house		2.33	0.35	6.67	1.00	0.00	0.00	6.67	0.00	6.67	2.51	0.93	2.55	1.00	1.99	0.00	2.55	1.99	0.56
Sanitary toilet	water sealed	2.33	0.00	30.00	1.00	20.31	0.65	30.00	2.33	27.67	4.65	1.00	0.00	0.00	0.00	0.00	4.65	0.00	4.65
	non water sealed	13.95	0.00	70.00	0.85	79.69	1.00	79.69	13.95	65.74	18.6	0.80	23.33	1.00	0.00	0.00	23.33	0.00	23.33
Rain water		5.81	1.00	0.00	0.00	0.00	0.00	5.81	0.00	5.81	4.65	1.00	0.00	0.00	0.00	0.00	4.65	0.00	4.65
Rain and Pond water		0.00	0.00	100.00	1.00	0.00	0.00	100.00	0.00	100.00	0.00	0.00	100.00	1.00	0.00	0.00	100.00	0.00	100.00
Tube-well water		0.00	0.00	0.00	0.00	100.00	1.00	100.00	0.00	100.00	0.00	0.00	0.00	0.00	95.31	1.00	95.31	0.00	95.31
Land ownership		37.21	0.00	51.67	0.24	98.44	1.00	98.44	37.21	61.23	40.70	0.00	51.67	0.18	100.00	1.00	100.00	40.70	59.30
Electricity connection		0.00	0.00	0.00	0.00	1.56	1.00	1.56	0.00	1.56	0.00	0.00	0.00	0.00	9.38	1.00	9.38	0.00	9.38
Solar connection		54.65	0.08	88.33	1.00	51.56	0.00	88.33	51.56	36.77	33.72	0.86	38.33	1.00	4.96	0.00	38.33	4.96	33.37
Cell phone users		68.60	0.00	88.33	1.00	78.12	0.48	88.33	68.60	19.73	32.56	0.00	48.33	1.00	34.37	0.11	48.33	32.56	15.77
Total TV (Composite Index)			7.39		14.61		9.65					8.59		12.80		7.46			

Source: Calculated by applying transformation process.

Chapter 6

Vulnerability Analysis

In the following chapter an attempt is made to analysis vulnerability which has taken place due to economic change after cyclone Aila. Discussion of vulnerability includes influencing factors of vulnerability, sensitivity analysis and vulnerability analysis on the basis of occupation, income, expenditure, savings, housing structure, drinking water, land use, agricultural land use, land ownership, household resources and infrastructures.

6.1 Influencing factors of vulnerability

Magnitude of vulnerability to cyclonic events depends on a number of factors. It also varies on scale of cyclonic events, levels of economic status, control over assets, management and livelihood opportunities. Depend on type of factors vulnerability can be varied but it is an integrated approach which works together. The influencing factors are as follows.

6.1.1 Location

Bangladesh is prone to nature calamities such as flood, river bank erosion, drought, cyclone etc due to its locational exposure. In general, north-western part of it is exposed to drought, Brammaputtro-Jammuna-Meghna estuaries to riverbank erosion and coastal region to cyclonic events. Bay of Bengal is considered as one of the pertinent cyclonic events breeding grounds of the world. Due to climate change, increase in SST leads the area as more suitable for cyclone formation. From life cycle of cyclone it can be seen that it generates from sea and ends to coast. Because of close location to Bay of Bengal the study area experiences number of cyclones each year and enhancing exposure to vulnerability.

6.1.2 Physiography

Geomorphologically, coastal region of Bangladesh is low laying area situated southern most part of Ganges floodplain. Average elevation of this area is less than 1 meter from mean sea level. At small scale this elevation may vary from 0 to .5 meter. As a result, the study villages are susceptible to any high tide or any possible cyclonic surges.

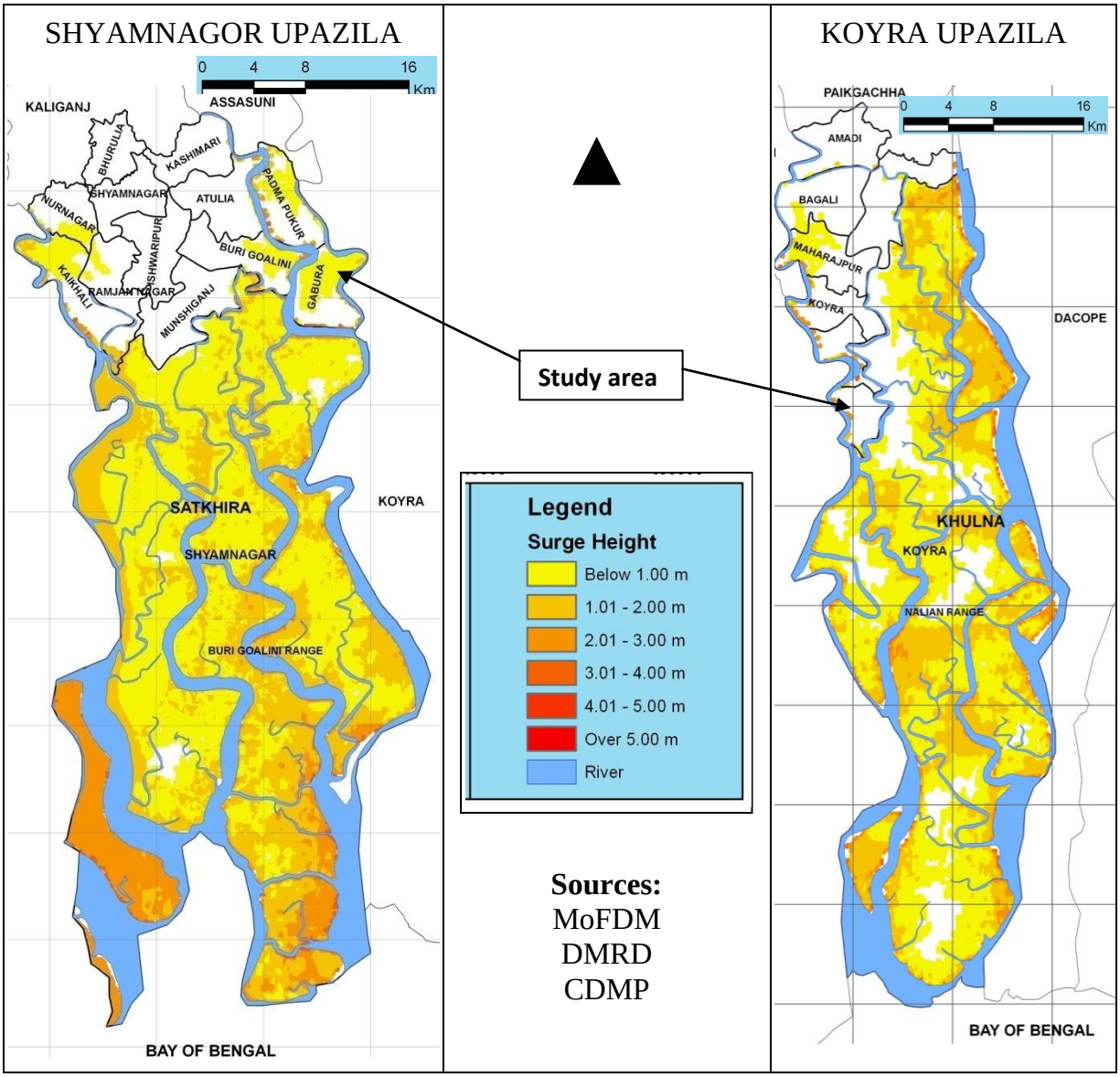


Figure 6.1 Probable cyclone surges affected area

6.1.3 Distance from coast

It is already mentioned that coastal region is susceptible to cyclonic events. Study area is situated within 70 km. from open sea coast line. On the basis of magnitude of cyclonic events a hundred of kilometers area can be severely affected. From analysis of satellite images it is found that average distance of Sora, Chakbara and Patakhali villages is 64.9, 65.49 and 60.86 kilometers from coast of Bay of Bengal (table 6.1).

Table 6.1 Distance of study villages from coast.

(Figures are in Kilometer)

Sora			Chakbara			Patakhali		
Nearest end	Farthest end	Average	Nearest end	Farthest end	Average	Nearest end	Farthest end	Average
62.88	66.92	64.9	61.15	69.75	65.49	57.12	64.60	60.86

Source: Image analysis 2015.

6.1.4 Distance from river

River is another influencing factor on which magnitude of vulnerability to cyclone is mostly dependent. Because, the rivers are influenced by tide and also connected to Bay of Bengal. Sora is bounded on west and south by Kholpetua River and Chakbara village is bounded on west by this river. But both of the villages are bounded on far-east by Kobotak river. On the other hand, Patakhali village is bounded on far west and east by Kobotak and Rai river respectively. Thus rivers are sources of earning as well as food and have great impact on community livelihood. Reversely vulnerable to livelihood due to cyclonic surges when it overtop embankment and wash away houses, agricultural field, aquaculture, road, fishes etc. Table 6.2 provides information that Sora is closed to river and its farthest distance is 2 km. Average distance of Chakbara village is 1.75 km. but it is closed to river and farthest distance is 3.5 km. Likewise, nearest, farthest and average distance of Patakhali village from river is 3, 6, and 4.5 km respectively.

Table 6.2 Distance of study villages from river

(Figures are in Kilometer)

Sora			Chakbara			Patakhali		
Nearest end	Farthest end	Average	Nearest end	Farthest end	Average	Nearest end	Farthest end	Average
0	2	1	0	3.5	1.75	3	6	4.5

Source: Image analysis 2015.

6.1.5 Distance from forest

Mangrove forest, Sunderban is situated along the coast of Bay of Bengal which is on southern side of the study area works as natural barrier to cyclonic events. Sundarbon, to some extent helps the area to reduce intensity of cyclone and its aftermath impact when crosses the area. The average distance of Sundarbon from Sora is 2.19 km, from Chakbara is 4.96 kilometers and from Patakhali is 2.41 kilometers.

Table 6.3 Distance of study villages from Sundarban

(Figures are in Kilometer)

Sora			Chakbara			Patakhali		
Nearest end	Farthest end	Average	Nearest end	Farthest end	Average	Nearest end	Farthest end	Average
.95	3.43	2.19	2.64	6.74	4.69	1.65	3.17	2.41

Source: Image analysis 2015.

6.1.6 Distance from embankment

It is already mentioned that the average elevation of the area less than 1 meter from MSL. Due to low elevation the area is susceptible to any cyclonic surges as well as high tide. In order to protect these areas from tidal inundation and cyclonic surges embankments were built by the then East Pakistan Water and Power Development Authority (EPWAPDA) and WAPDA of Bangladesh during 1961-1978 under the Coastal Embankment Project (CEP). Sora and Chakbara are on the bank of Kholpatua river and the embankment was built along the river bank but the Patakhali village is away from the embankment of Kobotak river.

Table 6.4 Distance of study villages from embankment

(Figures are in Kilometer)

Sora			Chakbara			Patakhali		
Nearest end	Farthest end	Average	Nearest end	Farthest end	Average	Nearest end	Farthest end	Average
0	2	1	0	3.5	1.75	3	6	4.5

Source: Image analysis 2015.

6.1.7 Connectivity

Connectivity to road is a vital factor of evacuation and rescue operation during disaster period and post disaster relief operations. The improved road communication networks accelerate the rate of evacuation and rescue operation (Hossain et. all, 2014). Only mode of transportation in the Study area is unpaved road and only transport is motorbike which is used for people transportation, not for goods. During cyclonic event people have to move on foot. Moreover, average distance of cyclone shelter from houses is 1.5 to 2 kilometers. So, it is quite impossible to take any assets to cyclone shelter during event also enhance vulnerability.

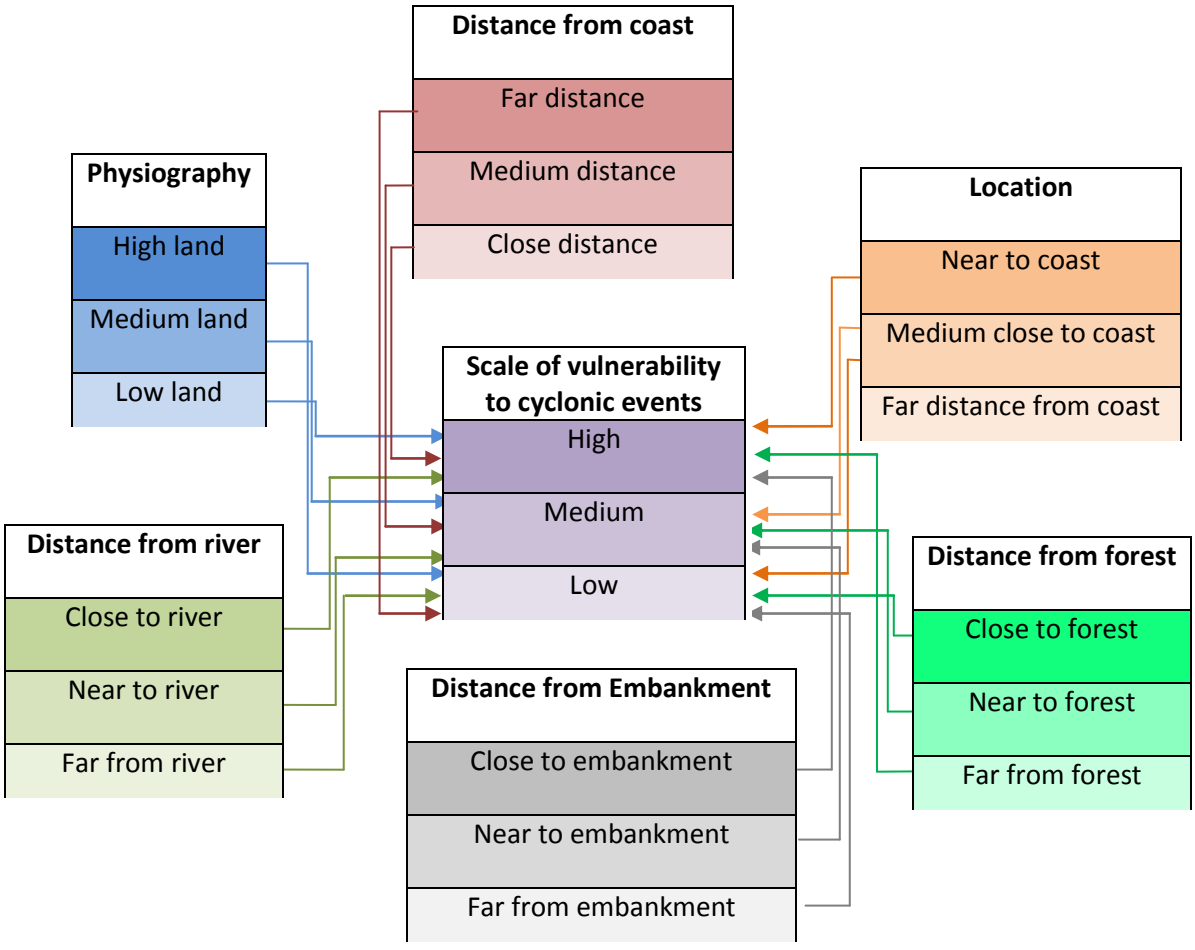


Figure 6.2 Level of individual and integrated influencing factors of the study area

The factors work together as an interdependent unit and also independently. Severity of vulnerability can be influenced by the one or all other factors. However, an integration

procedure of the influencing factors of severity of cyclone is shown in the following diagram.

To measure the comparative integrated influence of the factors on the study village point assignment method is adopted followed here. For individual factors 1 to 3 points is assigned depending on their severity. Detail is given in the table 6.5. Finally, summing up the all points total point is calculated.

Table 6.5 Integrated impacts of the influencing factors of vulnerability in the study area.

Influencing factors	Level	Assigned points	Study villages		
			Sora	Chakbara	Patakhali
Location	Close to coast	3	3	3	3
	Medium close to coast	2			
	Far from coast	1			
Physiography	High land	1			
	Medium land	2	2	2	
	Low land	3			3
Distance from coast	Far distance	1		1	
	Medium distance	2	2		
	Close distance	3			3
Distance from river	Close to river	3	3	3	
	Near to river	2			2
	Far from river	1			
Distance from embankment	Close to embankment	3	3	3	
	Near to embankment	2			2
	Far from embankment	1			
Distance from forest	Close to forest	1	1	1	
	Near to forest	2			
	Far from forest	3			3
Total			14	13	16

On the basis of the total points provided in the table 6.5 it can be seen that highest point is 16 gained by Patakhali village which indicates the most vulnerable village to cyclonic events. On the other hand, gained point of Sora is 14 and Chakbara is 13 means Chakbara is less vulnerable than the Sora village.

6.2 Sensitivity analysis

From the analysis of sensitivity in the light of economic change is shown in table 6.6 it can be said that in term of population density degree of sensitivity is moderate; occupational change it is moderate; income change it is severe; expenditure capacity change it is severe; saving change it is severe; housing structure change it is severe; drinking water change it is severe; land use change it is severe; change in agricultural land use it is severe and change in land ownership it is severe (for detailed see table 6.6).

Table 6.6 Sensitivity analysis in the light of economic change

1. Sector	2. Sub-sector	Sensitivity Scenario					
		3. Before event situation	4. After event situation	5. How the changes currently affect this sub-sector	6. Basis of analysis	7. Projected impact of possible changes	8. Degree of System Sensitivity to EC
Economy	Change in population density	Working and independent population was more than dependent.	Working and independent population is reduced	Unemployed and Dependent population has increased	From surveyed data analysis	Number of women, child and aged people will be increased may bring social insecurity and economic insolvency	Moderate
	Change in occupation	Majority people was involved with fishing and agricultural activities	A number of people has diverted to day labour	The change has brought economic insolvency.	From surveyed data analysis	More people may change their occupation from agricultural activities and fishing	Moderate
	Income	Most of the people ‘s monthly income was from 5000-10000 taka	Most of the people’s monthly income of Sora is from 5000-10000 taka, and Chakbara and Patakhali is from 10000-15000 taka	-Quality of life has decreased - Money related matter is negatively affected created a rank-down socio-economic livelihood environment	From surveyed data analysis	-income may not increase soon. -quality of life may not improve soon -Economic situation of the area have chance to be challenge for the stakeholders	Severe
	Expenditure capacity	Most of the people’s monthly expenditure was from 3000-6000 taka	As like before Aila same expenditure capacity was found in all study villages	Expenditures for food, cloth, treatment and others has become narrow creating insufficient calorie intake, treatment,	From surveyed data analysis	Loss in expenditure may reduce the minimum intake of basic needs for long time	Sever

				clothing and others things			
	Savings	Most of the people's monthly savings was less than 1000 taka. A remarkable portion people's saving was from 1000-2000 taka.	Apparently most of the people's savings have changed to subsequent next level. But in terms of inflation it is lower than before Aila.	Low savings has decreased investment capacity which effects income and expenditure capacity. It also decreased capacity of investment to improve living standard.	From surveyed data analysis	In near future poor savings will not be able to contribute in the economic development of the area.	Severe
	Housing structure	-More than 90% houses of all villages are katcha - Very few were Semi-pucca and Pucca	-Katcha houses have converted into either Semi-pucca or Pucca houses. - Conversion rate in Chakbara and Patakhali is high but in Sora is very limited	In economic perspective this change is positive even to adaptation capacity but this change is not made by own income. Because different GOs and NGOs facilitated the affected stakeholders.	From surveyed data analysis	This change will enhance the adaptive capacity of the people	Severe
	Drinking water	Almost all the people of Sora village drunk pond water. In Chakbara 100% people drunk rain water for eight months and pond water for rest of the	Same situation is found in Sora village but scarcity has increased because one pond out of two is contaminated by saline water which was washed away by	People of Sora village are severely affected by water born diseases like diarrhea, typhoid, hepatitis etc. In Chakbara situation is almost	From surveyed data analysis	Water born disease may increase in Sora and Patakhali village. If amount of rainfall decrease the drinking water scarcity will increase in Sora and Chakbara villages. But	Severe

		months of the year. But in Patakhali 95.31% people drunk tube well water.	cyclone surges. In Chakbara same situation is found in drinking water but water scarcity has increased. But in Patakhali nothing change is found in drinking water.	same but scarcity has increased. In Patakhali, in the mean time the damaging situation has recovered.		in Patakhali drinking water scarcity may not be more severe like other two villages.	
	Land use	Productive land such as water bodies, aquaculture, agricultural land and vegetation more than productive land such as settlement, bare land, tidal area.	Productive land has reduced and unproductive land has increased.	Less production insists low quality of life status reduced adaptation capacity enhanced vulnerability.	From surveyed data analysis	Long term less production may reduce the adaptation capacity and increase more vulnerability.	Severe
	Agricultural land use	Number of small piece of land cultivators is more than the big piece of land cultivator.	Number of big piece of land cultivators has increased and small piece of land cultivators has decreased.	Small farmers becoming economically weaker.	From surveyed data analysis	Number of small farmers will be increased and they will be weaker economically.	Severe
	Land ownership	40.70% people of Sora, 51.67% people of Chakbara and 100% people of Patakhali had land ownership.	Landlessness has increased in the study area except Chakbara village	Due to loss of land people becoming economically vulnerable.	From surveyed data analysis	Landlessness may increase in future and people may be more vulnerable economically.	Severe

Sources: Table- 5.1, 5.2, 5.4, 5.5, 5.8, 5.9, 5.10, 5.11, 5.14, 5.16, 5.18, 5.19 and Figure-5.1, 5.8

6.3 Vulnerability analysis

Vulnerability due to climate induced economic change is related to economic indicators, including change in number of earning population, literacy rate, occupation, income, expenditure capacity, saving, housing structure, availability of pure drinking water, general and agricultural land use, household resources etc. Parameter based discussion are as follows:

6.3.1 Occupational vulnerability

Tropical cyclone Aila has brought change in economic activities opportunities. Mallick et al.(2011) stated in their study that the physical infrastructure and livelihood condition of the cyclone Aila affected people were tremendously worse, therefore, they started to sell their own resources, shift from occupation to occupation, take micro-credit from many NGOs, and , in extreme cases, migrate to the cities for alternative income sources. Fishing in fresh water and river, agricultural activities and gathering forest resources were most of the people's economic activities. In Sora 8.2% people earned from fishing and 5.8% people from farming; in Chakbara 19.97% people from fishing and 3.9% people from farming; and in Patakhali 6.3% people from fishing and 3.1% people from farming now they have shifted to different less productive sector of earnings basically to day labour. Hence people was forced to work as day labour outside within their territory such as upazila proper or district proper even capital city. From field survey it is found that a number of people of all villages work in brick field in Satkhira/Khulna or capital city Dhaka for7 to 9 months every year. Due to change in land use pattern working opportunities in agriculture sectors have been reduced which creating serious unemployment problem in this area.

6.3.2 Income vulnerability

The national per capita income of Bangladesh was 618.1 US dollar in 2008 which has reached to 1314 US dollar in 2015. During this period the increasing rate is 112.62% (BBS, 2015). In this context the income level of majority people should be from 15000 to 20000 taka after Aila. Because, before Aila, income of most of the people was from 5000 to 10000 taka per month. Still now, income of highest portion people is from 5000 to

10000 taka per month in all villages except Chakbara village. If we consider inflation rate this range should be from 15000 to 20000 taka per month. So it can be said that people income level has not been increased which indicates people's income opportunity is not keep with economic programes due to Aila.

6.3.3 Expenditure vulnerability

Expenditures depend on income level. It is already mentioned that income level of the people has not been increased inflict people to shrink expenditure for their basic needs. From the discussion of expenditure pattern change it is found that sectoral and total expenditure of all villages has decrease comparatively. Because, total income has not been increased with inflation rate. Due to low expenditure for food calorie intake has reduced. At the same expenditure for treatment has reduced aftermath they have been suffering from different diseases. Likewise expenditure for housing is very low. As a result houses are structurally weak and unable to survive from cyclonic effects. So, it is needless to say that this susceptible situation makes the area more vulnerable for any upcoming cyclonic events.

6.3.4 Saving vulnerability

Likewise income and expenditure, savings of the area is very limited which is very low for any investment. Due to low saving they are unable to plan for investment to any income generating activities. Moreover, during extreme event they are unable to pay for basic needs like food, water, treatment, reconstruction of houses etc. which increase the vulnerability of the stakeholders of the area.

6.3.5 Vulnerability to housing structure

Table 6.6 provides information on damage of houses taken place in the study area due to Aila. It is found that almost 80% houses of the affected area were fully damaged, 8-20 % houses were mostly damaged and very few percentage houses were partially damaged. From the previous discussion on changes of housing structure it is found that a positive change in the housing structure basically in pucca and semi-pucca house. Though, the

changes are positive in structure but not too strong to prevent from cyclonic effects. Moreover, after Aila long time they were unable to remake their houses. During field survey from different official information it was found that various GOs and NGOs help the affected family to re-build damaged houses through house building project.

Table 6.7 Damage of houses due to Aila.

(in percentage)

	Sora	Chakbara	Patakhali
Partially	2.33	1.67	4.69
Mostly	8.14	18.33	12.50
Totally	89.53	80.00	82.81
Total	100.00	100.00	100.00

Source: Field survey 2015

6.3.6 Drinking water vulnerability

Drinking water vulnerability depends on availability and drinking suitability of underground water. Underground water of village Sora and Chakbara is contaminated by saline water where as Patakhali is free from excess contamination of any unwanted elements. All the people of Patakhali drinks tube-well water which is hygienic but people of Sora and Chakbara drink harvested rain water or ponds water. Though the rain water is hygienic but pond water is unhygienic. Few people those are economically solvent pay for bottle water or rain harvested water but others have to drink untreated pond water is highly unhealthy. So, obviously it can be said that people those are economically weak are more vulnerable to safe drinking water.

6.3.7 Land use vulnerability

Land is prime source of earning. Because all the man's economic activities perform on land. Usually, people's economic status depends on having quantity of land properties and its productivity. From sensitivity analysis it is known that productive land such as water bodies, aquaculture, agricultural land and vegetation and non productive land such as settlement, bare land, and tidal area. After Aila these productive lands have converted into less productive land. For example, in Sora village productive agricultural land has

converted into non-productive bare land and tidal land, and to less productive aquaculture. At the same, in Chakbara productive agricultural land has converted into less productive aquaculture and non-productive bare land. Likewise, in Patakhali village productive aquaculture has converted into permanent water bodies. It can be mentioned here that apparently aquaculture basically shrimp cultivation is more profitable than agricultural activities but due to siltation the productivity has dramatically reduced in the area. Moreover, for aquaculture only two labors are sufficient for take care where as for agriculture more than ten labours are needed same amount of land. As a result a huge number of people of the area is become unemployed pushes the area to economical vulnerability.

6.3.8 Agricultural land use vulnerability

Aquaculture area has increased in all villages. But small size aquaculture Gher has converted into big size. As a result small farmers are becoming agricultural land less. As like aquaculture crops land has also decreased in the study area. Likewise vegetables cultivation area also has decreased in the study area except Chakbara village. A small scale expansion in vegetation cultivation is found in Chakbara village. Hence, there is no crop found except shrimp cultivation which is cultivating for commercial purpose. It is needed to mention here that the agricultural practice in this area is subsistence type except aquaculture. So, this change is vulnerable to the livelihood of the people of this area. It is predicted that this area will be more vulnerability if any extreme cyclonic even hits this area again.

6.3.9 Land Ownership vulnerability

A small decreasing change in land ownership is found in the study area except Chakbara village. Though the change in overall land ownership is very limited but in case of agricultural land ownership a remarkable change is found. The small amount of land was sufficient to provide foods through agricultural practices. But due to converting into aquaculture this small piece of land is unable to supply necessary food demand force to sell the land. Again the big farmers by applying their social power make people bound to sell the land in lieu of lamp sum amount of money. As a result they become vulnerable in

two ways. Firstly, they loss their source of income and secondly they are to move for works as well as for income to other nearby city or capital city. The severity of the change may increase in near future because to recover from this situation needs integrated programme between government and stakeholders which is still absent.

6.3.10 Household resources vulnerability

Household equipments depend on the economic status of the stakeholders. There are few household equipments were found during survey which indicates that the residents of the area is economically poor. Most of the households are facilitated with cell phone and solar power. Number of solar power connectivity has increased in all villages. Though Patakhali was facilitated with electricity connection but due to Aila destroyed the system and unable to reset up yet. In case of others resources, most of the people have up to 14000 taka equivalent resources. That is very much limited to get preparation in order to cope with upcoming any event.

6.3.11 Infrastructure vulnerability

Among the infrastructures few pave roads, school buildings and cyclone shelters are main. This road is very low in quality and not suitable for any transport. There is a cyclone shelter both in Sora and Chakbara village but there is no cyclone shelter in Patakhali village. The nearest cyclone shelter is almost 3 km away from Patakhali village. Moreover, accommodation capacity of the shelters is one-fourth of the total population. Likewise, road communication from houses to cyclone shelters is not convenient. There is no transport in the area by which people and resources can be brought to cyclone shelters during emergency. On the other hand to protect from tidal and cyclonic surges the areas is bounded by embankment alongside the riverbank. Due to lack of proper maintenance this embankment is too weak to survive when surges hit. During Aila the embankment was overtopped by strong surges and the area was gone almost 10 feet water. Al things were gone under saline water. In four points of the embankment were damaged and the area was washed away twice daily by tidal surges. After three years the damages were recover by building closer. During this time the area was contaminated by over salinity makes the

area unsuitable for further agricultural activities. This area is still susceptible for any further cyclonic event.

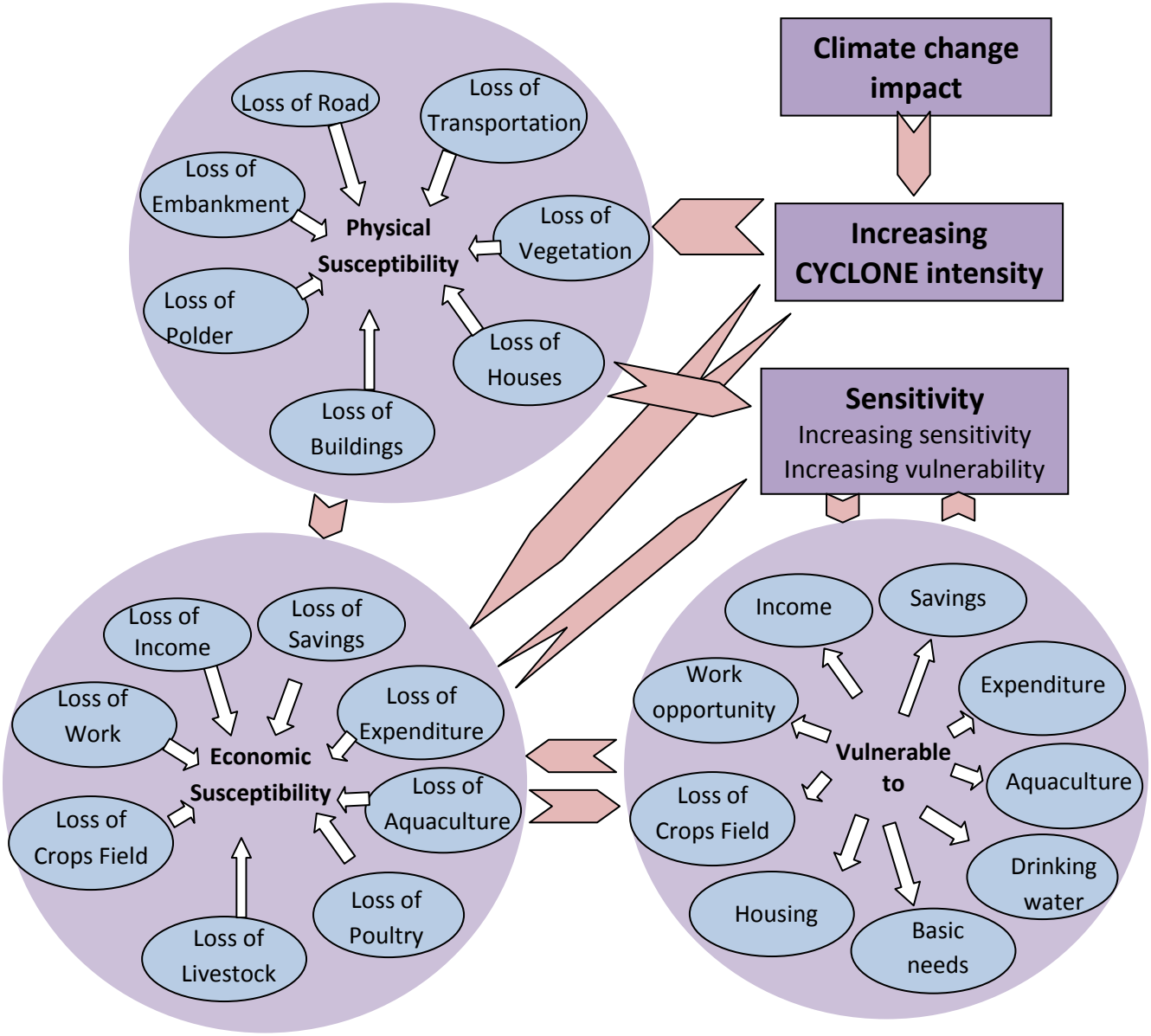


Figure 6.3 Linkage among cyclone, physical and economic susceptibility, vulnerability and sensitivity

6.4 Hypothesis testing related to economic variables (Occupation, Income, Expenditure, Savings and Land Ownership) basis on before and after Aila situation.

6.4.1 Sora Village.

Table 6.8 Test for determining association between main occupation of before and after Aila

H_0: There is no association between main occupation of before and after Aila.
H_1: There exists association between main occupation of before and after Aila.

Main occupation before Aila * Main occupation after Aila Crosstabulation

			Main occupation after Aila									Total
			Fishing	Farmer	Service	Labour	Carpenter	Shopkeeper	Motor cycle driver	Boatman	Others	
Main occupation before Aila	Fishing	Count	31	0	0	11	0	0	1	1	2	46
		Expected Count	20.9	7.0	1.6	10.7	1.1	1.1	1.6	.5	1.6	46.0
	Farmer	Count	3	13	1	1	0	0	0	0	0	18
		Expected Count	8.2	2.7	.6	4.2	.4	.4	.6	.2	.6	18.0
	Service	Count	0	0	2	0	0	0	0	0	0	2
		Expected Count	.9	.3	.1	.5	.0	.0	.1	.0	.1	2.0
	Labour	Count	4	0	0	8	0	0	0	0	0	12
		Expected Count	5.4	1.8	.4	2.8	.3	.3	.4	.1	.4	12.0
	Carpenter	Count	0	0	0	0	2	0	0	0	0	2
		Expected Count	.9	.3	.1	.5	.0	.0	.1	.0	.1	2.0
	Shopkeeper	Count	0	0	0	0	0	1	0	0	0	1
		Expected Count	.5	.2	.0	.2	.0	.0	.0	.0	.0	1.0
	Motor cycle driver	Count	0	0	0	0	0	0	1	0	0	1
		Expected Count	.5	.2	.0	.2	.0	.0	.0	.0	.0	1.0
	Boatman	Count	1	0	0	0	0	0	1	0	0	2
		Expected Count	.9	.3	.1	.5	.0	.0	.1	.0	.1	2.0
	Others	Count	0	0	0	0	0	1	0	0	1	2
		Expected Count	.9	.3	.1	.5	.0	.0	.1	.0	.1	2.0
Total		Count	39	13	3	20	2	2	3	1	3	86
		Expected Count	39.0	13.0	3.0	20.0	2.0	2.0	3.0	1.0	3.0	86.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.336E2[a]	64	.000
Likelihood Ratio	133.156	64	.000
Linear-by-Linear Association	16.449	1	.000
N of Valid Cases	86		

a. 76 cells (93.8%) have expected count less than 5. The minimum expected count is .01.

Comment: At 5% level of significance from above table, likelihood ratio for 64 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there is association between before Aila and after Aila main occupation.

Table 6.9 Test for determining association between total income of before and after Aila

H_0: There is no Association between total income of before and after Aila.
H_1: There exists association between total income of before and after Aila.

Total income before Aila * Total income after Aila Crosstabulation

			Total income after Aila				
			5000-10000 tk.	10000-15000 tk.	15000-20000 tk.	20000< tk.	Total
Total income before Aila	<5000 tk.	Count	3	1	0	0	4
		Expected Count	1.9	1.6	.5	.0	4.0
	5000-10000 tk.	Count	36	30	3	0	69
		Expected Count	32.1	28.1	8.0	.8	69.0
	10000-15000 tk.	Count	1	4	7	0	12
		Expected Count	5.6	4.9	1.4	.1	12.0
	15000-20000 tk.	Count	0	0	0	1	1
		Expected Count	.5	.4	.1	.0	1.0
Total		Count	40	35	10	1	86
		Expected Count	40.0	35.0	10.0	1.0	86.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.176E2[a]	9	.000
Likelihood Ratio	34.678	9	.000
Linear-by-Linear Association	26.566	1	.000
N of Valid Cases	86		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is .01.

Comment: At 5% level of significance from above table, likelihood ratio for 9 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between total income of before and after Aila.

Table 6.10 Test for determining association between total expenditure of before and after Aila

H_0: There is no Association between total expenditure of before and after Aila.
H_1: There exists association between total expenditure of before and after Aila.

Monthly total expenditure before Aila * Monthly total expenditure after Aila Crosstabulation

			Monthly total expenditure after Aila				
			3000-6000 tk.	6000-9000 tk.	9000-12000 tk.	12000< tk.	Total
Monthly total expenditure before Aila	<3000 tk.	Count	3	0	0	0	3
		Expected Count	.3	1.8	.8	.0	3.0
	3000-6000 tk.	Count	5	25	0	0	30
		Expected Count	2.8	18.5	8.4	.3	30.0
	6000-9000 tk.	Count	0	28	24	0	52
		Expected Count	4.8	32.0	14.5	.6	52.0
	9000-12000 tk.	Count	0	0	0	1	1
		Expected Count	.1	.6	.3	.0	1.0
Total		Count	8	53	24	1	86
		Expected Count	8.0	53.0	24.0	1.0	86.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.392E2[a]	9	.000
Likelihood Ratio	60.666	9	.000
Linear-by-Linear Association	37.886	1	.000
N of Valid Cases	86		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is .01.

Comment: At 5% level of significance from above table, likelihood ratio for 9 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That means, there is exists association between total expenditure of before and after Aila.

Table 6.11 Test for determining association between monthly savings of before and after Aila

H_0: There is no Association between monthly savings of before and after Aila.
H_1: There exists association between monthly savings of before and after Aila.

Monthly savings before Aila * Monthly savings after Aila Crosstabulation

			Monthly savings after Aila					
			<1000 tk.	1000-2000 tk.	2000-3000 tk.	3000-4000 tk.	4000< tk.	Total
Monthly savings before Aila	<1000 tk.	Count	29	18	4	0	0	51
		Expected Count	18.4	21.3	9.5	1.2	.6	51.0
	1000-2000 tk.	Count	2	18	12	1	0	33
		Expected Count	11.9	13.8	6.1	.8	.4	33.0
	2000-3000 tk.	Count	0	0	0	1	1	2
		Expected Count	.7	.8	.4	.0	.0	2.0
Total		Count	31	36	16	2	1	86
		Expected Count	31.0	36.0	16.0	2.0	1.0	86.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	89.658[a]	8	.000
Likelihood Ratio	46.054	8	.000
Linear-by-Linear Association	34.679	1	.000
N of Valid Cases	86		

a. 9 cells (60.0%) have expected count less than 5. The minimum expected count is .02.

Comment: At 5% level of significance from above table, likelihood ratio for 8 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between monthly savings of before and after Aila.

Table 6.12 Test for determining association between Land ownership of before and after Aila

H_0: There is no Association between land ownership of before and after Aila.
H_1: There exists association between land ownership of before and after Aila.

Land ownership before Aila * Land ownership after Aila Crosstabulation

			Land ownership after Aila			
			owner	Rented	No	Total
Land ownership before Aila	Owner	Count	32	3	0	35
		Expected Count	13.0	3.3	18.7	35.0
	Rented	Count	0	5	0	5
		Expected Count	1.9	.5	2.7	5.0
	No	Count	0	0	46	46
		Expected Count	17.1	4.3	24.6	46.0
Total		Count	32	8	46	86
		Expected Count	32.0	8.0	46.0	86.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.351E2[a]	4	.000
Likelihood Ratio	138.359	4	.000
Linear-by-Linear Association	81.911	1	.000
N of Valid Cases	86		

a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is .47.

Comment: At 5% level of significance from above table, likelihood ratio for 4 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between land ownership of before and after Aila.

6.4.2 Chakbara Village.

Table 6.13 Test for determining association between main occupation of before and after Aila

H_0: There is no association between main occupation of before and after Aila.
H_1: There exists association between main occupation of before and after Aila.

Main occupation before Aila * Main occupation after Aila Crosstabulation

			Main occupation after Aila										Total
			Fishing	Farmer	Service	Labour	Carpenter	Shopkeeper	Motor cycle driver	Boatman	Poultry	Others	
Main occupation before Aila	Fishing	Count	14	1	0	13	0	1	0	0	0	0	29
		Expected Count	8.2	4.4	1.9	9.7	1.0	1.9	.5	.5	.5	.5	29.0
	Farmer	Count	2	7	0	0	0	0	0	0	1	1	11
		Expected Count	3.1	1.6	.7	3.7	.4	.7	.2	.2	.2	.2	11.0
	Service	Count	0	0	4	0	0	0	0	0	0	0	4
		Expected Count	1.1	.6	.3	1.3	.1	.3	.1	.1	.1	.1	4.0
	Labour	Count	1	0	0	6	0	0	0	0	0	0	7
		Expected Count	2.0	1.0	.5	2.3	.2	.5	.1	.1	.1	.1	7.0
	Carpenter	Count	0	0	0	0	2	0	0	0	0	0	2
		Expected Count	.6	.3	.1	.7	.1	.1	.0	.0	.0	.0	2.0
	Shopkeeper	Count	0	1	0	0	0	3	0	0	0	0	4
		Expected Count	1.1	.6	.3	1.3	.1	.3	.1	.1	.1	.1	4.0
	Motor cycle driver	Count	0	0	0	0	0	0	1	0	0	0	1
		Expected Count	.3	.2	.1	.3	.0	.1	.0	.0	.0	.0	1.0
	Boatman	Count	0	0	0	0	0	0	0	1	0	0	1
		Expected Count	.3	.2	.1	.3	.0	.1	.0	.0	.0	.0	1.0
	Others	Count	0	0	0	1	0	0	0	0	0	0	1
		Expected Count	.3	.2	.1	.3	.0	.1	.0	.0	.0	.0	1.0
Total		Count	17	9	4	20	2	4	1	1	1	1	60
		Expected Count	17.0	9.0	4.0	20.0	2.0	4.0	1.0	1.0	1.0	1.0	60.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.183E2[a]	72	.000
Likelihood Ratio	122.960	72	.000
Linear-by-Linear Association	11.818	1	.001
N of Valid Cases	60		

a. 88 cells (97.8%) have expected count less than 5. The minimum expected count is .02.

Comment: At 5% level of significance from above table, likelihood ratio for 72 degree of freedom degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between main occupation of before and after Aila.

Table 6. 14 Test for determining association between total income of before and after Aila

H_0: There is no Association between total income of before and after Aila.
H_1: There exists association between total income of before and after Aila.

Total income before Aila * Total income after Aila Crosstabulation

			Total income after Aila				
			5000-10000 tk.	10000-15000 tk.	15000-20000 tk.	20000< tk.	Total
Total income before Aila	5000-10000 tk.	Count	15	26	0	0	41
		Expected Count	10.2	19.1	7.5	4.1	41.0
	10000-15000 tk.	Count	0	2	10	0	12
		Expected Count	3.0	5.6	2.2	1.2	12.0
	15000-20000 tk.	Count	0	0	1	5	6
		Expected Count	1.5	2.8	1.1	.6	6.0
	20000< tk.	Count	0	0	0	1	1
		Expected Count	.2	.5	.2	.1	1.0
Total		Count	15	28	11	6	60
		Expected Count	15.0	28.0	11.0	6.0	60.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	96.027[a]	9	.000
Likelihood Ratio	79.151	9	.000
Linear-by-Linear Association	43.434	1	.000
N of Valid Cases	60		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is .10.

Comment: At 5% level of significance from above table, likelihood ratio for 9 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between total income of before and after Aila.

Table 6.15 Test for determining association between total expenditure of before Aila and after Aila

H_0: There is no Association between total expenditure of before and after Aila.
H_1: There exists association between total expenditure of before and after Aila.

Monthly total expenditure before Aila * Monthly total expenditure after Aila Crosstabulation

			Monthly total expenditure after Aila				
			3000-6000 tk.	6000-9000 tk.	9000-12000 tk.	12000< tk.	Total
Monthly total expenditure before Aila	<3000 tk.	Count	1	0	0	0	1
		Expected Count	.0	.7	.2	.1	1.0
	3000-6000 tk.	Count	2	17	0	0	19
		Expected Count	1.0	12.7	3.8	1.6	19.0
	6000-9000 tk.	Count	0	23	9	0	32
		Expected Count	1.6	21.3	6.4	2.7	32.0
	9000-12000 tk.	Count	0	0	3	4	7
		Expected Count	.4	4.7	1.4	.6	7.0
	12000< tk.	Count	0	0	0	1	1
		Expected Count	.0	.7	.2	.1	1.0
Total		Count	3	40	12	5	60
		Expected Count	3.0	40.0	12.0	5.0	60.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	70.337[a]	12	.000
Likelihood Ratio	53.515	12	.000
Linear-by-Linear Association	33.488	1	.000
N of Valid Cases	60		

a. 17 cells (85.0%) have expected count less than 5. The minimum expected count is .05.

Comment: At 5% level of significance from above table, likelihood ratio for 12 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That means, there is association between total expenditure of before and after Aila.

Table 6. 16 Test for determining association between monthly savings of before and after Aila

H_0: There is no Association between monthly savings of before and after Aila.
H_1: There exists association between monthly savings of before and after Aila.

Monthly savings before Aila * Monthly savings after Aila Crosstabulation

			Monthly savings after Aila					
			<1000 tk.	1000-2000 tk.	2000-3000 tk.	3000-4000 tk.	4000< tk.	Total
Monthly savings before Aila	<1000 tk.	Count	11	19	2	0	0	32
		Expected Count	6.9	14.9	5.9	2.7	1.6	32.0
	1000-2000	Count	2	9	8	2	0	21
		Expected Count	4.6	9.8	3.8	1.8	1.0	21.0
	2000-3000 tk.	Count	0	0	1	2	1	4
		Expected Count	.9	1.9	.7	.3	.2	4.0
	3000-4000	Count	0	0	0	1	1	2
		Expected Count	.4	.9	.4	.2	.1	2.0
	4000< tk.	Count	0	0	0	0	1	1
		Expected Count	.2	.5	.2	.1	.0	1.0
Total		Count	13	28	11	5	3	60
		Expected Count	13.0	28.0	11.0	5.0	3.0	60.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	64.725[a]	16	.000
Likelihood Ratio	47.603	16	.000
Linear-by-Linear Association	34.366	1	.000
N of Valid Cases	60		

a. 21 cells (84.0%) have expected count less than 5. The minimum expected count is .05.

Comment: At 5% level of significance from above table, likelihood ratio for 16 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between monthly savings of before and after Aila.

Table 6. 17 Test for determining association between Land ownership before Aila and after Aila

H_0: There is no Association between land ownership of before and after Aila.
H_1: There exists association between land ownership of before and after Aila.

Land ownership before Aila * Land ownership after Aila Crosstabulation

			Land ownership after Aila			
			Owner	Rented	No	Total
Land ownership before Aila	owner	Count	31	0	0	31
		Expected Count	16.0	1.6	13.4	31.0
	Rented	Count	0	3	0	3
		Expected Count	1.6	.2	1.3	3.0
	No	Count	0	0	26	26
		Expected Count	13.4	1.3	11.3	26.0
Total		Count	31	3	26	60
		Expected Count	31.0	3.0	26.0	60.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.200E2[a]	4	.000
Likelihood Ratio	102.401	4	.000
Linear-by-Linear Association	59.000	1	.000
N of Valid Cases	60		

a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is .15.

Comment: At 5% level of significance from above table, likelihood ratio for 4 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between land ownership of before and after Aila.

6.4.3 Patakhali Village.

Table 6.18 Test for determining association between main occupation of before and after Aila

H_0: There is no association between main occupation of before and after Aila.
H_1: There exists association between main occupation of before and after Aila.

Main occupation before Aila * Main occupation after Aila Crosstabulation

			Main occupation after Aila								Total
			Fishing	Farmer	Service	Labour	Carpenter	Shopkeeper	Motor cycle driver	Others	
Main occupation before Aila	Fishing	Count	11	0	0	10	0	0	1	0	22
		Expected Count	6.2	2.1	1.0	8.2	.7	1.0	1.0	1.7	22.0
	Farmer	Count	0	5	1	0	0	2	0	0	8
		Expected Count	2.2	.8	.4	3.0	.2	.4	.4	.6	8.0
	Service	Count	0	0	2	0	0	0	0	0	2
		Expected Count	.6	.2	.1	.8	.1	.1	.1	.2	2.0
	Labour	Count	4	1	0	14	1	0	2	3	25
		Expected Count	7.0	2.3	1.2	9.4	.8	1.2	1.2	2.0	25.0
	Carpenter	Count	0	0	0	0	1	0	0	0	1
		Expected Count	.3	.1	.0	.4	.0	.0	.0	.1	1.0
	Shopkeeper	Count	1	0	0	0	0	1	0	0	2
		Expected Count	.6	.2	.1	.8	.1	.1	.1	.2	2.0
	Motor cycle driver	Count	1	0	0	0	0	0	0	0	1
		Expected Count	.3	.1	.0	.4	.0	.0	.0	.1	1.0
	Others	Count	1	0	0	0	0	0	0	2	3
		Expected Count	.8	.3	.1	1.1	.1	.1	.1	.2	3.0
Total		Count	18	6	3	24	2	3	3	5	64
		Expected Count	18.0	6.0	3.0	24.0	2.0	3.0	3.0	5.0	64.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.571E2[a]	49	.000
Likelihood Ratio	90.802	49	.000
Linear-by-Linear Association	8.670	1	.003
N of Valid Cases	64		

a. 60 cells (93.8%) have expected count less than 5. The minimum expected count is .03.

Comment: At 5% level of significance from above table, likelihood ratio for 49 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between main occupation of before and after Aila.

Table 6.19 Test for determining association between total income of before and after Aila

H_0: There is no Association between total income of before and after Aila.
H_1: There exists association between total income of before and after Aila.

Total monthly income before Aila * Total monthly income after Aila Crosstabulation

			Total monthly income after Aila			
			5000-10000 tk.	10000-15000 tk.	15000-20000 tk.	Total
Total monthly income before Aila	<5000 tk.	Count	2	0	0	2
		Expected Count	1.1	.9	.0	2.0
	5000-10000 tk.	Count	32	23	0	55
		Expected Count	30.1	24.1	.9	55.0
	10000-15000 tk.	Count	1	5	1	7
		Expected Count	3.8	3.1	.1	7.0
Total		Count	35	28	1	64
		Expected Count	35.0	28.0	1.0	64.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.254[a]	4	.010
Likelihood Ratio	10.944	4	.027
Linear-by-Linear Association	8.845	1	.003
N of Valid Cases	64		

a. 7 cells (77.8%) have expected count less than 5. The minimum expected count is .03.

Comment: At 5% level of significance from above table, likelihood ratio for 4 df at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between total income of before and after Aila.

Table 6.20 Test for determining association between total expenditure of before and after Aila

H_0: There is no Association between total expenditure of before and after Aila.
H_1: There exists association between total expenditure of before and after Aila.

Monthly total expenditure before Aila * Monthly total expenditure after Aila Crosstabulation

			Monthly total expenditure after Aila				
			3000-6000 tk.	6000-9000 tk.	9000-12000 tk.	12000< tk.	Total
Monthly total expenditure before Aila	<3000 tk.	Count	2	0	0	0	2
		Expected Count	.2	1.2	.6	.1	2.0
	3000-6000 tk.	Count	3	14	0	0	17
		Expected Count	1.3	10.1	5.0	.5	17.0
	6000-9000 tk.	Count	0	24	18	0	42
		Expected Count	3.3	24.9	12.5	1.3	42.0
	9000-12000 tk.	Count	0	0	1	2	3
		Expected Count	.2	1.8	.9	.1	3.0
Total		Count	5	38	19	2	64
		Expected Count	5.0	38.0	19.0	2.0	64.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	80.667[a]	9	.000
Likelihood Ratio	48.097	9	.000
Linear-by-Linear Association	29.684	1	.000
N of Valid Cases	64		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is .06.

Comment: At 5% level of significance from above table, likelihood ratio for 9 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between total expenditure of before and after Aila.

Table 6.21 Test for determining association between monthly savings before Aila and after Aila

H_0: There is no Association between monthly savings of before and after Aila.
H_1: There exists association between monthly savings of before and after Aila.

Monthly savings before Aila * Monthly savings after Aila Crosstabulation

			Monthly savings after Aila					
			<1000 tk.	1000-2000 tk.	2000-3000 tk.	3000-4000 tk.	4000< tk.	Total
Monthly savings before Aila	<1000 tk.	Count	18	15	1	0	0	34
		Expected Count	11.2	14.3	5.8	2.1	.5	34.0
	1000-2000 tk.	Count	3	12	10	1	0	26
		Expected Count	8.5	11.0	4.5	1.6	.4	26.0
	2000-3000 tk.	Count	0	0	0	3	0	3
		Expected Count	1.0	1.3	.5	.2	.0	3.0
	3000-4000 tk.	Count	0	0	0	0	1	1
		Expected Count	.3	.4	.2	.1	.0	1.0
Total		Count	21	27	11	4	1	64
		Expected Count	21.0	27.0	11.0	4.0	1.0	64.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.301E2[a]	12	.000
Likelihood Ratio	51.010	12	.000
Linear-by-Linear Association	34.425	1	.000
N of Valid Cases	64		

a. 15 cells (75.0%) have expected count less than 5. The minimum expected count is .02.

Comment: At 5% level of significance from above table, likelihood ratio for 12 df at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between monthly savings of before and after Aila.

6.22 Test for determining association between Land ownership of before and after Aila

H_0: There is no Association between land ownership of before and after Aila.
H_1: There exists association between land ownership of before and after Aila.

Land ownership before Aila * Land ownership after Aila Crosstabulation

			Land ownership after Aila			
			owner	Rented	No	Total
Land ownership before Aila	owner	Count	58	1	0	59
		Expected Count	53.5	3.7	1.8	59.0
	Rented	Count	0	2	1	3
		Expected Count	2.7	.2	.1	3.0
	No	Count	0	1	1	2
		Expected Count	1.8	.1	.1	2.0
Total		Count	58	4	2	64
		Expected Count	58.0	4.0	2.0	64.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	55.186[a]	4	.000
Likelihood Ratio	30.733	4	.000
Linear-by-Linear Association	46.596	1	.000
N of Valid Cases	64		

a. 8 cells (88.9%) have expected count less than 5. The minimum expected count is .06.

Comment: At 5% level of significance from above table, likelihood ratio for 4 degree of freedom (df) at asymptotic significant is .000 which is less than 0.05. So we may reject null hypothesis. That is, there exists association between land ownership of before and after Aila.

Chapter 7

Adaptation Strategy

Adaptation is an integrated concept includes environmental, economic, political, social and psychological factors. The IPCC (2007) defines climate change adaptation as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Adaptation is nothing but adjustment or actions undertaken which creates opportunities to minimize adverse effects of any physical and cultural environmental change made due to climate change. This is depended on available economic resources; technology, information and skills; infrastructure and institutions; and indigenous knowledge and equity. It also depends on *what* they are vulnerable to (droughts, storms, cyclones etc.), *who* is vulnerable, *how* future vulnerability is shaped, and at *what scales*. However, keeping in mind vulnerability discussed in previous chapter adaptation strategy taken by the stakeholders are as follows:

7.1 Adaptation to occupational vulnerability

Mallick (2011) shows that the existence of social networks or an institutional set-up in the area for a more collective ex-ante or ex-post strategy to cyclone and tidal surges is very thin except the movement to the nearby cities as a rickshaw puller or industry labour. Such rural-urban migration in Bangladesh is a household based strategy for maximizing income or wellbeing and is partially dependent on the support of the other family members, and/or district-based acquaintances, friends and neighbors. The respondents perceived migration as a way of maximizing their family's income and minimizing its risk. In terms of occupation people of this area are susceptible. From the change analysis it is found that people is bound to go low paid occupation. Due to Aila, inland fresh water aquaculture is lost and river resources are reduced. On the other hand agricultural land converted into marshy land and later on shrimp cultivation. Hence, for agricultural activities almost 5 times more workers need than the aquaculture. As a result, many people become workless. To adopt with the changing situation people work as day labour either in their own locality or any other city across the country. It is known during field survey that those are working as day labour are mostly worker of brickfields. Moreover,

many people take motorcycle driving as their main or part-time occupation. It is mentioned previously that roads are unpaved and in many cases on the dam of the rivers. Roads are narrow and not suitable for any vehicle except two wheelers. So, to transport people and goods an important means of transportation is motorcycle. That is why people accept motorcycle driving as profession to adopt with the adverse situation. Moreover, people basically women collect shrimp larvae from river to earn money. They also capture numerous non-shrimp fish fries using a very small net. It is also found that women especially the Hindu women in this union work in the field. They work in *Gher* to remove weeds that grow and float on the water that pollute the water and hamper the fish production. They get 100 taka per day to clean the *Gher* (Sultana and Mallick, 2013). Alternative livelihood options are very limited in the area. Recently, Crabs fattening is found as highly profitable and growing sector. Though it is limited in scale and can be emerged as a supplementary occupation of the people in future.

7.2 Adaptation to income, expenditure and saving vulnerability

Income, expenditure and saving are highly correlated with occupation. Due to divert from more productive occupation to less productive one, income, expenditure and savings of the dwellers are highly susceptible. If inflation rate consider the income of the dwellers has reduced. As a result expenditure and saving also have reduced. To adjust with reduced income people have reduced their expenditure on food, cloths, treatments and others daily expenditures. People are trying to increase income through involving different main and supplementary works such as shrimp larvae collection from river, cattle rearing, crabs fattening, and homestead vegetables cultivation. However people save money to adopt with the future hazard and they do not spend this money even though it is small in amount.

7.3 Adaptation to housing structure change vulnerability

Aftermath of cyclone Aila, people were forced to take accommodation on the roads or the dams through building temporary huts. Only once the dams were repaired a few months later did the inhabitants begin to return to their old places. During construction or renovation of houses some households shifted their homes to high positions or changed

their materials so that the houses can cope with a future cyclone (Sultana and Mallick, 2015).

Table 7.1 Change in housing structures and materials to adapt with the situation

(in percentage)

Plinth rising						
	Sora		**Chakbara**		**Patakhali**	
	Before Aila	After Aila	Before Aila	After Aila	Before Aila	After Aila
Yes	8.14	18.60	6.67	60.00	100.00	78.13
No	91.86	81.40	93.33	40.00	0.00	21.88
Total	100.00	100.00	100.00	100.00	100.00	100.00
Plinth structure change						
Mud	93.02	88.37	88.33	58.33	100.00	75.00
Wooden	4.65	8.14	3.33	18.33	0.00	6.25
Concrete	0.00	1.16	6.67	21.67	0.00	18.75
Others	2.33	2.33	1.67	1.67	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Plinth height in feet						
<1 feet	40.10	1.16	23.48	6.67	32.78	12.50
1-2 feet	39.90	13.95	17.34	15.00	37.74	40.63
2-3 feet	10.75	61.63	40.88	50.00	25.25	39.06
3-4 feet	6.63	19.77	15.74	25.00	4.23	7.81
4< feet	2.62	3.49	2.56	3.33	0.00	0.00
	100.00	100.00	100.00	100.00	100.00	100.00
Structural change of houses						
Yes	4.65	6.98	5.00	46.67	0.00	64.06
No	95.35	93.02	95.00	53.33	100.00	35.94
Total	100.00	100.00	100.00	100.00	100.00	100.00
Housing structure						
Mud wall	93.02	83.72	63.33	30.00	96.88	64.06
Wooden wall	3.49	10.47	25.00	38.33	1.56	10.94
Tin sheet	1.16	1.16	3.33	10.00	1.56	6.25
Concrete wall	0.00	2.33	6.67	20.00	0.00	18.75
Others	2.33	2.33	1.67	1.67	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field survey, 2015

After Aila 18.60% of Sora, 60.00% of Chakbara and 78.13% of Patakhali people has brought change in their housing structure. Hence, 8.14% people of Sora, 6.67% people of Chakbara and 100% people of Patakhali village were changed their houses as pre-disaster preparedness. The change was made through plinth rising, plinth materials change and

building materials change. For example, plinth of houses in all three villages mostly was made by mud and very few were made by wood or concrete before Aila. But after Aila those are economically solvent have made the plinth of the houses by wood or concrete. Moreover, cent percent people have raised plinth of house up to 4 feet based on the height of the land and probable height of surges. Plinth of most of the houses of Sora and Chakbara villages has risen by 2-3 feet and Patakhali by 1-3 feet.

Likewise, materials of housing have changed after Aila. Mud constructed wall has reduced whereas wooden, tin sheet and concrete wall made houses have increased. Changing rate of wooden wall houses is higher in Sora; tin sheet wall houses is higher in Chakbara and concrete wall is higher in Patakhali among the villages. Because, wooden or tin sheet or concrete wall is more resistant from water than mud wall.

7.4 Adaptation to general and agricultural land use vulnerability

The study reveals that major change in land use is found from agriculture to aquaculture and also to bare land due to Aila. Dams around the villages were broken by the storm surges of Cyclone Aila and total area was gone under water. The area was flooded by saline water twice daily until closers were built on broken dams after three years of the event. As a result a huge quantity of land has converted into aquaculture land. Moreover, due to increased salinity and high tidal inundation agricultural crops cultivation is extremely low in the area. Shrimp cultivation started in the mid eighties that are still prevalent, although the production has fallen tremendously due to cultivation for long time years after years in the same land paddy cultivation is also not possible due to severe salinity in the land (Alauddin and Rahman, 2013). However people raise height and width of the bank of Ghares to protect fishes from the risks of high tidal inundation and tidal surges considering water level. People also put pata and net to protect fishes from same situation. On the other hand return from aquaculture is lower than the crops cultivation. So, people trying to cultivate saline tolerate crops basically different types of rices. But still now it is predicted very small in scale. On the other hand bare land is trying to bring under social frosty. However, homestead land is advised to bring under vegetable cultivation.

7.5 Adaptation to drinking water vulnerability

The study villages are drinking water scarcity area except Patakhali village. Dakkhin Bedkashi union of Khulna district and Gabura union of Satkhira district are separated by Kobodak river. But it is surprising that the underground water of Gabura union is contaminated by saline whereas Dakkhin Bedkashi is free from saline contamination. So, people of Sora and Chakbara have been suffering by lack of pure drinking water. It has already mentioned that people of Sora are mostly dependent on pond water whereas Chakbara are dependent on rain, pond and treated water. During rainy season they harvested rain water and store in earthen vessel. They use this water from four to six months on basis of their storing capacity. On the other hand, when they use pond water, few people use water purifying medicine and few people do not take any measure of water purification.

7.6 Adaptation to household resources vulnerability

To quick recover and adjust with the damages which took place just after Aila, people sold off their household resources. According to Sultana and Mallik (2015) 17.4% of the respondents sold their resources to cope with the adverse situation induced by cyclone. 66.3% of them sold their cattle and other livestock, because of monetary urgencies and the burden of a shortage of fodders and adequate shelters. 59.6% sold their broken or even non-broken trees and plants (timber or wood plants) and only 5.9% sold their ornaments or other household assets like TV, Mobile phone, radio etc. None of them sold their land. During study it was found that houses of the area are poorly equipped, because the income is too marginal to provide food and others basic needs than bye household's equipments. However, it is surprising that stakeholders do not have well plan to save and manage the remaining household equipments pre-hazard, post-hazard or during hazard. But they apply few indigenous techniques to protect the household resources. As pre-disaster preparedness people build macha in room and put resources on it during event. Besides, food and other necessary goods put underground packaging in waterproof polythene bag when hazards hit the area.

7.7 Role of GEOs and NGOs to adapt the situation

During study it was found that different GOs and NGOs help people to develop livelihoods through improvement of plans and activities with the local community to reduce their disaster risks and to adapt to climate change. The Government of Bangladesh has a number of well-established social safety net mechanisms prepared in response to the event of a disaster, namely, Vulnerable Group Development (VGD), Vulnerable Group Feeding (VGF), Cash/Food-for-Work, Test Relief (TR) and Gratuitous Relief (GR). Similarly several NGOs like CCEC, World Vision, CARITAS, CCDB, Progoti, Islamic Relief, Gono Mukhi, Rupantor, Muslim Aids, Broti, Relief International, IPack, Uttoron etc. Bangladesh has short, mid and long term programmes to address the adverse impact of climate change. Mass awareness development training and advocacy progarmmes, tree plantation and afforestation, mainstreaming climate change issues into sectoral development policies and programmes, networks among organizations, civil society and media are short term; renewable energy development, improved water resource management, food security and crop diversification programmes are mid-term; and research, afforestation, development of suitable crop varieties, incorporation climate change issues in educational curriculum, infrastructures development and undertaking adequate projects and programmes are long-term programmes.

In order to manage disaster more comprehensively Bangladesh has also taken a National Plan for Disaster Management 2010-15. The aim of the plan is to take country's disaster management from conventional management to more comprehensive disaster management in the light of paradigm shift of disaster management. The National Disaster Management Council (NDMC) and Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) are responsible to coordinate disaster related activities at the national level. The Disaster Management and Releif Division (DMRD) under the Ministry of Food and Disaster Management (MoFDM) of the Government of Bangladesh coordinates national disaster management activities across the agencies. The Disaster Management Bureau (DMB), a technical arm of DMRD is responsible for overviewing and coordination all activities related to disaster management from national down to grass-roots level. Under DMB district, Upazila and Union level Management Committee work together with civil society member. The Union Disaster Management Committee

(UDMC) is the lowest administrative unit of disaster management. The UDMC consists of the chairman of Union Parishad as chairperson and members comprising all the Government departments' head at Union level, members of Union Parishad, NGO leaders, working in the respective union, and civil society members.

NGOs have played significant roles in the disaster management of Bangladesh over the last three decades. At present, a quarter of all foreign assistance to the country is channeled through the NGOs and increasing portion of these funds is used for disaster management. The DMB, the apex government organization responsible for coordination natural disaster management across all agencies, has been assigned the role of coordination the NGOs activities. The NGOs, both national and international ones, have been implementing a range of relief and rehabilitation programmes after cyclone Aila. Immediately after the cyclone, NGOs were mainly involved in humanitarian relief distribution and later they have taken on numerous rehabilitation programmes. The immediate support of NGOs has been diverse in nature and has included asset transfers (such as boats, nets, livestock and food), cash transfers and other non-food and emergency items (such as jerry cans, mosquito nets, pure water). These emergency interventions were initiated to address the basic survival and protection needs of the affected households. The taken relief and rehabilitation programmes helped people in sustaining livelihood after the Aila.

However, during survey, a number of NGOs found working till now from after Aila. But their aim and activities are different. For example, CARITAS arranged training programme on 'How to build cyclone and cyclonic surges resistance house' through "Amrao Pari" programme. Along with training they provided twenty thousand taka per house for plinth rising and repair wall and others structures of house in Sora and Chakbara village. Though it was very small in number, only few houses got this advantage. In order to overcome drinking water problem CARITAS also provided dram to harvesting and storing rain water. There is another programme of CARITAS to conduct training programme in order to train up farmers with salient tolerant crops cultivation.

In Patakhali village, UNDP built up a number of concrete houses for the victims. These houses are too strong to protect cyclone surges. Roof of this houses use for rain water harvesting which use for drinking purpose.

Center for Natural Resource Studies (CNRS) is working for recovering agricultural activities in the affected area. They arrange training programmes to train up affected people how to cultivate saline tolerant varieties crops.

Christian Commission for Development in Bangladesh (CCDB) dug one pond for each village Sora and Chakbara in order to supply drinking water. They have also established drinking water purifying plant for these two villages.

Chapter 8

Summery and Recommendation

This chapter intends to present summarized findings, recommendations and conclusion.

8.1 Summery of findings

Climate change is the most discussed issue in the environmental change research. Several research findings indicate about the adverse impact of this change. Bangladesh is the worst affected country of climate change. This study examines the changing pattern of economy in the light of economic indicators such as occupation, income, expenditure, savings, land use both agricultural and non-agricultural, and infrastructure that has taken place due to Aila of the affected area of Bangladesh. It also discusses the vulnerability regarding economic transformation and adaptation strategies for both indigenous and organization level.

8.1.1 General description

The study area is situated on the coast of the Bay of Bengal. Study villages are densely populated. Even Sora and Patakhali is more densely than national population density. Literacy rate in all three villages is low as compare to country and most people are involved with primary economic activities. Fishing and farming are the main occupation of the majority people. A considerable portion people are working as day labour also.

From the study it is found that income of most of the people of Sora and Chakbara is 6000-9000 taka and Patakhali is 3000-6000 taka per month. People are also involved with supplementary work and they earn money from these sources. The range of total income indicates that income of most of the people of Sora and Patakhali is 5000-10000 taka while in Chakbara it is 5000-10000 taka per month. So, Chakbara is better than other two villages in term of income.

Expenditure pattern of the study villages is discussed on the basis of monthly total expenditure. Total expenditure includes expenditure for cloth, treatment, drinking water and others. Information on total expenditure indicates that majority people monthly expenditure is taka 6000-9000. A significant percent people monthly expenditure is taka

3000-6000. It is observed that in term of expenditure pattern Chakbara is better than others two villages. Because, number of people of 9000 taka and more monthly expenditure group is more in Chakbara than other two villages.

Analysis of saving pattern indicates that saving level of the study villages is very low. Highest portion people's monthly saving is 1000-2000 taka and a significant portion people belongs to less than 1000 taka group.

From the housing pattern analysis it was found that in Sora Kacha house is more and Pucca and Semi-pucca house are more in Patakhali than other two villages. So, housing condition in Patakhali is better than other two villages while in Sora situation is the worst than other two villages.

Toilet facility of the study villages is very poor. Most of the people of all study villages use unhygienic non-sanitary toilet. Though all the people of Chakbara and Patakhali villages use sanitary and non-sanitary toilet but in Sora almost 21% people still now use open space for defecation.

Difference was also found among the villages in terms of sources of drinking water. In Sora 94.19% people drink pond water and 5.81% drink rain water; in Chakbara 100% people drink harvested rain water for 5-6 months and pond water for rest of the months; where as in Patakhali 100% people drink tube-well water.

In all three villages major portion land is devoted to aquaculture. Settlement and homestead vegetation also have occupied a considerable land. As compare to others uses agriculture has engaged with small portion of land. Bare land which occupies second highest portion of land is unproductive. In terms of occupation few people are engaged with agricultural activities basically aquaculture, crops, vegetables and fruits cultivation. Aquaculture and crops cultivation were found in all three villages but most of the farms are small in size. Vegetables and fruits cultivation was found in only Chakbara and it is also in very small scale. Agricultural land use pattern depends on land ownership. Difference was found in landownership among the villages. In Patakhali village 98.44%, in Chakbara village 51.67% and in Sora 37.21% people have land ownership.

Household equipment considers power connection, mobile phone and other resources. In all three villages there is no electricity connection but they use solar panel. Among the villages solar panel user is more in Chakbara village than other two villages. Chakbara is also more resourceful than other two villages in terms of others household resources.

8.1.2 Change Analysis

Number and density of population have changed in all the study villages except Patakhali. Literacy rate have increased in all the study villages. A massive change was found both in main and supplementary occupation. From the change analysis of main occupation it was observed that a number of people of all three villages have found to change their main occupation from fishing and farming to daily labour and motorcycle driving. Even fishing has converted from main occupation to supplementary occupation and consequently motorcycle driving from supplementary to main occupation of a consideration portion of people.

Income from both main and supplementary sources has increased in the study villages. Majority portion people's total income was 5000-10000 taka before Aila which is 10000-15000 taka after Aila. Mention to be needed here that inflation rate did not consider.

Change also found in sources of expenditure. Expenditure for all sources like cloth, food, treatment, drinking water, others and total has increased. Total expenditure of most of the people of all study villages was 6000-9000 taka before Aila. There was no variation found in number of this category's people. But a considerable portion people's expenditure was 3000-6000 taka before Aila which is 9000-12000 taka after Aila.

As like income and expenditure savings has also increased after Aila. Most of the people's saving was up to 2000 taka before Aila which is up to 3000 taka after Aila. A positive change also found in housing structures. During study it was found that people have changed their houses from either katcha to semi-pucca or semi-pucca to pucca or katcha to pucca in order to protect live and properties from others next cyclonic events. Positive change also found in toilet facilities.

Study villages are drinking water scarcity area except Patakhali. Tube-well water is available in Patakhali village and 100 % people use this water. While in Sora still now

94.19% people use pond's water which was 95.35% before Aila. Few people have started harvesting rain water for using drinking purpose. In Chakbara, no change is found in case of drinking water scenario. Almost all the people harvest rain water and use for near about 6 months and rest of the year use pond's water.

In case of land use change, major change was found in water bodies, aquaculture, agricultural land and vegetation. An areal expansion was found in aquaculture, settlement, bare land and tidal area while a reduction was found in water bodies, agricultural land, and vegetation in Sora village due to Aila. On the other hand, water bodies, agricultural land, vegetation and settlement have decreased while aquaculture and bare land have increased in Chakbara village due to Aila. In Patakhali village water bodies, vegetation and settlement, and bare land have decreased while water bodies and agricultural land have increased due to Aila. Basically, Aila has converted land from more productive to less productive one.

A negative change has also found in agricultural land use. Crops, vegetables and fruits cultivated land have reduced and land under aquaculture has increased due to Aila. Here need to mention that economic return from non-aquaculture land is more than the aquaculture. Because cyclonic surges of Aila has brought huge sandy sediments which reduced the per unit productivity of aquatic product basically shrimp product.

In case of land ownership, land ownership has reduced in all study villages except Chakbara. On the other hand rented land ownership has increased in Sora and Patakhali while it remains unchanged in Chakbara.

Overall development change analysis indicates that Chakbara was the most developed and Sora was the least developed village before Aila. But after Aila position of Chakbara is same while Patakhali is taken to least developed position.

8.1.3 Vulnerability analysis

Magnitude of vulnerability of economic change due to cyclone Aila depends on scale of cyclonic events, level of economic status of the stakeholders, control over the assets and livelihood opportunities. However, a number of factors such as location of the area, physiography, distance from coast, distance from river, distance from forest and distance

from embankment work individually and together by influencing each other which control the scale of vulnerability. Analysis of integrated influence of the factors indicates that Patakhali is more vulnerable than other two villages.

From sensitivity analysis it can be said that change in population density and occupation is moderately sensitive while income, expenditure capacity, savings, housing structure, drinking water, land use, agricultural land use and land ownership is severely sensitive to vulnerability to any cyclone and its aftermath effects.

Sector of economic vulnerability such as occupational, income, expenditure, saving, loss of housing structure, drinking water, land use change, agricultural land use change, land ownership, household resources and infrastructures are inter-related and effects each other (figure 6.2).

Land is the basic factors of creating occupational opportunities for the dwellers of the study area. Because the study areas are rural in characteristics and agriculture is the prominent economic activity of the dwellers. Tropical cyclone Aila has brought massive change in land use pattern. Due to Aila the most productive land has converted into less productive land. Such as, agricultural land has converted into aquaculture or water bodies or bare land in all three villages. The people those were dependent on agricultural activities became workless and forced to change their occupation mostly became day labour primarily brick field workers. The income from changed occupation is lower than the previous occupation. That is why they are bound to reduce their expenditure of different sources.

However, effect of Aila on housing structure was severe. Almost 80% houses were destroyed fully, and rest of the houses destroyed either mostly or partially. As a result, just after Aila people become homeless and after 6 years still they are unable to recover the damages fully.

In term of other infrastructure the area is very poor. Unpaved road, cyclone shelter, school buildings and embankments are the main infrastructures of the area. There is a cyclone shelter in both of Sora and Chakbara village. But the distance of cyclone shelter from Patakhali is 3 km. Again, there is a school building only in Sora village. Roads of three villages are unpaved which are not suitable for any other transport except

motorcycle. Accommodation capacity of those shelters is very limited in respect to demand. During cyclone, the only means to go to cyclone shelter or to any safe places is foot. As a result people try to safe their life rather than to take any other household resources. They loss the household resources. Very often people loss life due to take more time to reach to cyclone shelter. On the other hand, due to lack of proper maintenance embankments have become very weak which are vulnerable to any upcoming cyclone or cyclonic event.

8.1.4 Adaptation strategy

Adaptation is an integrated approach which depends on a set of factors those works together. Basically available resources, applied technology, early warning system, infrastructures, motivation, indigenous knowledge and equity etc. are the main forces of a society to cope with the adverse effect of economic change which occurred due to cyclone. From the study it is found that people occupationally vulnerable and to adapt with the situation they have shifted their pervious occupation into new low paid work like day labour, brickfield worker, rickshaw/van pooler. People also have accepted motorcycle driving as supplementary occupation. Motorcycle is an important means of transportation use for carrying goods and people in the study area. Along with man, women have involved with different works like fishing in the river and as day labour in Gher in order to support their family.

Income, expenditure and saving depend on mainly occupation. As dwellers of the area are vulnerable in terms of occupation, their income and expenditure for different purposes like food, cloth, treatment etc. had to reduce to adjust with the situation. To increase income people start cattle rearing, crabs fattening, saline tolerate crops cultivation with the help of different NGOs.

All the houses of the study area were affected by the Aila. After Aila people have brought change both in structure and building materials of their houses. Almost all the people have raised the plinth of the houses. Before Aila plinth of the houses were made by mud whereas after Aila a considerable portion houses plinth were found made by either wood or concrete. As like plinth, change was found in housing structure. Though the most of

the houses wall made by mud but use of others materials like wood, tin sheet, brick have increased in all three villages as pre-prepared measure of any upcoming cyclone.

Major change in land use was found that agricultural land has converted into non-agricultural activities usually into water bodies, bare land, and tidal land. People is trying to bring bare land under agriculture through cultivating saline tolerate crops. On the other hand bare and tidal land is trying to bring under forestation with the help of various GOs and NGOs under social forestry activities. Inundated area has brought under shrimp cultivation. To protect the shrimp Ghares from risks of high tide inundation and tidal surges people raise height and width of the bank of the Ghares. People also put pata and net to protect fishes from same situation. Homestead agriculture primarily vegetables cultivation is also increasing to fulfill own demand.

It is already mentioned that study villages are drinking water scarcity area except Patakhali village. To meet up the demand of drinking water people of Sora and Chakbara villages harvest rain water and use for near about six months. Rest of the months they use ponds water.

Houses of the study areas were poorly equipped. People take different strategy to protect their household resources pre, during and post cyclone. As pre-disaster measure people make macha in side of houses and put household resources on it during disaster. Moreover, food and other resources put underground packaging in waterproof polythene bag when hazards hit the area. Just after cyclone Aila people sold their cattle and others livestock, broken or unbroken trees, cell phone and ornaments etc.

To cope with the vulnerable situation different GOs and NGOs works with the stakeholders. But the vision and mission of different GOs and NGOs are different as per their working nature. Vulnerable Group Development (VGD), Vulnerable Group Feeding (VGF), Cash/Food-for-Work, Test Relief (TR) and Gratuitous Relief (GR) works under the umbrella of Bangladesh Government to help the vulnerable people during, pre and post disaster situation. In order to comprehensive disaster management in the line of disaster management paradigm shift Bangladesh was taken a National Plan for Disaster Management Programme 2010-15. To execute the plan NDMC, IMDMCC, DMRD, MoFDM are working together and Disaster Management and Relief Division (DMRD)

under the Ministry of Food and Disaster Management (MoFDM) of the Government of Bangladesh coordinates national disaster management activities across the agencies. Moreover both national and international NGOs have been implementing a range of relief and rehabilitation programmes after cyclone Aila. For example, CARITAS arranged training programme on 'How to build cyclone and cyclonic surges resistance house" through "Amrao Pari" Programme. They provided twenty thousand taka per house to rise and repairing house. Though, it was very limited in number. CARITAS also provided drams for harvesting rain water which use for drinking purpose. They have another training program to train up farmers on how to cultivate salient tolerant crops cultivation. Center for Natural Resource Studies (CNRS) has same programme. UNDP has built up a number of cyclone tolerate pucca house in Patakhali village. Roof of these houses use for harvesting rain water which use for household works. CCDB dug one pond in each village Sora and Chakbara and they also provided water purifying plant for these two villages.

Table 8.1 Summery of hypotheses tested related to occupation, income, expenditure, savings and land ownership.

No	Null and Alternative hypotheses	Statistical test	Remarks
Sora village			
1	**H_0:** There is no association between main occupation of before and after Aila. **H_1:** There exists association between main occupation of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
2	**H_0:** There is no Association between total income of before and after Aila. **H_1:** There exists association between total income of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
3	**H_0:** There is no Association between total expenditure of before and after Aila. **H_1:** There exists association between total expenditure of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
4	**H_0:** There is no Association between monthly savings of before and after Aila. **H_1:** There exists association between monthly savings of before and after Aila	Likelihood Ratio Sig. value-.000*	H_1 Accepted
5	**H_0:** There is no Association between land ownership of before and after Aila. **H_1:** There exists association between land ownership of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted

Chakbara Village			
1	**H_0:** There is no association between main occupation of before and after Aila. **H_1:** There exists association between main occupation of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
2	**H_0:** There is no Association between total income of before and after Aila. **H_1:** There exists association between total income of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
3	**H_0:** There is no Association between total expenditure of before and after Aila. **H_1:** There exists association between total expenditure of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
4	**H_0:** There is no Association between monthly savings of before and after Aila. **H_1:** There exists association between monthly savings of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
5	**H_0:** There is no Association between land ownership of before and after Aila. **H_1:** There exists association between land ownership of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
Patakhali Village			
1	**H_0:** There is no association between main occupation of before and after Aila. **H_1:** There exists association between main occupation of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
2	**H_0:** There is no Association between total income of before and after Aila. **H_1:** There exists association between total income of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
3	**H_0:** There is no Association between total expenditure of before and after Aila. **H_1:** There exists association between total expenditure of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
4	**H_0:** There is no Association between monthly savings of before and after Aila. **H_1:** There exists association between monthly savings of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted
5	**H_0:** There is no Association between land ownership of before and after Aila. **H_1:** There exists association between land ownership of before and after Aila.	Likelihood Ratio Sig. value-.000*	H_1 Accepted

*Level of significance at .05.

8.2 Recommendation

Bangladesh is not liable for climate change but the worst sufferer. From the discussion of the study it was found that people become economically vulnerable due to cyclone Aila. To recover the situation along with the indigenous knowledge several GOs and NGOs have taken a number of programmes and activities. Moreover, for quick recovery, better management and to develop sustainable adaptation strategy the study have suggested the following strategies.

- To recover economical vulnerability more work opportunities for the people should be created. For this, dependency on shrimp cultivation should be reduced by creating others crops cultivation opportunities. Because less number labor is needed to shrimp cultivation than crops. It is quite impossible that to reduced salinity of the soil at once sudden. However, it is possible to cultivate saline tolerate crops.

- Number of saline tolerate crops is very limited. Through the agricultural research saline tolerate HYV crops should be introduced.

- Different organizations (donor agencies) have supplied saline tolerate crops to the stakeholders which is very insufficient to fulfill the requirements of the area. So, the agriculture department of Bangladesh government have to insure the availability of saline tolerate seeds of different crops for the farmers. Government should supply the seeds by free or subsidized rate. Moreover, different programmes such as publicity, training, motivational etc. can be arranged for inspiring and promoting farming activities.

- Due to deposition of sediment with cyclonic surges of Aila per unit shrimp production of the area has reduced. To enhance productivity government has to monitor and give necessary advice to the farmers through Block Supervisor (BS).

- Other agricultural activities like poultry, dairy and livestock can be introduced in the area. Government should take necessary steps to train up farmers and provide logistics like capital through soft loan, chicken, vaccine etc.

- During survey it was found that the dams around the area to protect from high tide and cyclonic surges were old and almost damaged in condition (Appendix-G, figure-G6). These dams are too weak to protect from high tide and cyclonic surges. Planned construction of embankment with appropriate drainage system, height and width considering cyclone water level can only protect the aquaculture, livestock, agricultural crops and infrastructures as the effective adaptive structural measures in this area. So, it is utmost needed to repair and maintain dams in regular basis.

- Roads are unpaved and density is very low. Access to cyclone center during event is quite difficult and time consuming. Roads are needed to be widened, repair and paved in urgent basis. Besides, to raise accessibility more roads need to be established.

- As compare to the population number of cyclone shelter is insufficient. It is already mentioned that there is a cyclone shelter in each Sora and Chakbara village but there is no cyclone shelter in Patakhali village. So, more cyclone shelters need to be established.

- Plinth rising is one of the common and popular adaptation strategy to protect houses from the risks of climatic disaster, particularly, cyclone and flood in the coastal and flood prone areas. In the study area plinth rising is often adopted by mostly individual initiative and NGOs support without considering water level of flood and storm surge trend analysis of past events and future prediction, which need to be addressed for the long-term sustenance of the structures.

- Tree plantation around homestead, alongside the road, bare land and alongside the embankment by the individual initiative or under social forestry programme of different GOs and NGOs is another adaptation practice in the study area. But this is very limited as compare to the need. So, it is needed to inspire people to intensive homestead tree plantation through GOs and NGOs activities. Moreover, under social forestry programmes initiatives should be taken to afforestation of damaged forestry in large scale.

- To cope, the Bangladesh government will require more skilled manpower, more effective planning, an increase in economic strength, more in-depth studies, an increase in resources and an improved and adequate infrastructure. Gathering evidence of climate change and its impact at the local level, placing emphasis on local ecological knowledge and traditional innovation, and analysing community-level preparedness are essential components of the planning necessary to combat the impacts of climate change.
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- Even more importantly, it is vital that local people fully participate in policy making and programmes dealing with climate change impacts, mitigation and adaptation. Community-based adaptation should, therefore, be a central tenet of action on climate change in Bangladesh.

8.3 Conclusion

Globally most of the coastal areas of the world are at risk from natural hazards resulting from geological and meteorological disturbances. In Bangladesh, coastal areas cover over 6.8 million of household in 147 Upazila (Sub-district) along the coastal belt, which considered as risk prone area ecologically sensitive and climatically vulnerable. Cyclone Aila tore the coastal region in 2009 and brought massive damaged in the area. Based on the research result and discussion it could be concluded that before Aila economic systems of the area was suitable for crops based agricultural activities and people were solvent to fulfill their basic needs. Due to Aila it was inundated by the saline water and shrimp cultivation has replaced the major portion of crops cultivation. As a result, people loss their works, income opportunity, expenditure capacity, which have affected all the livelihoods relevant issues like shelter, foods, education, cloth, treatment etc. Even after a long time (7 years) of Aila the area is still unable to recover the situation. A number of programmes and activities have taken by the different GOs and NGOs with the help of national and international organizations. However, still now people are far from the before Aila situation. Because, the taken activities of different the organizations are different as per nature of their objectives. It is observed that till today there is no specific agency responsible for integration of coastal area planning in Bangladesh, therefore, all

different agencies, which have responsibilities for different sectors have to be included for comments and suggestions. It is expected that proper planning and good governance can also mitigate/reduce any sort of hazard, out migration and can increase the economic situation as well as livelihood through different income generating schemes in collaboration of government, nongovernment and international agencies.

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Appendix A: Coordination Schema

Table A 1 Coordination Schema

Section 1: Background information of household				
Complex Variable	Simple Variable	Value	Data Sources	Analytical Tools
Household members	Total population	Number	Primary data ▪ Questionnaire (Household survey) Secondary data ▪ Thana Statistical Office, Shamnagor, Dacope ▪ Regional Statistical office, Khulna ▪ Population Census, 2011 and 2001, Community Series: Satkhira and Khulna	Descriptive statistics ▪ Frequency distribution ▪ Percentage ▪ Mean ▪ Cross-tabulation Graphic presentation
	Household			
	Age	Year		
	Sex ▪ Male ▪ Female	Number		
	Migrated population			
Literacy rate	▪ Illiterate ▪ Literate	Statement		
Housing status	▪ Kacha (mud made) ▪ Pucca (brick constructed) ▪ Semi-Pucca (mixed kacca & pucca) ▪ Others	Statement/Number		

Section 2: To analysis the economic transformation process and pattern				
Complex Variable	Simple Variable	Value	Data Sources	Analytical Tools
	▪ Service	Statement/Number	Primary data ▪ Questionnaire (Household survey)	Descriptive statistics ▪ Frequency distribution

Occupation	▪ Agriculture - Farmer/Day labour ▪ Business ▪ Hotel and Restaurant ▪ Transport -Owner/Worker ▪ Construction ▪ Water, Electricity and Gas ▪ Industry -Owner/Workers		Secondary data ▪ Thana Statistical Office, Shamnagor, Dacope ▪ Regional Statistical office, Khulna Population Census, 2011 and 2001, Community Series: Satkhira and Khulna	▪ Percentage ▪ Mean ▪ Cross-tabulation ▪ Graphic presentation Analytical statistic ▪ Correlation test
Income and Expenditure	Per capita income	Taka (Bangladeshi Currency)	Primary data ▪ Questionnaire (Household survey) Secondary data ▪ Thana Statistical Office, Shamnagor, Dacope ▪ Regional Statistical office, Khulna ▪ Household Income and Expenditure Survey Report, 1991-92, 2000 and 2005,	Descriptive statistics ▪ Percentage ▪ Mean ▪ Cross-tabulation Graphic presentation Analytical statistic ▪ Correlation test
Land use	Agricultural purpose ▪ Crop land ▪ Livestock ▪ Poultry ▪ Aquaculture ▪ Horticulture ▪ Floriculture Industrial purpose	Acre	Primary data ▪ Questionnaire (Household survey) Secondary data ▪ Shamnagor and Dacope Thana Agriculture office ▪ Shamnagor and Dacope Thana Livestock Office ▪ Shamnagor and Dacope Thana	Descriptive statistics ▪ Percentage ▪ Mean ▪ Cross-tabulation Graphic presentation Analytical statistic

	Commercial purpose		Fisheries Office ▪ Shamnagor and, Dacope Thana land office ▪ Satellite image	▪ Correlation test
	Settlements			
	Others			
Land value	Agricultural land	Taka (Bangladeshi Currency/ Acre)	Primary data ▪ Key Informants ▪ Group Discussion Secondary data ▪ Satkhira and Khulna district Land Registry Office	Descriptive statistics ▪ Percentage ▪ Mean ▪ Cross-tabulation Graphic presentation
	Commercial			
	Industrial			
	Housing			
	Other			
Infrustructural change	Road network Transportation facilities Water supply Power supply Communication facilities Institutions Housing status Others	Km. Number and statement	▪ Satkhira and Khulna BRTA ▪ Satkhira and Khulna Water Development Board ▪ Shamnagor and Dacope thana LGED ▪ Satkhira, Khulna and Bagerhat district PDB	Descriptive statistics ▪ Percentage ▪ Mean ▪ Cross-tabulation Graphic presentation Analytical statistic ▪ Correlation test

Section 4: To identify the vulnerability level in the respect of economic transformation				
Complex variable	Simple variable	Value	Data Sources	Analytical Tools
Vulnerability	- Number of household - Number of people displaced - Loss of house - Loss of employment -Change of business -Change in agricultural activities - Loss of income -Loss of expenditure capacity -Loss of savings - Loss of household things - Change in infrastructures -Loss of houses - Loss of roads -Loss of transport -Loss of polder -Loss of vegetation -Loss of livestock -Loss of poultry - Loss of Governmental Buildings - Loss of embankments -Change in land use -Loss of marketing system	Km. Number and statement	Primary data sources Interview of key informants Officers of relevant office Group discussion Observation	Descriptive analysis Analytical statistic ▪ Correlation test

Complex variable	Simple variable	Value	Data Sources	Analytical Tools
Adaptation	-Reconstruction of house -Alternative shelter -Reconstruction of infrastructure - Reconstruction of road -Reconstruction of polder -Reconstruction of green belt -Recover of agricultural land/alternative uses -Strategy of recovering occupation/alternative occupation -Strategy of income generation -Strategy for collecting drinking water -Strategy for recovering poultry -Strategy for recovering fisheries -Strategy for recovering household equipments -Strategy for recovering loss transport			

Appendix B: Checklist

Table B 1 Checklist for secondary data and information collection

No	Types of information	Source institution
1	Geography: Location, Number of villages, Total area	Thana Statistical Office: Shamnagor Thana /Dacope Thana Thana, District Statistic office: Satkhira/Khulna Regional Statistical Office: Khulna
2	Demography: Total population, households, size of family, productive population, marital status, living duration	Thana Statistical Office: Shamnagor Thana /Dacope Thana Thana, District Statistic office: Satkhira/Khulna Regional Statistical Office: Khulna
3	Social status: Education, Housing status, Education	Thana Statistical Office: Shamnagor Thana /Dacope Thana Thana, District Statistic office: Satkhira/Khulna Regional Statistical Office: Khulna
4	Economic status: Occupation, income, expenditure, savings	Thana Statistical Office: Shamnagor Thana /Dacope Thana Thana, District Statistic office: Satkhira/Khulna Regional Statistical Office: Khulna
5	Land use	Satellite image analysis
6	Agriculture	Agriculture office: Shamnagor /Dacope Thana
7	Industries	BISIC: Satkhira/Khulna district
8	Infrastructure	Thana LGED office: Shamnagor /Dacope Thana, BRTA Office: Satlkhira/Khulna Power development Board: Satkhira/Khulna Village Power Development Board, BTCL
9	Land value	District Registry Office: Satkhira/Khulna
10	Map	LGED, SPARSO, CEGIS

2. Checklist for Regional Statistical Office, Khulna

Table B 2 Area and demographic characteristics (Population and household)

Name of Village	Year	Area (Km^2)	Population (Person)				Population density (Person/ Km^2)	Total Number of households	Migrated Households
			Total	Male	Female	Working population			
Sora	Before Aila								
	After Aila								
Chakbara	Before Aila								
	After Aila								
Patakhali	Before Aila								
	After Aila								

Study area profile:

1. Total area – Sq. km
2. Total number of villages -
3. Total population (Male & Female)-, (&)
4. Total migrated population
5. Total productive population – %
6. Population density-

Table B 3 Social characteristics (Education and housing status)

Name of the Village		Illiterate	Literacy	Housing status		
				Kacca (Mud)	Semi-pacca	Pacca (Brick)
Sora	Before Aila					
	After Aila					
Chakbara	Before Aila					
	After Aila					
Patakhali	Before Aila					
	After Aila					

Study area profile:

1. Literacy rate- %, 2. Hosing status: Kacca- %, Semi-pacca- % and Pacca- % (2001)

Table B 4 Economic status (Employment)

Name of the village	Year	Primary economic activity	Secondary economic activity	Tertiary economic activity
Sora	Before Aila			
	After Aila			
Chakbara	Before Aila			
	After Aila			
Patakhali	Before Aila			
	After Aila			

Study area profile:

1. Looking for work:
2. Service:
3. Household work:
4. Agriculture:
5. Water, Electricity and Gas:
6. Construction
7. Transport:
8. Hotel and Restaurant
9. Business:
10. Industry:
11. Others:

Table B 5 Income and expenditure (Taka/ Person/month)

Name of Village	Year	Income	Expenditure	Savings
Sora	Before Aila			
	After Aila			
Chakbara	Before Aila			
	After Aila			
Patakhali	Before Aila			
	After Aila			

Study area profile:

1. Per capital income:

2. Per capita expenditure:

3. Checklist for Tohosil Office)/SPARRSO

Table B 6 Land use (in percentage)

Name of village	Year	Agricultural purpose	Housing	Road and Railway	Industrial purpose	Cyclone shelter	Commercial purpose	Other
Sora	Before Aila							
	After Aila							
Chakbara	Before Aila							
	After Aila							
Patakhali	Before Aila							
	After Aila							

Peri-urban profile:

1. Total Agricultural land:
2. Total industrial land:
3. Total commercial land:
4. Total settlement area:
5. Roads and Railway:
6. Other:

4. Checklist for Thana Statistical Office

Table B 7 Institutions (in number)

Name of Village	Year	Educational institution	Post office	Public Health Center	Bank	Cyclone shelter	Local market	Bus station	Housing	Other
Sora	Before Aila									
	After Aila									
Chakbara	Before Aila									
	After Aila									
Patakhali	Before Aila									
	After Aila									

5. Checklist for Thana Agricultural/Livestock/Fisheries Office (Thana)

Table B 8 Agricultural land use (In percentage)

Name of village	Year	Crop land			Livestock	Poultry	Aquaculture	Horticulture	
		Rice	Wheat	Other				Vegetables	Fruits
Sora	Before Aila								
	After Aila								
Chakbara	Before Aila								
	After Aila								
Patakhali	Before Aila								
	After Aila								

Table B 9 Quantity of agricultural produces (in metric ton/year)

Name of village	Year	Crop land			Livestock	Poultry		Aquaculture	Horticulture		
		Rice	Wheat	Other		Meat	Egg(in no/day.)		Vegetables	Fruits	Other
Sora	Before Aila										
	After Aila										
Chakbara	Before Aila										
	After Aila										
Patakhali	Before Aila										
	After Aila										

6. Checklist for Thana LGED Office and BRTA, Satkhira

Table B 11 Transport network and transportation

Name of village		Sora		Chakbara		Patakhali	
Year		After Aila	Before Aila	After Aila	Before Aila	After Aila	Before Aila
Road (in Km.)	Metal (4 lanes)						
	Metal (2 lanes)						
	Metal (single lane)						
	Non-metal						
	Railway						
Private transportation (% of total population)	No. of motor bike						
	No. of microbus						
	No. of bicycle						
	No. of rickshaw						
	No. of rickshaw-van						
	Total						

Distance from Village to market (km.)	Village	Market-1 (local)	Market-2	Market-3	Market-4
	Sora				
	Chakbara				
	Patakhali				

Distance from village to cyclone shelter		Cyclone shelter-1	Cyclone shelter-2	Cyclone shelter-3	Cyclone shelter-4
	Sora				
	Chakbara				
	Patakhali				

7. Checklist for Department of Public Health Engineering (DPHE), Satkhira/Khulna

Table B 12 Source of drinking water (Percentage)

Name of village	Sora		Chakbara		Patakhali	
Year	Before Aila	After Aila	Before Aila	After Aila	Before Aila	After Aila
Tap						
Tube-well						
Well						
Pond						
Others						

8. Checklist for Power Development Board (PDB)- Satkhira/Khulna

Table B 13 Electricity Connection and Consumption

Name of village	Sora		Chakbara		Patakhali	
Year	Before Aila	After Aila	Before Aila	After Aila	Before Aila	After Aila
Number of household electrified						
Number of household solar panel						
No electricity/ solar panel						
Others						

9. Checklist for key informants

Name:……Village …….Age……..

1. Total number of household……Migrated household……..
2. Number of household displaced due to Aila……
3. Number of houses damaged due to Aila……
   Partially damaged……Mostly damaged……Fully damaged……
4. How many people displaced from their previous occupation?
   a) Agriculture to ……. No……
   b) Service to…….No……
   c) Business to ……..No……
   d) Others (Specify)…….No……
5. Change in Business:
   a) Before……..……..After……
   b) Before……After……
   c) Before……After……
   d) Before……After……
   e) Before……After……
6. Change in land use pattern:
   a) Agriculture to ……
   b) Settlement to……
   c) Business to ……
   d) Forestry to …….
   e) Water bodies to……
   f) Others (Specify)……
7. Change in Agricultural land use:
   a) Crops land to……
   b) Dairy to……
   c) Poultry to……
   d) Shrimp culture to……
   e) Horticulture to……
   f) Others (Specify)……

8. Change in infrastructures:
   a) Governmental Office……
   b) Non-governmental office……
   c) Roads……
   d) Embankments……
   e) Polders……

9 . Land value (Taka/Bigha) : Agricultural land: 2001 ……..2011……

Industrial land : 2001……2011……

Agricultural land: 2001 ……....2011……

Industrial land :2001……2011……

Commercial land :2001……..…..2011…….

Housing land: 2001…… 2011……

Others : 2001……2011…….

10. How many markets are in the surrounding area of the village and their name and distance?

1.…….

2.…….

3..…….

4. …….

11. How many houses have reconstructed?.....

12. What are the alternative shelters people taken?.....

13. How many buildings have reconstructed by the Government?.....

14. How many Km. roads have reconstructed by the Government?.....

15. How many Km. polders have reconstructed by the Government?.....

16. How many km. areas have brought under reforestation?

17. How people have regained agricultural land?

18. What are the strategy people have taken to recover lost occupation?

a)……

b)……

c)……

19. What are the strategies people have taken to generate income?

a)……

b)……

c)……

20. What are the strategies people have taken to collecting drinking water?

a)……

b)……

c)……

21. What are the strategies people have taken to recover loss of poultry?

a)……

b)……

c)……

22. What are the strategies people have taken to recover loss of fisheries?

a)……

b)……

c)……

23. What are the strategies people have taken to recover loss of household equipments?

a)……

b)……

c)……

24. What are the strategies people have taken to recover loss of vehicles?

a)……

b)……

c)……

25. How many km. distance of the village from river?.....

Is affect of cyclone depend on distance of village from river?.....

26. How many km. distance of the village from coast?.....

Is affect of cyclone depend on distance of village from coast?.....

27. How many km. distance of the village from embankment?.....

Is affect of cyclone depend on distance of village from embankment?.....

28. How many km. distance of the village from forest?.....

Is affect of cyclone depend on distance of village from forest?.....

29. What are the social collisions taken places after Aila?

a) Land…….

b) ……..

c)…….

d)…….

e)…….

30. What are the technological supports available to adopt with the situation? (Communication, technology, innovation, early warning systems, relevant technology etc……)

a) …….

b) ……..

c)…….

d)…….

e)…….

31. What are the resources available from Government to adopt with the situation? (Transport, water infrastructure, buildings, sanitation, energy supply and management, environmental quality.)

a) …….

b) ……..

c)…….

d)…….

e)…….

32. What are the policies Government have taken to enhance resilience? (Mode of governance, leadership legitimacy, participation, decentralization, decision and management capacity, sovereignty etc.)

(Pre-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

(During-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

(Post-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

33. What are the policies NGOs have taken to enhance resilience?

(Pre-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

(During-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

(Post-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

34. What are the policies people (indigenous) have taken to enhance resilience?

(Pre-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

(During-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

(Post-event)

a) …….

b) ……..

c)…….

d)…….

e)…….

35. What are the institutional measures have taken by the GO / NGOs to enhance resilience of the community? (Informal and formal rules for resource conservation, risk management, regional planning, property rights and risk sharing mechanisms etc)

a) …….

b) ……..

c)…….

d)…….

e)…….

10. Checklist for group discussion:

Consequences of economic transformation on:

1. Income
2. Diversified employment opportunity
3. Infrustructural change
   -Roads
   -Building
   -Institution
   -Water supply
   -Power supply
   -Communication
   -Cyclone shelter
4. Land use change
5. Land value change
6. Expenditure capacity
7. Land holding change
8. Housing condition change
9. Occupational change
10. Others

Appendix C: Questionnaire for Household Survey

Questionnaire for Household Survey
Number

Climate Change Induced Economic Transformation, Vulnerability and Adaptation in the Aila (Tropical Cyclone) Susceptible Areas of Bangladesh

Respondent's name: ……
Village:…….Date:…….
..

Part I: General Information

1. Sex ☐ Male ☐ Female

2. Age ☐ <18 Years ☐ 18-59 Years ☐ 59 Years <

3. Residential status ☐ Migrated ☐ Native
If migrated, how long have you been living?
From which area have you been migrated? ☐ Rural ☐ Urban
Cause of migration…….

4. Total household's member:…….Male……Female……..
How many dependent……..Independent…….
How many age between 18-59 years :
a) Their occupation…… Work area location……
Income (Taka) …….Education level…….
b) Their occupation…… Work area location……
Income (Taka) …….Education level…….
c) Their occupation…… Work area location……
Income (Taka) …….Education level…….

5. Education level: ☐ Primary ☐ SSC ☐ HSC ☐ Above HSC ☐ Illiterate

6. Housing status: ☐ Kacha (Mud) ☐ Pucca (Brick) ☐ Semi-pucca ☐ Others

7. Did Aila damage your house? ☐ Yes ☐ No
If yes, then a) Partially…… b) Mostly……c) Totally……

8. Elevaetion of your house……

9. Distance of your hose from river …….

10. Distance of your house from coast……

11. Distance of your house from embankment……..

12. Distance of your house from forest……

Part II: Economic status

1. Occupation & Work area location (after Aila):
Main……..
Supplementary……
(Before Aila) Main……..

Supplementary……

2. Income (taka): After Aila- From main source……From supplementary source
Before Aila- From main source……From supplementary source

3. How much land do you have? (After Aila)-Total……Rented……
Occupied…….……User……
(Before Aila)-Total……Rented……
Occupied…….……User……

4. What are the other resources do you have or had?
Before Aila (with value) After Aila (with value)

5. Purposes of using and portion of total land: ……

After Aila- Agricultural …….. Industrial …… Commercial …… Housing……. Others (specify)……..

Before Aila- Agricultural …….. Industrial …… Commercial …… Housing……. Others (specify)……..

6. Type of agriculture and area: After Aila- Crop cultivation……..Livestock…
Poultry…….. Aquaculture……. Vegetables and Fruits ……

Before Aila- Crop cultivation……..Livestock…….
Poultry…….. Aquaculture……. Vegetables and Fruits ……

7. What are the causes of specific agriculture operation?
-
-
-
-

8. Quantity of agricultural production:

After Aila- Crop ……..…… Livestock……. Poultry……..
Aquaculture……Vegetables and Fruits……..
Before Aila- Crop ……..…… Livestock……. Poultry……..
Aquaculture……Vegetables and Fruits……..

9. In which market you supply your product and how much?

After Aila- Crop ……..…… Livestock……. Poultry……..
Aquaculture…… Vegetables and Fruits……..……
How much km distance and fare from production area to marketing place?……
……
Before Aila- Crop ……..…… Livestock……. Poultry……..
Aquaculture…… Vegetables and Fruits……..……
How much km distance and fare from production area to marketing place?……
……

10. Which types of vehicle do you use for marketing your product? Before Aila-
By cycle Rickshaw Rickshaw van Pick up Track Other
Why?……
Do you have vehicle? If yes, then how long before you have bought this?
……..……...……
After Aila- By cycle Rickshaw Rickshaw van Pick up Track Other
Why?……
Do you have vehicle? If yes, then how long before you have bought this?
……..……...……

11. What type of commercial activities do you operate? After Aila:
……
Location:…….
Before Aila: ……
Location:…….

12. What is the source of drinking water? After Aila ……...
Before Aila……..

13. What type of daily using commodities do you buy from market or from local shop?
…….
Quantity of commodities……

14. Do you have electricity connection? After Aila……..
What is the purpose of using?……
Before Aila: ……
Location:…….

15. Do you have cell phone? After Aila……Before Aila……....
Purpose of using……..

16. Monthly expenditure (taka): After Aila- House rent……Cloths…….
Food……Treatment……Drinking water…….Others……..
Before Aila- House rent……Cloths…….
Food……Treatment……Drinking water…….Others……..

17. What type of toilet do you use?
(After Aila) a) Sanitary (water sealed) b) Sanitary (non-water sealed) c) Non-sanitary d) others (specify)……..…e) none
(Before Aila) a) Sanitary (water sealed) b) Sanitary (non-water sealed) c) Non-sanitary d) others (specify)……..…e) none

18. Have you raised your house to protect from cyclone surges? If yes, then what are these?
Before Aila After Aila

19. Have you made any structural change of your house to protect from cyclone effect? If yes then what are these:
Before Aila After Aila

20. Have you taken any measure to protect your agricultural field from cyclonic impact? If yes, then what are these?
Before Aila After Aila

21. Have you taken any measure to protect your poultry from cyclonic impact?
If yes, then what are these?
Before Aila After Aila

22. Have you taken any measure to protect your fisheries from cyclonic impact?
If yes, then what are these?
Before Aila After Aila

Appendix D: List of secondary data sources

1. Satkhira and Khulna district statistic office;
2. Satkhira and Khulna district disaster management office;
3. Shaymagor and Dacope Upazila (Sub-district) Statistical Office;
4. Shaymagor and Dacope (Sub-district) Agriculture Office;
5. Shaymagor and Dacope (Sub-district) Livestock Office;
6. Shaymagor and Dacope (Sub-district) Fisheries Office;
7. Local Government Engineering Department (LGED), Shaymagor and Dacope Upazila;
8. Tohosil Office, Gabura and Sutarkhali
9. Bangladesh Bureau of Statistics (Divisional office);
10. Center for Urban Studies (CUS);
11. Bangladesh Water Development Board (BWDB), Satkhira and Khulna district;
12. Bangladesh Power Development Board (BPDB), Satkhira and Khulna district;
13. Department of Public Health Engineering (DPHE), Satkhira and Khulna district;
14. Regional Statistical Office, Khulna;
15. Bangladesh Institute of Development Studies (BIDS), Khulna
16. Space Research and Remote Sensing Organization (SPARRSO)

Appendix E: Detail Land Use Change

Table E 1 Land use change pattern of Sora village (2004-2014)

Change Area	Area (acres)	Percentage	Change Area	Area (acres)	Percentage
Water body to water body	13.79	0.99	Vegetation to bare land	23.80	1.71
Water body to Aquaculture	0.44	0.03	Vegetation to settlement	7.78	0.56
Water body to agricultural land	1.56	0.11	Vegetation to tidal area	15.12	1.08
Water body to vegetation	0.89	0.06	Bare land to water body	11.12	0.80
Water body to bare land	3.34	0.24	Bare land to aquaculture	90.07	6.46
Water body to settlement	0.67	0.05	Bare land to Agricultural land	13.34	0.96
Water body to tidal area	53.60	3.84	Bare land to Vegetation	3.56	0.26
Aquaculture to water body	4.67	0.33	Bare land to bare land	179.47	12.87
Aquaculture to aquaculture	457.24	32.80	Bare land to settlement	44.70	3.21
Aquaculture to agricultural land	0.44	0.03	Bare land to tidal area	2.89	0.21
Aquaculture to vegetation	1.56	0.11	Settlement to water body	0.22	0.02
Aquaculture to bare land	84.51	6.06	Settlement to Aquaculture	5.56	0.40
Aquaculture to settlement	16.68	1.20	Settlement to Agricultural land	8.01	0.57
Aquaculture to tidal area	0.22	0.02	Settlement to vegetation	4.89	0.35
Agricultural land to Aquaculture	7.78	0.56	Settlement to bare land	46.04	3.30
Agricultural land to agricultural land	27.35	1.96	Settlement to settlement	33.58	2.41
Agricultural land to vegetation	2.45	0.18	Settlement to tidal area	2.00	0.14
Agricultural land to bare land	40.03	2.87	Tidal area to water body	7.34	0.53
Agricultural land to settlement	10.68	0.77	Tidal area to aquaculture	0.67	0.05
Vegetation to water body	0.44	0.03	Tidal area to vegetation	16.90	1.21
Vegetation to aquaculture	11.34	0.81	Tidal area to bare land	22.24	1.60
Vegetation to agricultural land	7.56	0.54	Tidal area to settlement	2.89	0.21
Vegetation to vegetation	29.80	2.14	Tidal area to tidal area	74.95	5.38
				1394.19	100.00

Source: Calculated from image processing (2004-2014)

Table E2 Land use change of Chakbara village (2004-2014)

Change Area	Area (acres)	Percentage	Change Area	Area (acres)	Percentage
Bare land to bare land	19.08	9.15	Aquaculture to bare land	7.47	3.58
Bare land to settlement	2.97	1.42	Aquaculture to settlement	0.72	0.35
Bare land to vegetation	0.27	0.13	Aquaculture to vegetation	0.72	0.35
Bare land to aquaculture	4.05	1.94	Aquaculture to aquaculture	24.48	11.74
Bare land to agricultural land	3.15	1.51	Aquaculture to agricultural land	0.09	0.04
Bare land to water body	1.71	0.82	Aquaculture to water body	0.9	0.43
Settlement to bare land	6.93	3.32	Agricultural land to bare land	18	8.63
Settlement to settlement	2.97	1.42	Agricultural land to settlement	1.71	0.82
Settlement to vegetation	0.54	0.26	Agricultural land to vegetation	0.81	0.39
Settlement to aquaculture	2.79	1.34	Agricultural land to aquaculture	47.25	22.66
Settlement to agricultural land	0.99	0.47	Agricultural land to agricultural land	21.51	10.32
Settlement to water body	0.09	0.04	Agricultural land to water body	1.62	0.78
Vegetation to bare land	12.15	5.83	Water body to bare land	9.36	4.49
Vegetation to settlement	2.07	0.99	Water body to settlement	0.81	0.39
Vegetation to vegetation	1.26	0.60	Water body to vegetation	0.18	0.09
Vegetation to aquaculture	3.96	1.90	Water body to aquaculture	1.44	0.69
Vegetation to agricultural land	2.52	1.21	Water body to agricultural land	0.72	0.35
Vegetation to water body	0.63	0.30	Water body to water body	2.61	1.25
Total				68.13	32.67

Source: Calculated from satellite image 2004 and 2014

Table E3 Land use change of Patakhali village (2004- 2014)

Change Area	Area (acres)	Percentage	Change Area	Area (acres)	Percentage
Water body to aquaculture	0.44	0.08	Agricultural land to agricultural land	6.89	1.21
Water body to water body	0.22	0.04	Agricultural land to vegetation	4.23	0.74
Aquaculture to water body	39.14	6.86	Agricultural land to bare land	3.56	0.62
Aquaculture to aquaculture	107.86	18.89	Bare soil to water body	51.60	9.04
Aquaculture to agricultural land	25.35	4.44	Bare land to aquaculture	59.60	10.44
Aquaculture to vegetation and settlement	8.01	1.40	Bare land to agricultural land	44.26	7.75
Aquaculture to bare land	70.95	12.43	Bare land to vegetation and settlement	63.16	11.06
Agricultural land to water body	2.67	0.47	Bare land	62.27	10.91
Agricultural land to Aquaculture	20.68	3.62	**Total**	570.88	100

Source: Calculated from satellite image 2004 and 2014

Appendix F: Accuracy Measure of Used Images

Images of Patakhali village

Table F1 Accuracy measurement of the image 2014 of Patakhali village

Class Name	Reference Total	Classified Total	Number Correct	Producer Accuracy (%)	User Accuracy (%)
Water body	5	6	5	100	83.33
Aquaculture	9	8	8	88.89	100
Agricultural land	12	13	12	100	92.31
Bare soil	6	5	5	83.33	100
Settlement and vegetation	1	1	1	100.00	100
Total	33	33	31		
Overall Classification Accuracy	93.94				

The classified image of 2014 has over all accuracy of 93.94 % and Kappa statistic is 0.9175. Producer accuracy is calculated by dividing the total number of correctly classified pixels for a class by the total number of reference sites for that class. The user accuracy is calculated by dividing the number of correct accuracy sites for a category by the total number of accuracy assessment sites that were classified in that category.

The class "Water body, agricultural land, settlement and vegetation" has the highest producer accuracy which is 100 %, followed by aquaculture 88.89 %, bare soil 83.33 %. It implies that Water body, agricultural land, settlement and vegetation have the highest probability of a references site being correctly classified. However, in the user accuracy, class "aquaculture, bare soil, settlement and vegetation" has the highest which is 100 %. In this case, the class water body has the least accuracy 83.33%. It implies that aquaculture, bare soil, settlement and vegetation have the highest probability that a pixel on the map actually represents that category on the ground.

Images of Sora village

Table F2 Accuracy measurement of the image 2014 of Sora village

Class Name	Reference Total	Classified Total	Number Correct	Producer Accuracy (%)	User Accuracy (%)
Water body	10	10	10	100	100
Aquaculture	11	10	10	90.91	100
Agricultural land	0	0	0	0	0
Vegetation	0	0	0	0	0
Bare soil	10	11	10	100.00	90.91
Settlement	2	2	2	100	100
Tidal area	1	1	1	100	100
Total	34	34	33		
Overall Classification Accuracy	97.06				

The classified image of 2014 has overall accuracy of 97.06, % and Kappa statistic is 0.9591. Producer accuracy is calculated by dividing the total number of correctly classified pixels for a class by the total number of reference sites for that class. The user accuracy is calculated by dividing the number of correct accuracy sites for a category by the total number of accuracy assessment sites that were classified in that category.

The class “water body, bare soil, settlement, tidal area” has the highest producer accuracy which is 100 %, followed by aquaculture 90.91%. It implies that water body, bare soil, settlement, tidal area has the highest probability of a references site being correctly classified. However, in the user accuracy, class “water body, aquaculture, settlement, tidal area” has the highest which is 100 %. In this case, the class bare soil has the least accuracy 90.91%. It implies that water body, aquaculture, settlement, tidal area has the highest probability that a pixel on the map actually represents that category on the ground.

Images of Chakbara village

Table F3 Accuracy measurement of the image 2014 of Chakbara village

Class Name	Reference Total	Classified Total	Number Correct	Producer Accuracy (%)	User Accuracy (%)
Water body	0	0	0	------	------
Aquaculture	7	7	7	100	100
Agricultural land	3	5	3	100.0	60.00
Vegetation	1	1	1	100	100
Bare soil	13	14	13	100.00	92.86
Settlement	1	0	0	-----	------
Total	24	24	23		
Overall Classification Accuracy	95.83				

The classified image of 2014 has overall accuracy of 95.83% and Kappa statistic is 0.9295. Producer accuracy is calculated by dividing the total number of correctly classified pixels for a class by the total number of reference sites for that class. The user accuracy is calculated by dividing the number of correct accuracy sites for a category by the total number of accuracy assessment sites that were classified in that category.

The class “bare soil, agricultural land, aquaculture, vegetation” has the highest producer accuracy which is 100 %, followed. It implies that bare soil, agricultural land, aquaculture, vegetation has the highest probability of a references site being correctly classified. However, in the user accuracy, class “aquaculture, vegetation” has the highest which is 100 %. In this case, the class agricultural land has the least accuracy 60%. It implies that aquaculture and vegetation land has the highest probability that a pixel on the map actually represents that category on the ground.

Appendix G: Photographs

a) Sora b) Chakbara c) Patakhali

Figure G1 Shrimp cultivation of the study villages

a) Saline tolerate paddy cultivation in Sora b) Vegetables cultivation in Chakbara c) Saline tolerate paddy cultivation in Sora

Figure G2 Agricultural activities of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G3 Housing structure of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G4 Cyclone shelter of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G5 Afforestation of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G6 Damaged dam of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G7 Broken dam and closer of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G8 Reforestation of damaged Sundarban nearby area of the study villages

a) Sora b) Chakbara c) Patakhali

Figure G9 Toilet structure of the study villages

a) Sora b) Chakbar c) Patakhali

Figure G10 Plinth structure of the study villages