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Vulnerability to Water-Logging and Livelihood Security in South-Western Region of Bangladesh

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VULNERABILITY TO WATER-LOGGING AND LIVELIHOOD SECURITY IN SOUTH-WESTERN REGION OF BANGLADESH

MPhil THESIS

A Dissertation Submitted in the Partial Fulfillment for the Degree of Master of Philosophy in Geography and Environmental Studies, University of Rajshahi.

SUBMITTED
By

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Examination Roll No.13512
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Session: 2013-14
MPhil Examination: 2020

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DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES
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রাজশাহী বিশ্ববিদ্যালয়
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Date: 29-12-2020

To whom it may concern

This is to certify that Md. Mahmudur Rahman M.Phil fellow (session 2013-2014) of the Department of Geography and Environmental Studies, University of Rajshahi "VULNERABILITY TO WATER-LOGGING AND LIVELIHOOD SECURITY IN SOUTH-WESTERN REGION OF BANGLADESH" is the title of his M.Phil. Thesis. Mr. Rahman thesis has been checked through plagiarism checking software and the similarity under of his thesis is found 28% which is within considerable limit according to university rules. Therefore his M. Phil. Thesis can be submitted for evaluation.

I wish his all success in life.

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Dedicated
To
My parents
And
Waterlogged
People in Vobodhaho

DECLARATION

I do hereby declare that the dissertation entitled "Vulnerability to Water-Logging and Livelihood Security in South-Western Region of Bangladesh" submitted to the Department of Geography and Environmental Studies, University of Rajshahi as part of the requirements for the Degree of Master of Philosophy is my own work. Neither nor any part of it was submitted to any other university or institute for any other degree or diploma or other purposes. My indebtedness to other works has duly been acknowledged at the relevant places.

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ভূগোল ও পরিবেশবিদ্যা বিভাগ
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CERTIFICATE

This is to certify that the research entitled "VULNERABILITY TO WATER-LOGGING AND LIVELIHOOD SECURITY IN SOUTH-WESTERN REGION OF BANGLADESH" is the original work of Md. Mahmudur Rahman. So far I know this is the candidate's own achievement and is not a conjoint work. He has completed this research under my direct guidance and supervision.

I also certify that the research is too satisfactory for submission in the Partial Fulfillment for the Degree of Master of Philosophy in Geography and Environmental Studies, University of Rajshahi

29.12.2020

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Abstract

Water logging constitutes the main hazard in the South-West region of Bangladesh. The severity of this hazard turns into a disaster and creates vulnerability due to existence of high population density with poor socio-economic status. Thus, this study examines the present status of the vulnerability situation of the affected households by water logging with the reference of Jessore district, the worst affected area by water logging. Moreover, this study looks into the livelihood security status and tries to sort out its significant determinants. The study uses field survey data and several mathematical and statistical methods to obtain the objective and total sample size are 377 out of 20576 households for measuring vulnerability, the study firstly uses Analytic Hierarchy Process (AHP) for giving weights to each variable. Secondly, it adopts Leon's matrix for calculating vulnerability score for each factors. Thirdly, the overall vulnerability level of the study area is calculated by aggregating the vulnerability scores of each factor. Livelihood security status is measured by using Household Livelihood Security Index. Moreover, the study applies econometric technique (2SLS) for determining the factors that influence the livelihood security of affected people by water logging. The study results reveal that rural people in the study area face the problems of social disruption in terms of school, housing, health, sanitation and market facilities. It is found that 40.34 percent households are in very high vulnerable condition and on an average; overall livelihood security is lower in the study area. The estimation of econometric model finds that all the security variables (economic, food, education and health) positively influence the economic security in the study area whereas family size and dependency ratio are significantly negatively associated with economic security as expected. Therefore, the study recommends facilitating financial and capital supports and livestock/fisheries based livelihoods may be encouraged. Trial and error based education enhancing programs are also marked as suitable policy of improving livelihood security status.

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List of Abbreviations

AHP	Analytic Hierarchy Process
ABSA	*Agricultural Bureau of South Astralia*
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
APO	Asian Productivity Organization
BARC	Bangladesh Agricultural Research Council
CEP	Coastal Embankment Project
CR	Consistency Ratio
ECLAC	Economic Commission for Latin America and the Caribbean
FAO	Food and Agriculture Organization
FFTC	Food and Fertilizer Technology Center
FAP	Flood Action Plan
GHG	Green House Gases
GDP	Gross Domestic Product
HLS	Household livelihood security
IPCC	Inter-Governmental Panel on Climate Change
IFPRI	International Food Policy Research Institute
IFI WATCH	International Financial Institutions and Trade Organizations
LS	Livelihood Security
M	Meter
NGO	Non-government Organization
NDMA	National Disaster Management Authority
OECD	Organization for Economic Co-operation and Development
SPSS	Statistical Package for Social Sciences
SVC	Standardized Vulnerability Score
TRM	Tidal River Management
UO	UnnayanOnneshan
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNDP	United Nation's Development Program
UNEP	United Nations Environment Programme
WVI	Water-logging Vulnerability Index
WFP	World Food Program
2SLS	Two Stage Least Squares
%	Percentage

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

One of the distinguishing physiography of Bangladesh is the funnel shaped coastline of Bay of Bengal (Blaikie et al., 1994; Paul and Routary, 2010; 2011).The southwestern portion of this country is situated on the vast deltaic plain of the mighty Ganges where the Sundarbans (largest mangrove vegetation of the world) manifest the separation of the shoreline from human settlement (Rashid, 1977). Severe natural disasters such as tropical cyclones, floods, tidal surges, prolonged water logging and land degradation endangered the communities of southwest coastal region with peoples' lives and repeatedly shaping the livelihood patterns (Sarker, 2012).These natural calamities displace the flow of economic growth of Bangladesh by lowering livelihood capacities of these areas. Due to tidal surge, flooding is very common hazard in the south-west coastal region of Bangladesh. According to (GAR) Global Assessment Report (2009) about 20 million people of Bangladesh are living with the risk of floods (The Daily Star, 2011). To control tidal surge, the country construct embankment in the south-west region of Bangladesh which alters the hydro geo-physical setting of these areas. This creates an adverse phenomenon namely 'water logging' through the south- west region of the country and thus disrupting livelihoods of about one million people of the affected regions (Islam et al., 2004; Ahmed et al., 2007). Heavy monsoon downfall, constrained surface runoff due to inadequate drainage, poor retaining of embankments, riverbed siltation, embankments of shrimp farms and lack of frequent flow from Indian dams namely Farakka and Damodar are the major factors alongside construction of embankment related to prolonged water logging in this region. Water logging is a form of flooding within the embankments caused by hydro- geo- physical factors where water remains stagnant for long time due to increased sedimentation of riverbeds and reduced height differential between embankment and peak water level (Islam et al., 2004). It continuously leads to large scale damages to crop, employment, livelihoods, and national economy of Bangladesh (Rahman, 1995; Ahmed et al., 1998). It is also disrupts the natural flow the rivers of southwestern Bangladesh and intimidating the

livelihoods communities (Rahman, 1995). The extended water logging of near about nine months in a year significantly hampered agricultural and other economic activities, rice production of this region notably decreased due to permanent inundation of arable lands and there are areas with people unnaturally living in waterlogged condition confront to lack of safe drinking water, sanitation facilities, shelter, food security and employment opportunity (Adri and Islam, 2010; 2012).

The heavy monsoon downfall intercepts this region with large scale inundation followed by a notable migration of able male members of the families searching for alternate living. Whereas the females is to abide by the miserable waterlogged living to take care of the family and livestock. Unemployment and migration result in family disheartenment in waterlogged communities (Ahmed et al., 1999; Salauddin and Ashikuzzaman, 2011). People are seemed to be doomed with faces depicted uncertainty and hopelessness having no options but to accept their destiny against will (Sarker, 2012). The adverse impacts of water logging on community, regional economy, politics and religious activities alongside no cushioning initiatives constantly leading it to become a national issue and the people to permanent victim. Moreover, due to the permanent water congestion sudden flood is occurred during rainy season. In the other words, the water logging situation causes recurring flood in every monsoon (Unnayan Onneshan, 2006). Climate change concerns like siltation of riverbed, changes in flow, increased monsoon precipitation, back water effect of sea level rise etc. are considered to exaggerate the water logging issue (Ahmed, 2006). In spite of being a large scale disaster in this region, a few negligible research initiatives for impact mitigation stipulate the inevitability of policy making to maximize the community benefits alongside risk reduction.

Therefore, it is worthwhile to investigate the severity of the phenomenon-water-logging and analyze the impacts of these hazards into rural communities considering rising population and low socio-economic structure. Considering the issue of water logging, this study is structured to describe the vulnerability situation of the affected people and their livelihood security and diversity status. The present study uses a composite methodology adopting from the studies of Huq (2012), and Akter and Rahman (2012). The methodology includes different mathematical and statistical

techniques which is relatively new in the field water logging studies. Thus, the study will give new insights into the study of water logging in Bangladesh.

1.2 Statement of the Problem

Bangladesh is a low laying country criss-crossed by a large number of rivers due to increased rainfall under climate change and at the same time rapid encroachment of wetlands, the country, especially the coastal region is facing problem of water logging. Last few decades, embankments have been constructed and cannels are being filled up to accommodate the increased population even in vulnerable coastal zone. The Gorai river is the major distributary of the Ganges River, passing through the south-west region, providing the majority of the dry season flow (DHV-WARPO, 2000). Main river systems of this region consist of the Gorai- Madhumat -Baleswar river system; the Gorai-Bhairab- Pasur river system, the Bhadra-Gengrail river system, the Hari-Teka-Mukteswari river system, Sibsa river system, the Kabadak - Betna- Kholpetua river system and the Mathabhanga-Ichamati-Kalindi river system. These river system criss cross the region through a complex network smaller rivers and rivulets. The flat and low lying coastal zone of south west region with an average elevation of less than one meter above mean sea level is drastically influential to tidal effects (Islam, 2005). and hydro-geo-morphological hazards like riverbed siltation, acute low flow and moisture stress in the dry season, salinity intrusion, storm surge, sea level rise and flooding are common (Halcrow-WARPO, 2001). Water logging is followed by flood results in disaster in this region due to high population density and poor economy. Any kind assessment of vulnerability of the community with a viewpoint of climate change requires evaluation of constant spatial hazard occurrences alongside socio-economic condition of the inhabitants.

Water logging is considered to be one of the major problems in crop production, affecting an estimated 12% of the global cultivated area (Li, 1997). Water logging decreases crop yield (Bhan, 1977; Belford, 1981; Bange, et al. 2004; Dickin and Wright, 2008). Previous studies have reported various negative effects of water logging on crops. It is evident that the people in the Southwest region of Bangladesh has already incurred uncountable havoc to their lives and livelihoods by losing

millions worth of properties and infrastructures due to water logging problem (Sarker, 2012). Water logging rotted the roots of economic activities of the people in the affected areas. The scale of damage is quite severe in terms of immediate loss of life, property, access to essential services (such as water and food), infrastructure and other assets which underpin livelihoods, health and sanitation, shelters etc. At the homestead level, the direct impacts are the loss of shelter, loss of animals and sensitive plants, less access to safe food and water, loss of basic services such as health or education (FAO, 2015). A large number of studies on water logging in the south west coastal region of Bangladesh already been conducted. For instance, according to Rahman (2003), water-logging has been a regular phenomenon for the hundreds of villages adjacent to the Kopadak River in Jessore and Satkhira district of Bangladesh since 2000. The analysis of satellite images revealed that over the years, water- logged area had increased from 865 hectares in 1999 to 19, 467 hectares in 2008. According to the local people there were no water logging problems in 1994 at the Kopadak basin area, but this started from 1999. At that time it was in small scale mainly in Jessore district but in the year 2000 the water logged area had increased significantly which was thought to be due to unusual water supply from upstream and heavy rainfall over the south west region of Bangladesh. Study in Biddanandakati revealed that water logging in some parts of Jikargacha and Monirampur was observed since 1985 and its magnitude was gradually increasing. The research study by Hassan (2014) detected water-logging area through Landsat imageries from 1972, 1989 and 2014 in Jessore district. A clear tendency of increasing agricultural damage due to water-logging from 1972 to 2014 is observed. The most vulnerable Upazilas in terms of damage are Monirampur, sadar, Keshabpur and Jhikargacha of Jessore district. About 32,830 hectares were identified as waterlogged areas, which is 13% of the total land. From this analysis, it is found that there is an apparent decline of agricultural land between 1972 and 2014. Agriculture land was 218,769 ha in 1972, which reduced to 96,515 ha in 1989 and further reduced to 55,184 ha in 2014. The main reasons for this downward trend include population pressure, natural disaster, salinity and urbanization. On the other hand, water bodies have gradually increased over the same period. Therefore, the present study is designed to address the impact of water logging on the socio-economic status and livelihoods of people in Abyahnagar, Manirampur and Keshabpur Upazilas in Jessore District of Bangladesh.

Considering the vulnerability situation of these areas due to water logging, the present study mainly tries to find out the answers of the following questions:

(i) What is the impact water-logging problem?
(ii) What is the vulnerability status of the affected households by water logging?
(iii) What is the livelihood security status of the affected people by water logging?
(iv) What are the significant factors that affect the livelihood security of the affected people by water logging?
(v) What are the appropriate policy recommendations in order to improve the livelihood security status of *the affected people by water-lo*gging problem?

1.3 Objective of the Study

In order to find out the answers of the above stated questions the study is conducted to analyze the impact of water-logging problem on the rural livelihoods and to assess vulnerability to water logging among the households in the study area and to assess the livelihood security status and determinants in terms of changing socio- economic and environmental conditions. However the following objectives are taken into consideration in conducting the present study.

1) To analyze the impact of water logging on rural households of the study area.
2) To present the vulnerability status of the affected households by water logging in the study area.
3) To describe the livelihood security status of the affected people by water logging in the study area.
4) To find out the significant factors that affect the livelihood security of the affected people by water logging in the study area.
5) To draw some appropriate policy recommendations in order to improve livelihood security status of the affected households.

1.4 Significance of the Study

The issue of water logging and its impact on the livelihood security status in the south west coast of Bangladesh always overlooked by most of the research. Thus, this study will provide some new thoughts in the scant knowledge on the particular issue. Moreover, most of the earlier studies were conceptual and descriptive studies citation. But the present study uses both statistical and econometric techniques such as, several indices and two stage least square. This will make a comprehensive study on the issue of water logging and helpful to draw some possible solutions of this hazard. As the issues and methods of vulnerability measurement are complex and multidimensional, the concept is seldom clear. The present study focuses on Analytic Hierarchy Process (AHP) for vulnerability measurement. This research will enrich the literature in the field of geography and will be helpful in drawing policies considering the improvements of vulnerability status of the affected people. This study analyzes the livelihood security status of the affected people by water- logging problem and determines its significant factors by using econometric method. This will give a clear picture of present livelihood status of the affected people in the study area. The present study is expected to be useful and will have strong implications in planning mitigating the impact of water logging problem.

1.5. Organization of the Study

The present study on vulnerability to water-logging and livelihood security contains seven chapters. The chapters are organized as follows. The first chapter describes the background and related problems of water logging and livelihood security with specific questions and objectives. This chapter also explains the significance of the present study. The second chapter contains the brief review of the latest literature regarding vulnerability to water-logging and livelihood security status. This chapter mainly reviews the different concepts, methods and specific findings of the previous studies and tries to identify the research gaps. Chapter three provides the complete methodology of the present study including research approach, sampling design, data collection and analysis techniques, empirical model, model estimation procedure and

different estimation issues. Chapter four describes the collected data highlighting the impact of water-logging problem on the socio-economic status of the households. Chapter five discusses the estimated results regarding vulnerability status of the people affected by water logging problem. Chapter six also describes the results of the livelihood security status and the empirical model estimated using 2SLS methods and tries to sort out the significant factors that affect the livelihood security of the affected people by water logging problem in the south west cost of Bangladesh. Finally, chapter seven represents the summary of the main findings and the concluding remarks, besides main chapterization, declaration, acknowledgement, abstract, contents, list of tables, list of figures of abbreviations, references and appendices are also provided as part of organization of thesis.

CHAPTER TWO

LITERATURE REVIEW

2. 1 Introduction

This chapter provides a review of earlier studies on the vulnerability to water logging and livelihood security status highlighting different concepts, methodologies and main findings. Firstly, the review is conducted to describe the earlier concepts, history and causes and consequences of water logging problem in the context of both national and international arenas. Secondly, this chapter of literature review depicts the literature on the concept of livelihood security and its determinants in the context of water-logging problem and finally, this chapter identifies some relevant gaps in the reviewed earlier literature.

2.2 Concepts of Water Logging

Water-logging is a flooding where water remains stagnant for long time (Islam et al., 2004). In some localities, this may last for at least three months, and may prolong up to 8-9 months or even become perennial. The depth of flooding varies, according to the topography of the area, and can reach up to 3m. Generally, acute saturation in the soil layers due to rise of water level results in disruption of air circulation in top soil followed by decrease of oxygen in areas affected by water logging (Anonymous, 1976). Water logging is defined as a condition of the soil in which excess water limits gas diffusion (Setter and Waters 2003). It can be identified as a process of subsurface hydrological dynamics where rainfall, capillary movement and infiltration are the moderators of soil moisture with surplus water in soil layers (Sujatha et al. 2000). Static rise of water table to the root zone over time influenced by inadequate drainage leads the fields to become unproductive wet deserts (Postel, 1992).

2.3 Historical Background of Water-Logging Problem in South-Western Region of Bangladesh

Bangladesh experiences severe flood and cyclone events and, in recent years, water logging has become a catastrophic problem along the cost (Moniruzzaman, 2011). From beginning of the 21st century a new problem "water logging" arose southwest coastal region of Bangladesh (Sarker, 2012; UO, 2006; Tutu et al., 2009). Water logging is not a new phenomenon in Bangladesh. It has been developed above the years encouraged by different hydro-geophysical factors as well as human interventions. If we look at the history, we see that the region experienced a drastically change in the management of land-river collaboration which was formerly known Tidal River Management (TRM) since seventeenth century. By this traditional method wooden sluice gates along with earthen embankments were constructed by responsible land lords or zaminders to the crop production from flooding. The salinity level of the fields were to be balanced by entering rain feed river waters through the gates and people used to maintain the structures for continuity (IFI WATCH, 2006). The system collapsed shortly after the abolition of land settlement system (Zamindary tradition) and the breakdown of TRM resulted in frequent crop production failure. In response, the government undertaken a gigantic project of permanent polder construction in 1959 ended with 39 polders of 1014100 areas in Jessore and Khulna (Aftabuzzaman, 1990). In 1960s the coastal embankment project nearly enclosed the tidal wetlands of this region. Within a few years water logging appears as the denouncement of the embankment project along with biodiversity loss, siltation of riverbeds with navigation affected and by the 1990s over a thousand hectares of land in Jessore , Khulna and Satkhira covered with permanent inundation (Sarker, 2012).

2.4 Reasons of Water Logging Problem in South-Western Region of Bangladesh

Water logging has become an acute problem in recent years for a variety of reasons: natural changes in river flow, increased sediment in riverbeds due to reduced sediment deposition on floodplains protected by embankments and a lack of proper operation and maintenance of sluice gates of the polders i.e. circular embankments (Sarker, 2012; UO, 2006; Tutu et al., 2009). In the early 1960s, a series of

embankment were constructed as a part of Coastal Embankment Project (CEP). Through the goals of the project of the area from tidal surges, it had a negative impact (Sarkar, 2004). Due to commissioning of Farrakka Brage in 1975, extreme low flow accelerated the process of sedimentation in the riverbed (DHV-WARPO, 2000). It reduced the difference between the embankment height and peak water level. Sluice gates became inoperable due to sedimentation and wrong placement. There for, spillage takes place one over an existing embankment; it inundates both agricultural lands and homesteads (Islam, et. al., 2004). The Coastal Embankment Project had eventually choked up the rivers by enhanced sedimentation within the riverbeds (Islam et al., 2004; Sarkar, 2004). Within the lack of coastal embankments, sedimentation should include or else happened in nature in the whole flood plain, in that way rapid lift of river beds should have been avoided. Therefore, spillage takes place one over an existing embankment; it inundates both homesteads and agricultural lands (Islam, et. al., 2004). So how the study area became severely waterlogged has been shown in map.

Since (2001) studied that the severity of water logging is in large every year and suffering of people is increasing simultaneously. These repeated flood situations in the adjusting water logged area has already caused massive havoc at the very beginning of the rainy season. The blending zone between fresh water and saline water has now been carried to north. Throughout the dry season, a combination of extreme low flow and increased salinity accelerate the process of sedimentation in the river bed, which eventually choke the river and severely reduce its drainage capacity. This is low drainage congestion becomes a regular phenomenon in the kobodak river bank areas of Keshabpur Thana, resulting into over bank spilage during each peak monsoon. Consequently, the entire basin becomes water logged for eight months.

2.5 Climate Change and Water Logging

Bangladesh is usually considered to be one of the most vulnerable regions of the world to climate change induced sea level rise. The region of South west coast is unsafe to induced sea level rise due to low elevation from sea level and a continuous process of land subsidence (Haq, et.al., 1999). Some climatic factors have been

analyzed below in order to depict the changing climate scenario of Bangladesh which is responsible for increasing water logging problem.

2.5.1 Temperature

The PRECIS (providing climates for impacts studies) have noticed that the end of 21st century, some parts of Bangladesh will be observed a sharp enhance in together rainfall and temperature with the concentration of Green House Gas (GHG) concentrations and sulphate aerosols (Kumar,et.al., 2006). For the temperature, warming appeared to be inevitable and increasing over time. So the detail result for Bangladesh suggests a heater summer and winter monsoon. However, the changes in temperature for 2020 will 1.4°C with a corresponding increasing by 2.8°C by the year 2050 (Mirza, 1997).

2.5.2 Rainfall

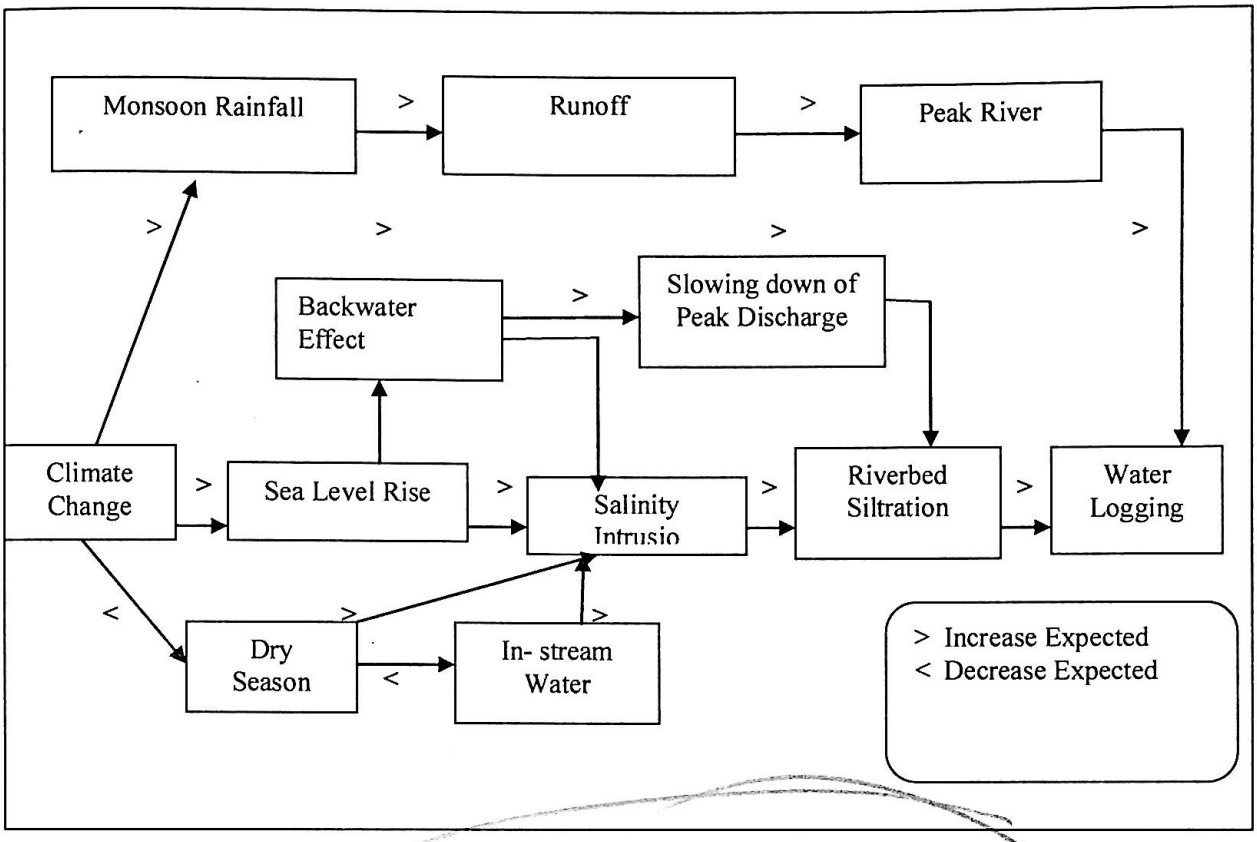
Water monsoon has been predicted through different modeling for Bangladesh. An increase pre monsoon rainfall is observed for 2020 and 2050. The result is obtained from pre monsoon rainfall through a regional climate model in one recent attempt under a south Asian regional modeling program to increase climate change scenarios for Bangladesh. Overall, the changes in rainfall for 2020 will be 9.1% with a corresponding increase by 22.7% by the year 2050 (Asaduzzaman, et.al., 1997). These changes would have several critical impacts in the south coastal region. The combination of reduced winter season perception and increased temperatures, resulting in higher evaporation rates, will reduce winter river flows (Houghton et.al., 1996).

2.5.3 Sea Level Rise

For sea level rise, the scenarios have so far been largely speculative and not based on any detailed modeling. The OECD (Organization for Economic Co-operation and development) study reiterated the fact that both subsistence and sedimentation would complicate the sea level rise scenario for Bangladesh. Furthermore it emphasized that higher mean sea level is going to increase problems of coastal inundation, inland flooding and salinization in the low lying deltaic coast. A review of literature and expert opinion suggests that sediment loading may cancel out the effect of compaction and subsidence, so that net sea level rise may be assumed. The Bangladesh country study put the range at 30-100 cm by 2100, while IPCC third assessment gives a global average range with slightly lower values of 9 to 88cm (Agrawala et al., 2003).

A further likely impact is that sediment transport characteristics of the river system would be altered. A sea level rise will exacerbate drainage problems in coastal zone (Mirza, 1997). This will occur in two ways; firstly, existing flood control infrastructure was designed for historical water levels and tidal fluctuations. A sea level rise would reduced the tidal range within which outflow occurs, decreasing the total discharge during each cycle. Secondly, tidal meetings points will migrate further inland. These locations were sediment deposition occurs, will impede upstream drainage and change drainage characteristics of the region (Choudhury et al., 2005). A massive environmental and human disaster in south-west coastal region is looming on the horizon. As a Jessore district is situated in the coastal zoned, it would face increased water-logging due to increased flood volumes to drain and increased sea levels downstream. South-western embankments might face occasional tidal overtopping, leading to saline water-logging within embanked (CEGIS, 2006). Various cause effect relationship towards the increasing water-logging under climate change has been shown in figure 2.1

Figure 2.1: Under climate change to different cause and effect interaction to increasing water logging



Source: Adopted from Ahmed et al., 2008

2.6 Water-Logging Problem and its Major Consequence in South-West Coast of Bangladesh

Water logging problem in the part of southern coastal Bangladesh is serious issues (Rahman, 2008). The problem of water logging might be more dangerous than flooding (Chowdhury, 2007). The water logging would affect the biophysical environment and consequently also affect the production of fish and paddy as well as the other socio-economic factors (Alam, 2007). Water logging rotted the roots of trees, and salinity killed off all vegetation, fruit trees died off, agriculture was drastically reduced and even homesteads vegetation and cattle rearing become impossible (Unnayan Onneshan, 2007). Environmental disasters such as water-logging, the silting-up of rivers and salinity have become common occurrences in south western region of Bangladesh and are causing unimaginable suffering for the

people (Ashraf-ul-alam, 2005). Permanent water logging has greatly reduced agriculture and related occupations. Stagnant water all over the area leaves no space for disposal of human and other wastes, causing pollution and proliferation of water-borne diseases. Children cannot go to school. Unemployment has led to increase in poverty, outward migration and overcrowding in urban slums, creating new problems (Pasha, 2009).

Water logging in the South-Western region of Bangladesh has a widespread impact on the 2-500,000 people. It creates social disruption in the form of school, housing, health, sanitation, market facilities and women's mobility. The people of water logged areas face the shortages of clean drinking water and have less opportunity for paid work (reduced cropping, transport disrupted, stifled non-farm activities. In agriculture, it is observed depressed Aman season production, possible reduced yield, returns from Boro and conversion of crop land to shrimp production.

Moniruzzaman (2012) studied that there are sectoral impact of water logging on the human settlement, agriculture, health and education in the south-western coastal areas of Bangladesh.

Water logging in South-Western Bangladesh affects adversely on social, economic, occupational, cultural, political, and religious condition. No fruitful initiatives are being taken to combat water logging. So people of the region are becoming the permanent victim of it.

2.7 Definition of Vulnerability

Vulnerability has been defined as the degree to which a system, or part of it, may react adversely during the occurrence of a hazardous event. This concept of vulnerability implies a measure of risk associated with the physical, social and economic aspects and implications resulting from the system's ability to cope with the resulting event (PROAG, 2014).

Vulnerability causes damages to lives, assets and livelihood by any kinds of hazard or disaster (Cardona, 2004 cited in Birkmann, 2006). Thus people become "vulnerable" if access to resources either at a household, or at an individual level is the most critical factor in achieving a secure livelihood or recovering effectively from a disaster (PROAG, 2014). To understand clearly the notion of vulnerability requires clear conception regarding vulnerability and idea about elements and factors of vulnerability.

Vulnerability could be understood in the context of the individual and household level. The concept of vulnerability within the disaster management context is too complex and varied. In general, it refers to the susceptibility of a community to harm from an event, often determined by a community's geographical exposure (Mahamud et al., 2008). Definition of vulnerability is broadly unclear and quite varying according to associations, NGOs and agencies. In general sense, vulnerability can be defined as the inability of a system to withstand against the perturbations of external stressors. When it comes to measure vulnerability, it is important to stay pragmatic, then to step aside from classic references to rights and laws. It is a concept that has been used in different research backgrounds (Adger, 2006; Smit and Wandel, 2006) but there is no consensus on its meaning and definitions.

To make vulnerability meaningful it need to have a deeper understanding of it. Vulnerability is also often 'discovered 'after the event, for example, various disasters related literatures find that most of the victims come from vulnerable groups. Disaster experts have developed many definitions of vulnerability. For instance, social scientists argue that vulnerability represents the set of socio-economic factors that determine people's ability to cope with stress or change. Whereas climate scientists claim that vulnerability relies on the likelihood of occurrence and impacts of weather and climate related events (Adger et al., 2004). Some definitions of vulnerability are below.

Vulnerability is a degree to which people is susceptible to harm on being exposed to a hostile factor. Also vulnerability indicates a state which arises from complex interaction between three elements: exposure, sensitivity, resilience (Ahmed, 2004).

Vulnerability concept is extremely sets in the natural hazards and poverty field (Paul et al., 2013).

Vulnerability is term used to exposure to hazards and shocks. People are more vulnerable if they are more likely to be badly affected by events outside their control. Vulnerability defines the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a hazard (Wisner et Al., 2004). It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event (or serious or cascade of such events) in nature and society.

So, vulnerability is a multidimensional concept. Although vulnerability is an intuitively simple notion, it is surprisingly difficult to define and even more difficult to quantify and operationalize. It is described in the literature in numerous and sometimes inconsistent ways. Definitions of vulnerability range from a focus on physical exposure to measures of socio-economic status and access to resources and to sociological investigations of the differential ability of groups to resist harm and to recover afterwards. A sample of definition on vulnerability is summarized below focusing different issues.

Cutter (1996) defined vulnerability as the likelihood that an individual or group will be exposed to an adversely affected by a hazard. It is the interaction of the hazards of the place (risk and mitigation) with the social profile of the communities. Gabor and Griffith (1979) referred vulnerability as a threat to which a community is exposed, taking in to account not only the properties of the chemical agents involved but, also the ecological situation of the community and the general state of emergency preparedness, at any point in time. George E Clark (1998) defined vulnerability as a function of two attributes: one is exposure (the risk of experiencing a hazardous event); and another is coping ability, subdivided into resistance (the ability to absorb impacts and continue functioning), and resilience (the ability to recover from losses after an impact).

The Third Assessment Report of the Inter-Governmental Panel on Climate Change (IPCC, 2001, p. 995) defines vulnerability due to climate change as the extent to which a natural or social system is susceptible to sustaining damages from climate change. It is defined as a function of the sensitivity of the system to change in climate (hazard), its adaptive capacity and the degree of exposure of the system to climatic hazards (McCarthy, et al., 2001). Similarly, Arakida (2006:291) defined vulnerability as condition resulting from physical, social, economic and environmental factors of processes that increase the susceptibility of a community to impact of hazard.

Generally speaking vulnerability is the manifestation of social, economic and political structures. It is mainly dealing with two elements such as exposure to hazard and coping capability of the people. People having more capability to cope the extreme events are naturally less vulnerable to hazard. So, vulnerability is the function of exposure to hazard and coping capacity at a certain point of time. Vulnerability is also connected with the access to opportunities, which defines the ability of people to deal with the impact of the hazard to which they are exposed. It means the characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of the risk or hazard.

The concept of vulnerability is being used in disaster management, environmental change research and development studies. The concept of vulnerability is still indistinct. Authors such as Vogel and O'Brien (2004) stress that vulnerability is:

i Multi-dimensional and differential (varies across physical space, among, and within social groups)
ii Scale dependent (with regard to time, space and units of analysis such as individual, household, region, system).
iii Dynamic (the characteristics and driving forces of vulnerability change over time).

2.8 Factors of Vulnerability

Hamburg University of Technology (2012) has identified six factors of vulnerability such as, poverty, livelihood, cultural beliefs, equity and gender and worker social

groups. On the other hand, UNESCO-IHE (2012) describe that, vulnerability consist of three factors (exposure, susceptibility and resilience) are responsible for creating flood vulnerability. The main factors that accelerate people's vulnerability to water logging are categorized into social, economical, environmental and structural factors.

The identification and the understanding of vulnerability and its underlying factors are important (Benson, 2004 cited in Birkmann, 2006). Corresponding measurable variables cover the structural, economic, social, educational, political, institutional, cultural, environmental and ideological dimensions (Schneiderbauer and Ehrlich, 2006). All these variability characteristics could be related to natural disasters and especially to flood events (Queste and Lauwe, 2006). The following sections explain the components of vulnerability.

2.8.1 Social Vulnerability and its Associated Variables

Social vulnerability is mostly visible after a hazard event (Cutter et al., 2003 cited in Tapsell et al., 2010). The nature of social vulnerability depends on the nature of hazard. Certain properties of a social system make it more vulnerable to certain types of hazard than to others (Brooks, 2003). Therefore, it can be said that social vulnerability is not a function of hazard rather it is function of social systems. There is no unique definition of social vulnerability. Because of, different authors have used it differently. Current literature reveals the fact that social vulnerability can encompass various aspects and features, which are linked to socially created vulnerabilities (Cutter et al., 2003 cited in Birkmann et al., 2010). Downing et al. (2006) has developed a definition of social vulnerability. They define six attributes to characterize social vulnerability.

i The differential exposure to stresses experienced or anticipated by the different units exposed;
ii A dynamic process
iii Rooted in the actions and multiple attributes of human actors
iv Often determined by social networks in social, economic, political and environmental interactions

v Manifested simultaneously on more than one scale

vi Influenced and driven by multiple stresses.

Social vulnerability is an important concept, underscoring the ways in which, and reasons why, people's differential access to and control over resources (such as land, money, credit, good health and personal mobility, to name but a few) are closely interwoven with their ability to survive and recover from disasters (Enarson,2002). The risk-scapes of hazards/disasters are also affected by poverty, population growth, land settlement into fragile areas, over exploitation of natural resources, inadequate communication structures and weak institutional bodies, global climate change (that is partially caused by human actions), as well as differential access to the kinds of information that could help people to protect themselves (GTZ, 2005).

Different matters have contribution to create social vulnerability. From existing literature, it is apparent that social vulnerability consists of various social matters. Social vulnerability is much more broadly used for estimating any kinds of disaster vulnerability (gender, age and income distribution). Within the debate of social vulnerability, the term exposure also deals with social vulnerability because that increases defenselessness such as exclusion from social networks (Birkmann, 2006).

The characteristics of external relations and the internal value system contribute to determine its level of vulnerability. For example, a functioning cultural community may provide strong social networks. Level of education and income among men and women vary significantly. Age structure is also important indicator to determine social vulnerability (Schneiderbauer and Ehrlich, 2006). People, who are socially deprived, disabled or in poor health are more vulnerable to flooding than others. Population subgroups that are vulnerable to the effects of flooding including the elder people, women, children, minorities, individuals with disabilities and those with low incomes (Hajat et al., 2003 cited in Queste and Lauwe, 2006). Factors such as language, community isolation and the cultural insensitivity of the majority population may also affect the social vulnerability. Within this approach, the following variables reflect social vulnerability: age, gender, employment, car ownership, disability, language skills (Queste and Lauwe, 2006; Canon, 2003).

Similarly, for capturing social vulnerability Baum et al., (2008) have used age, proportion of male and female, social capital or social networks, social isolation account of race and ethnicity. Birkman et al. (2006) have used social networks and membership of organizations as the variables of social vulnerability. They also used gender distribution as the variable of social vulnerability.

Common variables include socio-economic status, presence of disabilities, age, household or family structure, racial background, ethnicity, the social capital and social networks associated with adaptive capacity. A number of these potential variables are very familiar having more than 50 years rapidly proven their statistical power in urban social analysis (Cutter et al., 2003; Tapsell et al., 2002; Morrow, 1999; Rygel et al., 2006 cited in Baum et al., 2008).

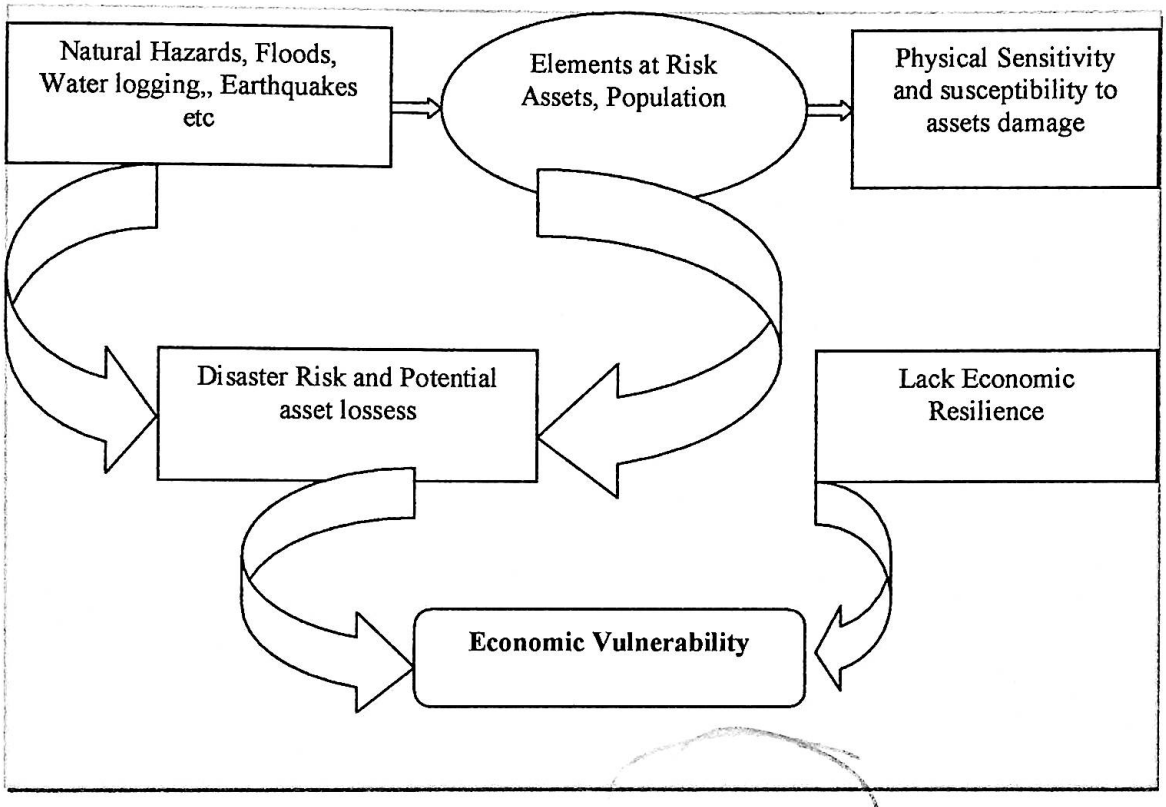
2.8.2 Economic Vulnerability and its Associated Variables

Vulnerability in many ways is related to poverty. The poor societies have little resources and opportunities to reduce vulnerability significantly. However, poverty has general link with income, occupation, ability of wealth. An economic factor is considered as a highly influential factor to create vulnerability at the national scale. A financial resource and strong economy have contribution to reduce vulnerability (Schneiderbauer and Ehrlich, 2006). Economic vulnerability is a set or composite index of indicators such as degree of export dependence, lack of diversification, export concentration, share of modern services and products in GDP etc. (Mechler et al., 2006).

Income, employment, health insurance, flood insurance and savings these variables have great role to create or reduce vulnerability to any kinds of hazards or disasters (Whyte, 2001; Queste and Lauwe, 2006; and Emrich, 2009). Insurance can help to manage disaster risk and reduce losses (Herrmann et al., 2010). Rich people have ability to absorb losses as they can recover the loss of materials and goods due to hazards quickly (Emrich, 2009). High-income families have high savings so they can recover any financial loss easily (Olorunfemi, 2011).

The ability to recover can be determined by household savings and individual or family related insurance (Schneiderbauer and Ehrlich, 2006). Birkmann et al. (2006) have used income, loans, savings and employment as the economic variable of vulnerability. They also used and land ownership as the variable of vulnerability.

Figure 2.2: Economic Vulnerability Structure and Natural Hazard



Source: Modified from Mechler, 2006

2.8.3 Structural Vulnerability and its Associated Variables

Structural vulnerability is another influential factor in flood disaster. It can increase the intensity of flood hazard. The previous literatures have showed very few variables to determine structural vulnerability. Among those housing quality, road networks, existence of evacuation road, damage system, and flood dams are mostly apparent (Whyte, 2001 and Coppola, 2007). Structural vulnerability can classify into three broad categories like, transport systems (roads, railways, bridges etc.), utilities (water, sewerage, and electricity) and telecommunication (Carter, 1991). It is also involves those factors, which are constituted by physical environment. The quality and altitude

of houses/buildings are important in structural vulnerability. For instance, a building may locate in a flood prone zone but raising the structure of the building may be reducing its structural vulnerability. Generally, the stability of a house depends on the material used to build it. This relates to determining vulnerability emanated from cyclones, floods. Buildings at low elevation near the coast or in occasionally flooded areas might be vulnerable to floods. House in the hazard-prone areas is a part of exposure that characterizes the spatial dimension of vulnerability. The location of human settlements and infrastructure plays a crucial role of determining the susceptibility of a community (Adger et al., 2004 and Birkmann, 2006). Living in dangerous locations makes individuals or community defenseless against hazards (Kiunsi et al., 2006). Schneiderbauer and Ehrlich (2006) state that, the poor people tend to live in locations of high risk, such as polluted areas, which makes them structurally vulnerable. In potentially hazard-strike areas of communication systems can be measure by the network of roads of the other traffic lines and mobile phone coverage (Queste and Lauwe, 2006).

2.8.4 Environmental Vulnerability and its Variables

The existing level of environmental degradation is one of the particular relevant factors for evaluating vulnerability for floods, droughts, cyclone and water logging. The effects of environmental degradation might vary with climatic conditions. The environmental sphere cannot be separated from the social and economic spheres because of the mutuality between human beings and the environment. Several existing vulnerability framework incorporate environmental components. Direct impact on vital resources (e.g. water, soil), environmental degradation increases the vulnerability of communities (Renaud, 2006).

The fact that the poor people tends to live in locations to higher risk, such as polluted areas of regions with sever climate, is also relevant in determining vulnerability to epidemics. In addition, the location and accessibility to drinking water has great importance for determining vulnerability (Schneiderbauer and Ehrlich, 2006; Olorunfemi, 2011). Vulnerability is not homogenous within any given area. It varies according to income, exposure, level of preparedness, etc within these unplanned

expansions with poor drainage and sanitation also the casus vulnerability to flooding (ADPC, 2005). In a manual for estimating the socio-economic effects of natural disasters, Economic Commission for Latin America and the Caribbean (ECLAC) provides broad outlines for the most probable types of infrastructure that may be damaged by disaster. For example, the manual explains how floods can contaminate clean water supply, damage buried pipes and semi-buried tanks, and pump equipment (Freeman and Warner, 2001). Fragility of natural environment also exacerbated conditions of vulnerability (NDMA of Pakistan, 2007).

2.8.5 Institutional Vulnerability and its Variables

The institutional infrastructure provides the framework of mitigate disaster, increase preparedness and response activates. Institutions usually manage these. Assessment of efficiency of quality of an institutional setting can often only be approached by using indirect variables, such as for example medical infrastructure. Existence of emergency management committee and aid during disastrous situation works as remedy to reducing vulnerability (Adger et al., 2004). Institution addresses floods or flood related disasters. It may influence the vulnerability of households and communities through several pathways. Lack of early warning systems, emergency service, governance and institutions can amplify the vulnerability at household or community level (Whytee, 2001 and ADPC, 2005). Weak early warning systems, lack of communications infrastructure and critical facilities further magnify vulnerabilities of communities for future disaster situations (NDMA of Pakistan, 2007). The people's access to information is important knowledge relating to early warning of post disaster emergency and relief actions. Influences of institutionalized capacities and practices on the disaster cycle are mediated by ecological and social resilience as well attributes of flood event itself.

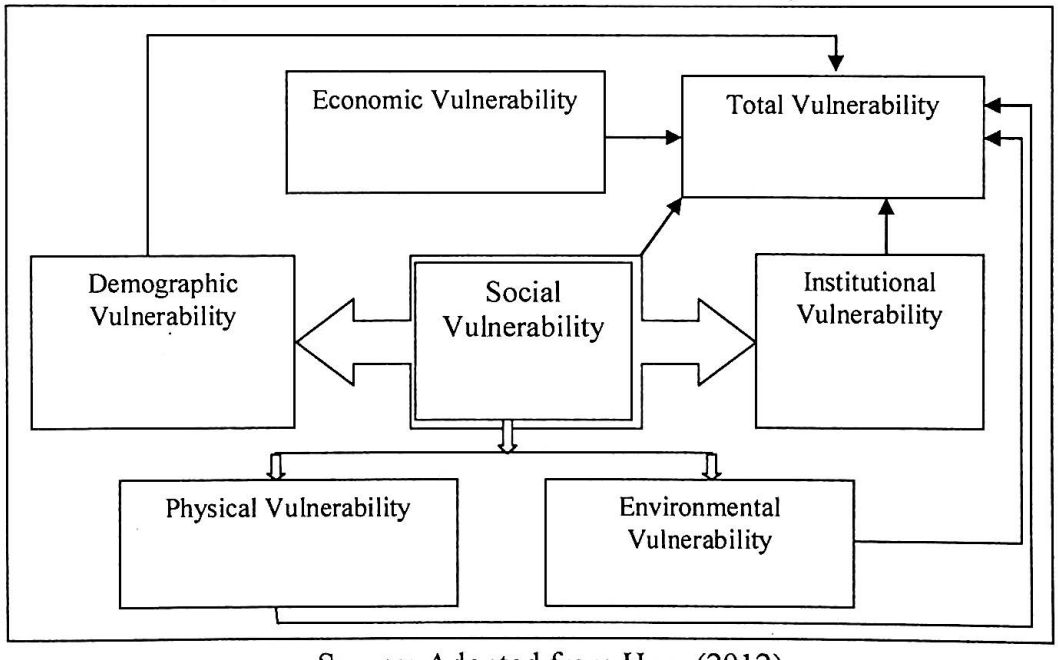
2.8.6 Demographic Vulnerability and its Variables

Very few literatures utter the name of demographic vulnerability. Population structure such as a high dependency ratio, number of young and elderly people among total

population indicate demographic vulnerability (Birkmann et al., 2006). NAS (2006) suggest that researchers should assess the linkages among the concept of people about hazards, locational, structural and demographical vulnerability. It also emphasise that studies should examine people's actual demographic vulnerability. On the other hand, DCPP (2007) mention that, population's vulnerability to all type of disasters depends on demographic growth, the pace of urbanization, settlement in unsafe areas, environmental degradation, climate change, and unplanned development. Doocy et al. (2007) have conducted a notable work. Their study finds that demographic indicator has much more contribution to create vulnerability. Population density, population growth rate also may be added as demographic vulnerability indicator (Cutter et al., 2003; Adger et al., 2004; Greiving, 2006; Bolin and Hidajat, 2006).

However, vulnerability factors mentioned before are interconnected with each other (Figure 2.1). Economic vulnerability can lead to the social vulnerability. Alternatively, the consequence of social vulnerability makes demographic and institutional vulnerability. It also partially is responsible in creating physical and environmental vulnerability.

Figure 2.3: Interconnection of Vulnerability Factors



Source: Adopted from Huq, (2012)

2.9 Earlier Debates on Vulnerability Measurement

2.9.1 Equation of Vulnerability and its Debates

Several institutions and experts for assessing, measuring and evaluating vulnerability of various hazards and disasters have developed a significant number of vulnerability equations. The present study, the equation related to water-logging vulnerability and livelihood security has been considered. Literature supports that in formulating vulnerability the first initiatives was taken by UNDP in 1992. UNDP provided formula is given below:

$$Vulnerability = \frac{Hazard \times Risk}{Manageability \cdot CopingStrategics}$$

The extent of disaster cannot be measured without knowledge of the resilience of the affected groups (Alwang et al., 2001). Thus they stated vulnerability equation as follows:

$$Vulnerability = Hazard - Coping$$

Simpson and Katirai (2006) used a vulnerability equation for measuring vulnerability of a community. That is:

$$Vx = \sum [\![[(Hapafa) + (Hbpbfb) + \cdots] \times \sum[(w1VM1 + w2VM2 + wnVMn)]]\!]$$

Where, V= Vulnerability to Community, x= community location; Ha,b,c.....= Agent of hazard (Earthquake, flood, hurricane drought, water-logging, ...); f= frequency of hazard; p=probability of hazard; w= weight, VM= Vulnerability measure/ indicator and n= number of measures.

Simpson and Katrai (2006) have developed another equation for measuring vulnerability as:

$$Vulnerability = hazard \times probability \times frequency \times Vulnerabilitymeasures(VM)$$

Flood vulnerability is combination of various factors and/or variables. Shoeb (2002) expressed vulnerability equation as:

$$Vulnerability = f[physicalcharacteristices + humancharacteristices + floodcharacteristices]$$

At last, introduced to the household vulnerability equation as follows:

$$Householdvulnerability = f[AHSICFPGET], [Sc, Sb, Tt, St, Ro], [D, Dt, Sd, Ss, W, V, Po, R], [Wo. Wt, Wa], [Tr, Ra, Rq]$$

Where, A= Profile of Age, H= Status of health, S= Household Savings, I= Households Income, C= Community Cohesiveness, F=Flood of Knowledge, P=Population of density, G=Gender, E=Ethnic, T=t Network of Transport, Sc= Susceptibility to damage of building contents, Sb= Susceptibility to building fabric, Tt=Time taken and restore infrastructure, St=Stories number, Ro=Building fabric Robustness D= Flood Dept. Dt= Flood Duration, Sd= concentrations of Sediment , St= Size of sediment, W=Wave/wind action, V=Velocity, Po=Population load to flood waters, R= Rate during flooding water rise onset, Wo=Warning given of not, Wt=Warning of time provided, Wa=Advice the content of warning, Tr=Time taken for assistance to arrive after during event, Ra=Amount of response, and Rq=Response quality.All societies are vulnerable to floods, under different cases and situations (UNSCO-IHE, 2012). Finally, UNSCO-IHE (2012) has introduced the following vulnerability equation:

$$Vulnerability = Exposure + Susceptibility - Resilience$$

For measuring social vulnerability specifically some vulnerability equation has been developed by disaster experts. For instance, Simpson and Katirai (2006) have developed a formula for measuring social vulnerability as follows:

$$\text{SoVI} = \text{Personal wealth} + \text{Age} + \text{Density of Built Environment} + \text{Single Sector economic} + \text{Housing Stock and tenancy} + \text{Race (African American} + \text{Hispanic} + \text{Native American} + \text{Asian)} + \text{Occupation} + \text{Infrastructure Dependence.}$$

Evaluating the previous vulnerability equations, the following formula has been devised by the author.

WVI=f (SocVul,EcoVul, PhyVul, Ins Vul, EnvVul, Dem Vul,)

Where, WVI= Water-logging Vulnerability Index; SocVul=Social Vulnerability; Eco Vul=Economic Vulnerability; PhyVul=Physical Vulnerability; Ins Vul=Institutional Vulnerability; EnvVul=Environmental Vulnerability and Dem Vul=Demographic Vulnerability.

2.10 Vulnerability and its Different Dimensions

Social, generational, geographic, economic and political processes, that influence how hazards, affect people in varying ways and with different intensities (Ahmed, 2004). Some groups are more prone to damage, loss and suffering in the context of differing Hazards. Key variables explaining variations of impact include class, occupation, caste, ethnicity, gender, disability and health status, age and immigration status, and the nature and extent social networks. Changing the social, economic, political factors usually means altering the way that power operates in society. The relative contribution of geophysical and biological processes on the one hand and social, economic and political processes on other to vulnerability varies from disaster to disaster, as well as from one community to another and from one place to another.

Vulnerability can be increased through entitlements, political powerlessness or social exploitation and discrimination (Cannon et Al., 2003). The interactions of the different factors of vulnerability will determine people's capacities, access to resources and ability to realize their rights. Food security, housing condition, educational facilities, social interactions, displacement, agricultural activities, employment security etc. determine the state of socio-economic vulnerability. On the other hand the state of water, sanitation, health etc. determines the environmental vulnerability of group of population.

The present research deals with such three especially vulnerable groups who have limited access to resource, information and have very limited capacity to bounce back from adverse environmental condition due to financial constraint. Wage labour, fisher and farmer are, therefore, as major livelihood groups.

2.11 The Context of Rural Poor's Vulnerability Facing Water-logging Problem

There are many ways in which poverty and disaster are interconnected. Livelihoods of rural poor are predominantly based on natural resources. Poverty forces them to degrade their environmental, which in turn reduces opportunity to enjoy services of these natural resources on a sustainable manner. Since water logging is likely to jeopardize the availability of natural resources base, poor people's livelihoods will face significant challenges in near future (Ahmed, 2005). In this nexus between poverty and water-logging disaster, sustenance of decent living under revitalized extreme weather events would be severely questioned, especially in countries such as Bangladesh where persistent poverty is prevailing. Frequently occurring natural hazards and occasional disasters are perceived to be the major causes of perpetuation of poverty in Bangladesh. Unfortunately, climate change will exacerbate both frequency and extent of natural hazards, often in the forms of floods, droughts, riverbank erosion, salinity intrusion, water logging, and cyclone storm surges (Haque et qal., 1996; Asaduzzaman et al., 1997; Choudhury et al., 2005).

2.12 Livelihood Security and Water Logging Problem

Livelihoods security approach evolved from the food crisis in the mid 1980s and Sen's (1981) theory on entitlement referring to the set of income and resource bundles (e.g. assets, commodities) over which households can establish control and protect livelihoods. The evolution of the concepts and issues related to this theory eventually led to the development of the broader concept of household livelihood security (HLS). The diversity in the interpretation of livelihoods approach has documented by Hussein (2002), which presents the key elements of livelihoods approaches of 15 development agencies, ranging from bilateral and multilateral to nongovernmental organizations (NGOs). Of them, CARE considers this approach as its integral part and defines HLS as adequate and sustainable access to income and resources to meet basic needs (including adequate access to food, potable water, health facilities, educational opportunities, housing, and time for community participation and social integration) (Frankenberger 1996). This definition is in fact derived from Chambers and Conway's

(1992) definition of livelihoods and is linked to basic needs. Chambers and Conway (1992) conceptualized sustainable livelihoods in terms of capacities and activities:

> "a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for next generation: which contributes net benefits to other livelihoods at the local and global levels in the long and short term".

CARE views that this livelihood approach can effectively incorporate basic needs and right-based approaches, which provide an additional analytical lens (Carney et al. 1999). This concept of HLS embodies three fundamental attributes of livelihoods: (1) the possession of human capabilities (e.g., education, skills, health, psychological orientation); (2) access to tangible and intangible assets; and (3) the existence of economic activities (Drinkwater and Rusinow, 1999).

Water logging significantly affects existing biodiversity in South-western region, which has important implication for lives and livelihoods of the people (Masud et al., 2014). Millions of people especially poor and landless farmers, sharecroppers, agricultural wage labors, petty traders and others lost their livelihood security due to water logging (IFT WATCH, 2006). Due to perpetual siltation in the rivers and as a consequence of unplanned development interventions on the river system, long-lasting water-logging in the human settlements is taking place in Bangladesh resulting in considerable loss and damage to dwelling houses, standing crops, shrimp farms, roads, educational institutions and so on (UNDP, 2011).

Households of the affected areas in Bangladesh live within different socio-economic, political and cultural contexts that influence the livelihood strategies to reach the desired outcomes. They are engaged themselves on agriculture, fish farming, fishing and the wage-based labor market etc. It is observed that a major portion of crop land in the coastal areas has inundated every year and standing crops have been fully destroyed. (FAO, ECBP, WFP, Shushilan). Homestead-based fish and vegetable farms have also been fully damaged. Similarly, household-based livestock suffered

significantly. All the homestead vegetables were damaged due to the deep and prolonged flooding/water logging (ECHO & Oxfam GB). Once the backbone of the local economy was affected this had a tremendous impact on the labor market, especially people employed in agriculture, fish and shrimp farmers and other daily wage earning activities. The alternative employment opportunities available in the area are predominantly pulling rickshaw vans and some ad hoc type labor-intensive activities. The surplus of labor has already substantially reduced wage rates (UNDP, 2011).

2.13 Measurement of Livelihood Security

The existing literature on livelihood analysis is skewed towards qualitative accounts and usually restricted to a geographical area or a particular resource management system and so conclusions are imprecise, often not possible to generalize them (e.g., Kabeer, 2004; Toufique and Turton, 2002; Lindenberg, 2002; de Haan et al., 2000; Toulmin et al., 2000; Ashley, 2000; Carney, 1999). Use of quantitative approach or Q-square approach to analyze livelihoods is inadequate. Jansen et al. (2006) applied a quantitative approach to analyze livelihood strategies and their determinants.

Till the beginning the nineties, not many studies assessing the livelihood security across the globe were available in literature. More recently, however, few studies have attempted to develop measures to assess livelihood security raising different methodological issues (Bouis, 1993; Haddad *et al.,* 1994; CARE, India, 1997; Drinkwater and Rusinow, 1999; Frank, 2000; David, 1999; Rahman and Alam, 2001; Christina *et al.,* 2001; CARE, USA, 2002; Fazeeha, 2002; Matshali, 2002; Ellis *et al.,* 2002). A livelihood approach, as a framework, explores how individuals, households, or communities behave under specific conditions, analyzing their ability to cope and adapt in response to external shocks such as drought or civil strife (De Waal and Whiteside, 2003; Masanjala, 2007).

Livelihood security approach is an integral part of many organizations working for the poor. This approach evolved from Sen's (1981) theory on entitlement. Entitlement refers to the set of income and resource bundles (e.g. assets, commodities) over which

households can establish control and secure their livelihoods. Lindenberg (2002) analysed livelihood security areas under five broad dimensions: economic security, food security, health security, educational security and empowerment. CARE developed a set of multiple indicators to assess each of the HLS dimensions based on a reflective workshop involving several other NGOs in Bangladesh (CARE 2004).

Hahn et al. (2009) constructed a measurement framework is discussed as follows: Indicators are identified and it is assumed that each indictor has equal weight to the overall HLS index. The indicators are then standardized following the procedure adopted in measuring Life Expectancy in Human Development Reports (also adopted by Hahn et al., 2009).

2.14 Factors Affecting Livelihood Security

International Food Policy Research Institute (IFPRI), CARE and their collaborators have been investigating the complexities of urban livelihood security and noted that very little is known about the determinants of livelihood security (IFPRI 2002). Studies in this area are still scanty. But it is identified that livelihood is closely linked to socio-economic status (SES), a term often used to reflect an individual's access to resources such as food, potable water, health facilities, educational opportunities, and housing (Drimie and Mullins, 2006; Elasha et al., 2005). Assets include the types of capital that can be used directly or indirectly to generate livelihoods and reflect natural (e.g., land, water), physical (e.g., infrastructure, roads), financial (e.g., money, savings, income), human (e.g., knowledge, education, ability to work), and social (e.g., networks, kin, membership in a group) forms (Carney, 1998).

However, household and individual livelihood strategies are not fully-described only by income, asset use, or labor. These are also determined by the diversity of the households' assets (tangible resources like physical, financial, or natural capital, and intangible ones like social and human capital), as well as the social institutions that govern how or whether one has access to assets (Leo and Annelies, 2005; Bebbington, 1999; Bury, 2004; Scoones, 1998; Leach et al., 1999; Ribot and Peluso, 2003; Schoenberger and Turner, 2008). Therefore, livelihoods are not merely a summary

measure of cash-equivalent resources, but are complex, multidimensional, and closely related to the natural and socioeconomic contexts in which people live (Ellis, 2000, Binder et al., 2013; DID, 2000).

2.15 Gaps in the Reviewed Literature

This chapter has tried to review comprehensively the previous literature and empirical studies on the vulnerability and livelihood security to water logging problem. From the review of available literature it is clear that the South-Western region of Bangladesh is severely affected by the problem of water logging and observed some theoretical and methodological weakness is in the previous literature. Firstly, most of the earlier studies on the water-logging problem are qualitative and failed to conceptualize the problem and its impacts on the rural households.

Secondly, the earlier literature verified the fact that there is a direct relationship between water-logging and livelihood groups. However, these studies only analyze and confirm this relationship between water-logging and its livelihood impact on the basis of qualitative survey data.

Thirdly, most of those studies only demonstrated the happening of environmental degradation as a result of intensive cultivation practice but as far as the researcher's concern no early study empirically assesses the extent of that environmental impact caused by agricultural activities.

Fourthly, people's vulnerability to water logging problem in South-western region of Bangladesh is seldom studied quantitatively. In assessing vulnerability measurement, it is identified that studies regarding calculation of vulnerability score to poor rural households is rarely conducted in Bangladesh.

Finally, although many researchers have showed the changing livelihood pattern of inhabitants in waterlogged areas of South-western coastal region of Bangladesh (Rajve, 2006), they did not use comprehensive methodologies. Some used Sustainable Livelihood Framework to assess the livelihood pattern of wetland community. But the

calculation of Household Livelihood Security Index and adoption of econometric methods like, 2SLS is rarely seen in the earlier research conducted on the specific issue of water logging.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter, the present study highlights the complete methodology of this research. The methods includes brief research approach, data collection technique, the calculation techniques of the indices of vulnerability and livelihood security and the empirical design of the statistical model. In this study, the vulnerability index is calculated for describing the vulnerability situation whereas livelihood security index is for measuring livelihood status in the affected households of research area by water logging. The statistical method (2SLS) is used to factors of determine influencing the livelihoods security in the affected households by water logging.

This chapter has eleven sections. Section 3.2 outlines a brief illustration of research approach. The discussion related with weighting variables and indicators is showed in section 3.3. Section 3.4 describes the methods of calculating the vulnerability scores. The formulas of constructing livelihood security indices are presented in section 3.5. Section 3.6 presents the empirical model of the determinants of livelihood security. Sources of data and selection of the study area are described in the consecutive two sections, 3.7 and 3.8 respectively. Section 3.9 briefly describes the selected study areas. Section 3.10 outlines the sampling design of the present study. Finally, the chapter ends with the description of the adopted analysis techniques of the present study.

3.2 Research Approach

A systematic research approach is a framework for answering research questions which is essential for obtaining the objectives of an empirical research. It involves strategic plans and the procedures for analyzing the data and interpretation. The plans involve several decisions such as, decision about deductive approach and inductive

approach. The relevance of hypotheses to the study is the major particular points between these two approaches. Deductive approach tests the validity of assumptions in hand, whereas inductive approach contributes to the emergence of new theories and generalizations. Inductive approach is often called quantitative approach which is usually used in collecting, editing, sorting, organizing and converting data into numerical form so that calculations can be made and at the same time conclusions can be drawn (Kothari, 2004). In the present study inductive approach is using achieve the objectives of the research. However, the appropriate selection of methods and techniques applied in this study is presented below.

The research methodology for the present study has been set based on reviewing the methods and techniques used in the earlier studies. The present research is an explorative type based on survey data and observations. Both quantitative and qualitative approaches of research have been employed in the study. There are some earlier studies which concentrated on empirical investigation on the field of vulnerability to water logging and livelihood security and diversity status. These studies are Shah (1989), Adnan (1990), Hanchett (1992), Nasreen (1995, 1999), Paul (1998) Ahmad (2003), Sarkar, Haque and Alam, (2003), Shmuck-Widman (1996), Valdiya ed. (2004), Zaman, (1999) Guarnizo (1992) Ninno, Dorosh, Smith and Roy, (2001), Chambers (1989), Elahi (1991) Haque and Zaman (1989), Hossain, Dodge and Abed (1992), Hossain, M. et al. (1987) and Murshid (1992). These research works were based on survey data though using different theoretical aspects. In these studies, their investigations were mainly concentrated on the impacts of water logging and related coping strategy.

The present study is designed to investigate the vulnerability and livelihood security status of the affected people due to water logging. For this purpose, it tries to sort out answers of the four basic research questions and mainly follows the methodology of the studies of Huq (2012) and Akter and Rahman (2012). Firstly, the study applies simple statistical analysis including mean, standard deviation, frequency etc. for describing the impacts of water logging problem on the rural households in the study area. Secondly, it follows the methodology of the study of Huq (2012) for calculating vulnerability score which will give the answer of the second research question of describing the vulnerability situation. Thirdly, this study follows the methodology of

the study of Akter and Rahman (2012) for finding the answers of the questions related with livelihood security status. The detailed methodology adopted here with this study is described below.

3.3 Weighting Variables and Indicators

There are several economic, social, structural, environmental and institutional factors related amid the vulnerability to water logging. For measuring vulnerability score, firstly the researcher selects some variables among these factors. Again, for measuring each variable, secondly the researcher selects different indicators. Thirdly, the present study uses Analytic Hierarchy Process (AHP) for assigning weights for each variable and their indicators. The Analytic Hierarchy Process (AHP) is a structured technique for dealing with complex decisions. Rather than prescribing a "correct" decision. The AHP originally has developed by Saaty (1980) and often it is referred as the Saaty method (Coyle, 2004 and Rahman, 2007). The AHP helps the decision makers to find the one that best suits their needs and understanding of the problem. The AHP has developed based on mathematics and psychology. It has three basic principles like decomposition, comparative judgment and synthesis of priorities (Malczewski, 1999 cited in Rahman, 2007). This process provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

In this study, pair-wise comparison method from the AHP approach is adopted following the study of Saaty (1980). The variables and indicators are compared to each other depending on their relative importance. A pair wise comparison has used based on Satty's Pairwise Rating Scale as a measure for this relative importance (Table 3.1) and the assigned value for each variable and indicators have distributed with a value of 1 to 9 according to their relative importance. In comparing a pair of variables or indicators according to their importance, 1 indicates equal importance.

Table 3.1: Saaty's Pairwise Rating Scale

Intensity of Importance	Definition
1	Equal Importance
3	More Important
5	Much More Important
7	Very Much More Important
9	Absolutely More Important
2,4,6,8	Intermediate Values

Similarly 3, 5, 7 and 9 refer to important most, important much more, important very much more and important absolutely more respectively. Satty, counts 2, 4, 6 and 8 as intermediate values (Coyle, 2004). The following sections describe the way of assigning weights for variables and indicators.

3.3.1 Assigning Weights for Variables

The structural vulnerability has been measured by using four variables. The variables are housing type (HT), shelter (S), road network (RN) and transport system (TS). For assigning weights of each variable, the study uses the AHP. The results justify which variable is more important in the context of vulnerability. First, it needs to provide an initial matrix for pairwise comparisons among the variables in which the principal diagonal contains entries of 1, as each variable is as important as itself.

	RN	HT	TS	S
RN	1			
HT		1		
TS			1	
S				1

There is no standard way to make the pairwise comparison but let us suppose that the study decides that housing type (HT) is more important than road network (RN) in context of water logging vulnerability. In the next matrix, that is rated as 3 in the cell HTRN and 1/3 in RNHT. The study also decides that road network (RN) is much more important than transport system (TS) considering water logging vulnerability so, 5 has been given in RNTS and 1/5 in TSRN as following matrix.

	RN	HT	TS	S
RN	1	1/3	5	
HT	3	1		
TS	1/5		1	
S				1

The present study, similarly judges that housing type (HT) is much more important than transport system (TS) in terms of people's water logging vulnerability, 5 has been given in HTTS and 1/5 in TSHT in next matrix. The same judgment is made as to the relative importance of shelter (S) in respect of transport system (TS). This forms the complete matrix, which is the Overall Preference Matrix (OPM).

	RN	HT	TS	S
RN	1	1/3	5	1
HT	3	1	5	1
TS	1/5	1/5	1	1/5
S	1	1	5	1

After calculating with standard methods (See Appendix), the eigenvector weights of the variables are as follows.

	RN	HT	TS	S	Eigenvector Weights
RN	1	1/3	5	1	0.232
HT	3	1	5	1	0.402
TS	1/5	1/5	1	1/5	0.061
S	1	1	5	1	0.305
Total					1.00
CR=0.073					

Here the Consistency Ratio (CR) is 0.073 that is below critical limit of 0.1, so the eigenvector weights can be used as the weights of each variable. In the same way, all variable's and indicator's weights have given with this process.

3.3.2 Assigning Weights for Indicators

Firstly, housing quality is used for measuring vulnerability by three indicators like,pucca (P), semi-pucca (S) and kutcha (K). For assigning weight of each indicator, the same method of assigning weight of each variable has been applied. First, it needs to provide an initial matrix for pairwise comparisons among the indicators in which the principal diagonal contains entries of 1, as each indicator is as important as itself.

	K	S	P
K	1		
S		1	
P			1

The study decides that kutcha (K) house is much more important than semi-pucca (S) house in terms of flood vulnerability. It is assumed that according to matrix. In the next matrix, that is rated as 5 in the cell KS and 1/5 in SK. The study also decides that kutcha (K) house is absolutely more important than pucca (P) house considering water logging vulnerability so 9 has been given in KP and 1/9 in PK also the study chooses that the semi-pucca (S) house is more important than pucca (P) house in concern of water logging. Therefore, 3 has been given in SP cell and 1/3 in PS cell as following matrix. This forms the complete matrix, which is the Overall Preference Matrix (OPM).

	K	S	P
K	1	5	9
S	1/5	1	3
P	1/9	1/3	1

After calculating with standard methods (See Appendix), the eigenvector weights of the variables are as follows.

	K	S	P	Eigenvector Weights
K	1	5	9	0.751
S	1/5	1	3	0.178
P	1/9	1/3	1	0.071
Total				1.00
CR=0.072				

Here, the Consistency Ratio (CR) is 0.072 that is below critical limit of 0.1, so the eigenvector weights can be used as the weights of each variable. In the same way, all variable's and indicator's weight have given with this process.

3.4 Calculating Vulnerability Score

The present study uses Leon's (2006) matrix and equation for calculating vulnerability score. The following matrix is given in table 3.2, simulated with the empirical data of household number 001.

Table 3.2: Matrix for Calculating Structural Vulnerability of a Household

Variables	Weights	Indicators and Weights		
Housing	0.402	Pucca	Semi-Pucca	Kutcha
		0.071	0.178	0.751
Shelter	0.305	Yes	No	
		0.125	0.875	
Road Network	0.232	Good	Bad	Very Bad
		0.077	0.231	0.692
Transport System	0.061	Good	Bad	Very Bad
		0.077	0.231	0.692

The household no. 001 reply as, the household's house is ***Kutcha.*** In the time of pervious water logging, the household went to shelter place means ***Yes.*** Then according to household no. 001, the road network is ***Very bad*** and transport system is also ***Very bad***

$V_{score} = 0.4020 \times .751 + 0.3050 \times .125 + 0.2320 \times .692 + 0.061 \times 0.692$

$V_{score} = 0.542$

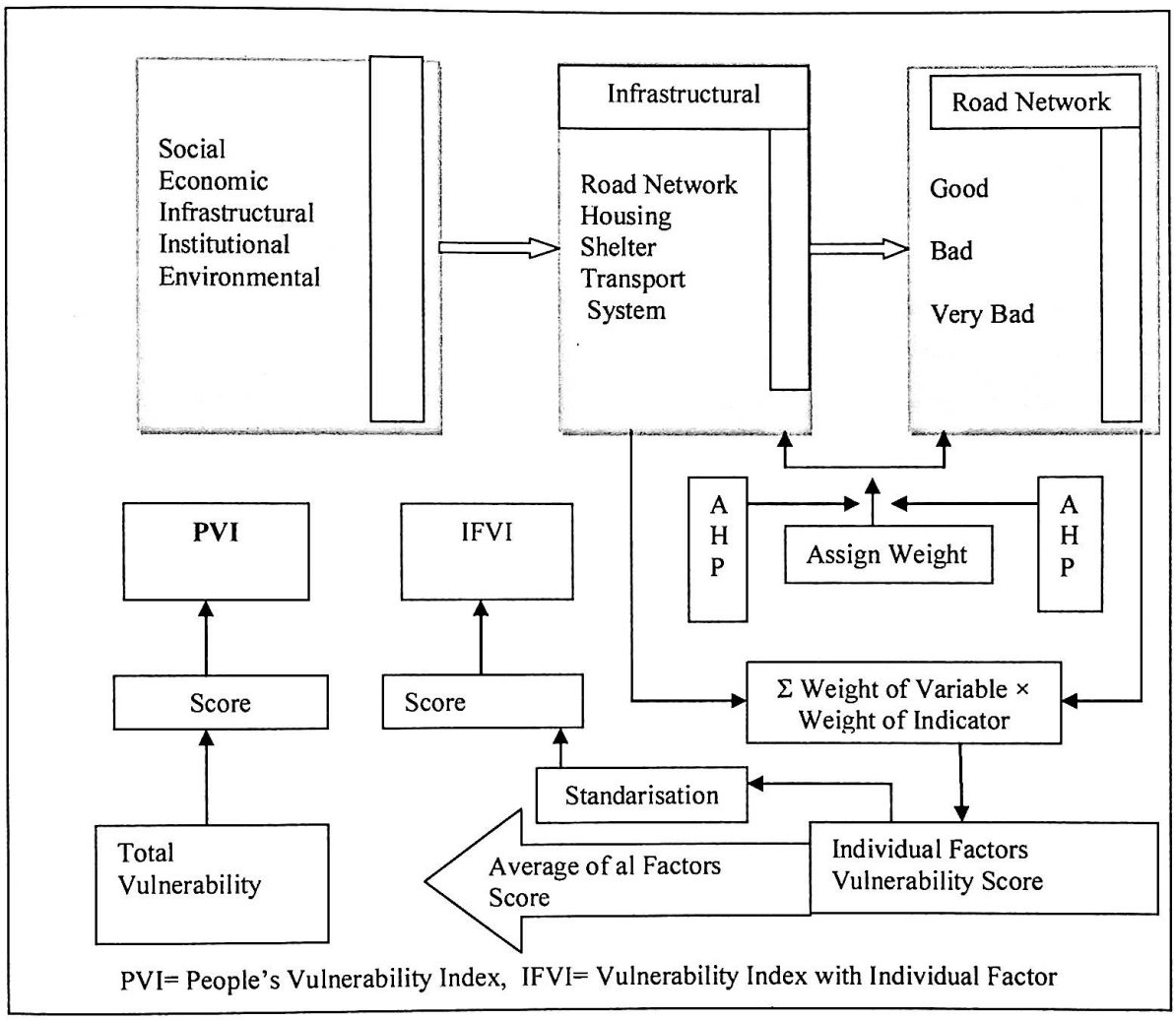
The equation is:

Vulnerability Score = $\sum$ Variable Weight ×Indicator Weight ----------

---

By using this equation the vulnerability score of each household has calculated. Finally, this study gives a conceptual model for the people's vulnerability indexing. The conceptual model is as follows:

Figure 3.1: Conceptual Model for Water Logging Vulnerability Indexing



Source: Huq, (2012)

Thus, the resulting summation unit was uniform but the scale range was different i.e. maximum and minimum score of each household represents different values. Therefore, it should be in a standard scaling system. In this study, the standard scale range from 0-100 has selected. In this uniform scale, 100 values represent most

vulnerable to flood. On the other hand, 0 values represent no vulnerability. According to this uniform scale, all scores of household level were standardized using maximum value as scaling point. The following equation has used for standardizing:

$$S_{VC} = \frac{IH_{VC}}{H_{VC}} \times 100$$

Where,

S_{VC} = Standardized Vulnerability Score

IH_{VC} = Individual Household Vulnerability Score

H_{VC} = Highest Vulnerability Score among Households

Source: Based on Rahman and Saha, 2007.

A practical example is given for standardizing of structural vulnerability of the household no. 001.

$S_{VC} = \frac{IH_{VC}}{H_{VC}} \times 100$ $S_{VC} = \frac{0.542}{0.772} \times 100$ $S_{VC} = 70.21$	Where, Individual Household Vulnerability Score $IH_{VC} = 0.542$ Highest Vulnerability Score of among Households $H_{VC} = 0.772$ Standardized Vulnerability Score Svc = ?

This is the final vulnerability score for the household no. 001 in terms of structural factor. Similarly, all-household's vulnerability score in terms of all factors (i.e. social, economic) has been calculated with the help of MS Excel programme.

Having calculated all factor's vulnerability index, the next step is to aggregate the factors to make the final vulnerability index calculation. For showing overall vulnerability of the study area, made up the average of all factors' vulnerability level of households of water logged areas. This approach has adopted from Sebald (2010). Finally, through this way the study finds the overall vulnerability index of the study

area. For showing the level of vulnerability, this study has also introduced a scale of vulnerability score as follows:

Table 3.3: Scale for vulnerability indexing

Range of Vulnerability	Degree of Vulnerability
0-25	Low Vulnerability
26-50	Moderate Vulnerability
51-75	High Vulnerability
76-100	Very High Vulnerability

Source: Adopted from Huq, (2012)

3.5 Livelihood Security Index

Livelihood security is an adequate and sustainable access to income and resources to meet basic needs. There is a range of on-farm and off-farm activities which would together act as sources of households' livelihood security (Frankenberger and McCaston, 1998). Household's livelihood security mostly depends on the endowments of sources and its position in the legal, political and social fabric of society (Drinkwater and McEwan, 1992). The level of vulnerability of a household's access to basic needs is increased by the risk of livelihood failure. Therefore, livelihoods are secure when households have secure ownership of, or access to, resources and income earning activities, including reserves and assets, to offset risks, ease shocks and meet contingencies (Chambers, 1989).

Many organizations use livelihood security approach developed from Sen's (1981) theory on entitlement to determine livelihood security status of poor households. Entitlement refers access to the set of income and resource bundles (e.g. assets, commodities) over which households can secure their livelihoods. Although there is diversity in defining Household Livelihood Security (HLS), many of the definitions were being derived from the work of Chambers and Conway (1992). They defined livelihood as a means of living which comprises the capabilities, assets (stores,

resources, claims, and access) and activities. A livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation.

In this study, HLS is examined as adequate access to income generating sources and stores of assets to meet basic needs such as necessary and nutritious food, quality education, better health facilities, clean water and sanitation, shelter and active participation in local community and social activities. Lindenberg (2002) analyzed livelihood security under five broad dimensions: economic security, food security, health security, educational security and empowerment. In this study, a composite set of HLS indices at the household level is developed by utilizing a set of indicators representing each of these dimensions using an approach similar to Hahn et al. (2009). CARE developed a set of multiple indicators to assess each of the HLS dimensions based on a reflective workshop involving several other NGOs in Bangladesh (CARE, 2004). This study is intended to select a suite of indicators from these recommended set that could be derived from the survey data to construct our livelihood security indices. A composite HLS index developed by CARE utilized rapid community appraisal technique where a few selected households were interviewed by a survey team of 10-12 persons spending about eight hours in a community (Lindenberg, 2002). This qualitative measure is based on a few selected households and so does not represent broader communities. The results cannot be generalized as the sample is not a representative number. In addition, questions are being raised on the reliability of the information which often reflects the views of those involved in the exercises.

The HLS index uses a balanced weighted average approach with a large number of indicators, where each indicator contributes equally to the overall index. The indicators are grouped into different domains representing security areas such as economic, food (necessary and nutritious), health, education, empowerment, water and sanitation etc. Since each indicator is measured on a different scale, indicators are standardized following the approach adopted in measuring 'Life Expectancy' in Human Development Reports following Hahn et al. (2009). For example, a standardized indicator j is given by:

$$zind_j = \frac{indicator_j - \min_j}{\max_j - \min_j} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, minimum and maximum values of the indicators are from the same community within which the household belongs. Once each indicator representing a particular livelihood security domain is standardized, then the relevant household livelihood security index for the particular domain is constructed by averaging the standardized indicators:

$$HLS_i = \frac{\sum_{j=i}^{J} zind_j}{J} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, J is the number of indicators used to construct the index. Once each HLS index is constructed, then the composite overall Livelihood Security (LS) index for the household is constructed by using the formula in equation (3):

$$LS_i = \frac{\sum_{i=1}^{n} w_i HLS_i}{\sum_{i=1}^{n} w_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, w are the weights determined by the number of indicators used to construct each HLS index. Weights vary between households because of household level variation in the number of indicators.

3.6 Econometric Model of the Factors that Determines the Livelihood Security

In order to suggest priority areas of intervention in strengthening livelihood security status, the present study is tried to examine the factors associated with the domains of livelihood security. The debates on the security level or cut off point regarding secure and insecure are ignored. The investigation on this debate may not add value in this study because this is a study of analyzing livelihood situation in poor settlements affected by a severe problem of water logging. The study is concentrated on measuring continuous variables of LS domains so that we measure the variability and underlying causes.

Therefore, five livelihood security indices including economic security, food security, health security, educational security and empowerment are calculated. In order to find out the determinants of these constructed HLS indices (eq. 2), the following specified system of equations are applied. The *i*th equation from the system of equations can be expressed as:

$$InHLS_i = \alpha_i + \gamma_i \sum_{i=1}^{5} InHLS_i + \sum_{k=1}^{n} \beta_{ik} InX_{ik} + \varepsilon_i$$

Where, Household Livelihood Security (HLS) indices are considered as the dependent/endogenous variables and X's are the exogenous/instrumental variables representing household's socio-economic circumstances as well as community level attributes that have influences on the livelihood security status. The estimation technique should explicitly take account for possible endogeneity of HLS indices. For the reason, 3SLS be the first candidate because estimates are more efficient asymptotically, but if the system is properly identified, for just identified equations 2SLS and 3SLS are equivalent, or if there is no cross equation co-variation (Theil, 1971). The choice could be based on the standard model specification tests (e.g., Hausman's Test). As it is prerequisite for 3SLS estimation, the possibilities of the presence of non-normality and heteroscedasticity are being tested. The possible endogeniety of HLS indices are also being tested. Based on the test results, the researcher presents the results based on both 3SLS and 2SLS methods.

3.7 Source of Data

This study is carried out with the help of analyzing both primary and secondary data. The primary data is collected from the Jessore district, a severely water logged area of Bangladesh. The selected respondents of the study area are interviewed by face to face conversation using a well-designed question schedule that is prepared with great care on the basis of research questions. A pilot surveys is also conducted to collect general information on households affected by water logging problem and to test the accuracy of the question schedule as well. The question schedule is modified according to the suggestions of expert and pre-tested, and finalized after necessary corrections. The question schedule includes both close and open ended questions.

Although the primary data are used in the study, the secondary data are also used from various sources. These sources are BBS (Bangladesh Bureau of Statistics), BER (Bangladesh Economic Review), FAO (Food and Agriculture Organization), MoA (Ministry of Agriculture), WB (World Bank), Bangladesh Meteorological Department (BMD), Agriculture Census, Population and Housing Census, Upazila Agriculture Extension Office, Upazila Statistics Office, Union Parishad Office and so on. Data are also collected from books, journals and reports related to the study.

3.8 Selection of the Study Area

In the present study, the researcher mainly uses primary data for calculation of proposed mathematical and statistical models. For the purpose of collecting primary data, the study areas are selected carefully so that results of the study area represent the real picture of crisis leaked by the problem of water logging. For selecting the sample area, all difficulties and complexities are taken into account. The data are collected from the respondents of three purposively selected upazilas (sub-districts) under Jessore district. The following section presents a brief description highlighting the reasons behind this purposive selection of the study area including location, area and population. This also includes a summary of the socioeconomic and vulnerability situation of the affected people in the study area by water logging problem.

3.9 Study Area Description

The southwest coast of Bangladesh is a distinctive saline water ecosystem containing the districts of Bagerhat Khulna, Satkhira, and the south-western part of Jessore. This is the part of lethargic delta of large Himalayan Rivers and located just beyond the Bay of Bengal and mangrove forest Sunderban. The larger part of the region is coast wetland created by the rivers flowing to the sea. Since the Southwestern region is situated in the coastal zone and it have a breakable ecosystem to its exposed to a number of calamities such as floods cyclones, land erosion, tidal surges, and repeated water logging, humiliation etc. that formed the lives and livelihood patterns of people. Throughout the decade of the 1960's, the Coastal Embankment Project was

implemented of the region encircling the majority of the tidal wetlands in high embankments. In a few years, the pessimistic impacts of the project began to seem. The biodiversity of the region became river flows and degraded were affected and many rivers silted up, affecting navigation. Before 1990, above a hundred thousand hectares of land in Jessore, Khulna and Satkhira districts became waterlogged that agriculture became hardly possible.

The following subsection provides a short description of the study area including location, area, population, socioeconomic and vulnerability characteristics of three upazials of Jessore district.

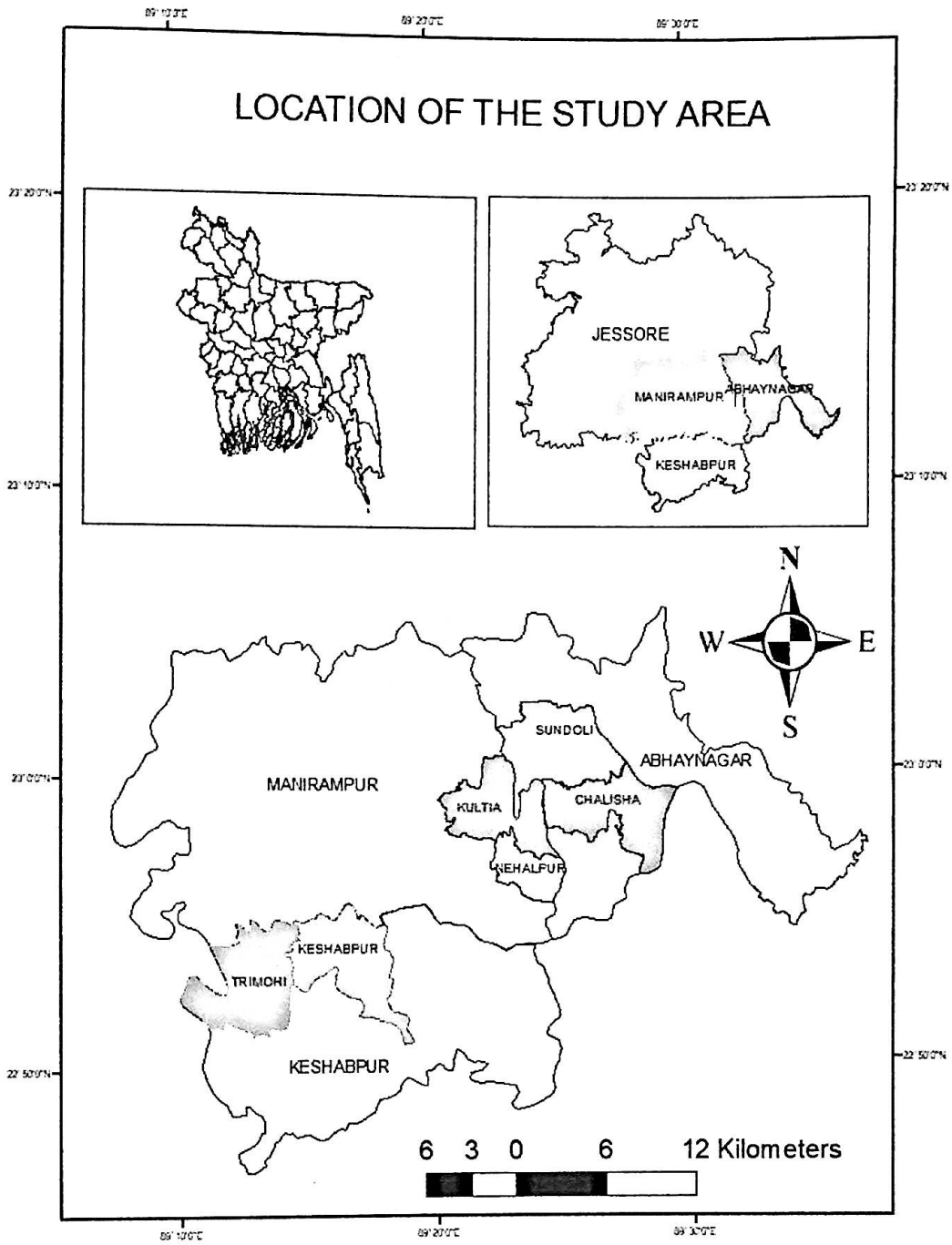


Figure: Location of the Study Area

Description of the Selected Upazilas (Sub-districts)

The selected upazilas are Abhaynagar, Manirampur and Keshabpur. People in Keshabpur, Manirampur and Abhaynagar sub-districts of Jessore are still facing severe water logging as a outcome of immoderate rainfall and drainage systems are very poor. Many educational institutions remain closed. Access to secure drinking

water, latrines, and road transportation systems has been disrupted. Thousands of people have been displaced and are residing in makeshift shelters (BRAC, 2016). These upazilas are selected purposively because the selected upazilas are the most horrible victims of this extended water logging problem (Rahman et al., 2010) and the study target is thus satisfied by analyzing the vulnerability situation of the affected people by water logging problem. The following figure indicates the affected areas of Jessore district by water logging.

5.10 Sampling Design

The primary data is collected from the purposively selected district, Jessore. From the Jessore district, the corresponding three upazilas named Abhaynagar, Manirampur and Keshabpur are also selected purposively. Then, a multi-stage simple random sampling technique is used for selecting the required respondents. Firstly, six unions are selected randomly from the respective three upazilas. The unions are Sundoli and Chalishia from Abhaynagar upazila, Kultia and Nehalpur from Manirampur upazila and Keshabpur and Trimohini from Keshabpur upazila, respectively. Then, collect a list of the households inhabited in these unions from the respective union parishads. By using simple random sampling technique, the required data are collected from 377 respondents at the third stage from the selected unions. The following table present the summary of the sampling methods of the research.

Table 3.4: Sampling Design

Step	Sampling Methods	Sampling Population
1	Purposive	Jessore District
2	Purposive	Three Upazilas
3	Simple Random	Selected 6 Unions
4	Simple Random	Selected 377 Households

For determining sample size from finite population, the following well known formula (Kothari, 2004) has been used. The formula calculates that 377 respondents are required for appropriate empirical analysis using 5% significance level.

$$n = \frac{z^2 . p.q.N}{e^2(N-1) + z^2 . p.q}$$
$$= \frac{(1.96)^2 \times 0.5 \times 0.5 \times 20576}{(0.05)^2 \times 20575 + (1.96)^2 \times 0.5 \times 0.5}$$
$$= 377$$

The following table describes the determination of sample size for the present study. Table 3.5 shows that by multiplying the respective weights of unions with determined sample size 377 out of 20576 households, the number of sample respondents from each union is determined.

Table 3.5: Determination of Sample Size

Name of the District	Name of the Upazila	Selected Unions	Total household of the selected unions	Weight	Sample Size
Jessore	Abhaynagar	Sundoli	3200	(3200/20576)=0.16	(377x0.155)=59
		Chalishia	3301	(3301/20567)=0.16	(377x0.160)=60
	Manirampur	Kultia	3573	(3573/20576)=0.17	(377x0.174)=65
		Nehalpur	3531	(3531/20576)=0.17	(377x0.172)=65
	Keshabpur	Trimohini	3546	(3546/20576)=0.17	(290x0.172)=65
		Keshabpur	3425	(3425/20576)=0.16	(290x0.166)=63
Total	3	6	20576	1	377

3.11 Data Analysis Techniques

The present study applies different mathematical, statistical and econometric techniques for obtaining the study objectives. The collected surveys data are primarily entered into MS excel software. The data are coded, sorted and edited with great care for avoiding misconceptions. Firstly, the mathematical and statistical calculations are performed by using MS excel software. Secondly, the MS excel data has imported into the SPSS software. The econometric estimations of 2SLS model has been performed by using SPSS software. Finally, the analyzed data are presented into tabular and graphical forms.

CHAPTER FOUR

WATER-LOGGING IMPACT ON THE SOCIO-ECONOMIC STATUS OF THE HOUSEHOLDS IN THE STUDY AREA

4.1 Introduction

Water logging is a type of hazard which creates enormous difficulties in continuing livelihoods of the people inhabited in the South-West cost of Bangladesh. The current study is mainly conducted toward investigate the water logging problem faced by the people of Jessore district, a severely affected area by the particular problem. For this purpose, a field survey is performed to gather detail information about the problem from the respondents who are the permanent victims by this hazard. The collected data from the field survey are analyzed in this chapter through using different statistical tools such as percentage, frequency, standard deviation and mean. The analyzed data are presented in tabular and graphical forms presenting the water logging impact on the socioeconomic status of water logged people in the study area. This chapter deals with a view of finding out the water logging impact and problem on the socio-economic status of the respondents using statistical tools.

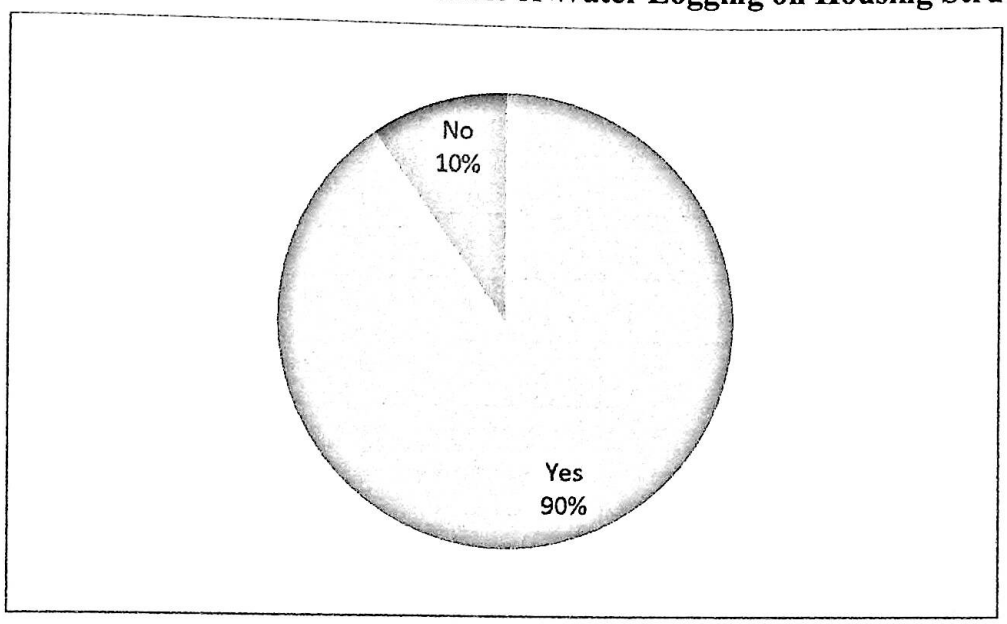
Water-logging problem is responsible to create disaster. There are some specific vulnerability factors to this disaster such as social, economic, structural, institutional, demographic and environmental. These indicators are observed in the study area. The major indicators, which make the people vulnerable and amplify the intensity of water-logging, are discussed below.

4.1 Impact on Housing

Water logging is a problem which collapses most of the mud made houses. Living of the general people in the water logged areas is impossible. Some people moved to safe places for living. Most of these displaced people live under open sky in inhuman

way. Most of the mud made houses were damaged completely and also damaged partially.

Figure 4.1: Response about Direct Effect of Water Logging on Housing Structure



Sources: Field Survey, 2019

From figure 4.1, it is showed that about 90% households were directly affected during water logging in terms of breakdown of their housing structure whereas only 10% households response that there is no direct effect on their housing structure during water logging problem. This indicates the displacement of human settlement in the study area.

Most of the houses are kacca before affecting the water logging problem but at the present houses are mostly semi pacca because of their learning lessons from the previous water logging. Now the communities people are tend to construct semi-pacca houses to cope with the water logging condition. The following table 4.1 shows the type of main house in the waterlogged affected area.

Table 4.1: Types of Main Houses (Pre and Post- Water Logged Conditions)

Types	Pre-Water Logging		Post Water Logging	
	Frequency	Percent	Frequency	Percent
Kacha	240	63.7	156	41.4
Pucca	47	12.5	34	9.0
Semi-pucca	90	23.8	187	49.6
Total	377	100	377	100

Sources: Field Survey, 2019

4.2 Electricity Facility

Due to governmental efforts, the availability of electricity facilities is increasing day by day. During pre-water logging period only 127 households were enjoying electricity facilities whereas 283 households are enjoying electricity facilities during post water logging problem. These figures are presented in Table 4.2.

Table 4.2: Availability of Electricity Facility (Pre and Post- Water Logged Conditions)

Response	Pre-Water Logging		Post Water Logging	
	Frequency	Percent	Frequency	Percent
Yes	127	33.7	283	75.1
No	250	66.3	94	24.9
Total	377	100	377	100

Sources: Field Survey, 2019

4.3 Sanitation and Water Facilities

Toilet facility is very important to clean environment and good health. Most of the toilets of the water logged households are damaged by dirty water or even washed away and flooded. Thus, the environment of the affected areas is polluted. The polluted sanitation made the environment unhygienic and spread out germs awfully. Gradually, water borne diseases spreads out. In present condition availability of toilet facilities are increasing. Table 4.3 shows most of the people are intending to use unhygienic toilets.

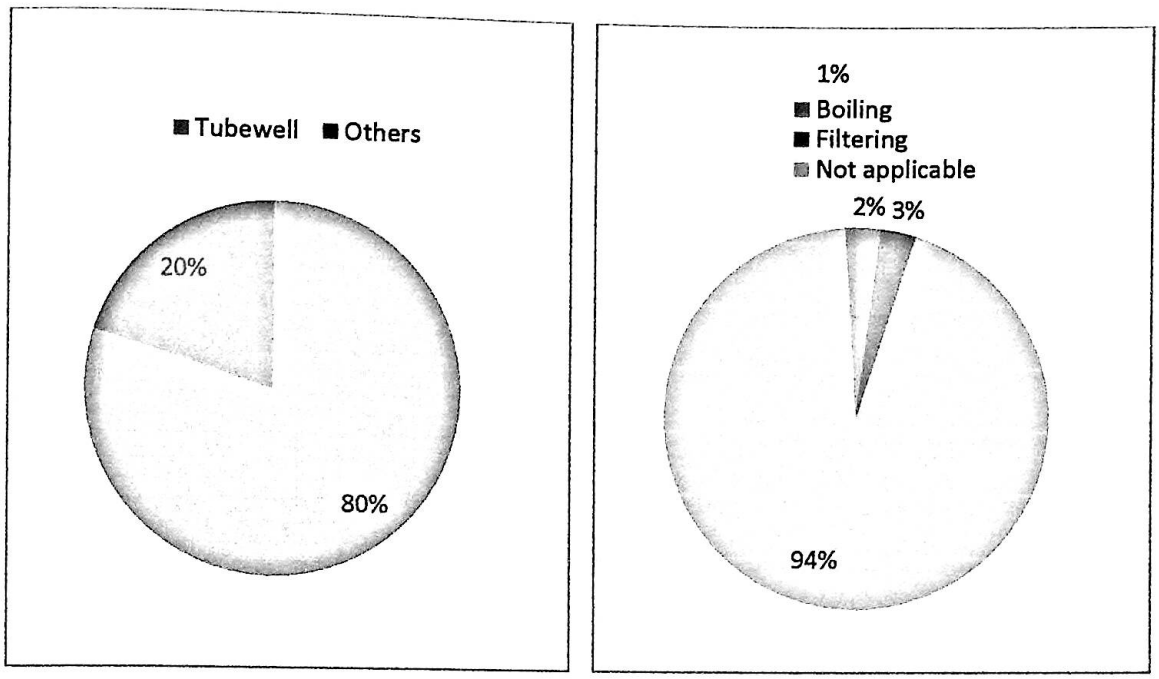
Table 4.3: Present Types of Sanitation Facility

Types	Frequency	Percent
Sanitary toilet (Healthy)	72	19.1
Kacha (Unhealthy)	275	72.9
No opportunity	30	8.0
Total	377	100

Sources: Field Survey, 2019

The core source of drinking water in the study area is shallow and deep tubewell. The majority of the people use tubewell water for the purpose of drinking, rest of them use different source of water whose have no access of tubewell. Respondents of the field survey said that some of them use pond water for household works and also use drinking purpose. As a result they suffer different kind of food poisoning and diarrhea diseases. The status of water facilities are shown in figure 4.2.

Figure 4.2: Water Facilities and Methods of Water Purification

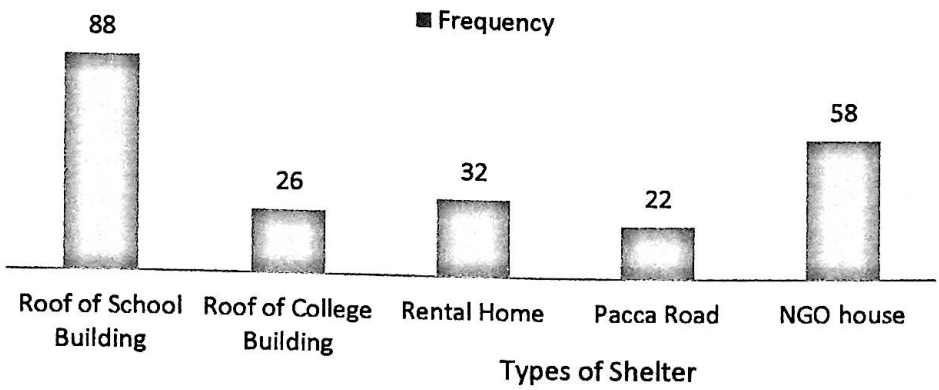


Sources: Field Survey, 2019

4.4 Living Place during Water Logging

Some people take shelter on mainly high embankment in polythene made hut, or small temporary sheds, educational institutions and some also left their living places and went nearby relative houses. It is found that most of the displaced people are living with their livestock in such type of small hut or temporary shed (Figure 4.3).

Figure 4.3: Shelter during Water Logging



Sources: Field Survey, 2019

According to the field survey it is found that about 70% of the houses were affected by water during water logging. As a result people took shelter to the road and many of them were going to their relatives houses in Khulna or nearby regions. After the period of severe situation most of the houses were built again because previous houses were damaged harshly. Survey result shows that 87% of the houses were fully water logged and people took shelter to other places where 13% of the houses are partially affected. That water logged condition remains about 6 months because of poor drainage condition. The coping strategies during Water Logging are represented in the following table 4.4.

Table 4.4: Coping Strategy during Water-logging

Living Place during Water-logging	Frequency	Percent
Own house (by hard work)	111	29.44
Relatives house	40	10.61
Others	226	59.95
Total	377	100

Sources: Field Survey, 2019

4.5 Reconstruction and Sources of Capital

Affected houses were reconstructed by their won cost and by the help of NGO and Government support. Reconstruction cost were provided by mainly UK based Solidarity Worldwide. About 45 % household were served by foreign organization, partially support from government sector, local authority, and 21% were done by own expense. Some of the people took loan from the bank for this purpose. Reconstruction of household, source of capital for reconstruction of houses, Legibility of constructed house and Satisfaction level for constructed houses are shown respectively in Table 4.5, Table 4.6, Table 4.7 and Table 4.8.

Table 4.5: Support regarding Reconstruction of Damaged House

Types of Support	Frequency	Percent
Full support from Government	0	0
Partial support from Government	65	17.24
Full support from NGOs	0	0
Partial support from NGOs	72	19.10
Own expense	197	52.25
Others	43	11.41
Total	377	100

Sources: Field Survey, 2019

Table 4.6: Sources of Capital for Reconstruction of Houses

Sources	Frequency	Percent
Savings	65	17.24
Bank loan	85	22.55
Loan from relatives	56	14.86
Selling of land	35	9.28
NGO loan	92	24.40
Others	23	6.10
Not applicable	21	5.57
Total	377	100

Sources: Field Survey, 2019

Table 4.7: Legibility of Constructed House

Type	Frequency	Percent
More durable	29	7.69
Moderate durable	170	45.09
Not durable	85	22.55
Vulnerable	93	24.67
Total	377	100

Sources: Field Survey, 2019

Table 4.8: Satisfaction Level for Constructed Houses

Level	Frequency	Percent
Fully satisfied	58	15.38
Partially	194	51.46
Not at all	125	33.16
Total	377	100

Sources: Field Survey, 2019

4.6 Household Income and Expenditure Pattern

Total numbers of employed persons are gradually increasing. For increasing their household income people are engaging themselves with the primary as well as secondary activities. Some people tend to migrate in local urban area for business purposes. Table 4.9 depicts the figures of the earning person per household.

Table 4.9: Earning Person per Household

	Pre-Water-Logging	Post Water Logging
Total number of earning member	483	461
Total Households	377	377
Average earning persons	1.28	1.22

Sources: Field Survey, 2019

Table 4.10: Main Household Income Sources

Sources	Pre-condition	Percent	Post condition	Percent
Agriculture	56	14.85	49	13.00
Day laborer	137	36.34	114	30.24
Service holder	62	16.45	69	18.30
Businessman	33	8.75	67	17.77
Poultry	12	3.18.	19	5.04
Livestock farming	47	12.47	26	6.90
Remittance	24	6.37	29	7.69
Others	6	1.59	4	1.06
Total	377	100	377	100

Sources: Field Survey, 2019

The main usual sources of income reported by the male respondents are Day Labour, agriculture and Business respectively (Table 4.10). It finds that the main earning source of the water logged people in the study area is agricultural activities. They produce important quantities of Boro rice, T., cash crops winter and vegetables including oilseeds, betel leaf, sugarcane and jute. The existing water-logging damages the transplanted monsoon-rice crops (and) results in a failure to plant properly (boro) rice crop. All of these have been remarkably affected by the water-logging with resumption of normal activities. Communities presented that the majority people currently are with no a few livelihoods at the entire. There is extremely slight working accessible in fisheries and agriculture for the reason that these areas are significantly affected by the water-logging. Therefore, the water logged households seek secondary job sources to maintain the livelihoods which are shown in figure 4.4.

Figure 4.4 : Secondary Household Income Sources

Sources: Field Survey, 2019

As the income source and belongings were washed away, the earning members of the families becomes jobless. The marginal farmers, poor, lower income households and others who are mainly dependent on wage/daily labor is the worst victim of water logging.

Table 4.11 presented that the average monthly household income in the study area was 11712 taka before affected by water logging problem which is reduced to 6704 taka after water logging. It is also found that most of the households are included into the monthly income group of 5000-10000 taka and 10001-15000 taka respectively

Table 4.11: Household (Monthly and Average) Income

Income Level	Pre-Water Logging	Percent	Post Water Logging	Percent
Below 5000	22	5.84	85	22.54
5000-10000	165	43.77	175	46.42
10001-15000	113	29.97	61	16.18
15001-20000	52	13.79	45	11.94
20001-25000	17	4.50	0	0
25001-30000	4	1.06	6	1.59
30001-35000	0	0	2	0.53
35001-40000	1	0.27	0	0
40001-45000	0	0	0	0
45001-50000	2	0.53	3	0.80
Above 50000	1	0.27	0	0
Total	377	100	377	100
Total Income	4415224		2527105	
Average Income	11711.47		6703.20	

Sources: Field Survey, 2019

Field survey finds that the displacement rate is very high in the study area. The displaced people cannot earn regularly as they lost their usual livelihood strategies. They mainly depend on income taken from assets sale. As these areas are affected by the water logging problem, the usual livelihood strategies in shrimp cultivation, agriculture and fisheries are hardly existed. Therefore, the affected households do not meet up their basic needs which increase their vulnerability scores. The expenditure pattern of the households is explained in table 4.12.

Table 4.12: Household (Monthly and Average) Expenditure

Level	Pre-Water Logging	Percent	Post Water Logging	Percent
Below 5000	43	11.41	105	27.85
5000-10000	261	69.23	210	55.70
10001-15000	54	14.32	26	6.89
15001-20000	11	2.92	28	7.43
20001-25000	7	1.85	6	1.59
25001-30000	1	0.27	1	0.27
30001-35000	0	0	1	0.27
35001-40000	0	0	0	0
40001-45000	0	0	0	0
45001-50000	0	0	0	0
Above 50000	0	0	0	0
Total	377	100	377	100
Total Expenditure	3035730		2256170	
Average Expenditure	8052.33		5984.54	

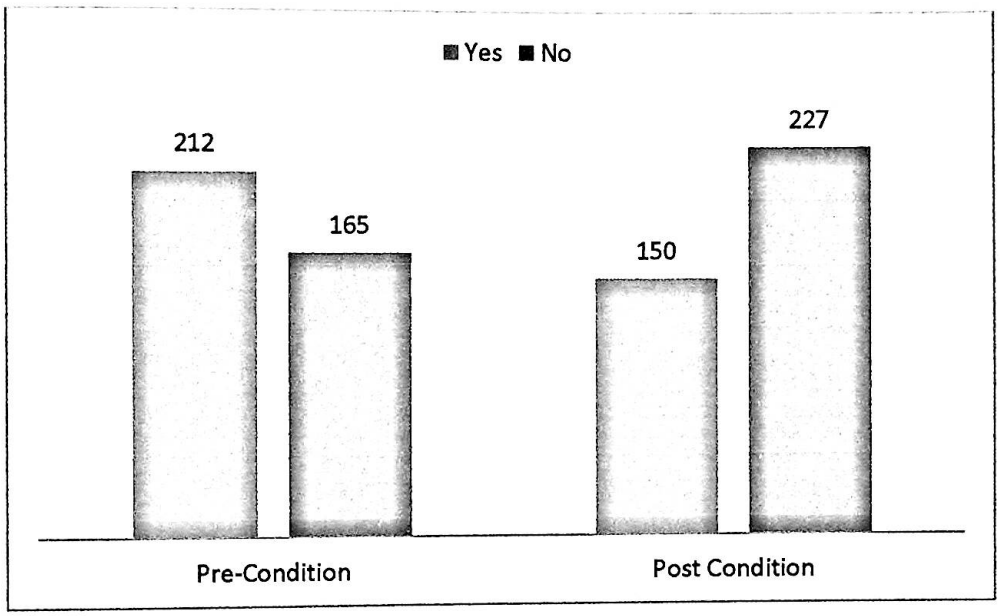
Sources: Field Survey, 2019

The above Table 4.12 presents the expenditure pattern of the households in pre and post condition of water logging. Table 4.12 shows that after water logging more than 100 people expense below 5000 taka monthly. On the other hand, very lower number of peoples' monthly expanse was 10000 to 20000. During water logging problem, the majority of the crop lands are submerged by the excessive water. Thus, the farmers lost their income sources from agricultural firms. They mainly relied on business and fishing activities.

4.7 Saving and Loan

Saving and loan opportunity play vital role for tackling any climatic hazards. Figure 4.5 shows that about 165 people do not save money during pre water logging condition in the study area. But in the post water logging condition, 227 people do not save any from their income. This indicates that people have less opportunity to save money as their expenditure rises due to water logging. Moreover, during water logging situation, households spent more money from their savings.

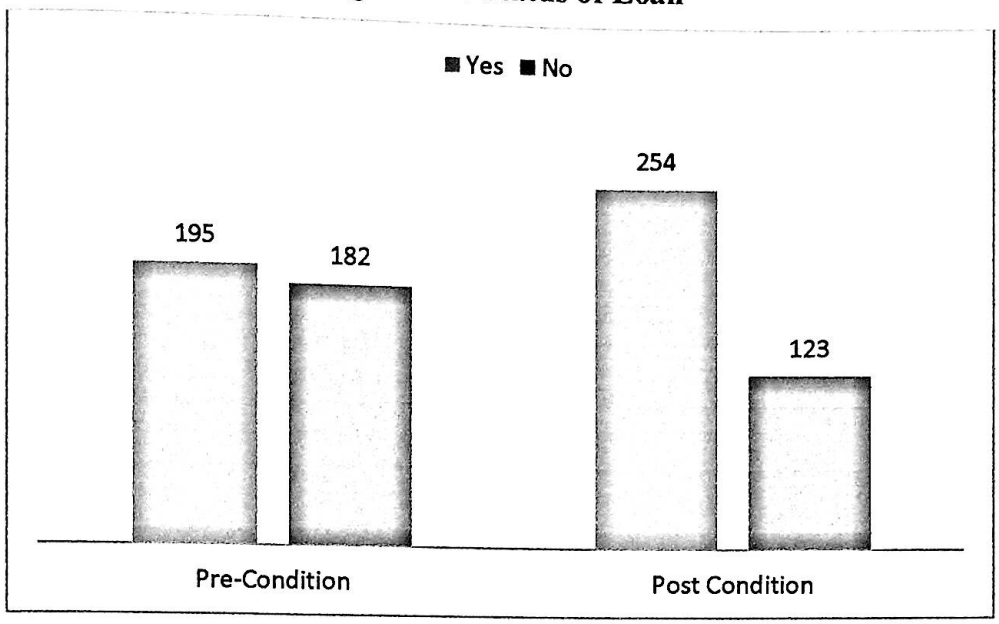
Figure 4.5: Status of Money Saving



Sources: Field Survey, 2019

Households affected by water logging problem are interested to take loan as their expenditure rises during water logging. Thus, the rate of loan taking is increasing from the pre water logging condition. The status of loan taken by water logged households is represented in this figure 4.6.

Figure 4.6: Status of Loan



Sources: Field Survey, 2019

Figure 4.6 presents the loan status of the affected people in the study area by water logging. It finds that people are interested to take loan after water logging for running their daily expenses.

4.8 Occupational Vulnerability

Field survey finds that most vulnerable occupations are share croppers, agricultural day laborers, small and landless farmers. On the other hand, people who belong to elite class and rich are less affected. The most important finding is that income of fishing community, transport worker and businessmen are increased.

Table 4.13: Vulnerable Occupations due to Water Logging

Types of Occupation	Highly Vulnerable	Moderately Vulnerable	Low Vulnerable	Risk Free
	% of total	% of total	% of total	% of total
Landlord	25	46	20	9
Sharecropper	92	6	2	0
Medium Farmer	57	22	15	6
Small farmer	78	13	9	0
Landless farmer	83	5	12	0
Day laborer	87	12	1	0
Job holder	2	10	19	69
Businessman	62	17	12	9
Poultry	12	19	33	36
Livestock farming	47	35	15	3
Fish farming	20	22	37	17
Others	6	66	14	14

Sources: Field Survey, 2019

4.9 Sectors of Vulnerability

In the study area most vulnerable sectors are agriculture, shelter, water supply, sanitation, public health, livestock and road networks. The less vulnerable sectors are fisheries and industries. The figures are depicted in table 4.14.

Table 4.14: Vulnerable Sectors due to Water Logging

Sectors	Highly Vulnerable	Moderately Vulnerable	Low Vulnerable	Risk Free
	%	%	%	%
Shelter	73	13	14	0
Agriculture	91	9	0	0
Fisheries	16	21	33	30
Livestock	55	27	18	0
Forest	57	14	25	4
Industry	12	4	9	75
Public Health	72	11	17	0
Transportation	42	33	25	0
Water supply	65	22	13	0
Education	26	45	29	0
Others	46	27	17	10

Sources: Field Survey, 2019

The socio-economic structure of the households affected by water logging is very responsive and damaged to the effects on different sectors. The households face many demerits which are described in the following table 4.15.

Table 4.15: Effects of Water Logging on Different Sectors

Sector	Demerits	Benefits	No Comments	Remarks
	Percent	Percent	Percent	
Agricultural Production	95	0	5	Household income is significantly decreased due the lack of employment opportunities
Fishing	25	65	10	Agricultural lands are transformed into shrimp production, increase in fish production in water logged areas
Education	100	0	0	Use of School or College as temporary shelter, Damage of communication network
Health	98	0	2	Water borne diseases, skin disease spread
Livelihood Strategy	85	0	15	Shorter working opportunities
Migration	45	0	55	People are bound to migrate during water logging
Household Job	57	15	28	Agricultural job sources are damaged, involved in shrimp production
House Condition	90	5	5	Houses are badly damaged
Business	95	0	5	Lack of Business activities due to bad transportation
Sanitation	87	13	0	Sanitation system are washed out, submerged
Water	100	0	0	Low quality
Socio-economic Structure	98	0	2	Damaged

Sources: Field Survey, 2019

4.10 Social Status

Social status of the households decreases substantially due to water logging problem. It depends on the availability of transportation, health and education facilities, identification card and on the existence of disable person. The transportation system of the entre area is severely submerged and damaged or washed away by the pressure water. The linking roads are also completely damaged. As a result people cannot visit to the health centre for health care vaccination and family planning issues. They cannot go to school due to inundated educational institutions and also cannot go to field for playing. They are facing various problems like Diarrhea, cholera, scabies etc. Now a day's, most of the household use mobile phone as a modern communication system for exchanging the news between each others. Most of the people have their national ID card. Table 4.16 presents the households social status in the study area.

Table 4.16: Participation in Social Organization, Vaccination, Family Planning, Communication Network (Mobile), NID, Education and the Existence of Disability

	Vaccination	Family Planning	NID	Communication Network(Mobile)	Disability	Education
Yes (%)	14	27	95	90	6	47
No (%)	86	73	5	10	94	53
Total	100	100	100	100	100	100

Sources: Field Survey, 2019

4.11 Chapter Summary

Climate change has been intensifying the water-logging circumstance due to the decreased dry time of year flow which increases heavy rainfall and the sedimentation at monsoon augmenting the problem of water-logging in the Jessore district beginning the previous two decades. Sea level rise (SLR) enlargement the backwater consequence which decelerating down the salinity intrusion and peak discharge intensify the siltation of riverbed to aggravates the problem of water-logging at the Kopotaksho basin area. There were a number of waterborne disease affected people in the water-logged area owing to scarcity of secure drinking water supply and sanitation. Most were affected by dysentery, diarrhea, cold, cholera, fever, scabies, skin diseases, pneumonia and malnutrition which ultimately deteriorate the health condition of the people of water-logged area. Affected people are suffering with lack of food and pure drinking water as water-logging is hampering agriculture and other income generating activities.

Due to loss of agricultural production by water logging, the livelihoods and food security are severely affected as a whole. The overall education rates of the area are decreasing alarmingly due to lack of communication during water logged situation. Educational institutes are used as a temporary shelter. Emergency health services are worst affected due to the absence of medicine and communication network. Many community people have the traditional tendency not to leave their own houses and prefer to stay home. Overlapping of resource from the different agencies also aggravate the existing situation. Lack of inter agencies coordination also play a significant role to recover from the adversaries of water logging. Because of seasonal migration is increasing due to water logging.

CHAPTER FIVE

VULNERABILITY STATUS OF THE PEOPLE AFFECTED BY WATER LOGGING IN THE STUDY AREA

5.1 Introduction

In present chapter, empirical results based on the calculation of vulnerability indices (social, economic, structural, environmental and institutional) are presented. This study has tried to identify the factors related to people's vulnerability during water logging in Jessore district. From five factors, (social, economic, structural, environmental) 23 variables are derived to measure the people's vulnerability through household survey in the study area. For getting a numeric vulnerability score of each household, with the help of the AHP, the weights of individual variables and indicators were determined finally, concludes with the overall vulnerability index of the water logged people in the study area.

5.2 Vulnerability Situation of the Affected Households by Water Logging

The study is carried out to measure people's vulnerability situation due to water logging. The study is undertaken in the water logged areas of the Jessore District. Data has been collected from total 377 households out of 20576 through questionnaire survey. For the grounds of survey, the study area was selected purposively and the surveyed households were selected by simple random sampling. The research has been conducted based on the selected factors, variables and indicators which are identified in the literature review chapter earlier. This section deals with measuring the vulnerability level of the surveyed households. It also encompasses various vulnerability indexes (i.e. economic, social, institutional, structural and environmental) of the people toward the water logging hazard of the study area.

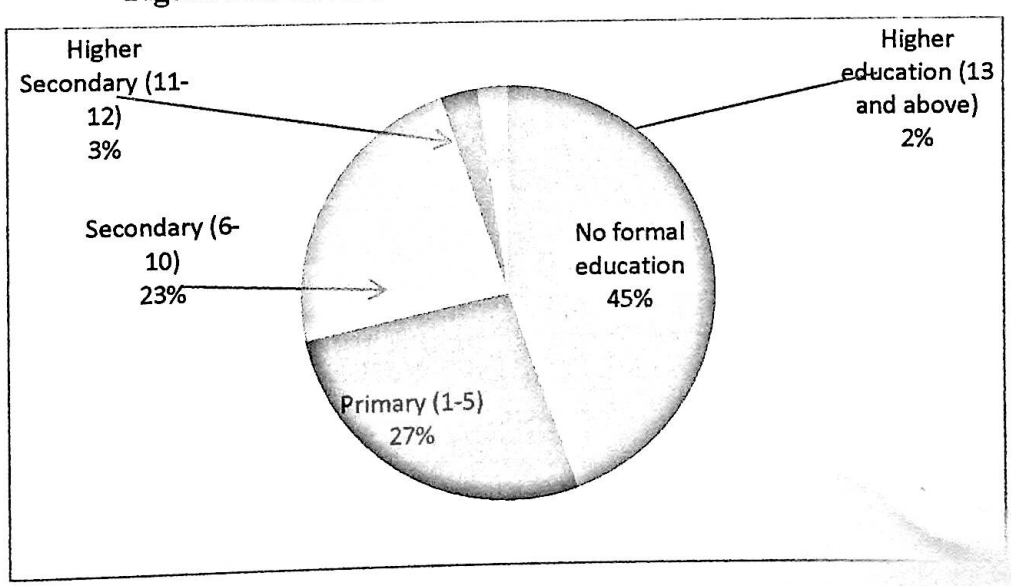
5.2.1 Measuring Social Vulnerability

In calculating the overall vulnerability of the people affected by water logging, the important and first step is to measure the social vulnerability to the hazards (Cutter et al., 2003). The calculation of the social vulnerability identifies the sets of people who are susceptible and more sensitive to the effects of the natural disasters. In measuring social vulnerability, the identified social factor and its variables are Education, Occupation, Types of household head, Gender influence, Age structure, and Family size, Existence of disable person, Preparation, and Social network. Firstly, Analytic Hierarchy Process (AHP) is applied to give weights to all variables (e.g. education, age, family size, social network) and indicators (i.e. for the variable of education; illiterate, bachelor etc.). Then, the Leon's (2006) matrix is applied to measure the vulnerability score of individual using the calculated weights. The empirical results related to social vulnerability analysis are presented in the following sections.

5.2.1.1 Education

Water logging problem turns into disasters not only due to overflowing the land, but also due to weak role of some variables. Poor level of education is one of them, which is partly responsible for vulnerability of the water logged people. It is expected that the households with education level of higher are less vulnerable to water logging.

Figure 5.1: Level of Education of the Household Heads



Source: Field Survey, 2019

Figure 5.1 represents that majority 45% household heads have no formal education. Besides, 27% and 23% household heads have studied primary and secondary education level. It is also observed that only 2% heads household have higher level of education. Finally, by analyzing the figure 5.1, it reveals that the highest number of household heads has no basic education and lower portions have higher education.

5.2.1.2 Occupation

Occupational distribution has significant effects on the vulnerability status of the water logged people. It is directly related to their enormous hazard. For example, some workers become jobless during the water logging period (Shoeb, 2002). Among the poorest daily laborers, rickshaw-pullers, and construction workers are most vulnerable groups (Cameron, 2009). Agricultural farming (farmer) activities are the main occupation of the surveyed respondents. But respondents in the study area are involved with different occupations as their secondary occupations. Most of the people are normally engaged with informal activities such as day labourer, rickshaw pulling, small job services and petty business. The giving out of the respondents by their main occupation is described in Table 5.1.

Table 5.1: Respondents by Main Occupation

Main Occupation	Frequency	Percent
Farmer	153	42.7
Wage laborer	35	22.6
Rickshaws/Van puller	28	7.4
Fishing	27	7.2
Professional (govt.)	8	1.9
Maid servant & other salaried worker	17	4.5
Handicraft	21	5.6
Petty traders	11	3.0
Medium/Large traders	6	1.6
Private/NGO worker	13	3.4
Total	377	100.0

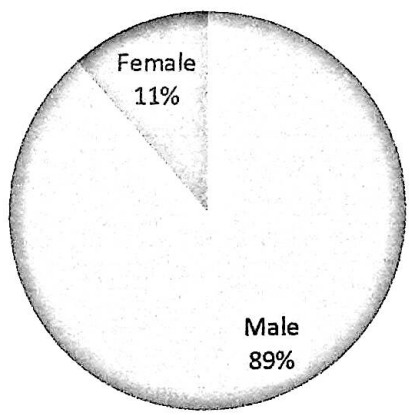
Source: Field Survey, 2019

Table 5.1 represents to the agricultural farming is the main occupation as 43% respondents are working as farmer. Again, a significant number of respondents have other activities such as wage laborer, rickshaw/van puller, fishing and handicraft. Beside this, some are working as government and non-government worker and petty to medium/large scale traders. This concludes that a diversified occupational status has been observed by the field survey.

5.2.1.3 Gender of the Household Head

Household head plays great responsibilities and influences his/her family. Normally rest of the family members depends on him/her in many ways. In terms of household head, the respondent families are characterized by male headed indicating the typical societies in Bangladesh. Figure 5.2 presents that, in surveyed area more than 80 percent household heads are male dominated while only 11% percent household heads are females.

Figure 5.2: Gender of the Household Head



Source: Field Survey, 2019

5.2.1.4 Age Structure

The elderly and children are generally considered as a vulnerable group to any type of hazards (Cutter, 2003). In addition, some studies directly use elders as an indicator for assessing vulnerability because they are living alone (Chang, 2007; Steinführer et al.,

2007 and Li et al., 2008). However, into the following Table 5.2, age classes (six classes with an interval of 10) are used to determine the overall state of the age distribution of households in the study area.

Table 5.2: Age of Distribution of Respondents

Age Groups (years)	Frequency	Percent
Less than 30	23	6
30-39	90	23.9
40-49	124	33
50-59	82	21.8
60-69	47	12.4
70 and more	11	2.9
Total	377	100

Source: Field Survey 2019

From Table 5.2, it is showed that the lower portion of the respondents is aged by 70 or more years. The larger portion of the respondents (33%) belong to the age between 40 to 49 years who are the most active and highly motivated toward hard work on their livelihood strategies. The portion 12.4% is in the range of 60 to 69 years while 2.9% are in the range of 70 and more years. This constitutes 15% respondents are elders who are the most vulnerable groups. It is also found that 23% respondents including within the age ranged from 30 to 39 years and 21% with their age 50 to 59 years.

5.2.1.5 Family Size

The size of the household is simply the total number of the members who are accommodated in one family. The distribution of households by their family size is shown in Table 5.3.

Table 5.3: Family Size Distribution of the Respondents

Family Size	No. of Respondents	% of Total Respondents
1 to 3	143	38
4 to 6	226	60
7 to 9	8	2.1
More than 9	0	0
Total	**377**	**100**

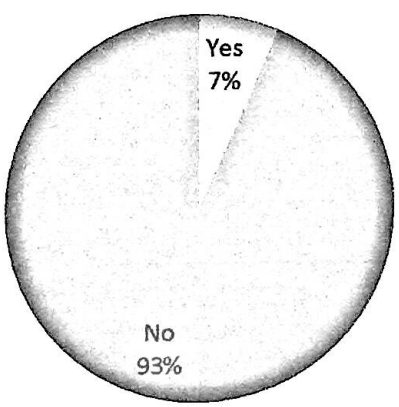
Source: Field Survey, 2019

Table 5.3 represents that among 377 household, 60% respondents have family members between 4 and 6. This indicates most of the households are accommodated with large family size. On the other hand, it is found that 38% households have 1 to 3 family members and only 2.1% households have 7 to 9 family members.

5.2.1.6 Existence of Disable Person

Presence of disable persons is a responsible factor to create vulnerability because in time of water logging a physically unfit person cannot move easily. Thus, it is impossible for disable to move safe place without the help of other persons. Therefore, disability is a vital cause for increasing vulnerability of a family.

Figure 5.3: Existence of Disable Persons



Source: Field Survey, 2019

The study finds that in the study area about 7% of the households contain disable persons whereas more than 80 percent households do not contain disable person (Figure 5.3).

5.2.1.7 Stockpile

Generally, people are more vulnerable who do not take preparation for future hazards. There are many criterions to identify the preparation level of the households or communities faced climatic hazard. The present study has been selected stockpile of dry food at household level to evaluate their preparation. Table 5.4 finds that in the water logged area, majority of the households (more or less 85.1%) have no reserve food to consume during water logging period and only 14.9 percent households keep dry food.

Table 5.4: Stockpile of Dry Food

Response	Frequency	Percent
Yes	57	15
No	320	85
Total	377	100.0

Source: Field Survey, 2019

5.2.1.8 Social Network

The households' vulnerability to water logging be able to be reduced by the adoption of neighborhood or social networks. Social network is a vital safety net for people to coping with water logging hazards. Because to rescue themselves from the hazards, it needs financial supports from their neighborhoods and relatives. Table 5.5 presents that in the study area nearly 59 percent household heads go to the local NGOs to meet up their financial problem. On the other hand, about one-fourth household heads (roughly 28.0%) go to their neighbors to solve their financial problem. The rest 36 and 14 percent household heads go to different banks and other options respectively.

Table 5.5: Borrowing Status

Money Lenders	Frequency	Percent
Neighbor	106	28.11
NGO	221	58.62
Bank	36	9.55
Others	14	3.71
Total	377	100

Source: Field Survey, 2019

5.2.1.9 Aggregate Social Vulnerability Index

Analytic Hierarchy Process (AHP) is applied to give weights to all variables (e.g. education, age, family size, social network) and indicators (i.e. for the variable of education; illiterate, bachelor etc.). Then the vulnerability score of individual household has calculated through the Leon's (2006) matrix. Finally, the following vulnerability index of studied area has been made with respect of field data as well as vulnerability score of household level.

After aggregating, it is observed from table 5.6 that about 54 percent households are socially highly vulnerable because of their illiteracy (45% respondent have no formal education), jobless, very high dimension of family, highly gender influence, extra-large dependency amount, no preparation, containing more disable persons and fragile social network. On the other hand, good number(25.20%) of households in the study area are moderately vulnerable in concern of social question to water logging hazard because of their poor educational qualification (23% respondent's educational quality are in between class five to ten), intermediate job type, slight big family size (about 60% households contain 4 to 6 members), middle gender force, fewer dependency proportion, small amount of households have preparation, containing little disable person and insignificant social network.

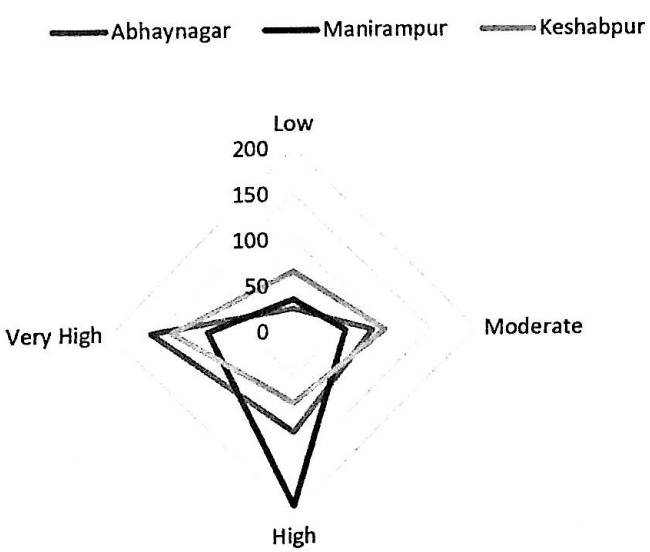
Table 5.6: Social Vulnerability Scores in the Study Area

Vulnerability level	Frequency	Percent	Scale
Low	12	3.18	0-25
Moderate	95	25.20	26-50
High	65	17.24	51-75
Very High	205	54.38	76-100
Total	377	100	

Source: Field Survey, 2019

However, the social vulnerability situation throughout the study area varies significantly. Figure 5.4 describes the levels of social vulnerabilities across the upazilas in the study area. The figure describes that most of the people of Abhaynagar upazila are very highly social vulnerable to water logging whereas people of Monirampur upazila are mostly high social vulnerable to water logging. The level of social vulnerability condition of the water logged people in the Keshabpur upazila is moderate to high.

Figure 5.4: Social Vulnerability Level among the Upazilas in the Study Area



Source: Field Survey, 2019

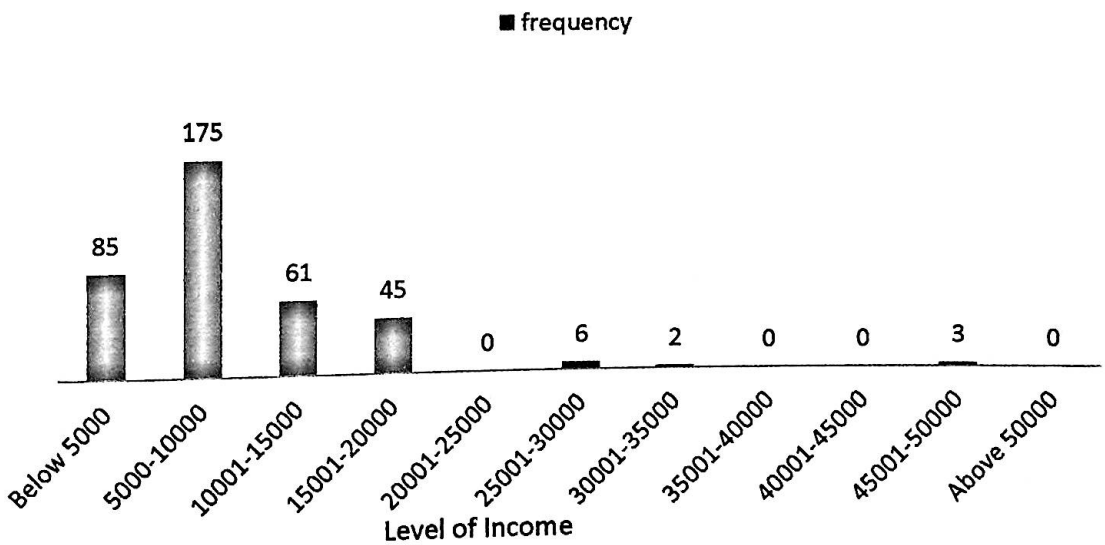
5.2.2 Measuring Economic Vulnerability

People's vulnerability to water logging is very much influenced by economic characteristics. Water logging increases the vulnerability of poor villagers economically and socially. On the other hand, economic condition can raise people's vulnerability to water logging. The researcher has chosen variables related to household income, savings, insurance, land ownership, vehicle ownership and loan status to measure economic vulnerability. The empirical results based on the field survey are discussed in the following section.

5.2.2.1 Household Income

For the reasons of describing vulnerability to water logging, this study has categorized the income levels into eleven groups. The surveyed data of the study area presents that 85 of total 377 samples are belonged to the lowest income group with monthly income below Tk. 5000. The largest number of households (175 samples) monthly income are in between Tk. 5000 to 10000, while 61 and 45 households monthly total income are in between Tk. 10001 to 15000 and Tk. 15001 to 20000. Only six households earn between Tk.25001 to 30000 per month. Rest two and three households monthly income is in between Tk. 30001 to 35000 and Tk. 45001 to 50000(Figure 5.5).

Figure 5.5: Monthly Household Income



Source: Field Survey 2019

Therefore, the figure depicts that the poor villagers are very much vulnerable to water logging crisis in terms of income.

5.2.2.2 Ownership of Land

Land ownership is one of the responsible variables for vulnerability to water logging. It is the key aspects of the vulnerability of different social groups. Land serves as not only place to live but also provides economic and livelihood resource i.e. place for production, security for bank loans. The surveyed data presents that most of the households in the water logged area have small ownership of land. Thus, in terms of land ownership, the people are very vulnerable to water logging hazards. The original scenario of land ownership in the study area is described in the following table 5.7.

Table 5.7: Land Ownership (Marginal)

Response	Frequency
Yes	100
No	277
Total	377

Source: Field Survey 2019

5.2.2.3 Savings

The power of resilience after water logging period depends mostly on household savings. Usually poor households in the study area cannot afford to keep any saving to face future calamity because of their poverty. The Table 5.8 reveals that in study area only 15percent households have savings to face evil days whereas most (above 85%) of the households have no savings to face calamity.

Table 5.8: Saving Status

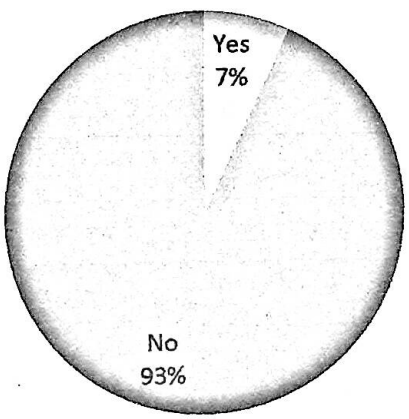
Saving Status	Frequency	Percent
Yes	57	15
No	320	85
Total	377	100

Source: Field Survey 2019

5.2.2.4 Insurance

The vulnerability due to water logging can be reduced by any kinds of insurance. The surveyed data of the study regarding insurance express that in the study area only 7 percent households have insurance, while 93 percent households have no insurance. Here, insurance means any type of insurance in any format. It may be insurance of health, vehicle, fire etc (Figure 5.6).

Figure5.6: Insurance Status



Source: Field Survey, 2019

5.2.2.5 Loan Status

High level of borrowing. For showing people's vulnerability, this study categorised the amount of loan into different groups, because the range of the amount of loan is

different but the number of classes have made uniform for quantifying. Table 5.9 presents the scenario of Borrowing status of the households affected by water logging. About 25percent households of total sample have no loan, whereas about 75 percent households have loan. It is found that 39.0, 10.0,40, 10 and 12.0 percent household's loan amount are in between 5001Tk- 10000Tk. 10001Tk.- 15000Tk., 15001Tk.-20000Tk., 20001Tk.- 25000Tk. and more than.25000 Tk. respectively.

Table 5.9: Loan Status in the Study Area

Borrowing Category	Frequency	Percent
No Loan or less than 5000 Tk.	94	25
5001- 10000 (Taka)	147	39
10001- 15000 (Taka)	38	10
15001- 20000 (Taka)	15	4
20001- 25000 (Taka)	38	10
More than 25000 Taka	45	12
Total	377	100

Source: Field Survey, 2019

5.2.2.6 Vehicle Ownership

General vehicle ownership is very useful to move from one place to another, specifically in the time of a disastrous situation. Who has own vehicle for moving, he/she is less vulnerable than there do not have personal vehicle. Therefore, the present study has selected ownership of vehicle as the variable of vulnerability. However, the surveyed empirical data portrayed that in the study area most (almost 68%) of the households have no vehicles while only 32 percent households have bi-cycle as well as rickshaw. Table 5.10 presents the vehicle ownership status in the study area.

Table 5.10: Vehicles Ownership

Types of Vehicle	Frequency	Percent
Private Car	0	0
Motorcycle	38	10
Bi-cycle	83	22
Nothing	256	68
Total	377	100

Source: Field Survey, 2019

5.2.2.7 Aggregate Economic Vulnerability Index

After aggregating six variables (i.e. income, savings etc.) of economic factor and the indicators (i.e. for the variable of savings indicator is like yes, no) of individual variables, the economic vulnerability index have been explained in the following sections. From the aggregated economic vulnerability index, it is clear that the majority (60%) households of the study area are economically very highly vulnerable to water logging hazard (Table 5.11). This is because of their low income, no land ownership, least savings, very few number of households keep insurance and little vehicle ownership.

Table 5.11: Economic Vulnerability Scores in the Study Area

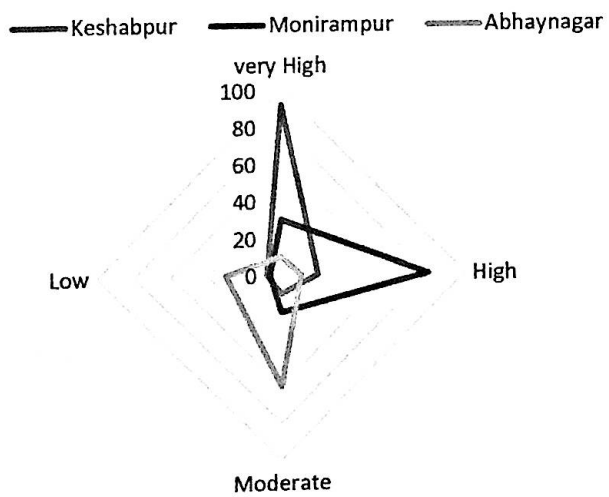
Level of Vulnerability	Frequency	Percent	Scale
Low	0	0	0-25
Moderate	38	10	26-50
High	113	30	51-75
Very High	226	60	76-100
Total	377	100	

Source: Field Survey, 2019

Table 5.11 also describes that 30 percent households in the study area are highly vulnerable to water logging hazard for the above stated similar causes. The causes are few households of slum area have good income, savings and insurance, but the influence of other variables of economic factor has so high. As a result, only 10 percent households are moderately vulnerable. It also obvious that, in the study area there are no low vulnerable households economically. The reason is that, there are no highly earned households in slum area also none of households of slum area have private car for leave the hazardous place.

However, the economic vulnerability situation throughout the study area is also varies significantly. Figure 5.7 describes the levels of economic vulnerabilities across the upazilas in the study area. The figure describes that most of the people of Keshabpur upazila are very highly economically vulnerable to water logging whereas people of Monirampur upazila are mostly high economic vulnerable to water logging. The level of economic vulnerability condition of the water logged people in the Abhaynagar upazila is moderate to high.

Figure 5.7: Level of Economic Vulnerability among the Upazilas in the Study Area



Source: Field Survey, 2019

5.2.3 Measuring Infrastructural Vulnerability

Water logging vulnerability is affected by the structural factors such as road networks, housing quality, transportation system, shelter and drainage system, existence of evacuation road, flood dams and location of geography. The present study has selected four variables to evaluate the vulnerability due to water logging in study area such as road network, transportation system, shelter and housing quality. The followings are the discussion of these variables based on the information of survey questionnaire.

5.2.3.1 Housing Quality

Housing quality is one of the mainly important variables of structural factor. It can increase or decrease the level of vulnerability (Emrich, 2009). The surveyed data shows that approximately 50 percent households are living in semi-pucca house while only 9 percent households living in pucca house. It is also found that a good number of people about 41 percent are living in kacha house. The following table 5.12 shows the housing types of the study area.

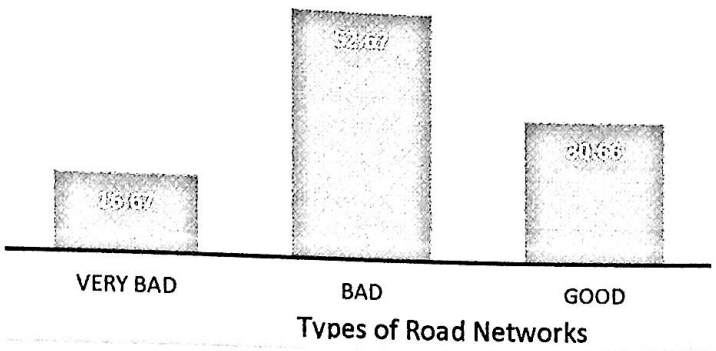
Table 5.12: Types of Main Houses

Types	Frequency	Percent
Kacha	156	41.4
Pucca	34	9.0
Semi-pucca	187	49.6
Total	377	100

Source: Field Survey, 2019

Thus, it is obvious that, due to fragile housing types make poor households more vulnerable to water logging.

Figure 5.9: Condition of Road Networks in the Study Area



Source: Field Survey, 2019

5.2.3.4 Transport System

Transport system is a significant variable of physical factor of vulnerability. The following table (Table 5.13) exhibits that 77 percent respondent among total respondents in the study area are thinking that the transport system is not good although only 6 percent respondents think the transport network is good. Rest of only 17 percent respondents is belief that the transport system is very bad.

Table 5.13: Condition of Transport System

Types of Transport	Frequency	Percent
Very Bad	64.09	17
Bad	290.29	77
Good	22.62	6
Total	377	100

Source: Field Survey, 2019

5.2.3.5 Infrastructural Vulnerability Index

The following structural vulnerability index of the studied area is calculated with the help of the AHP and the Leon's (2006) matrix. Table 5.14 reveals that most (66% households) of the households in the study area are structurally very extremely

vulnerable to water logging problem, owing to their easily broken type housing quality, bad road network and very poor transport system. Table 5.14

Table 5.14: Infrastructural Vulnerability Scores in the Study Area

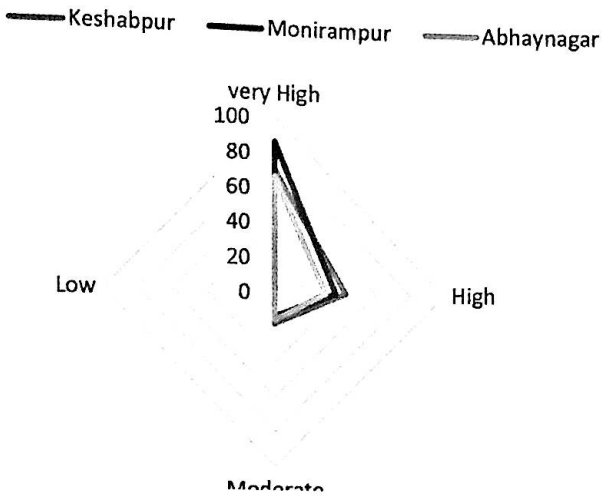
Level of Vulnerability	Frequency	Percent	Scale
Low	0	0	0-25
Moderate	0	0	26-50
High	128	34	51-75
Very High	249	66	76-100
Total	377	100	

Source: Field Survey, 2019

Conversely, 34 percent households of total households in the study area are structurally highly vulnerable because of their poor housing type. In addition, other structural facility is not sound (because about 77 percent respondents think that the transport network of their locality is bad). In the study area there are no high quality houses also they are living in inner side of the locality so simultaneously their road network and transport system is not so well. For this reason, it appears that none of households is lowly vulnerable to water logging.

Figure 5.10 shows that poor housing quality and living in outside of road makes people more structurally vulnerable to water logging. The figure depicts the levels of structural vulnerabilities across the upazilas in the study area. The figure describes that most of the people of the three upazilas are very highly structurally vulnerable to water logging whereas people of Monirampur upazila are more vulnerable to water logging.

Figure 5.10: Level of Structural Vulnerability among the Upazilas in the Study Area



Source: Field Survey, 2019

5.2.4 Measuring Institutional Vulnerability

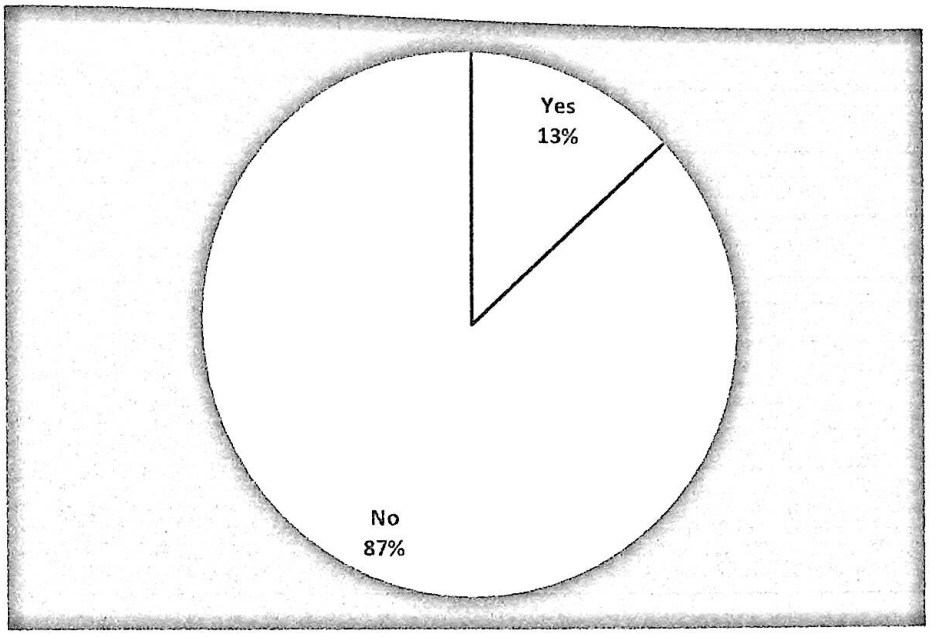
The vulnerability to any natural calamity can be mitigating by a good institutional set up. In general, existence of help during disastrous situation, early warning systems, emergency management committee, governance and emergency service etc. act as institutional vulnerability factors. This study considers only two variables, aid and emergency services during water logging to estimate people's vulnerability in terms of institutional facilities.

5.2.4.1 Aid during Water Logging

Households who have access to aid from their relatives and other sources including friends, local influential people, local shopkeepers, governmental and non-governmental organizations, are less vulnerable to recover their damage. Field survey data (Figure 5.11) presents that among the surveyed households, most households (approximately 87%) did not get aid during water logging because they were not able to go to that place where the relief distributors distributed the relief or the relief was not sufficient. Therefore, it was impossible to provide aid to every affected family. Nevertheless, the amount of help was very few. Moreover, relief distributions were

under-coordinated, inconsistent and had generally harder to reach affected areas. As a result, almost no household (who got help) were satisfied with that help.

Figure 5.11: Aid during Water Logging



Source: Field Survey, 2019

5.2.4.2 Emergency Services during Water Logging

To reduce vulnerability emergency services such as, food, shelter, medicine etc. are essential. Emergency services also can diminish the severity of hazard or disasters. During questionnaire survey, interviewee asked the interviewer about the availability of emergency services during recent water logging. Table 5.15 reveals that among the respondents majority (nearly 92.7%) respondents did not get any emergency services during recent water logging. While 7.3 percent respondents were, got emergency services during recent water logging. Table 5.15 depicts the scenario of available emergency services during recent water logging.

Table 5.15: Available Emergency Services during Water Logging

Response	Frequency	%
Yes	349	92.7
No	28	7.3
Total	377	100

Source: Field Survey, 2019

5.2.4.3 Institutional Vulnerability Index

The institutional vulnerability index is calculating with the same procedure as previously done. The following table shows the institutional vulnerability index of the study area. Table 5.16 demonstrates that most (78.9%) households in the study area are institutionally very extremely vulnerable to water logging. Because of most of the households did not get aid or emergency services during water logging period. Moreover, 13 percent households are highly vulnerable and only 8% are moderately vulnerable to water logging hazard. As a consequent of though the few households got relief but they did not get any emergency services. Table 5.16

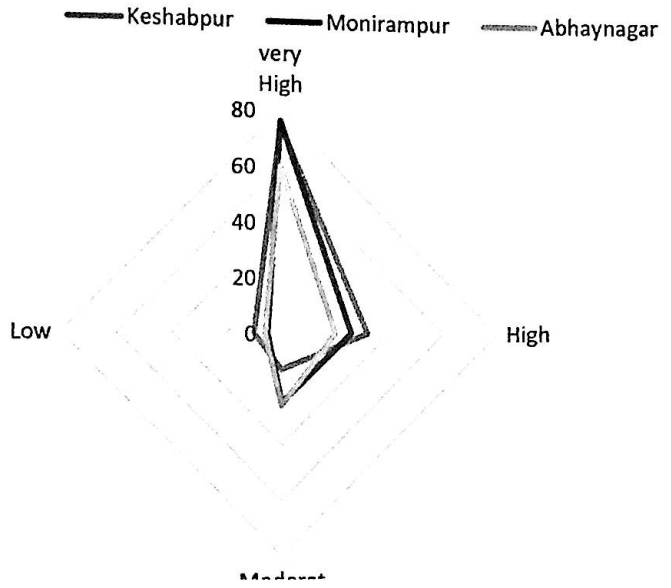
Table 5.16: Institutional Vulnerability Scores in the Study Area

Level of Vulnerability	Frequency	Percent	Scale
Low	0	0	0-25
Moderate	31	8.1	26-50
High	49	13	51-75
Very High	297	78.9	76-100
Total	377	100	

Source: Field Survey, 2019

Figure 5.12 presents the levels of structural vulnerabilities across the upazilas in the study area. The figure describes that most of the people of the three upazilas are very highly institutionally vulnerable to water logging.

Figure 5.12: Level of Institutional Vulnerability among the Upazilas in the Study Area



Source: Field Survey, 2019

5.2.5 Measuring Environmental Vulnerability

This study has considered only sanitation and water supply to evaluate environmental vulnerability to water logging. The followings are detail explanation.

5.2.5.1 Sanitation

If a household contain fragile or poor sanitation system then water logging can easily affect that household. Common toilet, twin-pit and pit latrines are commonly used by slum dwellers. Most of the toilets of the water logged households are damaged by dirty water or even washed away and flooded. Thus, the environment of the affected areas is polluted. The polluted sanitation made the environment unhygienic and spread out germs awfully. Gradually, water has borne diseases spreads out. In present

condition availability of toilet facilities are increasing. Table 5.17 shows most of the people are intending to use unhygienic toilets.

Table 5.17: Types of Sanitation Facility

Types	Frequency	Percent
Sanitary toilet (Healthy)	72	19.1
Kacha (Unhealthy)	275	72.9
No opportunity	30	8.0
Total	377	100

Sources: Field Survey, 2019

5.2.5.2 Drinking Water Facility

Water pollution is another environmental problem for the study area. However, limited number of households of the poor areas uses pure water for their daily activities, which is very often unsafe. Table 5.18 reveals that in the study area, more than half households (nearly 53%) are used tubewell water for drink, about 24% households drink pond or river water without boiling. Rest 18 and 5 percent households used tap and filtering water respectively for drinking.

Table 5.18: Types of Drinking Water in the Study Area

Types	Frequency	Percent
Tubewell	199.81	53
Filter	18.85	5
Tap	67.86	18
River or pond	90.48	24
Total	377	100

Source: Field Survey, 2019

However, the environmental vulnerability has worsened as the available tubewells are contaminated when water overflows during water logging period.

5.2.5.3 Environmental Vulnerability Index

Similarly, the following environmental vulnerability index in the study area has made based on the AHP and Leon's (2006) matrix. After aggregating all variables of environmental factor the Table 5.19 reveals that most *(74.7 percent)* of the households in the area are **very** highly vulnerable inconsideration of environmental situation, owing to about 72 percent households use unhealthy toilet.

Table 5.19: Environmental Vulnerability Scores in the Study Area

Level of Vulnerability	Frequency	Percent	Scale
Low	8	2	0-25
Moderate	70	18.7	26-50
High	17	4.6	51-75
Very High	282	74.7	76-100
Total	377	100	

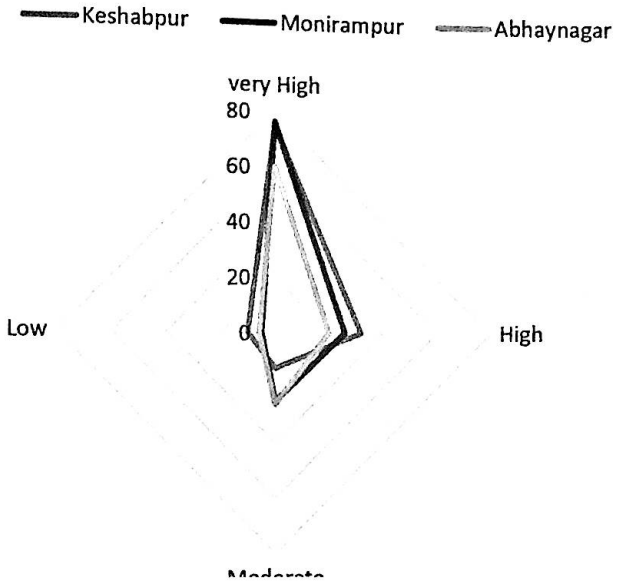
Source: Field Survey, 2019

Another cause such as drinking of unsafe water is responsible to make them very highly vulnerable to water logging. Because about 25 percent households are using water directly from river or pond without boiling. Moreover, rest 18.7 and 2.0 percent households in the study area are moderately and lowly vulnerable respectively.

Figure 5.13 show that unhealthy toilet and water supply make people more environmentally vulnerable to water logging. The figure depicts the levels of environmental vulnerabilities across the upazilas in the study area. The figure explains

that most of the people of the three upazilas are very highly environmentally vulnerable to water logging.

Figure 5.13: Level of Environmental Vulnerability among the Upazilas in the Study Area



Source: Field Survey, 2019

5.2.6 Overall Vulnerability Index

The ultimate goal of this study is to develop an overall vulnerability index, which represents the level of people's vulnerability to water logging in the study area. Following index has been developed by aggregating all factors' vulnerability level as done by Sebald (2010).The following Table 5.20 presents that highest number (66.52%) total households among the total in the study area are very extremely vulnerable to water logging disaster. Because of, most of the households in the study area are economically, structurally, institutionally and environmentally very highly vulnerable.

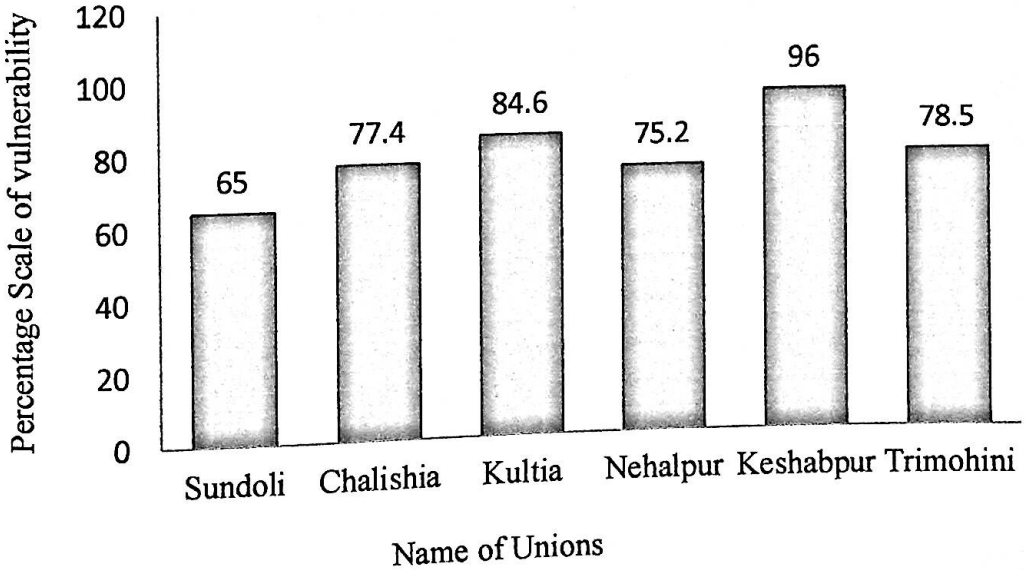
Table 5.20: People's Vulnerability Index of Study Area

Degrees of Vulnerability	Frequency	Percent	Range/Scale of Vulnerability Score
Low	14	3.61	0-25
Moderate	40	10.69	26-50
High	72	19.18	51-75
Very High	251	66.52	76-100
Total	377	100	

Source: Field Survey, 2019

It is observed from the Table 5.20 to good number (19.18%) households are highly vulnerable to water logging. Few (10.69%) households are in moderately vulnerable (Table 5.20). Whereas only 03.61 percent households in the study area are lowly vulnerable to water logging hazard. Therefore, at last it seems that vulnerability to water logging varies significantly across the study area. The following figure 5.16 shows the overall vulnerability scores according to the unions under three upazilas.

Figure 5.14: Scale of Vulnerability According to Unions



Source: Field Survey, 2019

Figure 5.16 describes the levels of overall vulnerability levels across the unions in the study area. The figure illustrates that most of the people of Keshabpur union under Keshabpur upazila and Kultia under Monirampur upazila are very highly vulnerable to water logging. Whereas the people of Keshabpur upazila are the worst victim of water logging phenomenon.

5.5 Chapter Summary

People's vulnerability to water logging in the study area is measured by Leon's (2006) matrix and Analytical Hierarchy Process (AHP). The detail discussion of this chapter finds that the people of study area are vulnerable to water logging problem. Nevertheless, the intensity of vulnerability among the households of Keshabpur and Kultia unions is much higher than that of other study unions considering future water logging.

CHAPTER SIX

LIVELIHOOD SECURITY STATUS AND DETERMINANTS

6.1 Introduction

The study uses different livelihood security indices to quantify the livelihood security status of the people inhabited in the study area. Moreover, the study estimates an empirical model by 2SLS method to find out the significant determinants of livelihood security. For this purpose, primary data has been collected using a well structured questionnaire consisting of different aspects such as migration, education of household, status of employment and earnings, composition of household, income of household ,transfers, social assistance and household assets, agriculture, savings, loan status, housing type, environmental status, water and sanitation, daily foods, consumption, diarrhoea and other illnesses, health, nutrition knowledge and practice, community participation, pre-school feeding, utilization of health care facilities for pregnancy,/birth and anthropometry general household livelihood security.

This chapter has four sections. Section 6.2 presents the calculated results of different livelihood security indices. Section 6.3 presents and discusses the estimated results of 2SLS estimation to determine the affecting of factors which the livelihood security status of the water logged households. Finally, the chapter ends with a concluding remark.

6.2 Livelihood Security Status

In the present study, the researcher considers several groups of livelihood including service holders such as daily wage laborers, rickshaw and van puller, farmers, sevice holder, forest resource extractors' fisherman, fry (shrimp) collectors, fishers and forest resource extractors etc. These groups are extremely affected by water logging hazards in the Jessore district of Bangladesh. Different livelihood security indices are calculated investigating the security status of the poor household's subsistence

system in the study area. On the basis of respondents security diversions has been followed to examine the security indicators. The researcher considers four security areas such as, economic, food, health, and educational security. For this purpose, the researcher considers different sets of indicators variables. To measure the vulnerability indicators the raw information is collected from the data collected by field survey. For example, as the economic status is a major factor of economic security, it works to make different income levels.

6.2.1 Economic Security

The researcher selects 10 economic security indicators as in Table 6.1. Table 6.1 describes the economic security indicators. If the indicators take larger values, the households are more advantages and secured economically. Table 6.1 shows the mean and standard deviation of the indicators for the different upazilas in the study area; Abhaynagar, Manirampur and Keshabpur. The economic security index was calculated by using the standardized values of these indicator variables. The report shows that the Economic security index of the three upazilas are statistically same and low in the study area. It is well-known to the poor villagers of Bangladesh are economically extremely insecure. It is observed from table 6.1 that households in the Manirampur upazila are able more with economic assets than other two upazilas. Thus, the value of economic security index of Manirampur upazila is relatively high than other two upazilas; Abhaynagar and Keshabpur.

Table 6.1: Economic Security Indicators in the Study Area

Indicators	Abhaynagar		Manirampur		Keshabpur	
	No. of Household					
	119		130		128	
	Mean	StdDev	Mean	StdDev	Mean	StdDev
Per person monthly income (TK)	931	720.51	1160	725.90	865	658.76
Per person own land/housing/pond (TK)	22347	61349.2	31692	74612.0	26341	52483.41
Per person livestock (TK)	526	1023.1	720	857.4	691	1201
Per person machinery and equipment/transport (TK)	1509	12345	1907	254.3	1209	974.38
Per person other asset (TK)	428	57.02	815	521.10	129	92.09
Proportion of 15-59 aged population	0.40	0.11	0.60	0.19	0.50	0.21
Proportion of 15-59 in employment	0.35	0.25	0.67	0.38	0.48	0.29
Per person female income (TK)	146	65.23	251	159.27	110	156.03
Per person current savings (TK)	2429	15890.03	4317	10344.7	1637	1088.5
Per person current loan (TK)	972	3840	628	212.90	1130	2666.74
Economic Security Index Value	0.170	0.061	0.182	0.084	0.176	0.67

Source: Field Survey, 2019

6.2.2 Food Security

For calculating Food Security index, the researcher divided the households into 8 groups and collected data on 24 hour recall basis. These groups are foods of animal origin, roots and tubers, cereals, pulses, fruits, vegetables, oils fats and, and snacks. Table 6.2 represents the distribution of households different food groups observed in 24 hours. The field survey finds that only 5 percent of the total households had healthy diets including 8 types of foods. Other households are unable to maintain the mentions types. About 73 percent of the households consume cereals plus four types of food intake in 24 hours (Table 6.2). It includes mixed foods which are mainly protein-rich high value products such as animal origin food (meat, eggs, milk, and milk products etc.) and fruits. Rice and wheat are the common diet in everyday meals. Three fourth of the total households consume tubers and roots, particularly potatoes. Monthly common item of food was fish in the group of livelihoods. Vegetables and protein-rich foods intake were quite low in the study area. In Table 6.2, it categorized the households based on regularity of food groups daily consumed. The most frequent number of taking food is four types of food groups in addition to cereals.

Table 6.2: Household Food Consumed Distribution in 24 Hours

Groups	No of Household	%
Cereals	2	0.6
Cereals + another item	11	3
Cereals + another two items	73	19.4
Cereals + another three items	57	15
Cereals + another four items	132	35
Cereals +another five items	49	13
Cereals + another six items	34	9
All items of food	19	5
Total	377	100

Source: Field Survey, 2019

The 6.3 presents the standard deviation and mean of food security indicators in the study area. At present the differences between three Abhaynaga, Manirampur and Keshabpur in foodgrain stocks of terms. In the study area, Abhaynagar upazila has more access to secured food owing to the availability of higher foodgrain stocks. The researcher includes 'number of main meals taken by women in household' in the indicator list of food security as a tendency of women has been noticed to skip the meals and have less food and they eat when the other members of the family first there. The significance of the food security is highly noticeable here. To this end, it is observed that peoples in the study area are many advantages in terms of food security in comparison to economic security but the average is still in between 0 to 1.

Table 6.3: Food Security Indicators in the Study Area

Indicators	Abhaynagar		Manirampur		Keshabpur	
	No. of Household					
	119		119		119	
	Mean	StdDev	Mean	StdDev	Mean	StdDev
Per day food frequency (meals and snacks)	10.1	4.11	12.60	4.19	11.50	5.21
Per day Dietary diversity (number of food types consumed	6.7	2.25	5.4	1.9	4.8	1.9
Per person household food grain stock (TK)	76	323.1	51	227	47	256.3
In the year, number of food convenient months	10	373.57	9	344.7	8.5	108.5
Number of women in household (main meals taken)	2.5	0.6	2.5	0.6	2.5	0.6
Security of Food Index Value	0.666	0.245	0.537	0.843	0.510	0.192

Source: Field Survey, 2019

6.2.3 Health Security

Health security index is constructed by using seven components. The calculated results rooted in the field study data are showed in table 6.4. Table 6.4 finds that people of the three upazilas were insecure to equally of health security but some are differences in terms of individual components. Sickness is significantly higher in Keshabpur. An estimated 91 percent of households in Keshabpur, 73 percent in Abhaynagar and 70 percent in Manirampur upazila had at least one member who was sick during the 30-days recall period. Consistently, body mass index is moderately lower in Keshabpur. Advanced analysis of data present that in Keshabpur close to 78

percent of girls and 64 percent of boys under age 5 were stunted while in Abhaynagar 63 percent of girls and 50 percent of boys were stunted. Another 40 percent of the children in Keshabpur and 25 percent in Abhaynagar were underweight for their height. The above indicators were existence of frightening malnutrition.

Table 6.4: Health Security Indicators in the Study Area

Indicators	Abhaynagar		Manirampur		Keshabpur	
	No. of Household					
	119		119		119	
	Mean	StdDev	Mean	StdDev	Mean	StdDev
Last 30 days (diarrhea incidence per person)	0.5	2	0.8	2.1	0.7	2.1
Last 30 days(other sickness per person days)	7.2	8.1	7.4	7.6	7.4	7.8
Number of days an active person unable to work due to sickness	3.5	4.3	5.5	6.0	4.5	5.3
frequency of antenatal consultation (per women)	4.2	2.1	4.2	2.3	4.2	2.1
Tetanus vaccination (per women doses)	2.3	0.8	2.3	0.8	2.3	0.8
BMI (per women)	20.9	3.2	19.9.2	2.9	21	3.6
BMI (per children<=5 years	14.9	6.3	14.9	5.3	15.1	6
Health security Index Value	0.135	0.225	0.133	0.186	0.134	0.271

Source: Field Survey, 2019

6.2.4 Education Security

All the indicators in Manirumpur upazila have been found lower average value. In rural areas, over all literacy rate is lower in the study area and it is reflected in the education indicators in Manirampur. Since the study area is more congested and so basic services are extremely poor, three fourth of the households in the selected area are not able to meet basic needs, such as education.

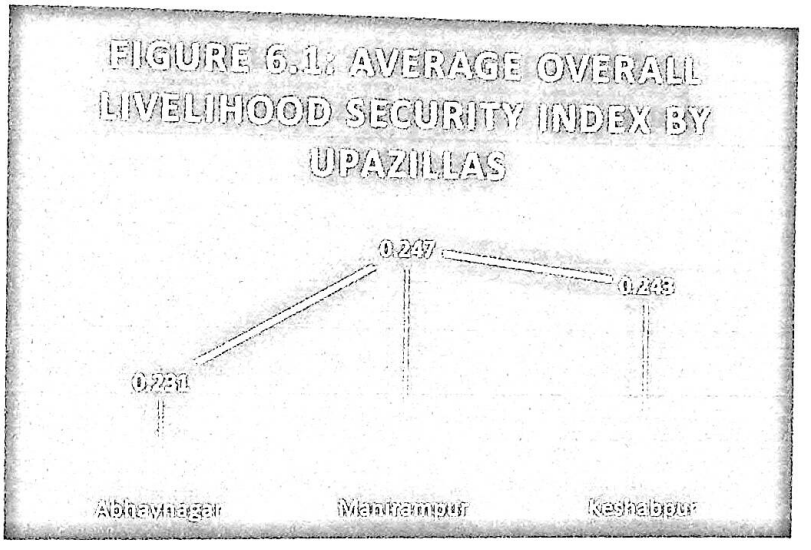
Table 6.5: Education Security Indicators in the Study Area

Indicators	Abhaynagar		Manirampur		Keshabpur	
	No. of Household					
	119		119		119	
	Mean	StdDev	Mean	StdDev	Mean	StdDev
7+ population can read and write (Literacy)	1.00	1.08	0.84	0.95	0.77	1.06
Male literacy (15+ male literate)	0.76	0.85	0.59	0.62	0.60	0.78
Female literacy (15+ female literate)	0.68	0.77	0.39	0.73	0.49	0.70
More than 10 years Education (Male and Female)	0.36	0.77	0.19	0.61	0.37	0.84
6-10 years children enrolled	0.55	0.52	0.32	0.70	0.29	0.51
11-15 years boys enrolled	0.27	0.43	0.12	0.31	0.17	0.50
11-15 years girls enrolled	0.15	0.47	0.15	0.16	0.24	0.60
16-23 years enroled	0.24	0.663	0.17	0.23	0.15	0.35
Education security Index Value	0.17	0.22	0.13	0.16	0.14	0.13

Source: Field Survey, 2019

6.2.5 Overall livelihood Security

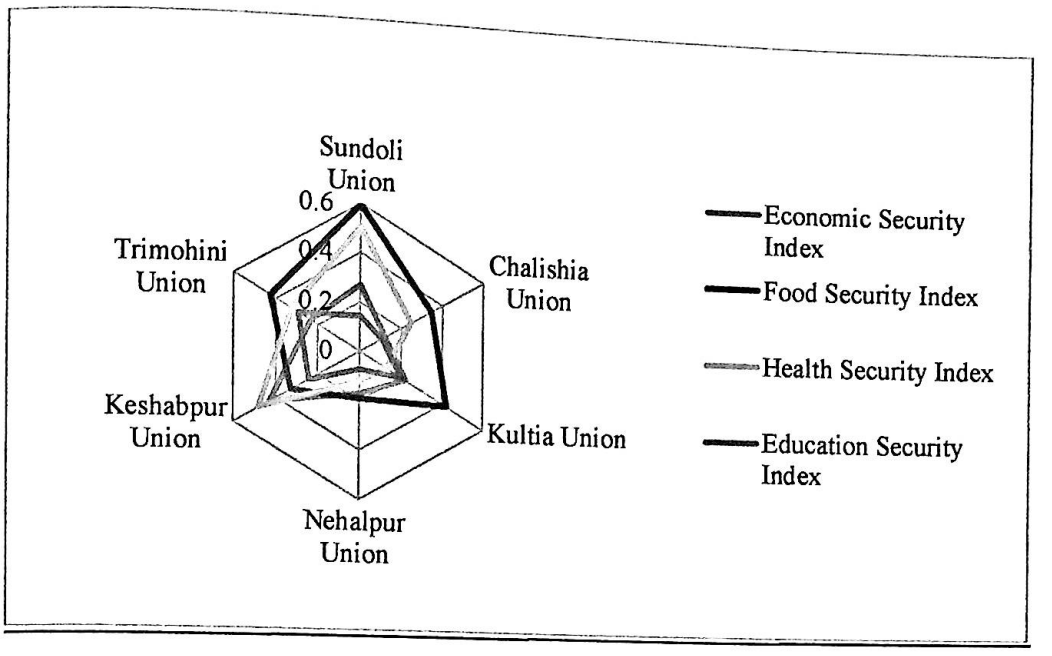
The educational, health, economic and food security domains are composed to comprise the overall livelihood security in the study area. Overall the combined Livelihood Security (LS) index used for the household is constructed by taking various weights. Weights vary between average level of livelihood security index is slightly high in Manirampur upazila, followed by Keshabpur and Abhaynagar upazilas. The livelihood security index is very low in Abhaynagar upazila as the area is surrounded by the *Vobodhaou bill* and it is the most vulnerable area affected by the water logging problem. The calculation of overall security index indicates that the



Source: Field Survey, 2019

Overall livelihood security index comprises five major security areas such as: food security, health security, economic security, educational security and empowerment. The variation arises from the major difference in economic, food, health, empowerment and education security indices. In all regions, it is observed that the majorities are less secured than the average. When the researcher tries to look the livelihood security status according to union; the problem of water logging is more severe to the livelihood security of the people inhabited in the study area. The following Radar chart diagram in figure 6.2 outlines the pictures of livelihood security indices according to unions studied in this study.

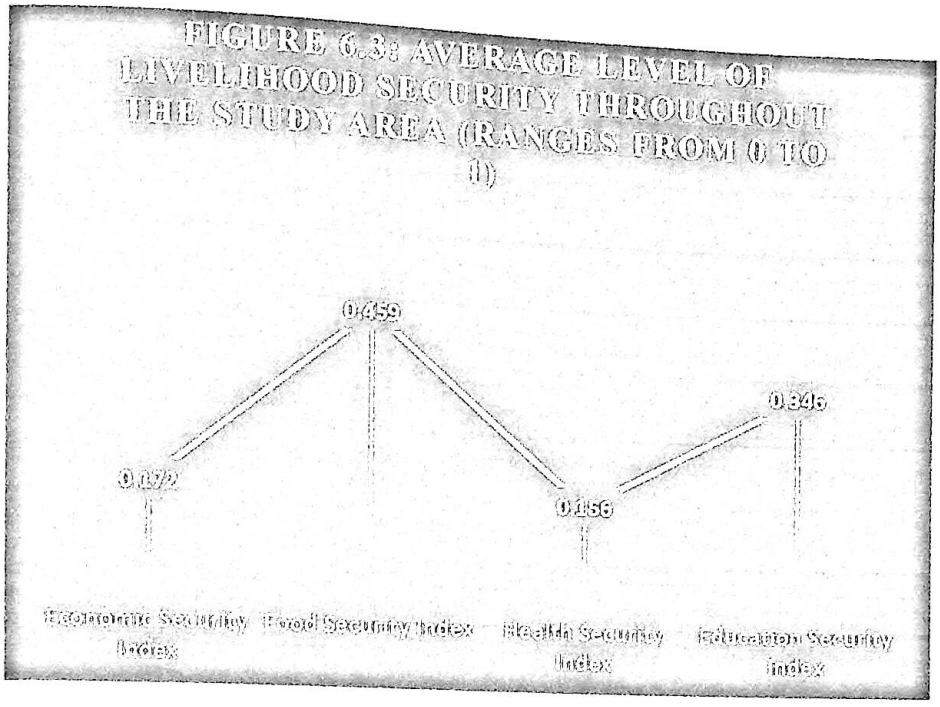
Figure 6.2: Average Level of Livelihood Security According to the Unions



Source: Field Survey, 2019

The above figure clearly depicts that Sundoli union among the other five unions in the study area performs well in all the security indices. This also reveals that people of Sundoli and Kultia unions are within a good position according to food security terms. Whereas health security status be high in Sundoli and Keshabpur unions compared to others.

On an average, the households are more food secured throughout the study area. The food security level is below 0.5 which is far less than the national statistics which indicates at present Bangladesh has enough necessary foods to be secured (CARE, 2004). The figure 6.3 also shows that the education security index is 0.346 throughout the study area but the other security indices are very low in the study area. In short, the study area is very insecure in terms of economic and health indicators.



Source: Field survey, 2019

The results depicts above can be justified with the following descriptions. It is found that the health related indicators, such as 'number of days unable to work due to 'underweight' sicknesses' etc. is very poor throughout the study area, because of the indicators in existence of frightening malnutrition. All the mentioned indicators, the above reports according to educational indicators show that status of educational service is relatively worse. All of the seven indicators have lower average value. Moreover, as the literacy rate is lower in rural areas, this is reflected in the education indicators in the study area. Also, this may be the impact of industrial/ manufacturing job opportunities. Apparently it seems that income per capita is higher but in the long run the impacts are not pleasing. The study area is more congested and so basic services are extremely poor. On the other hand, livelihoods and poverty related interventions are usually not targeted the households affected by the water logging problem.

However, regarding food security indicators, peoples in the study area are much better in terms of food security relative to other domains of livelihoods security but still the average is in less than the middle of the scale of 0 to 1. There are differences across the study unions/upazilas. Due to higher foodgrain stocks perhaps the access to food remains secured.

6.3 Determinants of Livelihood Security

The estimation results of 2SLS model are presented in this section. In order to estimate the models, the researcher includes the variables as defined in the methodology section. Besides livelihood security indices, the researcher specifies 10 variables representing household circumstances (X variables). The study assumes that for example the household which have higher level of family size and dependency ratio, their demand for basic needs is also higher. Thus, it was expected that these variables to affect livelihood security negatively, other things being equal. The security variables would affect each other positively. Other variables included are the characteristics of the household heads such as gender, age, marital status and education, etc. It has expected that their age and education may be positive linked with the security level other than variables such as gender and marital status etc. may be linked with security level either positively or negatively depending on the circumstances.

The researcher firstly performs specification tests. Chow test (Chow, 1960) identified the equations that should be modeled separately or use independent set of dummy variables to represent their differences. The variables transformed into log as to reduce the statistical problems. It found that the security variables are interrelated and have positive effect of these indicators.

The results presented in Table 6.6 founds to all the security variables are highly important determinants of economic security. This result is consistent with the prior expectation as they cause each other. For example, it can be said that if education security increases 10%, the economic security will be raised by 2%. Moreover, those household heads have access to better food will be economically more secured by 47%. Some factors/variables are significantly negative to economic security such as dependency ratio and family size of the households. The level of household education is a significant factor for influencing livelihood security. This indicates that with 10% increase in the level of household education level, health security status increases by 8%. But this estimation shows unexpected significant results when shows the relationship between education level and food security status.

Table 6.6: Determinants of livelihood security in the Study Area				
Variables	2SLS estimators of the estimated Coefficients (p-values are assigned into the parenthesis)			
	Economic Security	Food Security	Health Security	Education Security
lnESI	-	0.5612** (0.0422)	0.6868 (0.2720)	2.4144** (0.0464)
lnFSI	0.4764*** (0.0109)	-	0.6868 (0.2720)	2.4144 (0.4464)
lnHSI	0.1189** (0.0409)	0.0442** (0.0349)	-	-0.1913 (0.4467)
lnES	0.0634*** (0.0053)	-0.0059** (0.0137)	0.0621** (0.0421)	-
lnFS	-0.1200*** (0.0050)	-0.1187* (0.0618)	0.5585 (0.1926)	2.7049 (0.2896)
lnLH	0.0019 (0.1228)	0.0023*** (0.0023)	-0.0118*** (0.0073)	0.0188*** (0.0130)
lnDR	-0.007*** (0.0111)	0.0059*** (0.0099)	0.0648 (0.0271)	-0.1040** (0.0483)
lnAGE	-0.2797 (0.1057)	0.0921 (0.0978)	-0.3107 (0.280)	2.0994 (0.4247)
lnHE	0.0251*** (0.0154)	-0.0182*** (0.0139)	0.0824** (0.0388)	0.0356* (0.0698)
lnFH	0.1170 (0.1213)	-0.2072 (0.1078)	0.3112 (0.3116)	0.5392 (0.5410)
Variables	2SLS estimators of the estimated Coefficients (p-values are assigned into the parenthesis)			
	Economic	Food	Health	Education
lnHms	0.0844 (0.1286)	-0.0611 (0.1150)	0.5200 (0.3250)	-0.4320 (0.5737)
lnH-r or w or s	0.0884 (0.2718)	-0.0288* (0.0646)	0.0134 (0.1868)	0.0621 (0.3235)
lnH-r & w	-0.4730 (0.1869)	0.2328 (0.1719)	-1.1189 (0.4756)	3.0098 (0.7893
lnH-rbrt	0.0128 (0.1278)	0.0889 (0.1139)	-0.2933 (0.3272)	0.5012 (0.5679)
The star sign *** indicates 1% significance evel , ** indicates 5% significance level and * indicates 10% significance level				

6.4 Chapter Summary

The chapter presents the results of different livelihood security indices and the 2SLS models. This chapter quantifies the security of livelihood status of the people inhabited in the study area and finds significant determinants of livelihood security. Four security indices such as economic, food, health and education security index are computed based on a number of components. This computation finds that the average level of education, health and economic, status are tremendously low. Moreover, the study area is somehow managed to rich almost half way in terms of food security. From the results of overall security index, it can be concluded that study areas are insecure, wherever it locates. Irrespective of regional differences in opportunities, people in urban squatters appear almost equally insecure. The estimation results of 2SLS model reveal that all the security variables are highly significant determinants of economic security. This result is consistent with the prior expectation as they cause each other. Moreover, those household heads have access to better food will be economically more secured by 47%. Some factors are negatively associated with economic security such as dependency ratio and Family size are significantly negatively related with economic security as estimated. The level of household education is a significant factor for influencing livelihood security. But this estimation shows unexpected significant results when shows the relationship between education level and food security status. Therefore, implementation of programmes for developing economic condition, health and education is highly suggested. It will not be very difficult to implement those programmes to enhance education security and it will also develop over all security. Such preogrammes providing economic security would come up with better livelihood outcomes.

CHAPTER SEVEN

FINDINGS, CONCLUSION AND POLICY IMPLICATION

7.1 Introduction

Water logging is an ordinary and known problem in the city areas and south-western region of Bangladesh. Specifically, the rural areas of Jessore district are getting worsened in socio-economic status by the frequent water logging phenomenon. Most of people of these specific areas are marginalized and live in risky condition. Thus, the present study looks forward to investigate the vulnerability and livelihood security status of the people affected by the water logging problem. In addition, these study categories out the determinants of the household livelihood security. This chapter tries to link up between the specific objectives of the study and the major estimated findings. Based on the key findings and detail analysis, this chapter also draws a concrete conclusion and policy recommendations. Thus, this chapter discusses the inherent hypothesis and significance of the study.

The rest of the chapter is arranged into three sections. Firstly, the section 7.2 discusses the summary of the major findings which are estimated from the mathematical and statistical analysis. Secondly, a rigorous conclusion is drawn in section 7.3 and Finally, section 7.4 presents the policy implications based on the major findings.

7.2 Summary of the Findings

The present study has tried to describe the peoples' vulnerability and livelihood security status due to water logging and identify the factors associated to the livelihood security of the affected people by water-logging in selected areas of Jessore district. In order to obtain the study objectives, a rigorous and unique methodology is adopted. After different mathematical and statistical analyses, this study finds various results. These section there a summary discussion which is the major findings estimated earlier chapters of the present study.

The present study begins with an introductory chapter, which presents a clear insight into the background, problem, objectives and significance of the study. It is observed that Bangladesh is exposed and it is bared to a number of calamities such as floods, tidal surge, cyclone, repeated to water logging and soil erosion, devastating etc, that shaped the people patterns of live and livelihoods. Due to its unique geographical setting, the Southwestern part of the country, mainly Jessore district is the worst victim of water logging problem. The problem is turned to a hazard which displaces the flow of economic growth of Bangladesh by lowering livelihood capacities of these areas. The extended water logging of near about nine months in a year significantly hampered agricultural and other economic activities, rice production of this region notably decreased due to permanent inundation of arable lands and there are areas with people unnaturally living in waterlogged condition confront to lack of safe drinking water, sanitation facilities, shelter, food security and employment opportunity. As a result, the current study is designed to address the impact of water logging on the socio-economic livelihoods of people in Abyahnagar, Manirampur and Keshabpur Upazilas in Jessore District of Bangladesh. As the issue is always overlooked by most of the earlier researchers and the present study analyzes the livelihood security status of the affected people by water-logging problem and determines its significant factors by using econometric methodology, this study has provided some new thoughts in the scant knowledge on the particular issue.

Chapter two reviews various literature and empirical studies comprehensively regarding different concepts, vulnerability and livelihood security related to water logging problem. It clearly represents that the South-West coastal region of Bangladesh is severely affected by the problem of water logging and observed some theoretical and methodological weakness in the previous literature. This chapter finds that earlier studies examined and confirmed the correlation between water-logging and livelihood security of the affected people. Moreover, it is also observed that the calculation of different indices and adoption of econometric methods is rarely seen in the earlier research conducted on water logging.

In chapter three the methodology of the study is presented. The methodology includes a brief research approach, data collection technique, the calculation techniques of the

indices of vulnerability and livelihood security and the empirical design of the statistical model. This chapter is designed to describe the adopted methodologies for answering the four basic research questions. The methodology chapter describes the techniques of data collection to analysis. The chapter three describes that both primary and secondary data are relevant in conducting the present study. Primary data is collected through multi-stage simple random sampling method. It is also found from the methodology chapter that the present study adopts its methodology by following the studies of Huq (2012) and Akter and Rahman (2012). Firstly, the study applies simple statistical analysis including mean, standard deviation, frequency etc. for describing the impacts of water logging problem on the rural households in the study area. Secondly, it follows the methodology of the study of Huq (2012) for calculating vulnerability score which will give the answer of the second research question of describing the vulnerability situation. Thirdly, this study follows the methodology of the study of Akter and Rahman (2012) for finding the answers of the questions related with livelihood security status. For this purpose, the study uses livelihood security index for presenting livelihood security status of the people affected by water logging and applies 2 stages least square (2SLS) technique for the determinants of livelihood security as it estimates a simultaneous equation system.

Chapter four describes the impacts of water logging problem on the livelihood strategies of the water logging affected people in the study area. This chapter finds many significant impacts on the rural household's livelihood. The rural people face the problems of social disruption in terms of school, housing, health, sanitation and market facilities. The daily paid worker cannot continue their daily expenses for the water logging problem as it reduced cropping, transport disrupted, stifled non-farm activities. The frequent water logging phenomenon has depressed agricultural production and converted crop land to shrimp production.

Chapter five presents the vulnerability situation of the affected households by the water logging problem. This chapter analyzes raw data to present the vulnerability in five dimensions, such as social, economic, structural, institutional and environmental dimensions. By observing these five different vulnerability characteristics, finally, the

chapter summarizes the vulnerability situation by constructing an overall vulnerability index. The followings are the main findings of the constructed vulnerability indices.

Level of social vulnerability is calculated as 0.58 which indicates that a good number of households (58%) of the study area are socially in highly vulnerable condition owing to water logging. This is due to influence of various social causes like poor educational quality, insecure job, large family size, gender influence, and so on.

People's vulnerability to water logging is affected by economic characteristics of the households in the study area. The analysis finds that about 62 percent of the households in the study area are economically very highly vulnerable due to their low-income level or because of their overall poor economic condition.

Structural components has also significant role to raise or lessen people's vulnerability. In the study area, it is found that majority (66.0%) households are structurally very highly vulnerable to water logging. Because, the empirical data shows that the housing condition of the households is very poor and the road network of their locality is not good.

The present study reveals that the study areas are very highly vulnerable to water logging in terms of institutional facility. Because of majority (about 72.7%), households of the area did not get any kinds of help or relief (i.e. safe food, pure drinking water, good medical facilities etc.) from government or NGOs in the time of water logging problem.

Environmental variables also can intensify the water logging hazard. In the study area, most of the households (about 64.7%) are very highly vulnerable in consideration of environmental condition. Because, majority households (about 79.3%) of slum area are using low quality toilet, drinking dirty water.

After considering all factors related with vulnerability, the study finds that 40.34 percent households of study area are in very high vulnerable condition. While 27.59

percent, households are highly vulnerable to water logging. Moreover, rest 23.45 and 8.62 percent households are moderately and lowly vulnerable to water logging hazard.

Chapter six represents the livelihood security status of the affected people by water logging and the determinants that affect the livelihood security status. Firstly, the livelihood security status is calculated by using five major livelihood security indices such as food security, economic security, educational security and health security. This chapter finds that on an average, overall security is lower in the study area. But the variation arises from the significant difference in economic, education and food. The domain health security is statistically significant and observed very low throughout the study area (Rahman et al., 2012). Due to the estimated much lower median value, the overall index value is skewed towards the lower values of the indices. This means that the majority are less secured in terms of economic, food, health and educational security.

Secondly, this chapter finds the significant determinants that affect livelihood security status using 2SLS technique for estimating a simultaneous equation system. This analysis finds that all the security variables are highly significant determinants of economic security. The estimated coefficients appear within the expected positive signs. For example, it can be said that if education security increases 10%, the economic security will be raised by 2%. Moreover, those heads has access to better food will be economically more secure by 47%. These results are consistent for food, education and health security throughout the study area. Some factors are negatively associated with economic security such as; dependency ratio and family size are significantly negatively associated with economic security as expected. This result also finds that household education is a significant factor for influencing livelihood security. This indicates that with 10% increase in the level of household education level, health security status increases by 8%. But this estimation shows unexpected significant results when shows the relationship between food security status and education level.

7.3 Conclusion

The socio-economic status of the people of the south-western region of Bangladesh has been worsened due to the problem of water logging. The severity of the problem makes people's livelihoods vulnerable. Therefore, this study examines the vulnerability and livelihood security status of water-logged people in the Jessore region of Bangladesh.

Generally, Bangladesh is a country which faces different water related hazards, mostly in the form of storm surge, water logging, flood, riverbank erosion, cyclonic, drought, and salinity intrusion. Flood is the most regular hazard in this low lying country. Flooding due to tidal surge is also very common especially in coastal Bangladesh. To control the tidal surge, construction of embankment is one of the most popular practices in coastal areas of Bangladesh. Unfortunately, the project of embankment construction alters the hydro geo-physical setting of south-west Bangladesh and gave rise to an adverse phenomenon named 'water logging'.

Therefore, this study firstly tries to investigate the impact of water logging problem in Jessore district, one of the most affected regions of Bangladesh. Secondly, the study identifies respectively the vulnerability and livelihood security status of the affected people by using AHP process and calculating the livelihood security index. Finally, using 2SLS method the study identifies the most important factors which are responsible for increasing and decreasing the livelihood security status of water-logged people in the study area.

Although in some cases water was blessing for the study regions in terms of income and employment opportunities by shrimp production, this in turn causes uncountable havoc to the lives and livelihood of the people in the study regions. People of the area have fled in an exodus to save their previous lives this cruelty of disaster. The rural people face the problems of social disruption in terms of school, housing, health, sanitation and market facilities. The daily paid worker cannot continue their daily expenses for the water logging problem as it reduced cropping, transport disrupted, stifled non-farm activities.

The study estimates that almost half of the households in the study area are in very high vulnerable to water logging and the overall livelihood security is lower in the study area. But the variation arises from the significant difference in economic, food and education. The domain health security is statistically significant and observed very low throughout the study area. This study also finds that all the security variables are highly significant determinants of economic security. Based on the results and experiences gathered through the field survey, the researcher mentioned the following policy recommendations in the next section.

7.4 Policy Recommendations

The followings are the policy recommendations which may be effective in reducing vulnerability and improving the livelihood security status of the water logged people in the Jessore district of Bangladesh. The study also assures that these policies may be significant in adapting national policies and further studies.

- It is urgent to measure and monitor present issues comprehensively and to predict the future impacts of water logging problem to the lives and livelihoods of the study regions.
- For mitigating the identified impacts of water logging, coordinated efforts should be made through public to private agencies.
- It is urgent to provide proper incentives to the water-logged people for the development of coping strategies in times of water logging.
- Production technologies should be intensified for rice based aquaculture practice and promote technologies to increase availability of locally-produced nutrient densed food.
- Social awareness through effective trial and error based educational services and institutional capacity building programmes are needed in order to reduce vulnerability to water logging hazards.
- The government should provide access to financing and capital endowments.
- Given that the average level of education, health and economic, status are tremendously low. Moreover, the study area is somehow managed to rich almost half way in terms of food security. From the results of overall security

index, it can be concluded that study areas are insecure, wherever it locates. Irrespective of regional differences in opportunities, people in urban squatters appear almost equally insecure.

- The use of public mass media i.e. newspaper radio, television, etc. should be increased for creating awareness among the affected areas during water-logging.

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Appendix-A

HOUSEHOLD SURVEY QUESTIONNAIRE

Questionnaire No.:

Name of the respondent:

District:

Upazila:

Union:

Village:

1. General information about respondent:

Relationship with household Head (A)	Sex (B)	Age	Marital Status (C)	Education (D)	Occupation (E)		Occupational Change (F)	
					Main	Subsidiary	Before	Present

A. Relationship with Household head,
1= Household head, 2= Housewife, 3= Husband, 4 = Son, 5 = Daughter, 6 = Father, 7 = Mother, 8 = Grandfather/Grandmother.
B. Gender: 1 = Male, 2 = Female
C. Marital status: 1 = Unmarried, 2 = Married, 3 = Widow, 4 = Divorced.
D. Educational Status: 1 = Illiterate, 2 = >1<5, 3 = Primary school, 4 = >5<10, 5 = S.S.C 6 =H.S.C, 7=Bachelor. , 8=Masters, 9=others

E. Occupation: 01.Unemployed , 02.farmer, 03 .Wage labour ,04.Rickshaw/ Van puller ,05.Fishing , 06.Professional, 07. House hold worker, 08. Maid servant & other salaried worker, 09. Handicraft, 10.Drivers, 11.Beggar, 12.Petty traders, 13. Private/ NGO Worker, 14.Medium/ large traders, 15.Other occupation, ...

2. Background information

2.1 How many years have you stayed here? Ans... .....

2.2 Do you face any water logging problem in your area? Yes /No

2.3 If yes when (Period/Season of the year)?

Regarding Water-logging

2.4 How long the water remains stagnant in the catchments area?

.....

Which area is more vulnerable to water logging?

2.5 According to you, what are the main reasons for water logging in your area.....

2.6 What is the most vulnerable sector due to water-logging in your area?

Impact field	Rank	Impact field	Rank
Human live		Live stock	
Houses		Fishery	
Standing crops		public infrastructure	

3. Influence of social vulnerability

Family Structure

3.1 who is the head of your family: i) You ii) Father iii) Mother iv) Husband v) Others

3.2 Types of family: i) Single ii) Joint

3.3 number of family members:

Gender													
Age													

3.4 Brief information about total family members;

3.5 How many persons are unemployed? i) Yes ii) No

3.6 Is there any person who is disable/mental patient/aged person in your family? i) Yes ii) No

3.7 If yes how many persons? i) 1 ii) 2 iii) 3 iv) More

Social Networks

3.8 Do you have any relatives in this locality? i) Yes ii) No

3.9 If you need help (Financial or anything) then where will you go? i) Relative ii) Neighbors iii) Bank iv) NGO v) Others

3.10 Presently, any members of your family are involved in NGO or other local organization (e.g. somity)? i) Yes ii) No

3.11 If yes, how long days? i) 1-6 i) 6-1 month iii) 1-2 iv) 3-4 years v) More

Coping Strategy

3.12 What is the existing cropping pattern of your farm land? (i) Single crop (ii) Double crop (iii) Treble Crops

3.13 Did you reserve any food before the water logging? i) Yes ii) No

3.14 Do you think there will be another water logging in the future? i) Yes ii) NO

3.15 Do you have any personal vehicle? i) Yes ii) No

3.16 If yes, what is it? i) Van ii) Rickshaw iii) cycle iv) Motorcycle v) CNG vi) pick-up vii) others

4. Influence of Economic Vulnerability

4.1 Properties of the family: i) Land ii) Cattle iii) Agricultural Product iv) Gold v) Radio vi) TV vii) Mobile viii) Nothing ix) Others

4.2 Total family assets (TV, Fridge, Bed, Almeira, Woven, Vehicles, Showcase etc.....):

4.3 Did you continue yourself in your work the water-logging? i) Yes ii) No iii) partially

4.4 If no, why couldn't you continue in your work? i) Working area was water-logged; ii) I was stayed home to look after the possessions, iii) Due to illness

4.5 How many days you could not continue your work? i) 1-3 ii) 4-5 iii) 6-8 iv) 8-10 v) 10-15 days vi) more

4.6 Did your earnings decrease due to water-logged? i) yes ii) No iii) Increased

4.7 Did you lose any possessions due to water-logged? i) Yes ii) No

4.8 Total financial loses (Housing, income, medicine etc.):

Borrowing Status

4.9 Did your family borrow any loan during or after water-logged? i) Yes ii) No

4.10 Do you have any loan? i) Yes ii) No

4.11 If yes, from where? i) Neighbor's ii) NGO iii) Bank iv) Others

4.12 How much money you/your family have got as loan? First specify.....

i) 1000-5000 ii) 5001-8000 iii) 8001-10000 iv) 10001-15000 v) 15001-20000 vi) 20001-30000 vii) 30001-50000 Tk.

4.13 Did you sale anything to pay that loan? i) Yes ii) No

4.14 If yes, what? i) Domestic materials ii) domestic animals iii) vehicles iv) Land v) House vi) Others

4.15 How much was the interest of that loan? i) Interest free ii) 3/4/5/6/7/8/9/10/11/12/13/14/15/16/17 /more

Savings

4.16 Do you have any savings to face further water-logged or flooded? i) Yes ii) No

4.17 If yes, where do you save your money or possessions i) Bank ii) Post office iii) NGO iv) Own v) Relatives vi) Others

4.18 Do you have any kinds of insurances? i) Yes ii) No

4.19 If Yes, which kinds insurance? i) Life insurance ii) Fire insurance iii) Vehicle iv) Flood insurance v) Others

4.20 Any kinds of local emergency funding organizations are concentrated here? i) Yes ii) No

4.21 If yes, types of funding organizations: i) Government ii) Non-government iii) local iv) Others

5. Influence of Environmental Vulnerability

5.1 Sanitation facilities

What type of sanitation facility do you have in your house/area?

Code	type	Distance (time)	No, of users	Own/Sharing
1	Sanitary toilet			
2	Twin-pit			
3	Single-pit			
4	Kacha			
5	others			

5.2 During flood/water-logging, do you face any problem regarding toilet? i) Yes ii) No

5.3 Which water do you use in your daily life? i) Tube well ii) Pond iii) River iv) Others

6. Influence of Institutional Vulnerability

6.1 Did you get any relief during water-logging? i) Yes ii) No

6.2 If yes, who provided the relief? i) Government ii) NGO iii) Others

6.3 What did you get relief? i) Food ii) Cloths iii) Money iv)Medical facilities v) Others

6.4 If no, why did not you get relief? i) Not needed ii) Not provided iii) couldn't reach there

6.5Is here any emergency committee exist? i) Yes ii) No

7. Influence of Infrastructural vulnerability

Housing

7.1 Types of house: i) kucha ii) Pucca iii) Semi-pucca

7.2 Ownership of the house: i) Owner ii) Government iii) Rentiv iv) Relatives v) Others

7.3 Ownership of the land: i) Owner ii) Government iii)Rentiv iv) Relatives v) Illegal occupied

vi) Others

7.4 Did the water-looged damage your house? i) Yes ii) No

7.5 If yes, how much? i) A bit ii) not fitted for living

7.6 who did the reaper the house? i)Own ii) House owner iii) Others

7.7 How much money did you spend for repairing your house? Ans.....

7.8Who helped you by giving money? i) Self ii) Government iii) House owner iv) NGO v) Others

Shelter

7.9 Did you leave the house during water-logging? i) Yes ii) No

7.10 Did you go any shelter? i)Yes ii) No

7.11 If yes, How was the distance from your living house /shelter i) 1-2 ii) 2-3 iii)3-4 iv) 4-5 v) 5-6 km vi)More

7.12 What type of shelter? i) School ii) college iii) Public iv) Non-government institution v) On road vi) On embankment vii) relatives house viii) Others

Road Network

7.13 How is the road network of your locality? i) Very good ii) Good iii) bad iv) very bad v)others

7.14 Is the road inundated during rainy season? i) Yes ii) No

7.15 Is any evacuating road existing here? i) Yes ii) No

7.16 What is your comment about your transport system of this locality? i) very good ii) Good iii) Bad iv) Very bad v) other

7.17 Is any flood dam existing here? i) Yes ii) No

7.18 Is this area geographically flooded prone? i) Yes ii) No iii) No comments

8. Impact of water logging:

8.1 Did your house directly affect by water logging? Yes/ No

8.2 Did you directly affect by water logging? Yes/ No

If yes, please enumerate the amount of damages due to W.L.

Sector	Impact field	No.	Amount
	1. Loss of earning (Tk)		
Household Sector	2. Damage of house (Tk)		
	3. House reconstruction cost		
Agricultural Sector	4. Damage of crop (Tk)		
	5. Loss of livestock (No. &Tk)		
	6. Loss of poultry (No. & TK)		
	7. Loss of fishery (No. &Tk)		
	8. Loss of trees (No. &Tk)		
Social Impacts			
Environmental Problems			

9. Information about family expenditure

Expenditure	Amount(Tk.)
Food	
Cloths	
Transport	
Education	
Housing/Land rent	
Health	
Total	

9.2 Total household Income (Monthly).....

10. Influence of Livelihood Security

Economic Security

1. No of family members?

1.1 How many members of your family are engaged with income?

1.2 Their income (Per month)

1.....

2.....

3.....

4.....

1.3Total value of i) land.....

ii) House.....

iii) Animal Shed.....

iv) Pond.....

1.4 Total value of livestock asset: .....

1.5 Current value of machineries and equipment: .....

1.6 Value of other assets: .....

1.7 No. of active people in your family (15-59 years): .....

1.8 No. of 15-59 population are employed? .....

1.9 Have any women of your family are engaged in income earning activities? i) Yes ii) No

1.10 If yes, How many? .....

1.11 Women income (per month) .....

1.12 amount of saving (Tk.) .....

1.13 Amount of total loan (Tk.) .....

Food Security

1. No. of food groups consumed per day? .....

2. No. of meals and snacks consumed per day? .....

3. Total household food grain stock (Tk.) .....

4. No. of food convenient months in the year? .....

5. No. of main meals taken by women is household? .....

Health security

1. No. of per person suffer from diarrhea last 30 days? .....

2. No. of per person suffer from other sickness last 30 days? .....

3. No. of days an active person unable to work due to sickness? .....

4. Per women frequency of antenatal consultation? .....

5. Women's Height and weight in the households

Height	Weight
i).....	.....
ii)	.....
iii)	.....
iv)	.....
v)	.....

6. No. of children's Height and Weight

Height	Weight
i).....	.....
ii)	.....
iii)	.....

Education Security

1. No. of 7+ population read and write (Literacy)? .....
2. No. of Adult male 15+ literate: .....
3. No. of female 15+ literate: .....
4. No. of adult members have 10 years or more education: .....
5. No. of 6-10 years children enrolled in education: .....
6. No. of 11-15 years boys enrolled in education: .....
7. No. of 11-15 years girls enrolled in education: .....
8. No. of 16-23 years person in household enrolled in education: .....

Food diversity

i) Household takes only cereals .....

ii) Household takes cereals+ roots & tubers.....

iii) Do cereals+ roots & tubers+ pulses.....

iv) Do cereals+ roots & tubers+ pulses +animal origin food.....

v) Do cereals+ roots & tubers+ pulses +animal origin food +vegetables

vi) Do cereals+ roots & tubers+ pulses +animal origin food +vegetables +fruits

vii) Do cereals+ roots & tubers+ pulses +animal origin food +vegetables +fruits + fats & oils

viii) Do cereals+ roots & tubers+ pulses +animal origin food +vegetables +fruits + fats & oils +snacks

Socio-economic diversity

i) Who is the head of your family? i) Male ii) Female

ii) No. of family members? .....

iii) Land owned .....

iv) No .of active person (15-59 years)? .....

v) No. of inactive person (15-59 years)? .....

vi) Age of the household head .....

vii) Education of the household head .....

viii) Head can only write.....

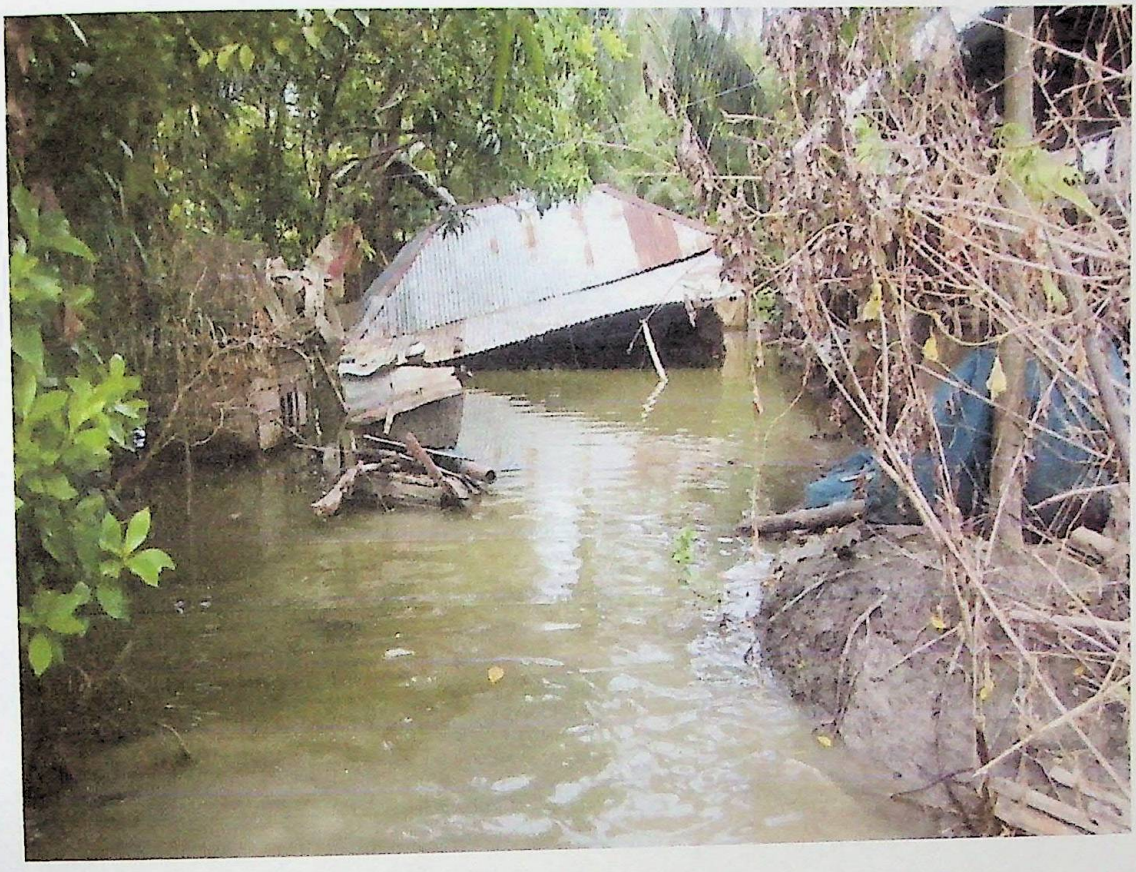
ix) Head can read and write .....

x) Household head received any training .....

xi)

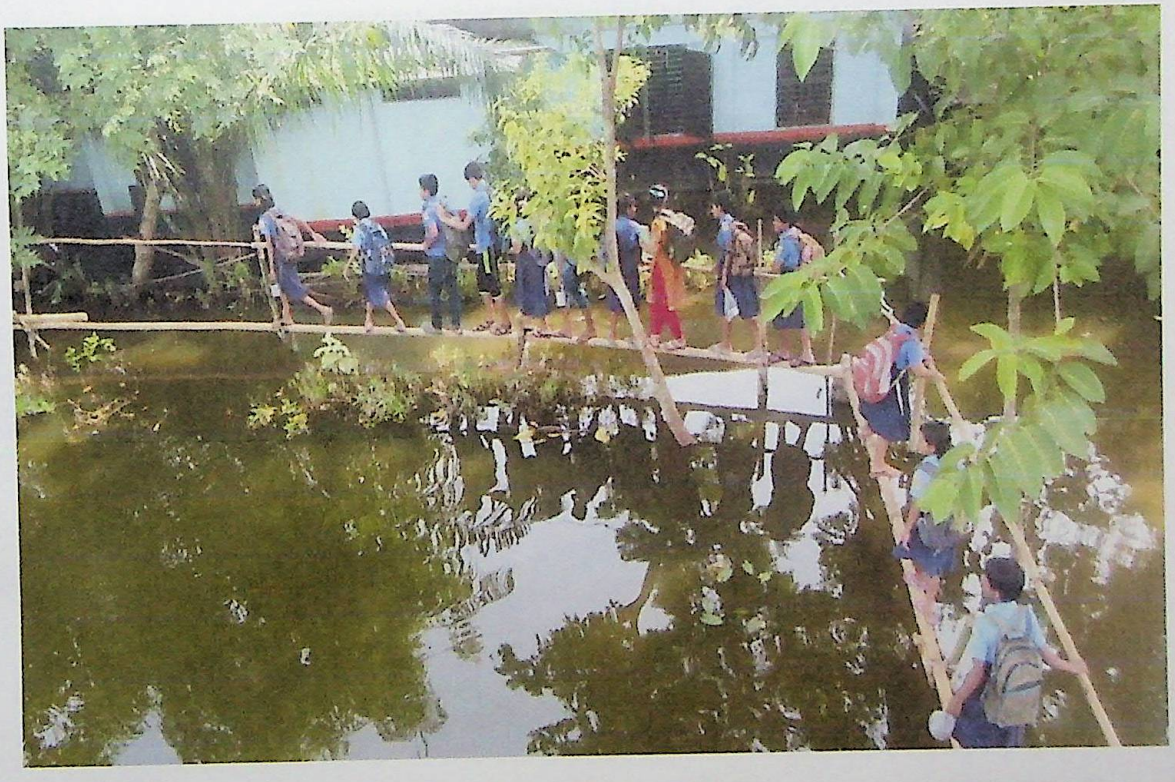
Appendix-B

Photograph of the Affected Areas by Water Logging



Source: Field Survey, 2019

Source: Field Survey, 2019



Source: Field Survey, 2019

Source: Field Survey, 2019

Source: Field Survey, 2019