MS Thesis

"Identification of Drought and Flood Induced Critical Moments and Coping Strategies in Hazard Prone Lower Teesta River Basin"

"Identification of Drought and Flood Induced Critical Moments and Coping Strategies in Hazard Prone Lower Teesta River Basin"

Sk. Junnun Al - Hussain

This thesis paper is submitted to the department of Geography & Environmental Studies, University of Rajshahi, as a partial fulfillment of the requirements for the degree of MS - 2015.

SUBMITTED BY

Roll No. 10116087
Registration No. 2850
Session: 2014 - 15
MS Exam: 2015

April, 2017
Third Science Building

Department of Geography and Environmental Studies,
Faculty of Life and Earth Science

Rajshahi University
Rajshahi - 6205

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Dedicated

To

My Family

Declaration

The author does hereby declare that the research entitled **"Identification of Drought and Flood Induced Critical Moments and Coping Strategies in Hazard Prone Lower Teesta River Basin"** submitted to the Department of Geography and Environmental Studies, University of Rajshahi for the Degree of Master of Science is exclusively his own, authentic and original study.

The author further declare that the thesis or any part of it at any form, has not been submitted to any other university or institute for any degree, diploma or for other similar purposes.

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Certificate

I have the pleasure to certify that the research entitled **"Identification of Drought and Flood Induced Critical Moments and Coping Strategies in Hazard Prone Lower Teesta River Basin"** is the original work of Sk. Junnun Al - Hussain. As far as 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 to the Department of Geography and Environmental Studies, University of Rajshahi in partial fulfillment of the requirements for the degree of Master of Science.

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Abstract

In north-western part of Bangladesh in lower Teesta basin area, people repeatedly confronted by natural catastrophe almost every year such as drought and flood. After the construction of two barrages in Gozaldoba and Dalia on Teesta river drought and flood occurs almost every year. Intensity and frequency of these calamities are also increasing in an alarming rate, which caused serious damage to livelihoods and economy of this area. Both the study villages Charkharibari and Jigabari are located in lower Teesta basin area which is equally drought and flood area. Charkharibari village is situated on Charland that is located on the right bank of upstream of lower Teesta River. Jigabari village is situated on inland that is located on the left bank of downstream of lower Teesta River. Between the two villages severity of drought and flood is higher in Charkharibari village. Assessment of agricultural critical moment shows, in both study areas drought affects directly the production of Boro (HYV), Potato, Maize and Onion. It extends from mid-January to February consists of 25-30 days of dry spell. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by pumping water from the nearby river by using shallow machines. In both study areas flood affects directly the production of Ground-Nut and T.Aus. This period falls in Monsoon. Type of coping strategy for stagnant water is selling crop in advance and sometimes no coping capacity.

Assessment of pecuniary critical moment shows, in both study areas drought affects directly the income sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village drought induced pecuniary critical moments extends from late-January to late-March consists of 45-60 days of dry spell. The main problems of this critical period are lack of agro-based work, acute financial crisis and acute unemployment. Local inhabitants try to cope with these problems during critical stage by temporary migration, borrowing loan, wage earning, by selling properties, by getting debit and by selling labor in advance. Flood induced pecuniary critical moments extends from early-July to mid-August consists of 5-30 days of flood stagnant water.

In both Charkharibari and Jigabari village drought induced nutritional critical moments extends from late-January to early-March consists of 30-45 days of dry spell. The main problems of this critical period are lack of cereal, lack of cooking materials and acute food shortage. Local inhabitants try to cope with these problems during critical stage by change in number of main meal intake, borrowing loan to buy food grain, borrowing food from other household, selling properties and borrowing food from shop by debit. Flood induced nutritional critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water.

In both Charkharibari and Jigabari village drought induced aquatic critical moments extends from late-January to mid-March consists of 45-60 days of dry spell. The main problems of this critical period are acute shortage of drinking water, scarcity of daily use water. Local inhabitants try to cope with these problems during critical stage by drinking unhygienic water from river, lessening their water usage. Flood induced aquatic critical moments extends from early-July to mid-August consists of 10-20 days.

In both Charkharibari and Jigabari village drought induced health critical moments extends from late-January to late-March consists of 45-60 days of dry spell. The main problems of this critical period are pox, black fever, skin disease, jaundice, women’s’ menstrual related problems and heat stroke. Local inhabitants try to cope with these problems during critical stage by managing somewhat medical facility that is available to them. In both Charkharibari and Jigabari village flood induced health critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water. Flood induced health critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water.

Assessment of drought and flood induced critical moments and their coping capacities show that Charkharibari village has more problems but less coping capacities than Jigabari village. And coping capacity against these critical periods are highly influenced by income, occupation, education, frequency and duration of hazards. Peoples’ demands varies during and after these critical periods. However it is evident that proper dissemination of information regarding early warning and assistance from governmental as well as non-governmental organizations can significantly improve the coping capacity of people.

Abbreviations and Acronyms

AEZ	Agro Ecological Zone
APF	Adaptation Policy Framework
BADC	Bangladesh Agriculture Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBC	British Broadcasting Corporation
BBS	Bangladesh Bureau of Statistics.
BMD	Bangladesh Meteorological Department
BPDB	Bangladesh Power Development Board
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
BWFMS	Bangladesh Flood and Water Management Strategy
CI	Cropping Intensity
CCIAV	Climate Change Impacts, Adaptation and Vulnerability
CDP	crop diversification program
CFC	Choloro Fluro Carbons
COP	Conference of the Parties
DAE	Department of Agricultural Extension
DAP	Detailed Area Development Plans
DFID	Department For International Development
EIA	Environmental Impact Assessment
EPB	Export Promotion Bureau
ENSO	El Nino Southern Oscillation
FAO	Food and Agriculture Organization
FCDI	Flood Control, Drainage and Irrigation projects

GBM	Ganga, Brahmaputra and Meghna
GCM	Global Climatic Model
GIS	Geographical Information System.
GOB	Government of Bangladesh.
Hec.	Hector.
HI-AWARE	Himalayan Adaptation, Water and Resilience
HH	Household
HRC	Horticulture Research Centre
HYV	High Yield Varieties
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
IWRM	Integrated Water Resources Management
FAP	Flood Action Plan
FFWC	Flood Forecasting and Warning Center
Km	Kilometer
LGED	Local Government Engineering Department
MOA	Ministry of Agriculture
MCA	Multi Criteria Analysis
MDG	Millennium Development Goal
NAPA	National Adaptation Program for Action
NGO	Non-Governmental Organization
NWMP	National Water Management Plan
NWP	National Water Plan
PET	Potential Evapo - Transpiration
PRSP	Poverty Reduction Strategy Paper
SAARC	South Asia Association for Regional Cooperation
SDG	Sustainable Development Goal
SPSS	Statistical Package for Social Scientists
Sq. Km	Square Kilometer
SRDI	Soil Resource Development Institute

SST	Sea Surface Temperature
TAR	Third Assessment Report
TK	Taka
TBP	Teesta Barrage Project
TRF	Teesta River Flood-plain
USA	United States of America
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organization
Yr.	Year

Glossary

District	: The Second order local Government unit in Bangladesh.
Jujubi	: A kind of kul which is locally known as Jujubi
Landowner	*:* A person who owns land.
Paved road	: Permanent metaled road, concrete of bituminous surface and other metaled Roads/structure.
Semi-paved road	: Brick mode semi permanent road/structure.
Union	*:* Smallest electoral unit of rural area, which is comprised of *mauzas* and villages, is known as union. A union has a *union*parishad.
Unpaved road	: Impermanent, unofficial, as opposed to *pucca road.*
Upazila	*:* A higher tier of the local government administration in Bangladesh. It is positioned in the third step of administration, *e.g.*, Division, District, and then *upazila*. *Upazila* comprises two or more unions and district is comprised of two or more *upazilas* and finally division consists of two or more districts. It is estimated that the administrative area of an *upazila*is about 181 sq. km on an average and an average of 176,000 populations live under its administration.
Village	*:* Smallest geographic area of rural area, which is known to the people as village. A village may be same as *mauza* or there may be more than one village in a *mauza*. A village is always populated.

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Chapter One

Background of the Study

1.1. Introduction

According to Fifth Assessment Report of IPCC, South Asia is the most vulnerable region of the world to climate change impacts. The international community also recognizes that Bangladesh ranks high in the list of most vulnerable countries on earth (McCarthy et *al*., 2001). Climate change is a major threat to sustainable growth and development in Bangladesh and the achievement of the Sustainable Development Goal (SDG). Although Bangladesh is the country least responsible for climate change; it is vulnerable to the effects, the increased incidents of both flooding and drought (Rashid et al, 2009). In the north-western part of the country the one of the major source of water for daily livelihood and particularly for agriculture is harvested from the Teesta River. Teesta Barrage Project (TBP), which is located at the Teesta flood plains, at Dalia in Lalmonirhat district has been a major source of surface water irrigation in north-west by gravity flow since 1990. But India has also constructed a barrage in its side of the territory at Gozaldoba. In addition, due to climate change, the weather in Bangladesh has changed especially in the North-western part, Teesta river basin area and in the southern part of Bangladesh. The incidents of floods, droughts, dry spells have all increased affecting both people's life style, livelihood practices like agriculture, fishing and other employment, and socio-cultural environments. The present study is concerned with the impact of increased number of drought and flood risks that affects the livelihood security and identification of critical moments and adaptation strategies of the inhabitants of the Teesta basin.

1.2. Statement of the Problem

Once Teesta was a narrow but deep river (Roy, 2014). But due to two barrages in both India and Bangladesh the sedimentation rate has increased. Himalayan glacier melt increases due to climate change, trigger the high erosion rate and as a result sedimentation increased. Due to lack of dredging the situation got worsen. The monsoons brings about a very dangerously high level of water flow, leading to massive flooding in the Teesta basin area, especially in the chars and surrounding low lying villages. During the monsoon India opens all the gates of their Gozaldoba barrage, which causes massive floods (Roy, 2014). In north-western part of Bangladesh, frequent flash floods devastate the poor and marginalized communities, destroying their homes and precious assets, year after year.

Climate change scenarios suggest an increase in extreme rainfall coupled with the melting of the Himalayans will contribute to a greater frequency of riverine and flash floods (WB, 2014).

TBP, which is located at the Teesta flood plains, at Dalia in Lalmonirhat district has been a major source of surface water irrigation in north-west by gravity flow since 1990. But Gozaldoba barrage, has resulted in a low water level in Teesta River that ultimately cause scarcity of water (Mbugua, 2011). This makes parts of north-western Bangladesh are becoming desert. Changes in rainfall pattern caused extreme water scarcity in the dry seasons (Ahmed, 2010). In Bangladesh, approximately twenty (Habiba et al, 2011) drought events have been experienced from 1973 to 2011. Nineteen of them occurred in the Teesta river basin area. The utmost rainfall variability is considered to be an important cause of drought in the north-western part of Bangladesh. The Teesta river basin area of Bangladesh identified as a recurrent and irresistible drought prone area (Paul, 1998). The recurrent drought and its severity accelerate to increase vulnerability and poverty (Rakib et al, 2013).

1.3. Operational Definition of Key Terms

Climate change, Hazard, Flood, Drought, Critical moment, Adaptation strategies.

Climate Change

"A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing's, or to persistent anthropogenic changes in the composition of the atmosphere or in land use." - IPCC, 2007.

Hazard

"A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage." – UNISDR, 2004.

Flood

"Flood is overflowing by water of the normal confines of a watercourse or other body of water. Rise in water level, usually brief, in the water level in a stream to a peak from which the water level recedes at a slower rate. Relatively high flow as measured by stage height or discharge." - WMO, 2000.

Drought

"Drought means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems." - UNCCD, 1994.

Critical Moment

'Critical climate stress moments' are defined as those moments when a household, communities and the livelihood systems they depend on are particularly vulnerable to climate and weather-related risks and hazards. This includes events differing for spatial and temporal scales (and responsible dynamical processes) such as: heat-waves, cold spells, flood, drought, hail). – HI-AWARE, 2016.

Coping Strategies

"Coping refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change." - UNFCCC, 2006.

1.4. Present Scenario of the Study Area

This project is conducted on the lower Teesta river basin. Below the present scenario of the project area is described in details.

1.4.1. Teesta River

The Teesta River originates in the Himalayas and flows through the Indian States of Sikkim and West Bengal before entering Bangladesh, where it flows into the Brahmaputra. Flowing through the length of Sikkim, the Teesta River is considered to be the lifeline of the state. The Teesta valley in Sikkim is rich in biodiversity, and the river provides livelihoods for the residents along its entire length of 393 km (245 miles). The Teesta River originates from the Pahunri (or Teesta Kangse) glacier above 7,068 meters (23,189 ft.), and flows southward through gorges and rapids in the Sikkim Himalaya (Meetei et al. 2007).

It is fed by rivulets arising in the Thangu, Yumthang and Donkha mountain ranges. The river then flows past the town of Rangpowhere the Rangpo River joins, and where it forms the border between Sikkim and West Bengal up to Teesta Bazaar. Just before the Teesta Bridge, where the roads from Kalimpong and Darjeeling join, the river is met by its main tributary, the Rangeet River (Chaudhuri & Chaudhuri, 2015). At this point, it changes course southwards flowing into West Bengal. The river hits the plains at Sevoke, 22 kilometers (14 mi) northeast of Siliguri, where it is spanned by the Coronation Bridge linking the northeast states to the rest of India. The river then goes merging up with the Brahmaputra River after it bifurcates the city of Jalpaiguri and flows just touching Cooch Behar district at Mekhliganj and moves to Fulchori in Bangladesh (Joshi, 2004).

The Teesta River has become a contested battleground between the government and the indigenous Lepcha and Bhutia communities in Sikkim, India. The government of India hopes to dam the last free-flowing 13 kms (8 miles) of the Teesta River for hydropower. Already over 71 kms (44 miles) of the river – which flows through earthquake-prone, ecologically and geologically fragile terrain – is either in reservoirs or diverted through tunnels for hydropower generation. These dams pose a threat to river communities and the rich biodiversity of the region. Studies of potential projects along the Teesta River lack the rigorous environmental and social assessments necessary and fail to properly address potential long-term cumulative impacts the dams will have. While the forces pushing for hydropower development in the region may be strong, they are rivaled by the spirit and perseverance of indigenous communities of Sikkim fighting dam development. These include the Affected Citizens of Teesta (ACT) and Sikkim Bhutia Lepcha Apex Committee (SIBLAC). Community efforts have resulted in the Government of Sikkim cancelling the construction of a total of 10 dams, with the last four cancelled in June 2012. Downstream, the issues and concerns are different. A bilateral treaty between India and Bangladesh on sharing Teesta waters has failed to materialize, despite efforts and a plethora of committees. While canals from barrages have helped agriculture in India and Bangladesh, the fishing communities have suffered. Farmers are very concerned, and say that given the number of hydropower dams planned upstream, they are not sure how long they will continue to get water when they need it. International Rivers is working to support groups that are fighting dams on the Teesta River and joins them in their efforts to protect this environmentally and culturally unique region in Northeast India.

1.4.2. Teesta Barrage

Teesta Barrage is located on Teesta river at Duane in Hatibandha upazilla in Lalmonirhat district of Bangladesh. The barrage is a 615m long concrete structure fitted with 44 radial gates having a discharge capacity of 12,750 cusec of water. It is used to divert 280 cusec of water for irrigation through a canal taking off on the right bank. The construction of the barrage started in 1979 and that of the irrigation canals in 1984, and was completed in 1997-98. Coordinate is 26°10'42"N 89°3'6"E. The idea of irrigation from the Teesta was conceived some time in 1935.

1.4.3. Climatic Hazards in Teesta River Basin

Due to climate change and several other reasons Teesta river basin area is facing several climatic extremes. Major climatic hazard in Teesta river basin are flood, riverbank erosion and drought.

1.4.3.1. Flood in Teesta River Basin

Once the Teesta that used to hold water throughout the year now dries up just after the monsoon. Numerous chars and shoals have been emerged on the riverbed. The discharge capacity of Teesta has drastically been reduced due to withdrawal of water and the discharge of heavy silts from the upper catchments. A series of dams and barrages erected over the vibrant river are virtually causing its death. The shrinkage of the river has been causing heavy erosion almost throughout the year displacing and making destitute hundreds of people every year. It seems certain that the dynamic equilibrium of the river will be impaired with the construction of a series of dams and the sediment load will be trapped within the reservoirs, reducing their capacity. This, in turn, could compel dam managers to release water during heavy rainfall, causing sudden flash floods downstream (Islam, 2009).

The most common water-related natural hazard in a deltaic floodplain such as Teesta river basin is flood. Flooding in Teesta river basin is the result of a complex series of factors.

These include a huge inflow of water from upstream catchment areas coinciding with heavy monsoon rainfall in the country, a low floodplain gradient, and congested drainage channels. Different combinations of these various factors give rise to different types of flooding (Ahmed and Mirza, 2000).

Three main types of natural floods occur in Teesta river basin: flash floods, river floods, and rainwater floods (Ahmad *et al*., 1994; Ahmad *et al*., 2000). Flash floods take place suddenly and last for a few hours to a couple of days. Run-off during exceptionally heavy rainfall occurring in neighboring upland areas is responsible for flash floods. Such floods occur as waters from the hilly upstream rush to the plains with high velocity, mauling standing crops and destroying physical infrastructure (Ahmed and Mirza, 2000).

Rainwater floods are caused by heavy rainfall occurring over Teesta river flood plain (TRF). Rainwater flooding is characteristic of meander floodplains, major floodplain basins, and old piedmont and estuarine floodplains. Heavy pre-monsoon rainfall (April-May) causes local run-off to accumulate in floodplain depressions. Later (June-August), local rainwater is increasingly accumulated on the land by the rising water levels in adjoining rivers. Thus, the extent and depth of rainwater flooding vary within the rainy season and from year to year (Ahmed and Mirza, 2000).

Normal river floods generally occur during monsoon. River floods result from snow-melt in the high Himalayas and heavy monsoon rainfall over the Himalayas, the Assam Hills, and the Tripura Hills outside Bangladesh. River floods extend beyond the active floodplains and damage crops in parts of the adjoining meander floodplains, mainly alongside distributary channels. The timing of the flood (whether early or late) and sometimes the duration of flooding are as important determinants of crop damage as is the absolute height reached by a particular flood. Sediments deposited in channels reduce the drainage capacity of minor rivers, road and railway bridges and culverts, as well as irrigation and drainage canals (Ahmed and Mirza, 2000).

1.4.3.2. Riverbank Erosion in Teesta River Basin

Riverbank erosion is one of the major natural calamities of Teesta river basin that took place in almost every year. The effect of this disaster is widespread. Riverbank erosion is one of the most unpredictable and critical type of disasters that takes into account the quantity of rainfall, soil structure, river morphology, topography of river and adjacent areas, and floods. Such calamity took tolls less in lives but more in livelihood as agricultural land and homesteads along with other livelihood options that are evacuated. The main reason of such variation is because of climate change induced intensifying rainfall pattern and unplanned interventions. Respondents of poor income level have less opportunity in expending money on food consumption, educational expense and getting health care facilities. Poor income also lessens the opportunity to invest in educational sector. However, bank erosion also evacuated schools and impedes the children in going to school that eventually increase the dropout rate. Moreover, during the period when bank erosion strikes, they faces enormous health burden. People of Teesta river basin areas are generally poor and such loss makes them ultra-poor. Such situation, in turn, makes them more vulnerable to migration and search for a hazardous job. The marginalized and poor people not only lost property but also experienced socioeconomic deprivation through displacement. Because of the dynamic character of the braided channeled river and the failure of structural measures, the sufferings of the people continue (Uddin and Basak, 2012). Every day, the number of people who are made landless increases because of the riverbank erosion. Many families are now livinh in temporary shelters on the Teesta river's embankment, and for them it has become exceedingly difficult to meet their basic needs. They are facing problems to do with food insecurity, and many cannot manage three meals a day (Naznin, and Syed, 2015).

1.4.3.3. Drought in Teesta River Basin

The Teesta has been drying up at different points during the dry season threatening the Boro cultivation in six northern districts. The once mighty Teesta is now bereft of water following construction of a barrage upstream at Gojoldoba point in Jalpaiguri of the Indian state of West Bengal. The farmers in Nilphamary, Lalmonirhat, Gaibandha, Rangpur, Dinajpur and Bogra are worried over the bleak prospect of getting required quantum of water from the Teesta for the irrigation of Boro fields. The construction of the barrage on this river across the border to divert its flow of water has badly affected the efficacy of the Teesta Barrage Project. According to Water Development Board sources, Bangladesh got only about two per cent of the required quantum of water from across the border last year.

The release of such low quantum water was affecting navigation, irrigation, fishery and ecology of our lower riparian country, the sources added (Islam, 2009).

On the other hand, they said, there should be 10,000 cusecs of water to bring an estimated 111,000 hectares under the Rabi crop program but only 1,000 to 1,200 cusecs are now available in the upstream of the Teesta Barrage. The Indian authorities are reportedly withdrawing the total water from the rivers Teesta and Mohananda through their Gojoldoba and Mohananda Barrages in the upstream. It can be seen from the chart below that the average lowest discharge of Teesta was above 4,000 cubic meter/sec before construction of the two barrages — one at Doani in Bangladesh and other at Gojoldoba in West Bengal. But after construction of two barrages the lowest discharge has drastically reduced to 529 cum/sec in 2000 and just after five years in 2005 it came down to just 8 cum/sec. I think, there requires no further explanation what is going to happen to the fate of the Teesta in the near future. On the other hand, in the Indian part, the mean annual discharge of the Teesta at Anderson Bridge was about 580 cum/sec a decade back and it declines to 90 cum/sec in the lean months. The peak discharge may be as much as 4,000-5,000 cum/sec. It was estimated that the peak discharge of the river at Jalpaiguri during the devastating flood of 1968 was 19,800 cum/sec (Islam, 2009).

The sediment load in the river increases with high monsoon discharge. It was observed that 72 per cent of the suspended load is transported between July and August when the bulk of discharge flows through the river. And these things altogether create a drought phenomenon in Teesta river basin every year (Islam, 2009).

Records show that 19 drought periods occurred in Bangladesh between 1960 and 1991. 12 of them was in Teesta river basin area. This means a drought every 1.6 years. In the decade between 1985 and 1998 the temperatures in Bangladesh increased by 1degree Celsius in the month of May and 0.5 degree Celsius in the month of November. This change in temperature is relatively high compared to the IPPC projection of 0.2 degrees Celsius per decade. Despite this increased warming in Bangladesh, extreme lower temperatures have been observed e.g. the lowest winter temperature in 38 years was recorded in 2007 reading 5 degrees Celsius. In the last 3-4 decades when climate change began to be observed in the NW region of Bangladesh, the situation has progressively got worse. Surface water has disappeared from ponds and canals and even major rivers have reduced water volume.

Deep wells, shallow machine wells used for irrigation and the tube wells used for domestic needs have been deepened with time as the ground water level continues to go down. Whereas the area of NW had become a food surplus area after introduction of deep well water for irrigation, and the development of Teesta Barrage Project, TBP, such gains are getting lost due to inadequate water (Mbugua, 2011).

1.4.4. Climatic Change in Teesta River Basin

It is sometimes easy to forget when using the term 'climate change' that actual climate change, the real on-ground realities, are locally based and part of smaller scale experiences that make up this larger term. Climatic changes and stressors upon livelihoods are experienced differently by different communities of people, despite their locations within, for example, the same river basin. As a result, adaptation pathways within river basins are also likely to be heterogeneous. Biggest climatic stressor upon livelihoods was water availability in Teesta river basin. Although there are natural water sources – small rivers flow in the lean season is insufficient to support livestock and crop production (Spencer, 2015).

As a result of climate change, water scarcity-especially in the Northern part of Bangladesh specifically in Teesta river basin is rising highly. A second result of climate change is the change in rainfall pattern, delaying monsoon rainfall means heavy rainfall occurs within a shorter period. Another consequence of climate change is the melting of Himalaya glacier at a fast rate, resulting in reduced water amounts in the Teesta eventually. Health related and social problems, as well as reduced food intake and malnutrition have devastating impact on the livelihood of the marginalized groups, the poor local farmers and especially women, children and elderly (Forid, 2013).

To cope with the adverse impact of climate change farmers have changed farming pattern. Now they are cultivating maize, Boro, ground nut, “china”, “kawn”, pulses, mustard, “gunji till”, wheat, tobacco, watermelon and other crops on vast tracts of sandy bed of these dried-up riverbeds now. Crop farming began long ago as the rivers dry up abnormally every year during dry seasons in Kurigram, Gaibandha, Nilphamary, Lalmonirhat, Rangpur, Bogra, Jamalpur and Sirajganj districts, said Nurul Amin Sarkar of Chilmari and Abdul Wahid of Kaunia. Taramon Bibi, Bir Pratik, said it took four hours in crossing the 25 km river-route from Chilmari to Rajibpur or Roumari by engine driven boat as the water vessels slowly move through huge zigzag channels due to appearance of hundreds of submerged shoals. Drought, flash floods and massive erosion are occurring almost every year due to unbridled rise of riverbeds from abnormal deposition of silts because of the ongoing climate change throughout the Teesta river basin. The experts said the future of human civilization would depend on the success of adapting with the adverse impacts of climate change and innovating newer ways towards the directions in the region (Ahmed, 2013).

1.5. Research Gap

A number of studies regarding climatic hazard and its impact on Teesta flood plain have been done. Some studies have done regarding the shortage of water and its impact on agriculture and aquaculture. Studies have been done to find the solution for rural poverty alleviation in Teesta Barrage Project (TBP) area. They have also found that changing cropping pattern to mitigate the water shortage problem. These studies have given emphasis mainly on impact of Teesta barrage on agriculture and fishery production. But, there is no research regarding to find the critical moments for drought and flood and adaptation strategies during critical moment. So, there is a research gap in those previous studies. As a result in this research paper is attempted to meet this gap.

1.6. Research Questions

The proposed research will try to find out the critical moments and adaptation strategies of the inhabitants against drought and flood. In doing so, the following relevant questions have been arisen by going through the literature:

I. How population of study area are affected by climatic and non-climatic factors or drivers?

II. Which activities are mostly affected by climate hazards and climate vulnerability and at what time of the year the adverse impact is the highest?

III. What is the most critical moment for the house hold (immediate relief, recovery) in post hazard situation?

IV. Which specific climate conditions (thresholds), biophysical and socio-economic factors cause these periods of high vulnerability?

V. What strategies generally people taken to adopt with critical moments?

1.7. Objective of the Study

General Objective The general objective of this study is to find out the critical moments and adaptation strategies for drought and flood of the inhabitants of lower Teesta river basin.

Specific Objectives In order to achieve the overall purpose, the following specific are to be pursued:

I. To identify the impact of climatic and non-climatic factors/drivers on the inhabitants.
II. To identify the most critical moment for the house hold.
III. To identify the most affected sector.
IV. To identify the specific climate conditions (thresholds), biophysical and socio-economic factors cause these periods of high vulnerability.
V. To identify the strategies people adopt to cope with critical moments.

1.8. Justification of the Study

Bangladesh's high vulnerability to climate change is occurred due to a number of hydro-geological and socio-economic conditions that include: (a) its geographical location in South Asia is between Himalayas and the Bay of Bengal, (b) other those 12% hill and 8% terrace region and deltaic topography with the low elevation, (c) extreme climate variability that is governed by monsoon, (d) high population density and poverty incidence; and (e) majority of the population are dependent on crop agriculture which is highly influenced by climatic variability and climatic hazard. Bangladesh is already facing the adverse impact of climate change on agriculture, biodiversity, extreme environmental hazards, and socio-economic conditions. Teesta is the fourth major trans-boundary river in Bangladesh. Upstream inflow in this river provides key support to agricultural production in lower Teesta River Floodplain (TRF) in the north-west region of the country. But after the construction of Dalia and Gozaldoba barrage this floodplain have become a both drought and flood prone area. In dry season there is an enormous reduction of water flow and less precipitation due to climatic variability resulting a cyclic drought phenomena. And on the rainy season when there is heavy rainfall and climate change induced accelerated Himalayan glacier melting cause a series of flash floods. So, the inhabitants of lower Teesta basin have to cope with drought and flood respectively in the same year. Available literature on the Teesta does not give a precise and uniform picture of critical moment and adaptation strategy either. Critical moments assessment aims to support community members and adaptation planners in the development of more tailored climate change adaptation responses by identifying bio-physical drivers and conditions leading to vulnerability and climate change impact. The information on weather and climate variability and climate change and specific thresholds associated with critical moments can be used to tailor the analysis of climate change models and to inform, tune and interpret the outputs of the hydrological impact model. And identifying the drivers of socio-economic and political drivers of vulnerabilities giving rise to the critical moments, as experienced and perceived by the most vulnerable and by a range of stakeholders at the local level. It will also identify the effectiveness of current coping strategies to overcome critical stress moments. In addition, differences in gender roles at household level due to institutional, cultural and societal constitutions or framework that govern local households are increasingly being recognized as an important area of focus in the study of climate change induced hazard adaptation. Furthermore, identification of the determinants of choices of adaptation strategies to hazardous events by gender and the impact of adaptation on livelihood cannot be underscored. By throwing light on these issues, novel insights from the study finding will; first, increase the understanding in the analysis of climatic stress critical moments and its determinants. Second, increase awareness of the role of gender in adaptation in order to improve gender and climate policies. In other words long term coping mechanisms implementation efforts if they are to be scaled up can be appropriately targeted using evidence from the study. Third, since the study delves into new grounds on estimation of the impact of adaptation strategies on livelihoods, this result is important to the public and policy makers through the incorporation of demand-side information into the design of the climate policy agenda and the roles of the key stakeholders in the implementation process. Given the absence of research on critical moments and adaptation strategies this type of research is important. Even though this research is undertaken in a single basin in Bangladesh, the basic methods and framework developed in this research are expected to be applicable elsewhere in the world and the research finding will be useful in enhancing the existing knowledge in this field to the scientific community. The above background, therefore, provides the necessary basis and justification for this research study.

1.9. Scope of the Study

The scope of this study is assessing critical climatic stress moments during flood and drought for different sectors in a region of a developing country where there is high dependency on agriculture and high vulnerability to climatic variability. The assumption here is that climate change has created extensive climatic variability causing increased intensity of both flood and drought; potentially resulting a series of critical moments for different sectors. Finally, this study utilizes the concept of critical moment analysis, a new type of situational vulnerability analysis that is aimed at understanding the specific climate conditions (thresholds), biophysical and socio-economic factors cause these periods of high vulnerability. Also this study will try to identify the strategies people adopt to cope with critical moments and further guidelines. It will find out which sector is most affected by flood and drought respectively. Beside this type of research is hardly found which give a scope of the present study.

1.10. Limitation of the Study

This study has a number of limitations. The study is mostly based on primary data and information. Due to the large area coverage, it was not possible to carry out a comprehensive direct field study covering the whole area. So, the study area was selected by simple random sampling. The main limitations are as follow:

- Time – There was a limitation of time, therefore all data and other necessary general information were collected within the shortest possible time.
- Sample size – The study was concluded in only two unions with a very small size of population, if bigger sample size was used then the values will be more significant, as statistical tests normally require a larger sample size to ensure a representative distribution of the population and to be considered representative of groups of people to whom results

will be generalized or transferred. Therefore, the scope of generalization is limited and may not accurately represent the actual situation prevailing all over Bangladesh. But, the sample size and area is no doubt represent which will be able to present the actual scenario in this context.

- Gender equity - This study is mainly based on primary data, which was acquired by house hold questionnaire survey. While doing survey it was difficult maintain gender equity which is 50% male respondent and 50% female respondent.
- Access – This study depends on having access to people, organizations. Study areas were remote places. For this reason access was limited.
- Fluency of language – Local dialect was a communication become an obstacle at the time of collecting primary data.
- Illiteracy – Most of people are not well educated. They cannot understand the value of providing proper information. So, sometimes they cannot provide accurate information. As a result, in some cases the accuracy of data depends upon their memories and sincerity.
- Secondary data – Though flood and drought in lower Teesta basin are very common hazard but there is limited research on this topic especially on assessing critical stress moments.

1.11. Theoretical Approaches and Conceptual Framework

A theoretical approach is a collection of interrelated concepts, like a theory but not necessarily so well worked-out. A theoretical framework guides the research, determining what things will be measure, and what statistical relationships will be look for. This chapter aims to illustrate various vulnerability assessment approaches.

1.11.1. Various Theoretical Approaches

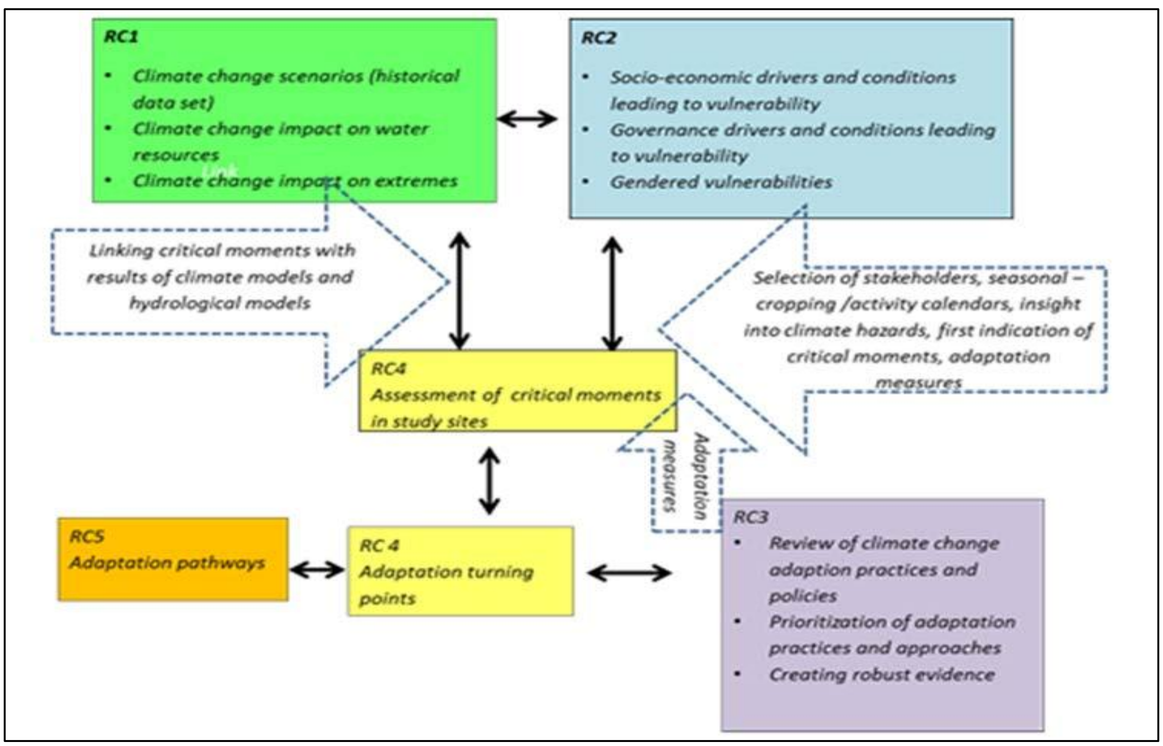
Different fields of research have developed their own approaches to vulnerability, often heavily influenced by their topical and disciplinary foci (Füssel, 2007; Gaillard, 2010; O'Brien et al., 2007; Sumner & Mallett, 2013). This has created multiple frameworks for understanding vulnerability to climate change and its subsequent classification (Adger, 2006; Gallopin, 2006; Luers, 2005; Vincent2007). The reductionist exposure perspective has been abandoned by hazards research that has come a long way from its initial focus on engineering structural interventions to control the physical risk of hazards. Since the 1970s, research on vulnerability has broadened the temporal and spatial scales of analysis of disasters, and the emphasis shifted towards including deeply embedded social characteristics (Sen, 1981; Wisner et al., 2004; Turner et al., 2003) and recognizing individual and collective perceptions of risk and the ways in which those perceptions affected hazard-related behavior. Work by Hewitt (1983) and Blaikie and Brookfield (1987) changed the direction of hazard research, emphasizing the influence of social structural factors on differential access to resources and hence differential susceptibility to environmental extremes. Political ecologists were more concerned with issues of class, type of economic development, international dependency, gender and deeper social structures in explaining the causal chain of vulnerability (Blaikie et al., 1994 Enarson and Morrow, 1998; Mustafa, 1998; Watts and Bohle, 1993; Wisner, 1993). Acknowledging how risk is perceived and handle by those experiencing it, the critical moment concept aims at building on and improve what (Tschakert, 2007) calls "second generation vulnerability assessment". These assessments move forward from the engineer-dominated, impact driven sectorial adaptation research (supported by most programs), and clearly showed the flaws of such approaches by highlighting the need of recognizing non-climatic factors, such as poverty control over assets, access to resources, institutional and social networks, education, gender ethnicity, that reproduce vulnerability in the first place (Pelling and High, 2005 ; Reid and Vogel,2006 ; Paavola and Adger, 2006, Mustafa et al 2010). To complete this study, several approaches were reviewed. Then one approach will be selected specifically to do the research. Approaches are listed below:

- Critical moment assessment approach
- IPCC, CCIAV approach

1.11.1.1. Critical Moment Assessment Approach

The critical moment assessment approach is originated approach from subsection of IPCC, vulnerability as expected poverty approach which is "Poverty Traps and Critical Thresholds". The critical moments approach is designed to acknowledge that climate change is an 'elusive hazard' (Kates, 1985) and 'cumulative, diffuse, slow-acting and insidious' (Hood et al., 1992). To support climate change adaptation decision making there is need for insight into local vulnerabilities, how these vulnerabilities are currently shaped by climate exposure and its impact and how this is likely to change in future. It also requires insight into communities' responses to reduce vulnerability or lack thereof. Leading on from the review, this study propose to specifically look into the dynamics of the exposure and sensitivity of the households and communities of the Teesta river basin region to climate change, which HI-AWARE focuses on, and identify when they are particularly vulnerable to climate stress with respect to sustaining their livelihood. To facilitate conceptualization and operationalization of our work, these time periods are called 'critical climate stress moments'. Its added value to vulnerability assessment and adaptation is to enable deeper understanding on the stress period, the complex interaction of drivers resulting in criticality and how people are (and could be) responding. A critical climate stress moment thus depends on the interaction of climate hazard and livelihood system characteristics. In addition, this deliverable postulates that looking at critical moments will allow tailoring the design of adaptation interventions (Annemarie et. al., 2016) (Fig-1.11.1.1).

Fig-1.11.1.1: critical moment assessment and the link with other Research Components (RCs)



Source: Adopted by Researcher from Annemarie et. al., 2016.

‘Critical climate stress moments’ are defined as those moments when a household, communities and the livelihood systems they depend on are particularly vulnerable to climate and weather-related risks and hazards. This includes events differing for spatial and temporal scales (and responsible dynamical processes) such as: heat-waves, cold spells, flood, drought, hail). In other words, critical moments are a combination of specific present and past conditions (context specific), in which climate stresses are particularly likely to be risky and adverse by a specific household or community and the system they depend on. A ‘moment’ refers to a time period shorter than a year and beyond. A ‘moment’ can be days, weeks or even months depending on the driver. After having defined critical climate stress moments, the abbreviated term 'critical moments' will be used in the remainder of this report. Breaking down the notion of ‘critical moments’ mean:

- Criticality for households and communities within selected livelihood systems
- Criticality for achieving food-security and other livelihood goals
- Criticality to climate and weather-related risks
- Intra-annual periods: Moments can be intra -annual periods of days, weeks or even months.
- Cascade of critical moments: A particular household or community may experience more than one critical moment over the year.
- Inter-annual*:* Critical moments are expected to shift with climate change. People may not experience the critical moment at the time of the climate stress but later in the year or even in the next year.

A *critical moment assessment* combines identifying:

- An appreciation of specific climate conditions under which a critical moment occurs; How such occurrences are perceived by those experiencing the effects, the temporal and spatial scales, and how this relates to climate trends and to the bio-physical drivers and conditions leading to vulnerability and climate change impact.
- The drivers of socio-economic and political drivers of vulnerabilities giving rise to the critical moments, as experienced and perceived by the most vulnerable and by a range of stakeholders at the local level. This analysis is conducted in close collaboration on Socio-economic, governance and gender drivers and conditions leading to vulnerability.

- To focus the research in HI-AWARE, it is suggested to follow initial scope for the critical moment assessment:
- Critical moments as perceived by households and/or communities within selected livelihood systems. The assessment focuses communities and their livelihoods for which participatory methods are used. The criticality of sectors will be addressed by generalizing critical moments experienced by households for a particular sector. The core of the field work at the household/community level will focus on the key livelihoods sectors.
- Criticality to specific to climate and weather-related risks (heat, flood, and drought) per region (upstream, downstream) with respect to the ability of households and communities to achieve their food security and livelihood goals. A critical moment is determined by the interaction of climate and weather-related stresses and the livelihood system characteristics and the capability of communities to respond to such risks;
- To keep the definition of 'moment' of crisis voluntarily open-ended and dynamic. This allows to capture both inter and intra-annual criticalities as experienced by those who are vulnerable, as well as by key-stakeholders and decision makers. A particular household or community may experience one or more critical moments within the year, and the temporal (as well as spatial) distribution of these moments may change over the years, or interacts with other risks (both environmental and socio-economic), and become critical only when several layers of hazards and risked are coupled;
- Current criticality to climate and weather-related risks, in terms of change in seasons and heat intensity, variability in rainfall and extremes (e.g. floods and droughts), changes in incidences and frequency of snowfall, frost, fog, high wind and wind gusts and hailstorms. Perceptions of change will be collected at several temporal scales, using various methods (both quantitative and qualitative) and addressing different stakeholders (e.g. households, key-informants, decision makers). (Intra-annual as well as on a span of time relevant for climate change assessment, >20years). Qualitative/quantitative information on weather and climate variability and climate change and specific thresholds associated with critical

moments will be provided. This information can be used to tailor the analysis of climate change models (post-processing, downscaling, bias correction), and to inform, tune and interpret the outputs of the hydrological impact model.

Applying the concept of 'critical moments' to the social dimensions of vulnerability permits analysis across diverse social locations, complex mechanisms of vulnerability creation that combine both climatic and non-climatic events as well as second-order effects of climate. This new knowledge helps to identify more tailored adaptation measures, which is important to increase climate resilience and adaptive capacities in the Teesta river basin area. In particular a critical moments assessment aims at improving our understanding of the following:

- At what time(s) of the year households and/or communities are currently particularly exposed and sensitive to climatic change;
- The specific climate parameters which are critical for households (allowing to focus climate change modelling and scenario development);
- Conditions under which households and communities are particularly vulnerable to climate stresses with respect to their livelihood system and wellbeing (allowing to focus adaptation);
- The effectiveness of current coping strategies to overcome critical moments;
- The prioritization and design of tailored adaptation interventions.

The critical moment assessment clearly builds upon and further refines the study on socio-economic and governance drivers giving rise to vulnerability. Basic information required include:

- Village map – resources map
- Major income generating activities (farm and on farm activities) and their relatively importance of agriculture i.r.t. livestock and of farm activities
- Farm types (e.g. rain fed agriculture, irrigated agriculture), major crops, cropping system(s) and cropping calendar specified for men and women
- Critical crop stages
- Landholding size
- Climate stresses / hazards
- Different social groups

- Crop production (from agricultural statistics)
- Crop prices
- Household income (from census)
- Access to markets, credit/finance
- Other socio economic, governance and bio-physical factors giving rise to vulnerability

For the critical moment assessment to start, basic information required historical trends in rainfall and temperature. Information about changes in occurrence of floods, hail storm and fog will be very useful for the interviews with community members and stakeholders. In line with the HI-AWARE work plan, the field work on critical moments is preceded by a literature review. The main objective of this review is to identify the already known critical moments or potential critical moments for agriculture, health, energy and floods. The results of the literature review will be used to inform the discussions with community members and other stakeholders on critical moments. As critical moments are perceived differently by different people, for the selection of respondents the diversity of farm types as well as the existence of different social groups should be taken into account (Annemarie et. al., 2016).

1.11.1.2. IPCC, CCIAV Approach

Assessments of climate change impacts, adaptation and vulnerability (CCIAV) are undertaken to inform decision-making in an environment of uncertainty. The demand for such assessments has grown significantly since the release of the IPCC Third Assessment Report (TAR), motivating researchers to expand the ranges of approaches and methods in use, and of the characterizations of future conditions (scenarios and allied products) required by those methods. This chapter describes these developments as well as illustrating the main approaches used to characterize future conditions in the studies reported in this volume. Although the following approaches and methods were all described in the TAR (Ahmad et al., 2001), their range of application in assessments has since been significantly expanded. Factors that distinguish a particular approach include the purpose of an assessment, its focus, the methods available, and how uncertainty is managed. A major aim of CCIAV assessment approaches is to manage, rather than overcome, uncertainty (Schneider and Kuntz-Duriseti, 2002), and each approach has its strengths and weaknesses in that regard. Another important trend has been the move from research-driven agendas to assessments tailored towards decision-making, where decision-makers and stakeholders either participate in or drive the assessment (Wilby et al., 2004a; UNDP, 2005).

The standard approach to assessment has been the climate scenario-driven ‘impact approach’, developed from the seven-step assessment framework of IPCC (1994). This approach, which dominated the CCIAV literature described in previous IPCC reports, aims to evaluate the likely impacts of climate change under a given scenario and to assess the need for adaptation and/or mitigation to reduce any resulting vulnerability to climate risks. A large number of assessments in this report also follow that structure.

The other approaches discussed are adaptation- and vulnerability-based approaches, integrated assessment, and risk management. All are well represented in conventional environmental research, but they are increasingly being incorporated into mainstream approaches to decision-making, requiring a wider range of methods to fulfil objectives such as (SBI, 2001; COP, 2005):

- Assessing current vulnerabilities and experience in adaptation,
- Stakeholder involvement in dealing with extreme events,
- Capacity-building needs for future vulnerability and adaptation assessments,
- Potential adaptation measures,
- Prioritization and costing of adaptation measures,
- Interrelationships between vulnerability and adaptation assessments,
- National development priorities and actions to integrate adaptation options into existing or future sustainable development plans.

The adaptation-based approach focuses on risk management by examining the adaptive capacity and adaptation measures required to improve the resilience or robustness of a system exposed to climate change (Smit and Wandel, 2006). In contrast, the vulnerability-based approach focuses on the risks themselves by concentrating on the propensity to be harmed, then seeking to maximize potential benefits and minimize or reverse potential losses (Adger, 2006). However, these approaches are interrelated, especially with regard to adaptive capacity (O’Brien et al., 2006). Integrated approaches include integrated assessment modelling and other procedures for investigating CCIAV across disciplines, sectors and scales, and representing key interactions and feedbacks (e.g., Toth et al., 2003a, and b). Risk-management approaches focus directly on decision-making and offer a useful framework for considering the different research approaches and methods described in this chapter as well as confronting, head on, the treatment of uncertainty, which is pervasive in CCIAV assessment. Risk-management and integrated assessment approaches can also be linked directly to mitigation analysis (Nakićenović et al., 2007) and to the joint assessment of adaptation and mitigation.

Two common terms used to describe assessment types are ‘top-down’ and ‘bottom-up’, which can variously describe the approach to scale, to subject matter (e.g., from stress to impact to response; from physical to socio-economic disciplines) and to policy (e.g., national versus local); sometimes mixing two or more of these (Dessai et al., 2004). The standard impact approach is often described as top-down because it combines scenarios downscaled from global climate models to the local scale with a sequence of analytical steps that begin with the climate system and move through biophysical impacts towards socio-economic assessment. Bottom-up approaches are those that commence at the local scale by addressing socio-economic responses to climate, which tend to be location-specific (Dessai and Hulme, 2004). Adaptation assessment and vulnerability assessment are usually categorized as bottom-up approaches. However, assessments have become increasingly complex, often combining elements of top-down and bottom-up approaches (e.g., Dessai et al., 2005a) and decision-making will utilize both (Kates and Wilbanks, 2003; McKenzie Hedger et al., 2006). The United Nations Development Program’s Adaptation Policy Framework (UNDP APF: see UNDP, 2005) has also identified a policy-based approach, which assesses current policy and plans for their effectiveness under climate change within a risk-management framework.

Table 1.11.1.2. Some Characteristics of Different Approaches to CCIAV Assessment. Note That Vulnerability And Adaptation-Based Approaches Are Highly Complementary.

	Approach			
	Impact	**Vulnerability**	**Adaptation**	**Integrated**
Scientific objectives	Impacts and risks under future climate	Processes affecting vulnerability to climate change	Processes affecting adaptation and adaptive capacity	Interactions and feedbacks between multiple drivers and impacts
Practical aims	Actions to reduce risks	Actions to reduce vulnerability	Actions to improve adaptation	Global policy options and costs
Research methods	Standard approach to CCIAV Drivers-pressure-state-impact-response (DPSIR) methods Hazard-driven risk assessment	Vulnerability indicators and profiles Past and present climate risks Livelihood analysis Agent-based methods Narrative methods Risk perception including critical thresholds Development/sustainability policy performance Relationship of adaptive capacity to sustainable development		Integrated assessment modelling Cross-sectoral interactions Integration of climate with other drivers Stakeholder discussions Linking models across types and scales Combining assessment approaches/methods
Spatial domains	Top-down Global -› Local	Bottom-up Local -› Regional (macro-economic approaches are top-down)		Linking scales Commonly global/regional Often grid-based
Scenario types	Exploratory scenarios of climate and other factors (e.g., SRES) Normative scenarios (e.g., stabilization)	Socio-economic conditions Scenarios or inverse methods	Baseline adaptation analogues from history, other locations, other activities	Exploratory scenarios: exogenous and often endogenous (including feedbacks) Normative pathways
Motivation	Research-driven	Research-/stakeholder-driven	Stakeholder-/research-driven	Research-/stakeholder-driven

Source: Adopted by Researcher from IPCC 4th Assessment Report, 2007.

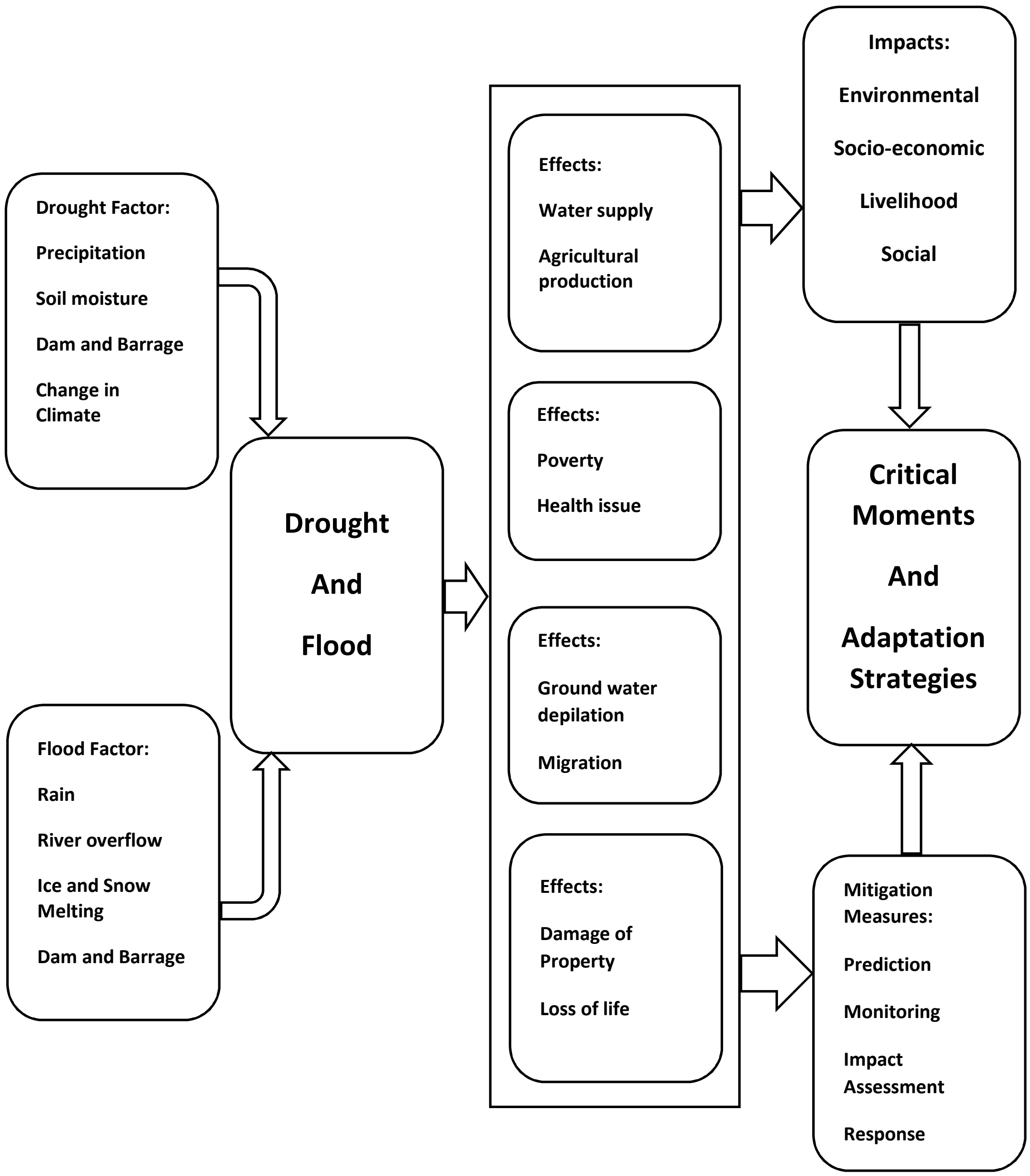
1.11.2. Selected Theoretical Approach

Critical moment assessment approach is the selected approach for this study. Details description of this method will be in Annex1 and Annex2.

1.11.3. Conceptual Framework

A conceptual framework is an analytical tool with several variations and contexts. It is used to make conceptual distinctions and organize ideas. Strong conceptual frameworks capture something real and do this in a way that is easy to remember and apply (Fig-1.11.3).

Figure-1.11.3: Conceptual Framework



Source: Developed by Researcher.

1.12. Feasibility of the Study

This study is feasible in many ways. Because, in todays context the issue is burning. There is enough literature to review. Various govt. and NGO's are supportive in context with the study. Study area is full with key informants. The study is funded by DFID and IDRC. Enough time is allocated for this research.

1.13. Utilities of the Study

The research finding will be useful in enhancing the existing knowledge in this field to the scientific community. This study will provide an accurate picture of the area and finalize with some recommendations which will be helpful to the policy makers and different governmental organizations and NGO's whose are working in this area or in this context.

1.14. Organization of the Thesis

This thesis is organized into eight chapters which capture the major stages and themes of the research. The first chapter provides introduction dealing with operational definition of the key terms, statement of the problem, present scenario of the project area, objective of the study, justification of the study, theoretical approach with conceptual framework of the study, expected outcome, scope and limitation of the study. Chapter two presents a brief review of the existing research literature in context of climate change induced flood and drought risk assessment in Teesta river basin. Chapter three is compared with the study area, data and methodology. In fourth chapter the geographical setting of the study area, physical, demographic, cultural characteristics, socio-economic characteristics and household conditions of the respondent have been presented. Chapter five represents the comparative vulnerability analysis of the study area. Chapter six represents the assessment and identification of critical threshold moment for flood and drought respectively. Chapter seven discuss the analysis of resilience approach for mitigation and adaptation strategies for critical moments. Chapter eight presents the role of institutional assistance for flood and drought induced critical moments. Chapter nine reveals the results and draws the recommendation and conclusion.

1.15. Work plan of the Entire Study

STEPS IN THE RESEARCH PLAN	DEADLINE FOR COMPLETION
Submission of the proposal	June, 2016
Design of a research plan	July, 2016
Gaining access/getting permission to work in a particular area/have access to data, etc.	July, 2016
Literature review	August, 2016
Defining of a universe, a sample frame, sampling OR setting up of selection criteria, etc.	September, 2016
Design and testing of questionnaire, if appropriate	September, 2016
Design of a final questionnaire/schedules, etc.	October, 2016
Interviews/posting of questionnaires, etc.	October, 2016
Editing of completed questionnaires, grouping and coding of data, entering data into a computer	November, 2016
Design and testing of a computer program	November, 2016
Raw tabulations/draft analysis of qualitative data	December, 2016
Analysis of data	December, 2016
Report up of findings	January, 2016
Presentation of final research product(s)	February, 2017
Writing papers for different journals	March – June, 2017

Source: Developed by Researcher.

1.16. Conclusion

Bangladesh is the country least responsible for climate change; it is particularly vulnerable to the effects - the increased incidents of flooding, drought, river bank erosion and cyclones. In the north-western part of the country the main source of water for daily livelihood and particularly for agriculture is harvested from the Teesta river. Drought and floods are among the most devastating natural hazards in the lower Teesta river basin, claiming more lives and causing extensive damages to agriculture, vegetation, human and wild life and local economies. The present study will try to assess the critical moments and adaptation strategies for Drought and Flood of the inhabitants of lower Teesta river basin. Finally, this study will try to give some policy recommendations for the policy makers so that they can formulate needed policies to reduce the intensity of the impact of drought and flood of lower Teesta river basin inhabitants.

Chapter Two

Review of Literature

In this section; the concepts, themes and reviews related to this study have been discussed. The concepts of climate change, flood, drought, critical moment, adaptation strategies and reviews related to these topics have been presented.

2.1. Concept of Climate Change

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors such as biotic processes, variations in solar radiation received by earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as "global warming" (America's Climate Choices: Panel on Advancing the Science of Climate Change; National Research Council, 2010).

The IPCC refers climate change to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/ or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, Fourth Assessment Report; 2007).

This definition defers from that in the United States Framework Convention on Climate Change (UNFCCC), where climate change has been referred to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. The UNFCCC thus makes a distinction between climate change attribution to human activities altering the atmospheric composition, and climate variability attribute to natural causes.

2.1.1. Causes of Climate Change

Both natural and anthropogenic activities are responsible for changing the climate. Some of the causes of climate change are:

a. Greenhouse gases
    i. Water vapor
    ii. Carbon dioxide
    iii. Methane
    iv. Nitrous oxide
    v. Choloro fluro carbons (CFCs)
b. The role of human activity
c. Solar irradiance
d. Internal forcing mechanisms
    i. Ocean variability
    ii. Life
e. External forcing mechanisms
    i. Orbital variations
    ii. Volcanism
    iii. Plate tectonics

Most climate scientists agree the main cause of the current global warming trend is human expansion of the "greenhouse effect" – warming that result when the atmosphere traps heat radiating from Earth toward space. Certain gases in the atmosphere block heat from escaping. Long-lived gases that remain semi-permanently in the atmosphere and do not respond physically or chemically to changes in temperature are described as "forcing" climate change. Gases, such as water vapor, which respond physically or chemically to changes in temperature, are seen as "feedbacks".

2.1.2. Climate Change in Bangladesh

Bangladesh is one of the most vulnerable countries to climate change due to its geographical location. According to current scientific understanding, the state of wellbeing and survival of the people in Bangladesh will be under serious threat due to climate change over the coming decades (CCC, 2012). Assessment of average temperature and precipitation over Bangladesh has been done using a new version of MAGICC/ SCENGEN based upon over a dozen recent GCMs. The results obtained by Agarwal et al., 2003 for changes in temperature have been adopted by The National Adaptation Program for Action (NAPA) for Bangladesh. But the results of Agarwal et al. regarding changes in precipitation were modified. Identified changes are as follows.

Table 2.1.1: Scenarios Provided in NAPA Document

Model	Year	Temperature change (°C) Mean (standard deviation)			Precipitation change (%) Mean (standard deviation)			Sea Level Rise (cm)
		Annual	DJF	JJA	Annual	DJF	JJA	
GCM	2030	1.0	1.1	0.8	5	- 2	6	14
PRECIS	2030 (Max)	0.3	-0.02	1.3*	4	8.7	3.8	
	2030 (Min)	1.18	0.65	1.78*				
GCM	2050	1.4	1.6	1.1	6	- 5	8	
PRECIS	2050 (Max)	0.2	0.07	0.89*	2.3	4.7	3.0	
	2050 (Min)	1.24	0.59	1.65*				
GCM	2100	2.4	2.7	1.9	10	-10	12	88

Source: NAPA, 2009

Note: DJF stands for December, January and February, JJA Stands for June, July and August and * refers to June, July, August and September

A scenario of sea-level rise has also been presented in the NAPA document. However there were no evidences presented in the document in support of the data. Eventually the upper values of the IPCC SLR Scenario was adopted for developing the scenarios for 2050 and 2100, while the curve was extrapolated for developing the 2030 SLR scenario (NAPA, 2009). Using a number of GCMs including Canadian Climate Centre Model (CCCM), Geophysical Fluid Dynamics Laboratory equilibrium model (GFDL), and 1% transient model of GFDL (i.e., GF01), a model-driven climate change scenario was generated.

Table 2.1.2: Outputs of GCM Exercise Using GFD01 Transient Model

Year	Average Temperature			mperature increase			Average Precipitation			Precipitation Increase		
	W	M	Ave	W	M	Ave	W	M	Ave	W	M	Ave
	(^{o}C)			(^{o}C)			Mm/month			Mm/Month		
1990	19.9	28.7	25.7	0.0	0.0	0.0	12	418	179	0	0	0
2030	21.4	29.4	27.0	1.3	0.7	1.3	18	465	189	+6	47	10
2075	22.0	30.4	28.3	2.1	1.7	2.6	00	530	207	-12	112	28

Source: Ahmed, 2006

Note: W stands for winter (i.e., December, January and February: DJF) and M Stands for monsoon (i.e., June, July and August: JJA).

Another model-driven climate change scenario was generated based on ensemble technique which is applicable for Bangladesh.

Table 2.1.3: GCM projections for changes in temperature and precipitation for Bangladesh

Year	**Temperature change (°C) mean (standard deviation)**			**Rainfall change (%) mean (standard deviation)**		
	Annual	**DJF**	**JJA**	**Annual**	**DJF**	**JJA**
Baseline average 2030	1.0 (0.11)	1.1 (0.18)	0.8 (0.16)	3.8 (2.30)	-1.2 (12.56)	+4.7 (3.17)
2050	1.4 (0.16)	1.6 (0.26)	1.1 (0.23)	+5.6 (3.33)	-1.7 (18.15)	+6.8 (4.58)
2100	2.4 (0.28)	2.7 (0.46)	1.9 (0.40)	+9.7 (5.8)	-3.0 (31.6)	+11.8 (7.97)

Source: Agarwal et al. 2003 and Ahmed, 2006

Note: DJF stands for December, January and February, JJA Stands for June, July and August

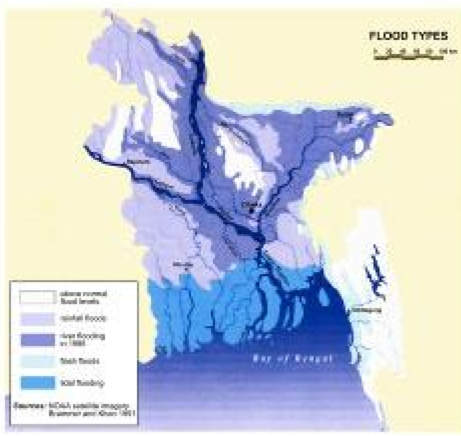
2.2. Concept of Flood

Many of us have this idea that floods (or flooding) is simply, too much water around your house. People think that can be fun. Wrong. Flooding is a lot more than that. Flooding is extremely dangerous and has the potential to wipe away an entire city, coastline or area, and cause extensive damage to life and property. It also has great erosive power and can be extremely destructive, even if it is a foot high. Flood is a natural event or occurrence where a piece of land (or area) that is usually dry land, suddenly gets submerged under water. Some floods can occur suddenly and recede quickly. Others take days or even months to build and discharge. When floods happen in an area that people live, the water carries along objects like houses, bridges, cars, furniture and even people. It can wipe away farms, trees and many more heavy items. Floods occur at irregular intervals and vary in size, duration and the affected area. It is important to note that water naturally flows from high areas to low lying areas. This means low-lying areas may flood quickly before it begins to get to higher ground. In this lesson, we shall see more about what causes flooding, the types of flooding, some effects of floods and what we can do before, during and after floods occur.

2.2.1. Flood Nature and Classification

A flood is a relatively high stream or tidal flow that overtops the natural or artificial banks in any reach of stream or coastal plain. The overtopping of the banks results in spreading of water flow, the floodplains and generally comes to conflict with inhabitants and their activities (Shahjahan, 1998). Floods in Bangladesh can be classified into four categories (Ahmed et al., 2000); which are namely: flash, riverine, rainfall – inundated and storm surge floods. A flood season in Bangladesh can start as early as May and can continue until November. According to Kachic, 1998 Bangladesh is subjected to four types of flooding:

- River flooding,
- Flash flooding,
- Urban flooding, and
- Tidal or storm surge flooding.



Types of flood:

- Monsoon flood
- Flash flood
- Rain flood
- Flood due to storm surges and tids

Flood differs in:

- Location
- Timing
- Intensity
- Duration

Fig 2.2.1: Types of Flood in Bangladesh. (Source – Brammer and Khan, 1991.)

However, James, 1998 classified the flood hazards in Bangladesh into seven flood environments:

- Main rivers (Jamuna, Padma and Meghna) where floods originate outside the country, last up to months; cause major erosion and extreme events can cut new channels that destroy everything in their paths.
- Secondary rivers that cause flooding from rainfall in the country and backwater from the main rivers.
- Chars on river floodplains of major rivers where people live in flimsy houses to be near their land, move to higher ground during major floods, and often return to new sites afterwards.
- Beels and haors where water can stand for up to six months.

- Flash flood areas, generally belong to hilly or in urban areas, where floods rise quickly during intense rains.
- Impoldered areas where flooding is caused by water logging or drainage congestion.
- Coastal areas where flooding can come from cyclonic storm surges off the Bay of Bengal.

The flood hazards also vary with geologic condition. The central part of the country (along a NW-SE line is running through Dhaka) is slowly rising and thus becoming fewer flood prone and safer for industrial development. The NE portion of the country and some coastal areas are subsiding and becoming less suited. Major rivers are moving westward, and thus development would be better located in the eastern banks. Finally, embankments are less dependable in areas with clay beds that are subject to liquefaction during earthquakes or with sand lenses where percolating flood water may boil to the surface behind the levees (IBID, 2008).

However, two main types of floods are regularly experienced in Bangladesh (Ahmed et al., 2000). These are:

- Flash floods on the eastern and northern rivers, which are characterized by a sharp rise of water and high flow velocity, and
- Monsoon floods in the major rivers and their tributaries and distributaries which rise slowly and inundate large areas through overbank spilling.

Flood events vary greatly in magnitude, timing and impact. Handmer et al., 1999 noted that the term “flooding” can cover ‘a continuum of events from the barely noticeable through to catastrophes of diluvian proportions’. There are a number of measurable characteristics through which events can be differentiated, including flood depth, velocity of flow, spatial extent, content, speed of onset, duration and seasonality (Few, 2003; Parker, 2000). Floods may vary in depth from a few centimeters to several meters. They may be stationary or flow at high velocity. They may be confined to narrow valleys or spread across broad plains. They may contain sewage and pollutants, debris or such quantities of sediment that they are better termed mudflows. They may be slow to build up or rapid in onset as in flash floods. They may last from less than an hour to several months.

2.2.2. Causes of Flood

Floods in Bangladesh are a recurring phenomenon. Global warming, deforestation in the upper riparian regions and human interventions in the natural functioning of the ecosystem for increasing productivity leading to economic growth, will only cause more frequent natural disasters such as floods. As the population grows and urbanization takes place at an enhanced rate, flood damages will increase and more and more people will become more intensely vulnerable (Khuda et al., 2000).

According to FFWC (2013), there are two distinct seasons, a dry season from November to April (or May) and the wet (flood) season from June to September (or October). Over 80% of the rainfall occurs during the monsoon or rainy season also known as flood season. The normal annual rainfall of the country varies approximately from 1,200 mm in the west to over 5,000 mm in the east. Long periods of steady rainfall persisting over several days are common during the monsoon, but sometimes local high intensity rainfall of short duration also occurs. Floods in Bangladesh occur for number of reasons. The main causes are excessive precipitation, low topography and flat slope of the country; but others include:

- The geographic location and climatic pattern: Bangladesh is located at the foot of the highest mountain range in the world, the Himalayas, which is also the highest precipitation zone in the world. This rainfall is caused by the influence of the south- west monsoon. Cherapunji, highest rainfall in the world, is located a few kilometers north east of the Bangladesh border
- The confluence of three major rivers, the Ganges, the Brahmaputra and the Meghna: the runoff from their vast catchment (about 1.72 million km^2) passes through a small area, only 8% of these catchments lie within Bangladesh. During the monsoon season the amount of water entering Bangladesh from upstream is greater than the capacity of the rivers to discharge in to the sea.

The springtides of the Bay of Bengal retard the drainage of floodwater into the sea and locally increase monsoon flooding. A rise of MSL at times during the monsoon period due to effect of monsoon winds also adversely affect the drainage and raise the flood level along the coastal belt.

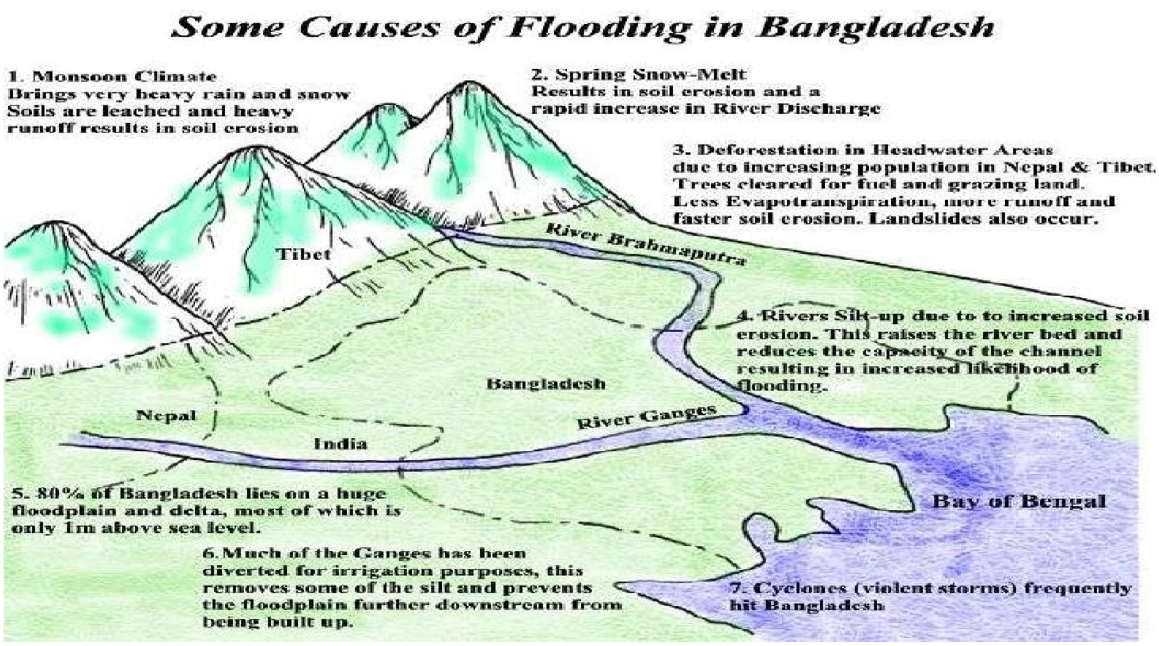
The cause of flood in Bangladesh can be attributed to the following ecological and epidemiological variations (Kafiluddin, 1991).

- Geomorphic processes occurring in Bangladesh.
- Accelerated rate of snow melting in the Himalayans.
- Excessive rainfall in north-eastern India and in the Indian states of Assam, Arunachal, Meghalaya etc.
- Excessive local rainfall leading to excess run-off in excess of safe channel conveyance capacity.
- Silting of rivers within the country.
- Anthropogenic perturbations of the environment and the green-house effect of global warming.
- Deterioration of drainage channel by natural silting up, shoal formation, or obstruction.
- Drainage congestions due to faulty development programs and encroachments on floodplains.
- Effect of constructions and embankments and polders causing increase in flooding elsewhere.
- Failure of water retaining structures, dams etc.
- Tidal surges and sea waves.

Siddique et al., 2000 identified that the floods in Bangladesh, which is an extremely flat and riverine country, are a recurring phenomenon and they take place almost every year. The first comprehensive report of Prof. Mahalanabis (1972) on floods in Bengal shows that moderate floods have occurred once in 2 years on an average, while severe floods have occurred once in six to seven years on an average. Floods in Bangladesh can be attributed to the following two factors:

- Natural
- Man-made.

Fig 2.2.2: Causes of Flooding in Bangladesh. (Source – Saifullah, 2009.)



However, Ahmed et al., (2000), discussed that, there can be various factors that may influence the hydrological regime of a river basin and trigger floods. These factors may be categorized into two groups: climatic factors and non-climatic factors. In general, a low intensity flood may occur due to climatic factors, particularly due to high intensity rainfall induced excessive flows in the rivers. But for a catastrophic flood to occur, a number of non-climatic factors interact with one or more of the climatic factors.

Floods across the globe have many different causes and characteristics (Dolcemascolo, 2004). Drawing on (Parker, 2000), Table 2.2.1 provides a simplified typology of flood causes and associated flood types.

Table 2.2.1: Causes of Flood

Cause	Examples of flood types
High rainfall	Slow-onset riverine flood Rapid-onset flash flood Sewer/ urban drain flood
Tidal and wave extremes	Strom surge Tsunami
Thawing of ice	Jokulhlaup Snowmelt

Structural failure	Dam-break flood Breaching of sea defenses

Source: Adopted from Few et al., 2004.

The leading cause of floods are heavy rainfall of long duration or of high intensity, creating high runoff in rivers or a build-up of surface water in areas of low relief. Rainfall over long periods may produce a gradual but persistent rise in river water levels that causes rivers to inundate surrounding land for days or weeks at a time. In August 2002, for example, intense rainfall of long duration induced extreme flooding spanning five countries of central and Eastern Europe (Caspary, 2004). Intense rain from storms and cyclones, on the other hand, may produce rapid runoff and sudden but severe flash floods across river valleys. Excessive snow melting and dam breaking can lead civilization to devastating flood. In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides becoming the country's worst natural disaster counting the number of death toll up to 4983 (Malik, 2013). The flooding from these events is typically more confined geographically and persists for shorter periods, but the violence of the event can be highly damaging and dangerous. Intense rain can also cause standing water to develop in urban areas when the capacity of drainage system is exceeded (Few et. al., 2004).

Ahmed et al., (2000) explained that precipitation play a vital role in the occurrences of flood. Precipitation patterns of the Ganges, Brahmaputra and Meghna (GBM) river basins are significantly different. Intra-regional variability of precipitation of these river basins is also high. Mean precipitation in the basins of the Ganges, Brahmaputra and Meghna (GBM) rivers are 1553 mm, 1067 mm, and 2749 mm respectively. However, precipitation varies widely within various parts of a river basin. In Table 2.2.2 precipitations of the major river basins are presented.

Table 2.2.2: Rainfall Statistics for the Monsoon 2012 over the Four Basins

Month	Brahmaputra Basin(mm)		Ganges Basin(mm)		Meghna Basin(mm)		South Eastern Hill Basin(mm)		Monsoon average (mm)	
	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual
May June July	315.4	139.9	191.8	54.9	491.0	269.0	290.4	133.6		
August	433.5	301.7	327.0	256.6	621.0	675.0	599.8	748.7		
September	496.1	339.9	397.8	284.5	650.5	505.7	728.5	726.5		
	339.7	215.0	337.8	210.0	537.9	425.3	536.9	429.7		

Total	1938.1 1278.6	1553.1 1067.1	2749.6 2092.4	2473.5 2217.8	
% More/Less	34% less	31% less	23.9% less	10.3% less	23.6% less

Source: Adopted from FFWC, 2012.

The snow and ice cover in the Himalayas is within a range of 30,000 – 332,000 sq. km. (Bahadur, 1985).

Table 2.2.3: Snowmelt Contribution to the Ganges and Brahmaputra Systems.

Basin	Specific glacier runoff renewable component (mm/year)	Specific mass-loss rate in 1961-1990 nonrenewable component (mm/year)	Glacier- covered area in 1961-1990 (km^2)	Specific mass-loss rate in 2001-2010 nonrenewable component (mm/year)	Glacier-covered area in 2001-2010 (km^2)	Ice loss between 1961-1990 and 2001-2010 (km^3)
GANGES	1,100	400	12,541	600	9,012	320
BRAHMAPUTRA	800	250	16,247	350	14,020	170
Data accuracy (%)	±30	±30	±5	±30	±5	±50

Basin	1961-1990			2001-2010		
	Total Seasonal Snowmelt (km^2)	Contribution to Mean Annual Flow		Total Seasonal Snowmelt (km^2)	Contribution to Mean Annual Flow	
		(km^2)	(%)		(km^2)	(%)
GANGES	13.2	6.9	2	10.5	5.6	1
BRAHMAPUTRA	25.8	15.6	2	23.4	14.3	2

Source: Adopted from Savoskul and Smakhtin, 2013.

It is widely believed that the waters from snow and glacier melt play a significant role in flooding in Bangladesh (CBJET, 1980) and in some river basins in India (Ayog, 1980). Detailed information on the Himalayan snow coverage and melt processes is not known. The volume of snow water is only 7% and 3% percent of the mean annual flow of the Ganges and Brahmaputra rivers, indeed a minor contribution (Savoskul and Smakhtin, 2013). Table 2.2.3 presents contribution of snowmelt in the runoff of Ganges and Brahmaputra River.

There have been strong arguments that the El Nino Southern Oscillation (ENSO), a phenomenon that causes positive anomalies in the sea surface temperature (SST) of the southern Pacific Ocean and thereby arming of the ocean, induces strong monsoons in the Indian subcontinent (Partha and Pant, 1985; Chowdhury, 1998). It is; therefore, believed that ENSO includes both drought and flooding in the GBM region (Chowdhury, 1998).

Significant changes in the morphological behavior of the principle distributaries of the Ganges and Brahmaputra rivers in Bangladesh took place in the first few decades of the tenth century. Over the years, these distributaries lost their conveyance capacity due to excessive siltation (for example, Teesta have almost dried up after Kaunia in Rangpur). This has resulted in floodwaters being concentrated in the southeastern part of the country (Ahmed et al., 2000).

Unplanned construction of the road, railways and flood control embankments sometimes causes drainage congestions. After the independence of Bangladesh, thousands kilometers of rural roads and railroads have been constructed. Since most of the roads aligned east-west and the rivers are aligned north-south, the roads do not allow free flow of water and cause drainage congestion. It has been observed in the past that, in many cases, comprehensive hydrological studies including extensive modeling exercises had not been carried out to plan proper layouts, drainage facilities etc. construction of the polders has also caused local interference in passage of floodwaters, as it has been demonstrated by Chowdhury and Islam (1989). Such factors often inhabit egression of floodwaters through the channels and increase retention time in the adjoining floodplains.

Deforestation in the upper catchment areas have influence the total volume of water available for runoff, modifying the time distribution of runoff and contributing increased sediment input to the rivers. Deforestation may have some role in coarse silt generation and is unlikely to have any direct link with increased runoff generation that cause flood in Bangladesh. Generation of coarse silt instead of fine clayey silt influences higher rate of sedimentation in the flat riverbeds resulting in further decrease in river gradients. As a result, the ability of the rivers of Bangladesh for water transportation towards the sea-mouth is decreasing, which has a significant effect on decreasing the return period of floods (Savoskul and Smakhtin, 2013).

2.2.3. Statistics of Flooding

According to FFWC, 2013 many parts of the Asia during monsoon frequently suffer from severe floods. Some parts of India and Bangladesh experience floods almost every year with considerable damage. The floods of 1954, 1955, 1974, 1987, 1988, 1998, 2004 and 2007 all caused enormous damages to properties and considerable loss of life. The floods of 1987, 1988 1998, 2004 and 2007 flood caused heavy damage. During the monsoon 2012, the flood was not a severe one and stayed for short duration in all the four basins, the Brahmaputra, the Ganges, the Meghna and South Eastern Hill Basin. In the South Western part of the country experienced prolong flooding in few stations, longer than the previous flood years, especially part of Khulna, Jessore and Satkhira districts. During the monsoon-2012 other flood affected districts (part of full, on the low-lying areas) are Gaibandha, Sirajganj, Tangail, Jamalpur, Rajbari, Kushtia, Faridpur, Manikgonj, Munshigonj, Madaripur, Gopalgonj, Sariatpur, Sylhet, Sunamgonj, Netrokona, Sherpur, Moulvi Bazar, Kishoregonj, Brahmmanbaria, Habigonj, Chandpur, Chittagong, Bandarban and Cox's Bazar. Percent of total area of Bangladesh affected by the flood are available since 1954 is presented in Table 2.2.4.

Table 2.2.4: Year-Wise Flood Affected Area in Bangladesh.

Year	**Flood Affected area**		**Year**	**Flood affected area**		**Year**	**Flood affected area**	
	Sq.-Km	**%**		**Sq.-Km**	**%**		**Sq.-Km**	**%**
1954	36,800	25	1975	16,600	11	1995	32,000	22
1955	50,500	34	1976	28,300	19	1996	35,800	24
1956	35,400	24	1977	12,500	8	**1998**	**1,00,250**	**68**
1960	28,400	19	1978	10,800	7	1999	32,000	22
1961	28,800	20	1980	33,000	22	2000	35,700	24
1962	37,200	25	1982	3,140	2	2001	4,000	2.8
1963	43,100	29	1983	11,100	7.5	2002	15,000	10
1964	31,000	21	1984	28,200	19	2003	21,500	14
1965	28,400	19	1985	11,400	8	2004	55,000	38
1966	33,400	23	1986	6,600	4	2005	17,850	12
1967	25,700	17	1987	57,300	39	2006	16,175	11
1968	37,200	25	**1988**	**89,970**	**61**	**2007**	**62,300**	**42**
1969	41,400	28	1989	6,100	4	2008	33,655	23
1970	42,400	29	1990	3,500	2.4	2009	28,593	19
1971	36,300	25	1991	28,600	19	2010	26,530	18
1972	20,800	14	1992	2,000	1.4	2011	29,800	20
1973	29,800	20	1993	28,742	20	2012	17,700	12
1974	52.600	36	1994	419	0.2			

Source: Annual Flood Report 2012, FFWC, BWDB.

2.2.4. Impacts of Flood

The consequences of flooding are by no means solely negative. Seasonal river floods, in particular, play a crucial role in supporting ecosystems, renewing soil fertility in cultivated floodplains (Wisner et al., 2004). In region such as floodplains of Bangladesh, a 'normal' level of seasonal flooding is therefore regarded as positive; it is only when a flood reaches an abnormal level that is perceived negatively as a damaging event (Parker, 2000).

Flood damages comprise broadly two groups, direct and indirect (Islam, 2005). Direct damages are physical and ‘visible’ losses arising out of direct contact with water (e.g., damages to house structure). Indirect impacts are the consequences of direct contact of property with water and are revealed through interruption and disruption of economic and social activities (e.g., production losses due to direct loss of machinery).

The effects of damaging flood described by Brammer, 1999 is as follows:

a. Damage or destroy an established crop, leading to partial or total loss of the crop;
b. Prevent farmers from planting their normal crop on time or at all;
c. Cause farmers to an alternative (often lower-yielding) crop or crops; and/or
d. Impoverish farmers so that they may have to sell part of their land or other property, reduce the level of inputs they use on flowing crops, take additional loans and/or fail to repay existing loans on time.

Moreover, the burdens of such damages are borne, directly or indirectly, more by the poor then by the non-poor. The poor suffers heavily because of losses of employment, damage to crops, housing, and property (Hyder, 2016). The landless and marginal farmers in many cases sell their household belongings, livestock, poultry birds and even land and homesteads for survival. They accentuate a process of pauperization and social differentiation. The vast majority becomes poorer (IBIB, 2008). In flood affected regions traditional agriculture practices do not undergo fundamental change because of the risk of the setbacks in production activities due to flood (Hossain et. al., 2008). Since High Yielding Varieties (HYV) require costlier inputs, the farmer don’t feel encouraged to invest money in producing these crops for fear of losing their assets. The region therefore, remain perpetually depressed. (Ahmed, 2006) States that, depending on the terrain and topography about 6 million hectares of cultivable land are susceptible to flooding. The floodplains of the country may be categorized in five classes based on their flooding characteristics, as presented in Table 2.2.5.

Table 2.2.5: Land Types Based on Flood Depth.

Land	Description	Flood depth	Nature of flooding
FO	Highland	Not flooded	Intermittent or flooded up to 30
F1	Medium	30 to 90 cm highland	Seasonal

F2	Medium	90 to 180 cm lowland	Seasonal
F3	Lowland	Over 180 cm	Seasonal (<9 months)
F4	Lowland/ very	Over 180 cm	Seasonal (>9 months) or perennial

Source: Ahmed, 2006.

There exists a strong relationship between (flooding) land-type and cultivars used during monsoon (*Kharif*-II) season. Susceptibility to yield reduction of a particular variety is higher if the land in question has higher susceptibility of flooding. Land type F0 is not flooded, whereas land type F4 is flooded for more than nine months of the year with a maximum flood depth of more than 1.8 meters. About 3.3 million hectares are subjected to flood depth of 30 to 90 centimeters. An area of about 0.076 million hectares has a flood depth of more than 1.8 meters, which remains under water for more than nine months in a year. Severe floods, which cause extensive damages to crops and some damage to property, especially roads, occur at intervals of about 7-10 years. Catastrophic floods, occurring at intervals of 20-50 years or more, almost totally destroy crops in adjoining floodplains, and also cause considerable damages to houses, roads and other infrastructure. The 1988 and 1998 floods are rated as 50-100 year events. Coverage of inundation and damage caused by major floods during the period 1954 to 1998 is presented in Table 2.2.6.

Table 2.2.6: Inundation Area and Damage Caused by Floods during 1954 -1998

Year	Area inundated	Proportion of total area	Cost of damage	Population affected	Deaths
	Square kilometers	%	Million Taka	Million persons	Number of
1954	36,920	25	1,200	N/A	112
1955	50,700	34	1,290	N/A	129
1956	35,620	24	900	N/A	N/A
1962	37,440	25	560	N/A	117
1963	43,180	29	580	N/A	N/A
1968	37,300	25	1,160	N/A	126
1970	42,640	28	1,100	N/A	87
1971	36,475	24	N/A	N/A	120
1974	52,720	35	28,490	30	1,987
1984	28,314	19	4,500	20	553
1987	57,491	38	35,000	30	1,657
1988	89,970	62	> 100,000	47	2,379
1998	> 100,000	74	> 120,000	>55	1,050
2004	> 58,000	~ 40	> 200,000	>36	~ 750

Source: Ahmed, 2006.

Note: N/A means data not available in common sources. Please note that the available flood damage information is not always complete and consistent.

2.2.5 Flood Management

(WMO, 2003) states that, in Bangladesh, flood management strategy has been under continuous change since early sixties of the last century. Flood Management strategies can be divided into three distinct phases of its development, which are as follow:

a) Phase-I: 1960 to 1978

b) Phase-II: 1978 to 1996

c) Phase III: 1996 to 2000 onwards

a) Phase-I: Just after the two consecutive disastrous floods of 1954 & 1955, United Nations commissioned a Mission led by Mr. Krugg to look into the problems of flood in this country and to suggest remedial measures. In 1956 the Krugg Mission finalized its Report and submitted it to the then Government of Pakistan. Principal recommendations of Krugg Mission were following:

- To formulate a Master Plan for Water and Power Development;
- To constitute a statutory body to deal with water and power development;
- To conduct intensive hydrological survey and investigations.

Krugg Mission mainly focused on protecting the agricultural lands from the flood because of the fact that at that time agriculture was the mainstay of economy. Moreover, self-sufficiency in food was the cornerstone of the Government policy. As a result, a Water Development Master Plan was prepared in 1964 where structural options having large project portfolios were given priority. Accordingly, Government started implementing large projects with the objectives of providing flood protection, improving drainage and providing irrigation. Implementation of large and medium FCD projects were time consuming and during the implementation of these projects some medium scale flood occurred specially one in 1968 which caused lots of suffering to the people. As a result the Government realized that only through structural measures flood problems couldn’t be solved or mitigated. In 1972 the Government decided to also go for non-structural measures also developing e.g. flood forecasting and warning system to mitigate flood problems.

b) Phase-II: With the implementation of some large Flood Control, Drainage and Irrigation (FCDI) projects, the Government came to realize that the implementation of large projects involves large investments as well as longer duration; as a result it takes long time to derive benefits. Government then opted for implementation of small and medium scale FCD projects to provide early benefits. While all these projects were implemented the Government came to realize that water resources development should not be focused only on agriculture rather it should take into account other sectors related to water resources utilization and development for economic as well public goods. Environmental protection also came to the fore. As a result the issue of formulation of a National Water Plan (NWP) came to the notice of the Government. The Government took initiative in 1982 to formulate a NWP looking into various aspects of water use and the demand and interest of different stakeholders involved in the water sector. NWP was finalized in 1986 but it did not receive Govt.'s approval due to some of its drawbacks. After disastrous floods of 1987 & 88, formulation of a National Water and Flood Management Strategy came to forefront again for obvious reasons. All the international Development Partners supported a project entitled Flood Action Plan (FAP) from 1990 to 1996 to formulate a national Flood and Water Management Strategy. FAP was mainly a study project involving 26 components. On the basis of FAP activities the Government formulated Bangladesh Flood and Water Management Strategy (BWFMS) in 1996. In BFWMS some policy guidelines for water resources development and management were envisaged i.e. Peoples Participation, Environmental Impact Assessment (EIA), Multi- Criteria Analysis during planning process were made mandatory in all future water sector projects.

c) Phase III: At the end of FAP studies, Government realized that all the issues concerning the water resources development and utilization have not been addressed in the light of Integrated Water Resources Management (IWRM) in these studies. Then the Government again embarked on formulating a National Water Management Plan (NWMP) cross cutting different sectors of national economy in the light of IWRM in 1998.In order to guide the preparation of NWMP, the Government formulated a National Water Policy (NWPo) in 1999. NWMP was prepared in 2001 with 25 yr projection. Program period was divided into three phases e.g. short term for 5 yrs., medium term with 10 yrs. And long term with 25 yrs. period. It was formulated with a program approach, not with a project approach. This is no doubt a shift in the Government policy. It identified various conflicting water needs and to ensure equitable water use and balanced economic growth. NWMP has 84 programs cross cutting 11 different sectors of economy. Access to

Safe Drinking Water and Sanitation has been given topmost priority. In the NWMP the issue of poverty reduction has not been addressed explicitly, but the Government wants to put it as a top most economic goal. NWMP is now awaiting Governments approval.

2.3. Concept of Drought

Drought refers to a considerable and prolonged lack of rainfall over a wide area that significantly affects agriculture, domestic water supply and water-dependent economic activities and may lead to famine. Scientifically, drought is defined on the basis of non-availability of rainfall, leading to decrease in base flow and surface flow of water bodies and depletion of soil moisture (Nandargi, et al., 2005). Drought is primarily an agricultural phenomenon that refers to conditions where plants are responsive to certain levels of moisture stress that affect both the vegetative growth and yield of crops. It occurs when supply of moisture stored in the soil is insufficient to meet the optimum need of a particular type of crop. As a consequence of usual hydro-meteorological variability, drought occurs in pre-monsoon season when the potential evapo-transpiration (PET) is higher than the available moisture due to uncertainty in rainfall, while in post-monsoon season it is due to prolonged dry periods without appreciable rainfall (Karim et al., 1990). In both the seasons, due to sudden increase in temperature coupled with non-availability of rainfall causes a sharp rise in PET.

(Saha, Ali and Shahid, 2013) states that, the offset of drought is slow as it is influenced by climatic fluctuations over an extended period of time. The affected area is widespread. Drought causes -

- Soil degradation
- Loss of crops
- Loss of other economic activities
- Starvation/malnutrition of human beings/grazing animals
- Spread of diseases
- Migration of people and livestock

Drought is not aridity or desertification. Aridity is a dominant feature of dry regions which refers to permanent conditions of low average precipitation or available water. Destruction and degradation of land resources processes may lead to desertification of an area which in its first place was not an arid region. Drought may lead to desertification or aridity if it prevails for a prolonged period accompanied with destructive land use practices (Nandargi, et. al., 2005). Based on (Warren, et. al., 1992), drought occurs when moisture supply is abnormally below average for period upto 2 years.

One may relate to occurrence of drought with certain physical observations:

- Development of continually broken cracks on the dried up topsoil;
- Burnt-out yellowish foliage in the vegetation cover (top yellow syndrome), particularly observed in betel nut trees and bamboo groves; and
- Loosening of soil structure, ending up in the topsoil transforming into a dusty layer.

Based on literature review it can be said that there lacks a working definition of drought. Nevertheless, the different meteorological, hydrological, agro-ecological and socio-economic definitions that have been suggested can be merged into a comprehensive definition such as: On the basis of non-availability of rainfall (rainfall deficiency by more than 25% from normal long term average) for a prolonged time period over a wide area, a decreased condition in base flow and surface flow of water bodies leading to depletion of soil moisture which ultimately causes plant water stress and reduced biomass causing reduced yield can be defined as drought (Saha, Ali and Shahid, 2013).

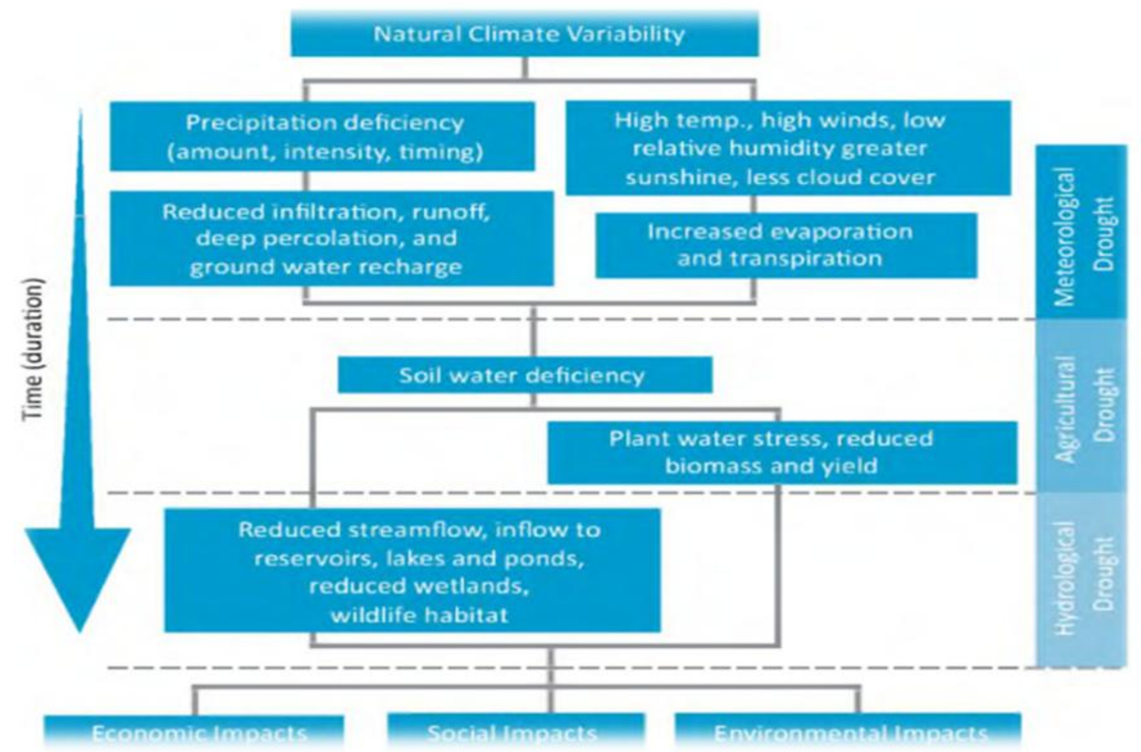
2.3.1. Drought Nature and Classification

Research by Donald A. Wilhite, director of the National Drought Mitigation Center, and Michael H. Glantz, of the National Center for Atmospheric Research, in the early 1980s uncovered more than 150 published definitions of drought. The types of drought to be considered are (Fig - 2.3.1):

a) Meteorological
b) Hydrological
c) Agricultural
d) Socio-economic
e) Seasonal

Meteorological and agricultural droughts are frequently, but erroneously, considered synonymous. Meteorological and hydrological droughts are physical events, but agricultural drought refers to the impact of the first two on agricultural production. It is necessary to distinguish between these types and clarify where and how they overlap. Both climate variability and climate change influence such aspects as time (season, intra-season), location and length of drought occurrence (Saha, Ali and Shahid, 2013).

Fig 2.3.1: Types of Droughts and Their Impacts over Time.



Source: Adopted from Saha, Ali and Shahid, 2013.

a) Meteorological drought occurs when the reduction in rainfall for a specified period (day, month, season or year) is below a specified amount - usually defined as some proportion of the long-term average. It is usually an expression of precipitation's departure from normal over some period of time. These definitions are region-specific and presumably based on a thorough understanding of regional climatology.

b) Hydrological drought refers to deficiencies in surface and subsurface water supplies based on measurements of stream flow and lake, reservoir and groundwater levels. When precipitation is reduced or deficient during an extended period of time, this shortage eventually will be reflected in declining surface and subsurface water levels. However, hydrological measurements are not the earliest indicators of drought because of the time between reduced periods of precipitation and reduced water in streams, rivers, lakes and reservoirs.

c) Agricultural drought occurs when there is not enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.

d) Socio-economic drought occurs when physical water shortage starts to affect people, individually and collectively. In more abstract terms, most socio-economic definitions of drought are associated with its effect on the supply and demand of a product that has market value.

e) Seasonal drought is related to deficit soil moisture during certain periods within a season. In Bangladesh, three types of droughts are recognized during monsoon season:

- Early-season droughts are due to delayed onset or early breaks in monsoon rainfall.
- Mid-season droughts are caused by intermittent, short or extended dry spells.
- Terminal-season droughts are caused by early withdrawal of monsoon rainfall. In the Barind tracts of Bangladesh, terminal droughts are more frequent and coincide with the most important growth phases of the rice crop (Saha, Ali and Shahid, 2013).

2.3.2. Causes of Drought

The causes of drought in Bangladesh are related to climate variability and non-availability of soil moisture leading to reduced harvest. Decrease in rainfall, shortage of surface water and groundwater recharge cause depletion in soil moisture. The immediate cause of rainfall shortage may be one or more factors including absence of moisture in the atmosphere or large-scale downward movement of air within the atmosphere which suppresses rainfall. Changes in such factors involve changes in local, regional and global weather and climate. While it may be possible to indicate the immediate cause of drought in a particular location, it is not often possible to identify an underlying cause. Some studies (e.g., Karim et. al., 1996) show that crop yields potentially increase with an increase in temperature of a few degrees celsius. Reduced precipitation in winter would have a negative effect on yields. Other changes such as effects on crop pest and disease incidence could also reduce crop yields.

Short-term drought episodes can be linked to global atmospheric and oceanic circulation features. For example, the El- Nino/ Southern Oscillation (ENSO) phenomenon, which results from the development of warm surface water off the Pacific coast of South America, affects the levels of rainfall in many parts of the world, including monsoon rainfall in Bangladesh. On a larger scale, the link between sea surface temperature and rainfall has been suggested as a possible cause of long, dry regimes. Increasing levels of carbon dioxide and other greenhouse gasses have been suggested as causes of rainfall changes, which are, in turn, attributed as climate change. There is strong evidence that climate change will alter the rainfall pattern, and as a result more frequent droughts are estimated. Among the local-level causes are human-induced changes resulting from vegetation loss due to over exploitation of resources and deforestation (Saha, Ali and Shahid, 2013).

2.3.3. Statistics of Drought

Bangladesh experienced severe droughts in the years 1951, 1957, 1961, 1972, 1976, 1979, 1986, 1989 and 1997. Most of these droughts primarily occurred in pre-monsoon and post-monsoon seasons, but in some extreme cases the pre- monsoon droughts had extended into the monsoon season due to delayed onset of the monsoon rains, e.g. the 1979 drought (Table: 2.3.1), (Choudhury, et al., 2003).

According to (Saha, Ali and Shahid, 2013), the dry zone in Bangladesh is located in the (greater) districts along the country's western border, together with some adjoining parts of Bogra, Pabna and Faridpur districts. The mean annual rainfall in this area is 1,250-1,750 mm, falling mainly in 4-5 wet months between May-June and September-October. This dry zone includes the following agro-ecological regions:

- The Barind Tract, especially the High Barind in the west;
- The southern part of the Old Himalayan Piedmont Plain;
- The high western part of the Ganges River Floodplain;
- The western part of the Ganges Tidal Floodplain in Khulna District.

Some soils in other agro-ecological regions have a low moisture-holding capacity which provides similar problems to those occurring in the dry western districts. These drought prone soils include the following:

- Most deep and shallow terrace and valley soils on the Madhupur Tract;
- Most soils in the Northern and Eastern Hills, especially those on south-facing slopes;

- The high western part of the Ganges River Floodplain;
- The western part of the Ganges Tidal Floodplain in Khulna District.

Some soils in other agro-ecological regions have a low moisture-holding capacity which provides similar problems to those occurring in the dry western districts. These drought-prone soils include the following:

- Most deep and shallow terrace and valley soils on the Madhupur Tract;
- Most soils in the Northern and Eastern Hills, especially those on south-facing slopes;
- Sandy soils on the highest parts of floodplain ridges, especially in the north-western part of the Teesta Floodplain, the south-eastern part of the Karatoya-Bangali;
- Floodplain, the Old Brahmaputra Floodplain (e.g., in Narsingdi District), the Middle;
- Meghna Floodplain, and the Northern and Eastern Piedmont Plains;
- Sandy alluvium on river char land; and
- Many silty and clay floodplain and terrace soils whose topsoils have been puddled for the cultivation of transplanted Aman paddy.

Kharif drought prevails intermittently on highland and medium highland soils from June through October. The T. Aman crops grown on these lands are affected by drought (Saha, Ali and Shahid, 2013).

Table 2.3.1: Historical Details of Different Droughts That Occurred in Bangladesh.

Year	Description
1865, 1866, 1872, 1874	Reported to occur in Dhaka, Bogra and Sundarbans. Crop suffered greatly in most cases.
1951	Severe drought in north-west Bangladesh substantially reduced rice production.
1973	Drought responsible for the 1974 famine in northern Bangladesh.
1975	Drought affected 47 % of the country and more than half of the total population.
1978 – 79	Widespread damage to crops reducing rice production by about 2 million tons, directly affecting about 42 percent of the cultivated land and 44 percent of the population.
1981	Severe drought adversely affected crop production.

1982	Drought caused a loss of rice production of about 53,000 tons.
1989	Drought dried up most of the rivers in Northwest Bangladesh in several districts, including Naogaon, Nawabganj, Nilphamary and Thakurgaon.
1994, 1995, 1996	Immense crop damage, especially to rice, jute and bamboo clumps.
	No comprehensive study has been done on the droughts that was occurred after 1995-96.

Source: Adopted from Saha, Ali and Shahid, 2013.

2.3.4. Impacts of Drought

According to various study, every five years, Bangladesh is affected by the major country-wide droughts. However, local droughts occur regularly and affect crop production. The agricultural drought, linked to soil moisture scarcity, occurs at different stages of crop growth, development and reproduction. Monsoon failure often brings famine to the affected regions and as a result crop production reduces drastically (Alam et al., 2011).

Northwestern regions of Bangladesh are particularly exposed to droughts. A strong drought can cause greater than 40% damage to broadcast *Aus*. During the *kharif* season, it causes significant destruction to the T. Aman crop in approximately 2.32 million ha every year. In the Rabi season, about 1.2 million ha of agricultural land face droughts of different magnitudes. Apart from the agricultural loss, droughts have important effect on livestock population, land degradation, health and employment. Between 1960 and 1991, drought events occurred 19 times in Bangladesh. Very strong droughts hit the country in 1961, 1975, 1981, 1982, 1984, 1989, 1994, and 2000. Past droughts have naturally affected about 53% of the population and 47% of the country. The associated crop production decline, lower employment opportunities and losses of assets contributed to raise household food insecurity. Consumption of food fell, along with household capability to meet food requirements on a sustainable way. Vegetables and several other pulses varieties are in short supply throughout the drought (Paul, Hossain, 2014)

Droughts cause major problem in household health because its subsequent impact of decreasing food consumption leads to significant increases in illnesses. It also causes an increase in chronic energy deficiency among the agricultural workers (Alam et al., 2011).

2.3.5. Drought Management

Drought management for agriculture crops is generally performed through soil and water management. Soil management may be defined as caring for the soil to maintain fertility, preserving topsoil, and providing a media for plants to penetrate with roots so as to obtain water and nutrients needed for their growth. Agricultural water management, in simple terms, is the management of the earth surface or soil to get water into the soil, remove unwanted water, and control the loss of water by runoff. The drier regions of the country are normally concerned with preserving water in the soil and adding additional water to it as needed by crops. This is accomplished by some form of irrigation, usually from a limited supply of water (Saha, Ali and Shahid, 2013).

In Bangladesh, the farmers follow traditional farming practices to control moisture loss from soil surface during the dry season. Immediately after the harvest of monsoon crops, farmers plough the land and keep it fallow for the next Rabi crops. The tilled layer acts as a barrier against moisture loss from the sub-soils. The farmers utilize the residual moisture of the soils for the following dry land Rabi crops. Mulching is also another practice adopted by the farmers. There are crops which have high water requirements and are usually grown with the help of irrigation. However, in many places, farmers grow potatoes and various types of vegetables under soil mulching. Mulching greatly retards the evaporation, so that more of the available water can be used by the crops. In addition to this practice, farmers add organic matters to their cropland to raise the moisture retention capacity of the soils (Saha, Ali and Shahid, 2013).

2.4. Concept of Critical Moment

As per the IPCC dominant framework (IPCC 2007, 2014), the triad of Vulnerability, Adaptive capacity, and Resilience has oriented most of the research revolving around adaptation. In particular, policy-oriented science in the field of adaptation to climate change usually starts with vulnerability assessments that offer a ‘snapshot’ of the present situation at a given scale, typically at the local level. These vulnerability studies tend to focus on ‘what’ (e.g. infrastructures, sectors) and ‘who’ will be most vulnerable to climate change under different climate scenarios. Such analysis is then followed by the identification and assessment of ongoing and potential adaptive measures at different temporal scales, i.e. immediate, mid-term, and long term. Relatively less attention is given to the ‘when’ question i.e. when are people particular vulnerable to climate change. The concept of critical moments is designed as an attempt to overcome some of the bottlenecks that vulnerability research seems to have encountered over the last years, especially when it comes to articulating the temporal dynamism and the complexities associated with vulnerability to weather and climate risks. In particular, critical moments address the challenge to better link vulnerability assessments and adaptation policy (Annemarie, 2016). The emergence of the concept of critical moments descends from the acknowledgement that the contribution of vulnerability analyses to the policy realm has been peripheral at best. The literature has identified broadly three set of reasons why vulnerability assessment have so far largely failed in bridging the gap between science and policy: In particular, Mustafa et al. 2010 identifies three shortcoming. First, there is the question of spatial scale. Policy makers are generally concerned with aggregate populations at the meso- and macro-national scales, while vulnerability research is interested in household and community differentiation at the micro scales. Second, there is the issue of the need for context specific or generalized one fits all solution. Most policy makers need simple, generalized, actionable, preferably quantitative information for input into policy process, while the work of most vulnerability analysts results in spatially and temporally nuanced, complex, generally qualitative information directed towards understanding root-causes rather than prescribing actions (Annemarie, 2016).

The third issue deals with what type of change is looked for, incremental or transformative adaptation. Many vulnerability analysts are concerned with systematic change and fundamental inequities in the prevailing political and economic structures that policy makers may often represent and reproduce (see e.g. Wisner et al. 2004).

Increased understanding about stress moments of vulnerable households in terms of timing and context specific climatic, socio-economic and other biophysical causes can improve tailoring and prioritization of adaptation measures to increase resilience to climate variability and climate change. In particular, it is crucial to address the issue of temporal scales in vulnerability research supporting immediate, mid-term and long term adaptation (Annemarie, 2016).

2.5. Concept of Climate Change Coping

According to various study, the issue of coping to climate change has moved high on the UNFCCC negotiating agenda. Since COP 7, when three specific funds were created to support implementation of various measures that facilitate vulnerability assessment and adaptation, adaptation has become an increasingly important component of the international climate change dialogue (Tirpak, and Levina, 2006). Many key adaptation terms and concepts are defined by the IPCC in its Third Assessment Report (TAR) and earlier reports. Adaptation itself is not defined in either the UNFCCC or the Kyoto Protocol. Various other scientific/policy communities use slightly different definitions or freely use terms that have meaning in a common usage, such as, for example, vulnerability, resilience, adaptability but may take on greater significance in a negotiation setting. In addition, UN bodies and national climate programs have their own definitions of the same terms. It was observed that interpretation of some of key adaptation terms by scientific groups or policy makers can be quite different, which may lead to varied or false expectations and responses (IPCC, 2007). There is a body of literature that has been created in the last 5-10 years that is devoted to the discussion of vulnerability and adaptation to climate change. As in other fields, scholars and policy makers have invented and used terms to explain their ideas and positions. However, the issue of adaptation is much less mature than mitigation and hence it has not been the subject for rigorous policy analysis, particularly economic analysis. This may change as both national and international policy options are given more serious consideration. If this is to occur, scholars and policy-makers may be well served to agree on the usage of some of the key terms and concepts. Examples of such terms are adaptation, vulnerability, impacts, and adaptive capacity. Some other terms, less crucial for defining the concept of adaptation, might be freely used as common words that do not require strict definitions. Examples could be: coping, resilience, and adaptability (Tirpak, and Levina, 2006).

2.5.1. Nature of Climate Change Coping

The nature of adaptation is linked with its versatile definitions.

Coping - Actions taken to help communities and ecosystems cope with changing climate conditions, such as the construction of flood walls to protect property from stronger storms and heavier precipitation, or the planting of agricultural crops and trees more suited to warmer temperatures and drier soil conditions (website of the UNFCCC Secretariat, 2006).

Adaptation - Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC TAR, 2001).

Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented. (UNDP, 2005)

Adaptation – The process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with climate variability and climate change. (UK Climate Impact Programme - UK CIP, 2003)

All four definitions differ from one another in several ways. First, they all use different words to describe what adaptation is. The first key words in the definition that express adaptation as 'actions', 'adjustment', 'process' and 'outcome' can be interpreted differently by various stakeholders. 'Process' seems to be a very broad and open ended term that does not include any particular time or subject references and can easily incorporate 'actions' and 'adjustments'. The word 'actions' crystallizes 'process' into something more concrete. However, it is still not clear whether 'action' is the same thing as 'measure'. Clarifications on the implications of these words are needed, especially given a wide use of the term 'adaptation measure' (see the only definition of 'adaptation policies and measures' from the UNDP). 'Adjustment' seems to imply a process that leads toward some standard or goal. The UK CIP offers additional interpretation of adaptation as an outcome. Expectations from adaptation as an outcome might be much higher than expectations from it as a process. Funding aspirations and evaluation of achieved results would also vary accordingly (Tirpak, and Levina, 2006). Another consideration is the way the term is understood by the UNFCCC and the IPCC. It appears that the UNFCCC uses the term 'adaptation' in a narrower way than the IPCC. The examples incorporated into the UNFCCC definition imply a very technical interpretation of the term (construction of walls, changing crops). The IPCC broadens this definition by distinguishing various types of adaptation (e.g., anticipatory, reactive, public, planned adaptation, etc.) and focuses not only on technical adaptation measures but also on institutional responses. The IPCC definition also includes adaptation of natural systems not just human. These seemingly small differences might create different expectations from different stakeholders, depending on the meaning of the term that they decide to use. One can already see that community-based adaptation practitioners and advocates use a more technical interpretation of the term (the one closer to the UNFCCC definition), while adaptation policy-makers use a broader definition and emphasize the institutional/policy side of adaptation. These varied interpretations could have serious financial implications (Tirpak, and Levina, 2006).

2.5.2. Classification and Approaches of Climate Change Coping

Basically climate change coping can be divided into several types.

a. <u>Short-term coping</u>: Time period of short-term adaptation is less than 10 years. It is essential to initiate and encourage urgent response measures to prevent or mitigate short-term impacts that are already occurring and likely to arise from climate change. During at least the next few decades, it will be essential to initiate and encourage – to the greatest extent possible and as quickly as possible – urgent adaptation and recovery measures for impacts that have a high likelihood of arising from climate change already occurring despite mitigation efforts.

Examples:

- The introduction of heat-resistant crop varieties and promotion of appropriate cultivation methods, to address the declining crop quality and yields.
- Measures to protect against the loss of local fish varieties, bleaching of coral etc.
- Crisis management arrangements and improvements in early warning systems, to deal with sea-level rise and with rising damage in confined areas and from intense rainfall events.

To consider the likelihood that an impact may be caused by climate change, it is useful to refer to relevant resources such as IPCC reports and to seek the advice of experts when necessary (Mimura et al., 2010).

b. Medium- and long-term coping: Time period of medium-term adaptation is 10-30 years. And for long-term adaptation the required time span is more than 30-100 years. Response measures are necessary to enhance adaptive capacity to prevent and mitigate possible impacts, by assessing the risks of impacts that may occur in the medium and lonf term, and by controlling the impacts, reducing vulnerabiity, and strengthening resilience.

   Examples such as, taking action to clarify issues that reuire cooperation and cross-sectoral initiatives among multiple departments and sections within an organization, for the purpose of more efficient implementation of measures; reviewing the collection and organization of basic data and information relating to impact assessments and adaptation measures, and where found to be inadequate, identifying issues that require priority attention and implementing systematic improvements. And prioritizing climate change adaptation measures within the comprehensive plans of local governments including establishing organizations that cooperate with local research institutions, non-profit organizations, and various other types of organization.

c. Information consideration: Usable platforms, tools, and information infrastructure are needed for the publication and sharing of basic information and information sources, such as research data and future projectios, as well as risk management studies. Local information provides the basis for adaptation measures, so it is important to move as quickly as possible to strengthen collaboration among research projects already underway and among practitioners regionally and individual sectors.

   Examples such as, improving and promoting the use of basic information about research data and future projections; developing and providing information about examples of risk assessments and assessment tools; setting up internet portal sites for impacts and adaptation information that will be useful for governments along with promoting information exchanges and collaborative research with local research institutes.

d. Awareness raising: To the extent possible and as quickly as possible, it is important to initiate and encourage communication about risk and the provision of risk-related information to citizens and other concerned parties, while adequately considering and efficiently using existing structures and frameworks. This information is the basis for all adaptation measures, including decisions about implementing adaptation measures.

Examples such as, risk-related information provision, communication about risk, and awareness-raising activities (combined with mitigation efforts) targeting citizens and businesses. Also sharing of information among relevant government departments; establishing supportive institutional arrangements; creating collaborative arrangements among governments, research institutes, and NGOs (Mimura et al., 2010).

2.5.3 Steps of Climate Change Adaptation

According to Mimura et. al., (2010) general simplified first five steps for climate change adaptation planning and implementation is given below:

Step 1: Share knowledge and approaches to adaptation, and examine existing measures

- Share knowledge and approaches about the need for, the importance of, and concepts relating to adaptation.
- Compile information about adaptation-related aspects of existing policies and measures, and identify areas where gaps exist.

↓

Step 2: Assess the risks associated with climate change impacts

- Collect and analyze existing, readily available monitoring results information, etc.
- Assess risks of climate change impacts using existing information (identify high-risk events and areas).

↓

Step 3: Promote communication, and decide adaptation plans, programs, and measures

- Share risk assessment results with the public and stakeholders.
- Determine the necessity of adaptation measures, consider their levels of importance, and prioritize adaptation planning and implementation in the policies.

↓

Step 4: Start with the most feasible initiatives

- First, initiate urgent response measures to prevent and/or mitigate short-term impacts.
- Next, consider adaptation measures where socio-economic benefits are clearly higher than costs.
- Track and assess progress and effectiveness of adaptation measures (overall assessment of progress).

↓

Step 5: Consolidate risk assessments and adaptation measures based on monitoring and the latest knowledge

- Identify areas and items requiring priority monitoring and consider and improve methodologies and arrangements for them
- Improve future projections using the latest research results and local monitoring data.
- Reassess risks, review and integrate adaptation measures.

Source: Modified by Researcher from Mimura et al., 2010.

2.6. Reviews Related to Climate Change, Flood, Drought, Teesta and Adaptation Strategies

In a recent study of flood and erosion in Teesta river basin it is found that, almost ninety five percent of the respondents opine that the embankment and barrage made by India over the border is the main cause for sudden flood and bank erosion. The same percent think that the Teesta Barrage (at Dalia-Doani point made by Bangladesh in1986) will bear no fruitful result if India does not obey the International water-sharing pact. The study was carried out among the households who had lost land and properties due to Teesta River disasters who now have to live on the embankment or nearby villages of the Teesta River bank. The study shows that ninety one percent of the respondents were shown as landless and only 10 percent had some land and the average amount of land of that 10 percent is 1.45 acres. The 73 percent of the respondents drink tube-well water, 29 percent drink ground well water but most of the people use river water for bathing and dish washing. The 86 percent of the respondents thinks that the housing and sanitary condition of the area is not healthy and not suitable for human habitation (Fakrul, and Higano, 1999).

A recent study conducted in Teesta river basin describe that, environmental flow is essentially required for the sustenance of the river itself as well as for the whole ecosystem including poor's livelihood which is largely shaped by the river flow especially in a country like Bangladesh. However, in the period of 2001 – 2006 (post-barrage-2), the dry season (December – March) mean flow is observed only 80 m whereas mean January, February and March flow is observed only 40, 24 and 57 m3s-1 respectively; all these values are quite below from the environmental flow requirement (Mullick, Babel, and Perret, 2010).

In a very recent study of water scarcity and vegetation in Teesta river basin shows that, overall vegetation and soil moisture content in downstream declined over the study period which has been correlated to the water scarcity. Difference between water supply and demand is determined by the existence of water scarcity. As a result, it is defined in relation to water needs for livelihoods. Overall vegetation has been declined between year 1989 and year 2010. Soil moisture contain also found as turned down except 2000 image. It has found vegetation biomass and soil moisture content has been increased partly in natural harvested area than farmland but Teesta Barrage Project (TBP) boundary has not correlated with these changes. Grey floodplain soil area becomes greener than other type of soils. Disparity between supply and demand has been increased due to climate change, less water flows in Teesta River during dry season and high demand for irrigation, biodiversity and human consumptions. Teesta River water is playing an important role to keep balancing among water supply in this region. Uneven water control in upstream can be a reason of massive damage in downstream because supply of irrigation water for downstream crops is a matter of life and death (Sarker et al., 2011). Teesta River water flows and rapid population growth in downstream area are correlated to the vegetation change over time in the study area. As a result, balance in water sharing between two neighboring countries is very important to avoid inevitable environmental degradation and to reduce further conflict risks (Rahman, 2013).

A study conducted on the problems and prospects of Teesta barrage found that, when there is excessive rainfall on the Himalayas, or the snow and ice on the mountain melt more than usual, the excessive water flowing through the Brahmaputra, the Teesta, and the Dharla etc. When excessive water in the rainy season exerts pressure on the Gozaldoba barrage and becomes threat to this barrages, the authority open up all the sluice gates all at once to get rid of all the excessive water causing flash floods in Bangladesh. Had the barrage not barred the natural flow of the rivers (even with the excessive water from the Himalayas), these flash floods would not have occurred. On the other hand in dry season this area become a desert. One fourth of the fertile agricultural land of northern Bangladesh will become wasteland due to shortage of water. Reduction in agricultural production due to insufficient water for irrigation in dry season and over flooding in the rainy season (Fakrul, and Higano, 1999).

In a very recent study of anthropogenic impact on morphology of Teesta River shows that human are mostly responsible for changing river morphology which includes water flow, water quantity, water current and river environment etc. Intensive uses of river water in various purposes of human needs and environmental unfavorable trees like Eucalyptus plantation around the settlement also responsible for reducing water quality as such kinds of tree consume more water than other tree and their leaves do not compose easily. The study also shows that excessive control of water discharge of Teesta River by man-made structure makes this river useless for the study area people. As a result downstream river environment become rude by losing its sediment contamination and sufficient water quantity and flow. The result reveals that water discharge quantity has been significantly reduced at Dalia Point of Teesta River. This extensive uses of water in intensive irrigation purposes which is lowering the water quantities of Teesta River day by day. Intensive agricultural practices require huge quantities of water and most of the water is extracted from the river. A few amount of water extracted from ground water table where as river water is not available and costly to carry that means the area is either far from the river or shortage of water make the distance (Khan, Reza, and Islam, 2015).

A study conducted on the impact of climate change in Teesta river basin described that, due to climate change the future flow of Teesta River at Dalia may face problem to meet the future Surface Water Routing (SWR) of the Teesta Barrage Project (TBP) (for both phases) during the entire critical period of October for the unavailability of sufficient flow. Due to climate change the future flow of Teesta River at Dalia would decrease during the critical period of October compared 10% of the observed baseline condition. To meet the future Surface Water Routing (SWR) of Teesta Barrage Project (TBP) the in-stream demand should be lower than 40%. The maximum shortfall would be during the 2nd decade of October, when the Surface Water Routing (SWR) may be as high as 493.23mJ/sec and the available now from the Teesta may be as low as 288.04m3/sec. Besides this, the Surface Water Routing (SWR) is so high that it may exceeds the maximum capacity of the canal head of 283mJ/sec. From the analysis of climatic data, it was found that due to the climate change the crop water requirement for T. Aman in Teesta Barrage Project (TBP) would increase in the future projections (2025 and 2050) from that of the base line period. Flow augmentation from other internal rivers (Jumuneshwan, Komtoa etc.) is theoretically possible (although the extent of alleviation is not very high) and needs further study on technical, economic and social aspects. Analysis, has shown that if all the available flow is diverted, then with climate change the future Surface Water Routing (SWR) could be met (Rahman, 2008).

The case study in the Teesta Barrage Project (TBP) area in context of water sharing suggests that the present flow in the Teesta River is inadequate to meet the present irrigation requirement, while the fluctuation in the flow rate affects directly the availability of water in the TBP area. According to the Agricultural Extension Officer of Dimla sub-district, water supply from the Teesta River has provided the opportunity for supplementary irrigation in transplanted Aman rice fields in the monsoon season. Irrigation coverage in recent years suggests that the present river flow at Dalia is lower than the estimated water requirement in TBP area. Farmers in this area reported that irrigation water availability from the Teesta River is uncertain and delayed. Irrigation water availability from Teesta River has increased farm labor use in two crop seasons. Unilateral withdrawal of Teesta water by India upstream limits irrigation water availability in the TBP area. The interrelationship between the surface and groundwater resources of the deltaic plain suggests that changes in the rate of the Teesta River water flow, affects directly the availability of groundwater. Farmers now demand more water from the Teesta River and an expansion of irrigation facilities. However, this irrigation water supply has introduced rice and wheat cultivation in the dry season. Irrigation water supply in the dry season is delayed in this area. India plans to link thirty major rivers including the Teesta River for diverting water to her water-scarce southwest. The irrigation water availability from the river has been always less than that planned. This irrigation water availability has reduced dependency on groundwater and decreased number of shallow tube wells in the village by about 75.0%, from more than 500. The Teesta River water flow is one of the major contributors to recharge the aquifers. However, farmers experience water stress in standing Aman rice fields in years when the rainy season ends early (Islam, Azam, and Islam, 2007). In a very recent study conducted on imapct of climate change in bangladesh discussed that, translating the GCM projections of climate parameters provided in section 2, it may be concluded that the country will be highly susceptible to: (a) increased flooding, both in terms of extent and frequency; (b) increased moisture stress during dry periods leading to increased drought susceptibility in terms of both intensity and frequency; and (c) increased salinity intrusion during the low flow conditions. It is prognosticated that, under climate change scenario evapo-transpiration will increase significantly, especially during the post-monsoon and pre-monsoon seasons, in the backdrop of diminishing rainfall in winter and already erratic rainfall variability over time and space (Karim et al., 1998). Since climate change would increase susceptibility to natural disasters, as mentioned in earlier sections, the anticipated toll on livestock sector would be quite high (Ahmed, 2005a; GOB, 2005). With the possibility of increasing frequency of such high intensity floods, it may be argued that Aman production is likely to suffer heavy damages under climate change. The Bangladesh NAPA, however, considered that the implications of climate change on human health was rather uncertain, though it echoed with Agarwala et al. (2005), the Bangladesh NAPA also commented that the anticipated adverse impacts of climate change on peoples' livelihoods will be disproportionate on the poor (GOB, 2005). Under a severe climate change scenario which is associated with 60 per cent moisture stress, yield of Boro might reduce by 55 to 62 per cent. Since climate change will have significant influence on water-related hazards and disasters, peoples' livelihoods will also be severely affected (RVCC, 2003; Ahmed and Schaefer, 2004; Asaduzzaman et al., 2005). It is reported that, Aus production would suffer by 27 per cent while wheat production would decline by 61 per cent under a moderate climate change scenario. Global warming and the resultant climate change could have profound effects on the water resources of Bangladesh both surface and ground water (Ahmed, 2006).

In a study conducted on farmers perception about climate change found that, the major challenging issue for the livelihoods of a farmer is climatic hazards in the farmland in particularly drought (Mengistu, 2011).The production variation, economic crisis and food scarcity influences the seasonal starvation (Monga) among the rural people in this study area. The negative consequences of these effects directly make a linkage to socio-economic conditions regarding with farmers perception, surface water, groundwater and river discharge is decreased in account of long term statistical variation of precipitation rate and cloud formation. Farmers' perception greatly emphasized on the depletion of groundwater level, water shortage, drought impacts respect to agricultural production. In the situational cases, farmers may adapt to adverse climatic condition using alternative technological access (Mengistu, 2011) and individual agricultural management strategy (Charles and Rashid, 2007) in the rural community. Their perception deals congruent with scientific evidence of climatic effect through long term practical experience in the agricultural activities and crop production. Concurrently, natural precipitation, groundwater level and river discharge make a victim for water crisis in the agricultural sector due to anthropogenic and natural hazards. According to farmer's perception, they are going to lose their agricultural soil fertility and crop cultivation opportunity due to drought hazards. The anthropogenic stress and climatic effects on agricultural soil jointly lead to agricultural hazards like as drought. The rainy season and it's in intensity has been decreased due to climatic effects and enhance drought severity (Habiba et al., 2012). Drought hazards and its negative impacts influence the production rate for specific crops like as wheat, pulse and vegetables which are more vulnerable for the climatic hazards. Most of the farmers reported that a few crops like as wheat, pulse and vegetables production rate has been decreased due to lack of rainfall and heat wave. Most of the farmers assured that basic cause of drought at the northern part of Bangladesh is extreme climatic conditions (Rakib et al., 2014).

A recent study describes that, in all the hydro-model projects built thus far, siltation has been a major problem, with projected capacities decreasing at alarming rates, often before the entire project is completed! Evaporation from the reservoirs and seepage of water from canals deprived the marginal land of the command area from the water that it was assured during the planning of the project. How will these projects upgrade the standard of living of the local people? Will the tectonically fragile area be able to support such massive structures and the reservoirs they create? What will be the effects on the region's rich biodiversity? Can the security of the livelihoods of people in both the upstream and downstream regions be guaranteed? These and several other valid questions raised on issues of social justification, ecological sustainability and economic viability of this project remain unanswered. An inclusion in this series is the ongoing Teesta Barrage Project (TBP) in Jalpaiguri district and hydro power projects of the National Hydro Power Corporation (NHPC) (stage III and IV) in Darjeeling district of West Bengal. President K.R. Narayan expressed his concern on Republic Day, 2001 when he said, "Let it not be said by future generations that the Indian Republic was built on the destruction of the green earth and innocent tribals who have been living there for centuries." In the post-Independence period, the number of victims who have been displaced from their homeland due to the construction of large reservoirs is, at a conservative estimate, 50 million. Nehru, in the 29th annual meeting of the Central Board of Irrigation and Power (held on the November 17, 1958) advocated for a multitude of smaller projects, but his successors remained fixated on gigantic projects. Monsoon water would be conserved and two or three crops raised annually on good soil that now yields only one." Similarly, the installation of a multitude of mini hydro power projects and the utilization of solar and wind power would help meet local needs. Only recently has it been widely acknowledged that the communities bearing the social and environmental cost are invariably tribals or other disadvantaged sections of society, who rarely receive water, electricity or any of the other benefits from the project (Rudra, 2003).

A study on sediment management in Teesta shows that, the desilting arrangement in hydroelectric projects is essential to manage the silt in the discharging water so as to prolong the life of runner and other turbine parts. The high cost of desilting arrangement raises a question as to whether we could have an improved metallurgy and protective coatings which could allow higher sediment particle size through the turbines and thus reduce the size and cost of the desilting system. The underwater part is primarily controlled by its metallurgical properties. The cast and heat treated microstructure as well as the mechanical properties have significant effect on its erosion resistant behavior. The metallurgist and scientist community should take this challenge of developing appropriate technology for some new materials having better erosion resistance (Ojha, 2014).

In a study focused on the impact of climate change in Teesta Barrage Project (TBP) describes that, the Teesta Barrage Irrigation Project (TBIP) is a blessing to the distressed people with supplying irrigation water through a network of canal system and a Barrage across the river Teesta at Doani in Lalmonirhat District mainly for supplementary irrigation during Monsoon. Therefore, the main objective of the TBP is to increase agricultural production through irrigation and thereby create employment opportunities in the vast area of northern Bangladesh by supplying sufficient water during Monsoon season when there might have irrigation water scarcity. So, lacking in sufficient flow of water in the Teesta River, irrigation system is likely to be hampered and climatic conditions of the surrounding region has been dampened day by day. But in the dry season India retraces water from the Teesta River for using in agricultural fields and navigation purposes in their land. However, water increases productivity in the agricultural sector and the cost effectiveness of irrigation infrastructure are increasingly necessary to enhance the reliability of the water supply to the farmers. It has recognized that water resources project like Teesta Barrage Project is necessary for the development of a nation. In the rainy season they depart excessive water through the Gozaldoba Barrage to the Bangladesh area causing floods. During the dry season, December to January, relative humidity drops, small streams dry up, and the volume of water in big streams and rivers is reduced in some parts. The successful implementation of the Teesta Barrage Irrigation Project was a dream comes true for them. The primary source of water for agricultural production for most of the world is rainfall. Variation in agro-climatic parameters e.g. rainfall, temperature, humidity, evaporation, evapo-transpiration etc. Except in April, the maximum mean monthly evaporation was 3.25 inch and 4.82 inch for the year of 1980 and 2000 respectively, which indicate that the evaporation after implementation of the project have increased by 32.57%. But evaporation was slightly decreased in April by 6%. Temperature is an independent variable among the climatic elements whose variation causes corresponding changes in the pressure distribution and consequently in the direction of wind as well as its velocity which controls atmospheric humidity, condensation formation of cloud and their drafting in the sky, precipitation and storms. However, surface water is the best option to produce more food which would enable the farmers to use cheaper irrigation water that would also be environment friendly (Sarker, Pramanik, and Ara, 2011).

According to a recent research focasing on the present situation of Teesta river basin describes that, the construction of the barrage on this river across the border to divert its flow of water has badly affected the efficacy of the Teesta Barrage Project. Due to the obstruction on its water flow, the Teesta was heavily silted up and changed its courses at many places, especially in the lower catchment, and erodes its both banks engulfing thousands of hectares of land every year. The dams and barrages already constructed in the river Teesta have caused a negative impact on free flow of its water. The once mighty Teesta is now bereft of water following construction of a barrage upstream at Gojoldoba point in Jalpaiguri of the Indian state of West Bengal. The Indian authorities are reportedly withdrawing the total water from the rivers Teesta and Mohananda through their Gozaldoba and Mohanada Barrages in the upstream. The discharge capacity of Teesta has drastically been reduced due to withdrawal of water and the discharge of heavy silts from the upper catchments. Moreover, the ambitious objective of both the Bangladesh and Indian authorities of irrigating Thousands of hectares of land to increase agricultural production is also gradually dwindling with scarcity of water during the lean period in the river. It can be seen from the chart below that the average lowest discharge of Teesta was above 4,000 cubic meter/sec before construction of the two barrages — one at Doani in Bangladesh and other at Gozaldoba in West Bengal. On the other hand, they said, there should be 10,000 cusecs of water to bring an estimated 111,000 hectares under the Rabi crop programme but only 1,000 to 1,200 cusecs are now available in the upstream of the Teesta Barrage. On the other hand, in the Indian part, the mean annual discharge of the Teesta at Anderson Bridge was about580 cum/sec a decade back and it declines to 90 cum/sec in the lean months. The farmers in Nilphamary, Lalmonirhat, Gaibandha, Rangpur, Dinajpur and Bogra are worried over the bleak prospect of getting required quantum of water from the Teesta for the irrigation of boro fields. The Teesta is going to embrace the fate of the Aral Sea project in Russia and Irtysh-Karaganda Canal in Kazakhtan which have been proved to be ecological disasters of water management (Roy, 2015).

In a study focused on the political economy of Teesta river basin describes that, seeing like a state: bilateral negotiations between India and Bangladesh have been dominated to date by state actors that have exercised dominant control over policy and governance issues concerning the river and its management. Legitimate stakeholders and actors excluded from the table: Legitimate stakeholders and powerful actors and their concerns have largely been neglected and have found little voice in formal negotiation processes. Legitimate interests excluded from the table: Bilateral negotiations are reductionist in nature, centered on arriving at a technical formula to determine the quantity of water that both countries can claim. This narrow approach has excluded a range of economic, social, and cultural interests from bilateral discussions and prevented the development of a basin wide, integrated approach to planning, management, and conservation of the Teesta River Basin. Weak articulation of stakeholder interests: The space for the articulation of legitimate stakeholder interests by communities in the Teesta Basin is limited, with few opportunities for local perspectives and knowledge to trickle up to influence the formal negotiation process. State control of data and information: The state in both countries exercises dominant control over data and information related to the river and its management. Local communities have limited and extremely localized knowledge of factors affecting the river regime. Such a compartmentalized understanding of the basin's ecology has made it difficult for communities to articulate a common platform of action or develop a counter narrative to the state's dominant discourse (TAF, 2013).

In a study describes that, after the operation of Gozaldoba Barrage started the flow in Teesta River became significantly low which increased after the Teesta Barrage operation started in Bangladesh. This is because after the construction of Teesta Barrage water stored in the monsoon could be used in the dry season. The annual peak discharges have an increasing value after the operation of Teesta Barrage. It has increased about 24% after the operation of Gozaldoba Barrage. During the dry months (November to May) of a year the discharges are found to be decreasing after the operation of Gozaldoba Barrage by India. A decrease of about 88% is found after the operation of this Barrage, but which increased up to 2.5

times after the operation of Teesta Barrage. But after construction of Gozaldoba Barrage decrease is observed in case of lowest annual discharges. The decrease is about 85%, but after construction of Teesta Barrage the lowest annual discharge increased to almost four times the initial value. In case of dry months the maximum discharge values were always found in the month of November and the minimum values were found in the months of February and March. After construction of Gozaldoba Barrage and even after the Teesta Barrage, Bangladesh gets an increasing amount of water. The maximum values were found in the months of August and September. After commissioning Gozaldoba Barrage in India in 1985, flow reduced up to 88% in Bangladesh which was found increasing up to 2.5 times after the operation of Teesta Barrage in Bangladesh in1990. The diversion of water by the Farakka Barrage has introduced significant changes in the hydrology of the Ganges River system in Bangladesh. There are concerns that the reduced dry season flow has significant socioeconomic impacts in the Bangladesh part of the basin by altering the hydrological pattern and helping saline water to penetrate further inland from the sea. The study reveals that principle of equitable and reasonable utilization, obligation not to cause significant harm, principles of cooperation, information exchange, notification, consultation and peaceful settlement of disputes are widely acknowledged by modern international conventions, agreements and treaties This study also suggests for formation of a regional river commission with the co riparian countries, undertaking a common storage reservoir and also to ratify the UN convention on the Law of the Non-Navigational Uses of International Watercourses as recommendation for proper management of Trans boundary Rivers (Afroz, and Rahman, 2013).

A study conducted on impact of climate change in Teesta river basin area describes that, climate has changed in the last two decades and the severe water crisis period occurs for 2-4 months every year, between February and June, depending on the particular area. People have suffered because of these conditions and have tried to adapt. This is seen in the various activities they do during times of water scarcity. They fetch water for domestic and livestock, from neighbors' tube well that still have water. They also fetch from deep well/shallow machine. They even use water from ponds and canals for bathing and washing. They make mud construction for keeping water. Some people spend a lot of money for crop production due to increased cost of irrigation, hoping for a better harvest.

Some deliberately use food money for irrigation leaving the family with almost nothing to eat. Other people eat fewer meals per day, others borrow from neighbors, and some eat nothing while others just drink water. People have adapted to eating any available food/leaves/grasses. Some of the foods eaten during periods of scarcity are: Kishore which includes rice, arrow roots and its leaves; other foods are green fruits like Jack fruit, mango, green banana, banana stem. Kawn, wild game, shazna leaves, boiled maize, sweet potatoes, and pulses are also eaten. On the more negative side is that people sell land, trees, and livestock in order to buy food and diesel for irrigation. They even sell rice in advance at low rates. People have changed from using the old type of open shallow wells [kua] to tube well, deep well, and shallow machine. These new types of wells are many in the areas visited and are regularly extracting water from the ground. Change from open shallow wells to the tube well has improved people's health. People have various opinions as to the reason of the water scarcity, e.g. 8% of the groups had no idea. Other reasons put forward were: 83% said that lack of water is a result of less rain. It is clear that the respondents gave answers which were similar to the question they were asked, showing total lack of understanding of the current times affected by climate change. There are a number of crops which do not require much water for irrigation. But people prefer growing paddy rice which requires 90 days of irrigation water. Some of the said crops are maize, wheat, and pulses. The farmers believe their yields are low per hectare. There is also the problem of cooking preparation in the case of maize, to make it more palatable. Tube well is used by 100% groups for domestic water and 92% use shallow machine for irrigation. The proliferation of shallow machine and tube well, leads to water misuse and wastage. The increased cost of irrigation has been a major complaint by all groups (Mbugua, 2011).

A study conducted on impact of drought in Teesta river basin area describes that, drought hazards are ultimate consequences of climate change which has been evolving through unevenly changes of climatic variables. Its pervasiveness's such as intensity and magnitude are not same. The severity of the climatic hazards is dependent on direct and indirect factors that are always inducing change and augmenting negative derivatives of climate change. Its discontinuation and anomalous changing pattern indicate to long term instability of the climatic controlling variables such as temperature. It might be brought to global change whereas the anthropogenic input always adding into the atmosphere would be enough to induce devastating disasters. In Bangladesh, drought is frequently experienced at regional scale or extensively depending on cause and time. And, the main agriculture founded component of the national economy is already on downward trends due to continuous losses in agriculture productivity. Simultaneously, water and land use patterns have been identified as vulnerable components in the gearing up of social status with enhanced socioeconomic growth which is already on backward trends. So, the negative consequences tend to expedite temperature and rainfall uncertainty, agricultural damage, worsen socioeconomic condition, social and food insecurity. To make balance among the social components it is very important to take some initiative at the national and international levels for accelerating the existing ways of development. On the observational status, it is possible to make some efforts in the mitigation purpose at local scale and obtain balance of agriculture productivity and local agricultural demands. The combined approach includes maintenance of water and land use management for achieving sustainability in the agricultural sector and overall socioeconomic development. It is also important to fulfill the sub-categorical aspects of the three key elements fit on the drought mitigation model to achieve sustainable development. All measures which are mitigations of drought events for sustainability in the agricultural sector should be given consideration (Rakib et al., 2015).

Chapter Three

Research Methodology

This chapter is focused mainly on type of research, research design and methodology to be used in data collection and its analysis. The chapter also includes nature of the study, sources of the study, selection of the study area, map of the study area, sampling techniques used to specify the target groups within the research area, types of respondents, distribution of the sample, data collection techniques, data analysis process and methodological framework of the study.

3.1. Nature of the Study

The research methods will be applied in the study are both exploratory, descriptive and analytical in nature; because how, what or why questions will be posed (Yin, 1994).The study is exploratory because in this study an attempt has been made to find out the most critical moment for the house hold and to find out the specific climate conditions (thresholds), biophysical and socio-economic factors cause these periods of high vulnerability for flood and drought respectively. It also emphasizes to investigate the existing strategies people adopt to cope with critical moments. At the same the study is descriptive, because it will discuss the pattern of lifestyle change of affected dwellers of the study area.

3.2. Sources of the Study

This study is carried out in three sequential stages. They are; risk assessment from literature review, critical moment assessment from literature review, and critical moment assessment from field survey.

3.2.1. Risk Assessment from Literature Review

Almost all the people become landless due to climatic hazard and impact of climate change. The sanitary and housing condition is unhealthy and unsuitable for human habitation; and it leads to several sectoral risks (Fakrul, and Higano, 1999). For the last two decades overall vegetation has been declined. It leads to ecological and bio-diversitycal risk (Sarker et. al., 2011). Due to shortage of water in dry season and excess of water in rainy season there is acute food and water shortage. Which cause livelihood insecurity (Fakrul, and Higano, 2004). Sedimentation rate has increased which ultimately leads to floods and sand cover in the agricultural field. It causes lose in agricultural production and causes food insecurity (Khan, Reza, and Islam, 2015). Due to flood, several water borne diseases spread and causes health insecurity (Islam, Azam, and Islam, 2007). During flood and drought period, there is loss of income and it causes economic insecurity (Rakib et. al., 2014).

3.2.2. Critical Moment Assessment from Literature Review

In the month of January, February and March the mean flow is the lowest which cause drought (Mullick, Babel, and Perret, 2010).

In the month of July, August and September the mean flow is the highest which cause severe floods in the basin area (Islam, Azam, and Islam, 2007).

3.2.3. Critical Moment Assessment from Field Survey

For this purpose these questions will be asked:

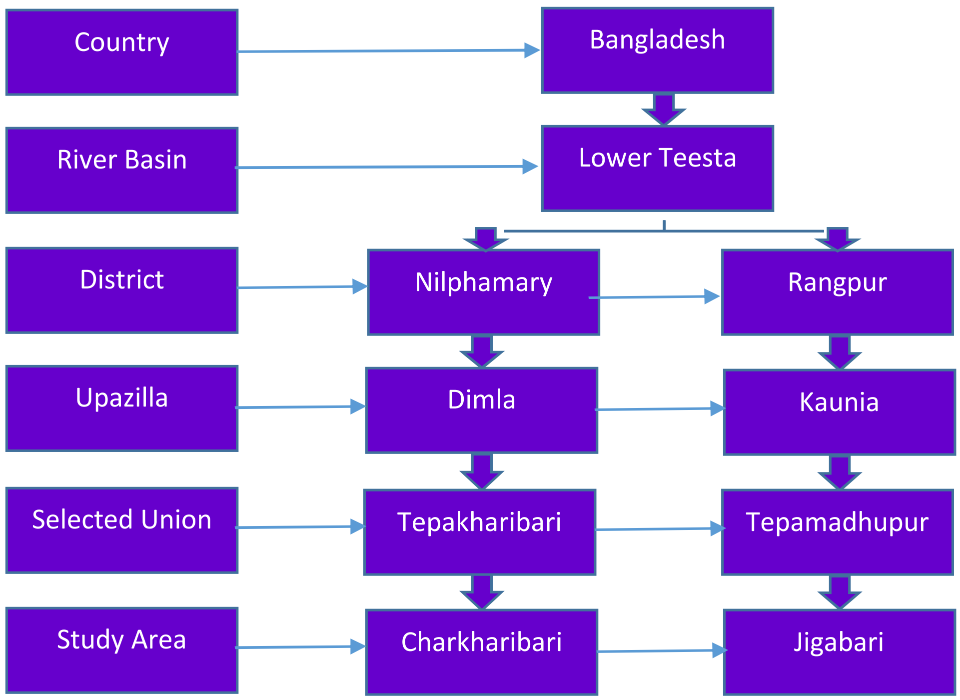
- Considering people's activity calendar, which times in the year people's life can be most impacted by climate hazards? How do these periods of stresses vary across different social groups and within households?
- Which specific climate conditions (thresholds) and other biophysical and socio-economic factors cause these periods of stresses?
- What's the impact of these periods of stresses on people's livelihood? How does the impact vary across different social groups and within households?
- What strategies have people already adopted to cope with critical moments? To what extent do people perceive these strategies as being effective?
- What are likely changes in climate conditions due to climate change and how will it affect critical moments?

3.3. Selection of the Study Area

The study area has been selected purposively taking the locational advantage, flood and drought proneness, topographic nature and population diversity under consideration. The study is conducted in Charkharibari village of Tepakharibari union of Dimla upazilla in

Nilphamary district and Jigabari village of Tepamadhupur union of Kaunia upazilla in Rangpur district (Fig-3.3). Both of the districts are in lower Teesta basin area. Physically these two districts are constituted in two natural divisions. They are plain land and low land.

Fig-3.3: Selection of Study Area.



Source: Developed by Researcher.

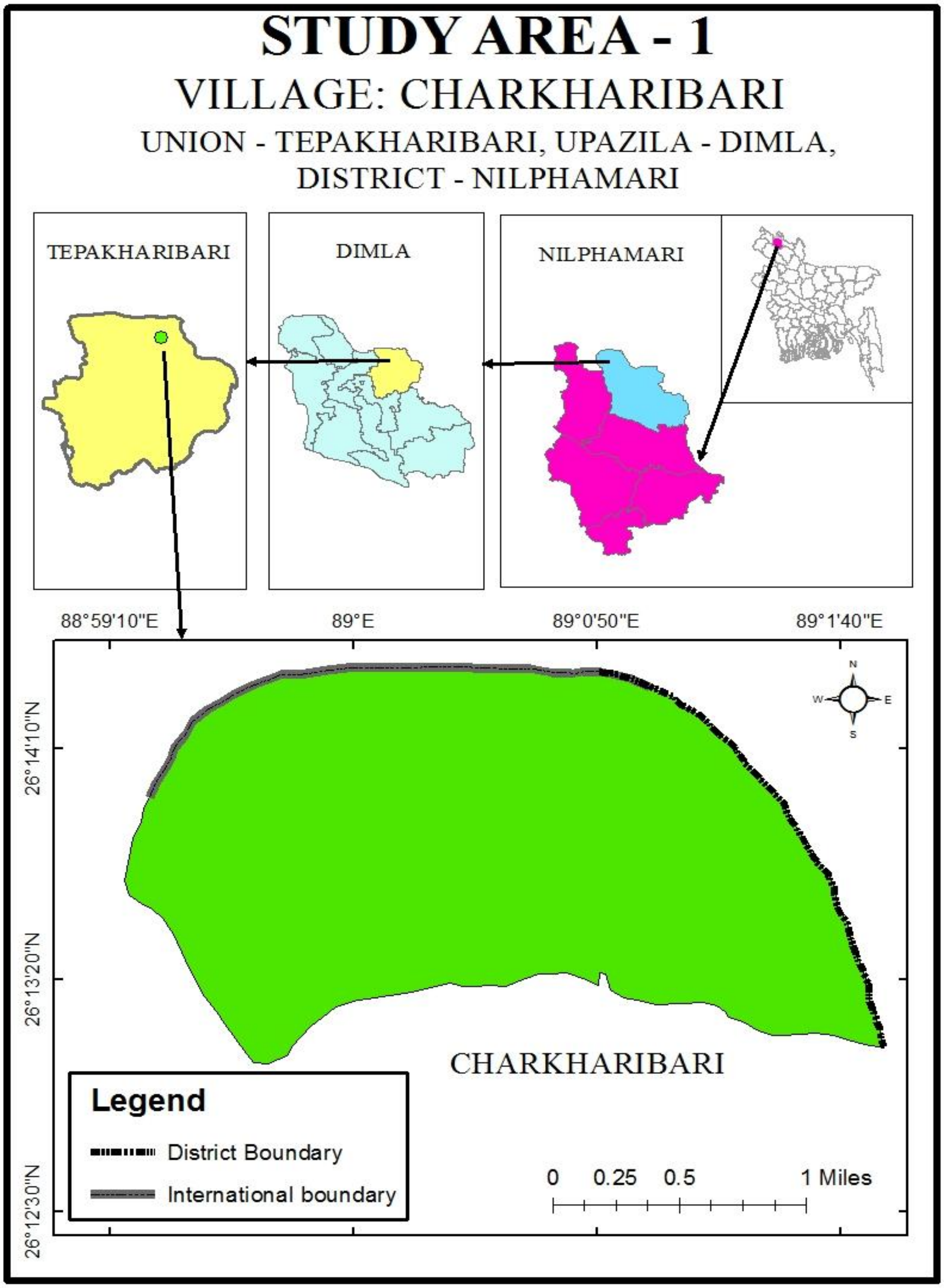
3.3.1. Reasons for Taking the Study Area

The study areas has been chosen for the following reasons.

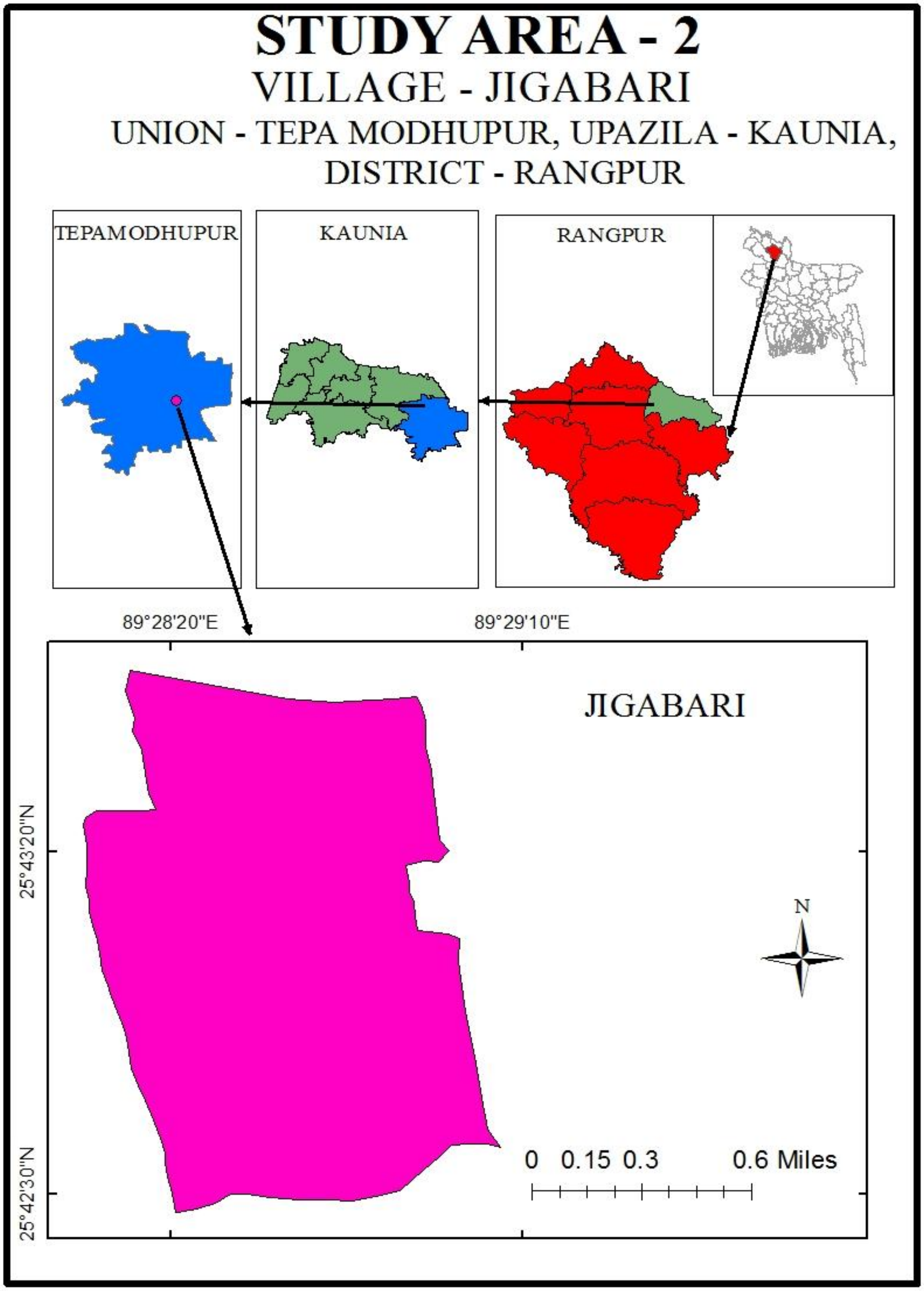
- Both of the study area are nearest to Teesta River.
- Both of the study area are affected with flood and drought simultaneously.
- Population density is higher in comparison to other areas of Teesta river basin.
- Essentially a flood prone area having a past flooding history.
- Essentially a drought prone area having a past drought history.
- The unions and villages of the selected upazilla presents the selected affected sectors.
- These two areas has relatively high concentration of agriculture and river based occupations.

- Not already, or planned to be; covered by any research in concept of critical moment assessment in these selected areas.
- Not already, or planned to be; covered by any research in respect of local coping mechanisms in these selected areas.
- Of relatively small size, in terms of population, poverty and other sectors to keep the study in a manageable form.

3.3.2. Maps of the Study Area



Source: Developed by Researcher.



Source: Developed by Researcher.

3.4. Sampling Techniques

Many professions (business, government, engineering, science, social research, agriculture, etc.) seek the broadest possible factual basis for decision-making. In the absence of data on the subject, a decision taken is just like leaping into the dark. Sampling is a procedure, where in a fraction of the data is taken from a large set of data, and the inference drawn from the sample is extended to whole group. The surveyor's (a person or an establishment in charge of collecting and recording data) or researchers' initial task is to formulate a rational justification for the use of sampling in his research (Raj, 1972). If sampling is found appropriate for a research, the researcher, then:

- Identifies the target population as precisely as possible, and in a way that makes sense in terms of the purpose of study (Salant, and Dillman, 1994).
- Puts together a list of the target population from which the sample will be selected (Salant, and Dillman, 1994). This list is termed as a frame (more appropriately list frame) by many statisticians (Raj, 1972).
- Selects the sample and decide on a sampling technique (Salant, and Dillman, 1994), and;
- Makes an inference about the population (Raj, 1972).

All these four steps are interwoven and cannot be considered isolated from one another. Simple random sampling, systematic sampling, stratified sampling fall into the category of simple sampling techniques. Complex sampling techniques are used, only in the presence of large experimental data sets; when efficiency is required; and, while making precise estimates about relatively small groups within large populations (Salant, and Dillman, 1994).

Two specific kinds of sampling techniques was used to conduct this study. Those sampling techniques are:

- Purposive sampling, and
- Simple random sampling without replacement.

Purposive Sampling

It is the one in which the person who is selecting the sample is who tries to make the sample representative, depending on his opinion or purpose, thus being the representation subjective. In purposive sampling, sampling is done with a purpose in mind. In this study; country, river-basin, districts and upazillas were purposively selected (Fig: 3.4.3).

Simple Random Sampling without Replacement

When a certain element is selected and we have measured the variables needed in a certain study and it can be selected again, we say that we make sampling with replacement. This sampling technique is usually called simple random sampling. In the case that the element cannot be selected again after being selected once, we say that we have obtained the sample through a random sampling without replacement. In this study; unions and villages were simple randomly with replacement selected (Fig: 3.4.3).

3.4.1. Determining Sample Size

The study population is finite. For determining sample size from finite population the following well known statistical formula will be used (Kothari, 1998) (Table-3.4.1).

$$n = \frac{z^2.p.q.N}{e^2(N-1) + z^2.p.q}$$

Here,
n = Sample size
N = Total number of households
z = Confidence level
p = estimated population proportion
q = 1-p
e = error limit of 5%

$$= \frac{(1.96)^2 \times 0.5 \times 0.5 \times 1099}{(0.05)^2 (1099 - 1) + (1.96)^2 \times 0.5 \times 0.5}$$

$$= \frac{1055}{3.7054}$$

=285

Table-3.4.1: Sample Size Determination and Sample Distribution

Name of District	Name of Upazilla	Name of Union(village)	No. of House holds	Population of village	Proportion of Household (%)	No of Households/ Respondents
Nilphamary	Dimla	Tepakharibari (Char Kharibari)	771	3722	771/1099 =70.15%	285x70.15% =200
Rangpur	Kaunia	Tepamadhupur (Jigabari)	328	1226	328/1099 =29.85%	285x29.85% =85
Total			1099	4948	100%	285

Source: Developed by Researcher with the help of BBS, 2011.

3.4.1.1. Reserve Sample

Due to migration and other demographic reasons household members can be unavailable during field survey. In some cases the respondents are ineligible to response. It is difficult to predict the non-response rate. In this case researcher can consider a reserve sample of 10% of the initial sample (Kothari, 2004) (Table-3.4.1.1). The reserve sample for this study will be = (285 x 10%) = 28.5 = 29

Table-3.4.1.1: Reserve Sample Distribution

Sample village	Distribution	Reserve sample (10% of initial sample
Char kharibari	200	20
Jigabari	85	9
Total	285	29

Source: Developed by Researcher.

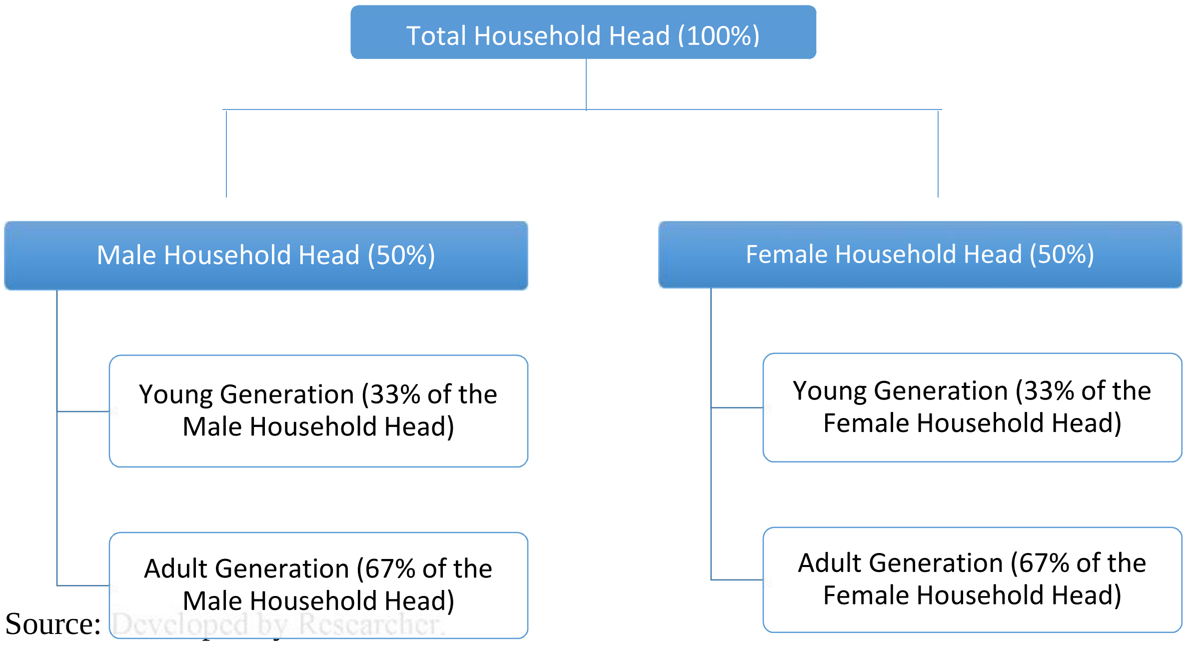
3.4.2. Types of Respondents

The questionnaire survey used in the study is household questionnaire survey. A household means a group of persons normally living together and eating in one mess (i.e. with common arrangement of cooking) with their dependents, relatives, servants etc. A household may be a one person household or a multi person household. In other –words, when a group of persons living together generally maintain a family or family like relations and take meals from the same kitchen is termed as a household. Popularity, it is described as "Khana". In some cases there may be more than one households in a single house or in one dwelling arrangement. Similarly, a household may have more than one house or structure or shed. The household must be distinguished from a family which consists of blood related members who may live in different places but members of the household must share the same kitchen and live together (BBS, 2011).

In this study data will be collected from the household head. A household head is a person living alone in a dwelling unit shall be considered as the head of that household. In a household consisting of a group of persons, a member is treated as the head whom the other members been to be so. Generally, the eldest male or female earner of the household is considered to be the head of the household (BBS, 2011).

Types of respondents will be in details in the (Fig-3.4.2).

Fig-3.4.2: Types of Respondents.

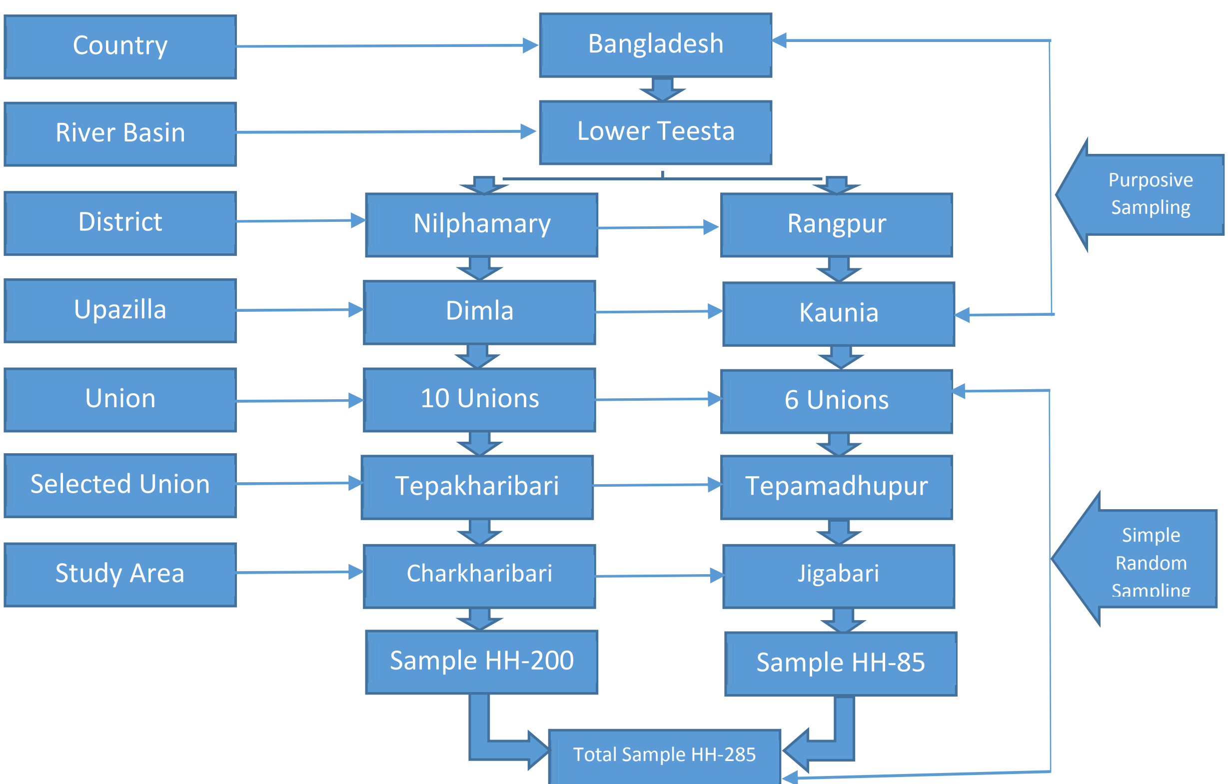


Source: Developed by Researcher.

3.4.3. Distribution of Sample

Distribution of samples will be in details in the (Fig-3.4.3).

Fig – 3.4.3: The Sample Design and Distribution of Samples



Source: Developed by Researcher.

3.5. Sources of Data and Collection Methods

The most important step of research is data collection. Data collection is the first task for any research. Data collection on selected area is essential for whole research work. The data collection should be proper and right otherwise the research would be invalid. The relevant data and information used in this study have been collected from both primary and secondary sources. Primary data has been collected directly from the study area. A questionnaire survey was conducted in the study area with a view to collect quantitative data as well as qualitative information. In the study both primary and secondary data will be used in the analysis of the situation.

So, for collecting accurate data, qualitative and quantitative information play a vital role in the research work. For this study relevant information and data were collected from two sources.

3.5.1 Primary data sources, and

3.5.2 Secondary data sources.

3.5.1. Collection of Primary Data

Primary data is collected from the household of Charkharibari and Jigabari village during survey period. Some data are collected from key informants by informal interviews. In addition, observation and group discussions were conducted in order to gather additional and supplementary information about the flood and drought induced critical stress moments; and its impact on socio-economic situation and its impact on people's economic condition and coping strategy (i.e. how the people cope with this situation).

Methods of primary data collection are used as follows.

- Reconnaissance survey,
- Standardized Household questionnaire survey,
- Informal interview with stakeholders and key informants,
- Participatory observation, and
- Photography.

Reconnaissance Survey

A reconnaissance survey was conducted in first field visit to conceptualize the overall practical situation and obtaining background information of the study area for selection purpose and designing sample size before starting the standardized questionnaire survey. In fact before doing the survey, a pretest of questionnaire was done in Charkharibari and Jigabari village for 10 respondents, which helped to clarify questions which is inconsistent, unclear on irrelevant to the research. Based on the result, further review, modification and correction were done.

Standardized Household Questionnaire Survey

Primary data is collected by questionnaire survey from the household of Dimla upazila's Charkharibari village and Kaunia upazila's Jigabari village during survey period. Standardized questionnaire is designed according to variables, values that had been constructed in the research co-ordination schema. A questionnaire survey is conducted at house hold level through face-to-face interviews by using a standardized questionnaire to obtain general information of house hold, household's income and expenditure, the social structure, critical climatic stress moments, causes of critical moments, effect of critical moments on their livelihood; and people's adaptation strategy or coping mechanism to the precarious environment, their priority and needs during the period of critical moments. The questionnaire contained both open ended and closed questions. And, before doing the survey, a pretest of questionnaire was done in Charkharibari village for 5 respondents and Jigabari village for 5 respondents which helped to clarify questions which is inconsistent, unclear on irrelevant to the research. Based on the result, further review, modification and correction were done. The survey was done by survey team including the researcher and two assistants.

Informal Interview with Stakeholders and Key Informants

Informal interview was conducted in this study, which was involved discussion on different issues related to critical moments and adaptation strategies. The target groups for the interview included special interest groups of knowledgeable individuals (key informants) such as several government officials, well-informed and unbiased persons like village elder, local leader, school teachers and other educated people.

Participatory Observation

Several participatory field observation was done during several field survey periods with analytical and scientific mind. This helped the researcher to understand the present physical condition of the study area, settlement pattern, housing types, drainage system, health facilities, economic activities etc. Observation sheets were used to record the above-mentioned parameters.

Photography

Photography is one kind of primary data sources. It provides actual and accurate visual presentation of study area. By using photography can show their holistic situation or pattern of house, crops field etc. To represent the actual conditions many photographs has been taken from the study area.

3.5.2. Collection of Secondary Data

To complete research work accurately, some secondary data has taken. Secondary data on physical setting, total household population, institutional framework, policy guidelines and maps of the study area were obtained from several Govt. and NGO office, published Government statistical yearbook, physical map from LGED, Upazilla Agriculture office, Vumi office etc. On the other hand, Secondary data was collected from several government bodies, non-governmental organizations as well as from several published out put such as reports, books, documents, journals, maps and papers from different libraries. The secondary data sets required for the study land use and land use change related different data and information was collected from Bangladesh Bureau of Statistics (BBS), Local Government Engineering Department (LGED) and websites. These data was used primarily to understand and conceptualize the real situation. The sources of all secondary data sources are mentioned in Table-3.5.1.

Table 3.5.1: Sources of Secondary Data.

Type	Sources
Government	Bangladesh Water Development Board (BWDB) Bangladesh Meteorological Department (BMD) Institute of Water Modeling (IWM) Flood Forecasting and Warning Centre (FFWC) Water Resource Planning Organization (WARPO) Bangladesh Bureau of Statistics (BBS) Local Government Engineering Department (LGED)
Local Authority	Water Development Board of Teesta Barrage Project LGED of Nilphamary and Rangpur District Upazilla Parishad of Dimla and Kaunia Union Parishad of Tepakharibari and Tepamadhupur
Research Institution	International Centre for Integrated Mountain Development (ICIMOD) Bangladesh Centre for Advanced Studies (BCAS) Centre for Environmental and Geographic Information Services (CEGIS) Institute of Bangladesh Studies (IBS)
Library	Central Library of Rajshahi University Central Library of Dhaka University Central Library of Jahangirnagar University Central Library of Begum Rokeya University Library of RDRS
Universities	Institute of Water and Flood Management, BUET, Dhaka. Dept. of Geography and Environment, University of Dhaka. Dept. of Geography and Environmental Studies, University of Rajshahi. Dept. of Geography and Environment, University of Jahangirnagar, Dhaka. Dept. of Geography and Environment, University of Begum Rokeya, Rangpur.
NGOs	BCAS RDRS Disaster Forum

Source: Developed by Researcher.

3.6. Data Analysis Process

The collected data is analyzed first to eliminate the unnecessary and irrelevant information through checking and verification before coding process and then Ms-Excel and SPSS 22.0 (Statistical Package for Social Science) software was used for tabulation, analysis and graphic presentation. Arc GIS 10.2 and Arc View 8.1 software were also exercised for mapping analysis. To fulfill the specific objectives of the study, based on the nature and extent of availability of data, the following descriptive statistics, analytical statistics and qualitative analysis were adopted for analyzing data.

3.6.1. Descriptive Statistics

Different types of descriptive statistics such as frequency distribution, percentage, average and cross tabulation etc. were applied for analyzing data. Various statistical illustrations such as pie chart, line and bar diagram were used for graphical presentation to elaborate the economic condition, employment, income and expenditure situation and their causes and consequences due to flood and drought in the certain area. SWOT (Strength, Weakness, Opportunities, Threat) analysis will be done to understand comparative vulnerability.

3.6.2. Analytical Statistics

To find out the similarities and differences as well as relations among different quantitative variables selected in both flood and drought prone areas several tests such as Chi-square test, Regression analysis and Correlation analysis were applied.

Chi-square test: Chi-square test is a simple technique which works by testing a distribution actually observed in the field against some other distribution determined by H_{o}- for example, that the objects under the study area evenly spread over the landscape. Chi-square test was applied to find out or test for determining relationship between some variables such as relationship between social consequence and environmental consequence of flashflood and drought in the study area and also some other relevant categorical data.

To compute Chi-square test the following formula is used (Wonnacott and Wannacott, 1990).

$$x^2 = \sum \frac{(Oi - Ei)^2}{Ei}$$

Where, Oi=Observed frequency

Ei =Expected frequency

x^2=Chi-square

Chi-square test is, therefore, a measure of the aggregate difference between observed frequencies and those expected under H_o, so that the greater its value the less likely it is that H_o is correct.

Correlation Analysis:

The statistical tool with the help of which the relationship between two variables studied is called correlation whenever two variables are also related that a change in the value of the other, in the study away, that-

i. An increase in the one is accompanied by an increase or decrease in the other, or
ii. A decrease in the one is accompanied by a decrease or increase in the other, and then the variable is called correlated.

As a measure of intensity of linear relationship between two variables, Karl Pearson (1867-1936), a British Biometrician, developed a formula called correlation coefficient. Correlation coefficient between two random variables X and Y, usually denoted by r (X, Y) is a numerical measure of linear relationship between them and is defined as-

$$R(X, Y) = \frac{COR\ (X,Y)}{\sqrt{VAR(X)VAR(Y)}}$$

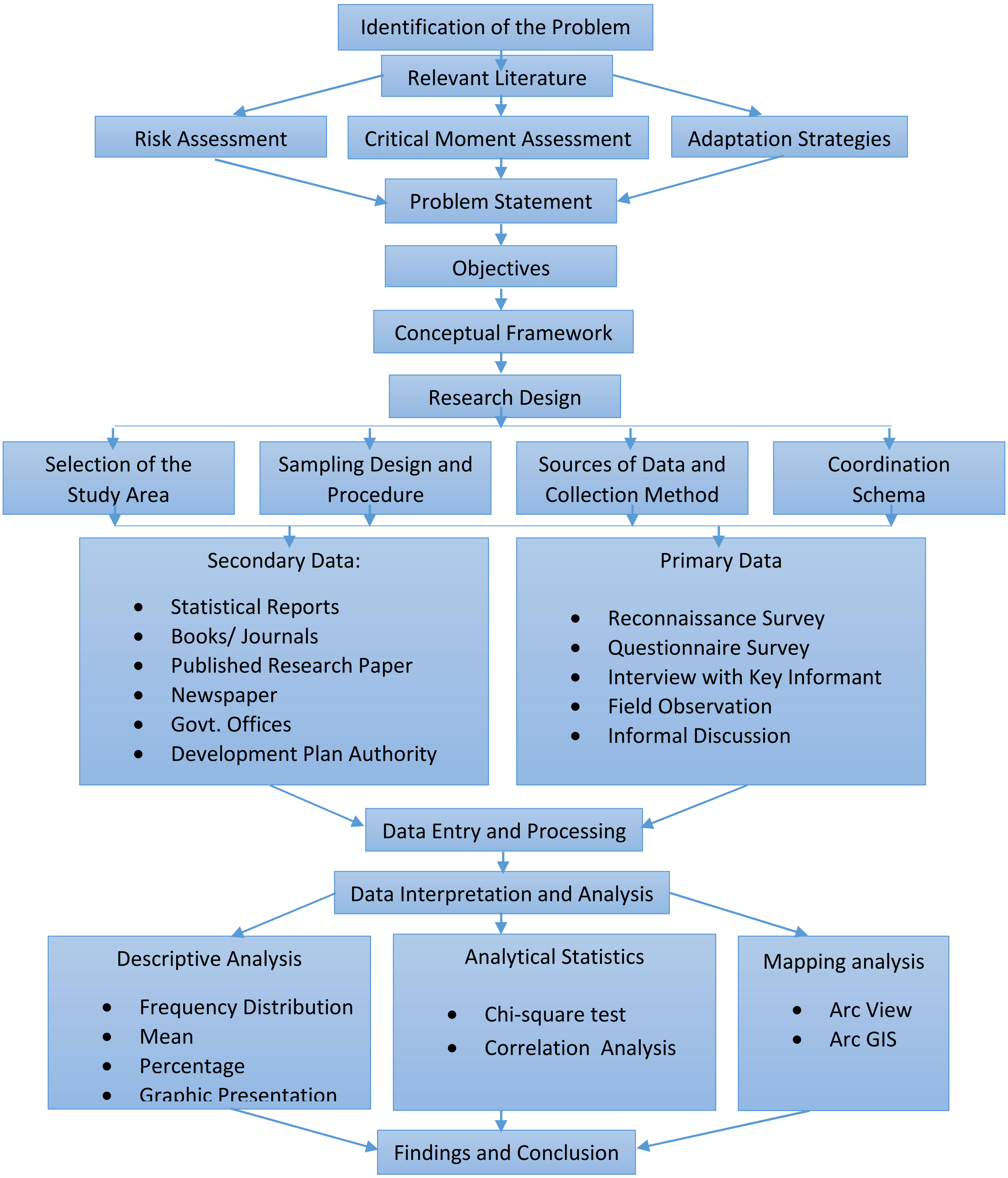
3.6.3. Qualitative Analysis

Some informal interviews have been taken to get an overall impression of critical moments to climate change induced flood and drought occurrence. The interviews help to linking and connecting the relationship between critical moment and climate change.

3.7. Methodological Framework

(Fig-3.7) describes the methodological framework.

Fig-3.7: Schematic Diagram of Methodology.



Source: Developed by Researcher.

Chapter Four

Study Area and Respondents Profile

This chapter is focused mainly on the description of study areas. The chapter also includes the description of respondents' profile.

4.1. District Profile

In Bangladesh, lower Teesta basin area includes five districts. They are Nilphamari, Lalmonirhat, Rangpur, Gaibandha and Kurigram. Among these districts I have selected two districts by simple random sampling. The selected districts are:

4.1.1 Nilphamari district, and

4.1.2 Rangpur district.

4.1.1. Nilphamari District

Nilphamari is one of the five districts in lower Teesta basin area in Bangladesh.

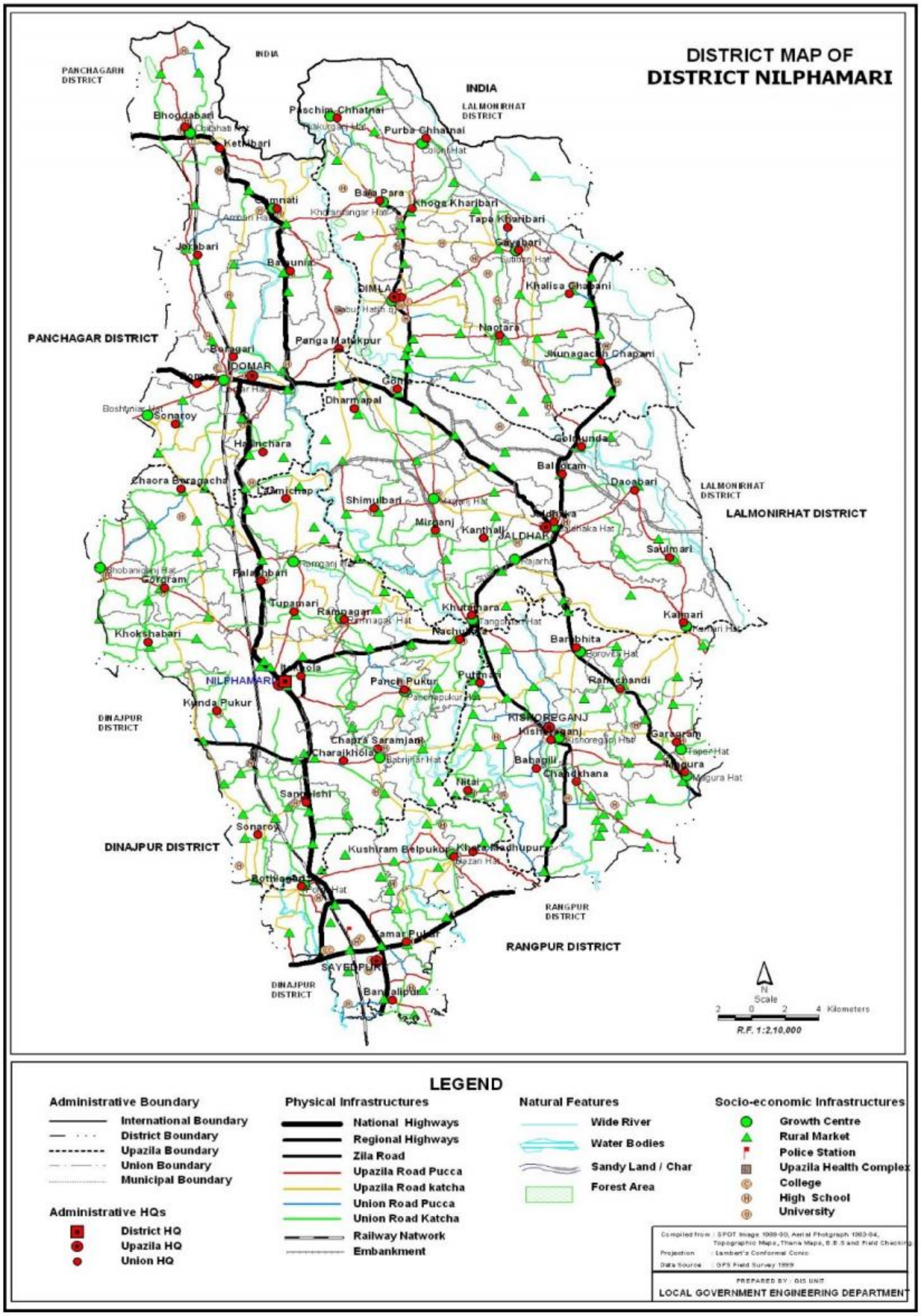
4.1.1.1. Background Information of Nilphamari District

Nilphamari district was one of the sub-divisions of Rangpur District. It was upgraded to a district in 1984. Nothing is definitely known about the origin of the district name. But it is said that the present place of the district was once prominent for **Nil** (Indigo) cultivation. A big **Nil** '**Khamar**'(meaning farm) was set up here, as such the area was called Nilkhamari. The present name of the district Nilphamari is the phonetic corruption of the original name **Nilkhamari** (BBS, 2011).

4.1.1.2. Geographical Settings of Nilphamari District

Nilphamari district is surrounded on the north by West Bengal State of India, east by Lalmonirhat District and Rangpur District, south by Rangpur District and Dinajpur District and west by Panchagarh District and Dinajpur District. It lies between 25º44' and 26º19' north latitudes and between 88º44' and 89º12' east longitudes (Fig–4.1.1.2). The total area of the district is 1546.59 sq. km. (597.00 sq. miles) of which 33.54 sq. km. (12.95 sq. miles) is riverine and 6.26 sq. km (2.42 sq. miles) is under forest. Teesta Barrage Project, one of the biggest irrigation projects of the country, begins from Dalia of this district (BBS, 2011).

Fig-4.1.1.2: Map of Nilphamari District.



Source: Modified by Researcher from LGED District Maps.

4.1.1.3. Temperature and Rainfall of Nilphamari District

Nilphamari’s climate is classified as warm and temperate. When compared with winter, the summers have much more rainfall. According to Köppen and Geiger, this climate is classified as Cwa. The annual average temperature of the district varies maximum 32.3°C to minimum 11.2°C and the annual average rainfall of the district is recorded 2931 mm (BBS, 2011). Below the (Table-4.1.1.3) shows year wise temperature, rainfall and humidity data of Nilphamari district from year 2008-2011.

Table-4.1.1.3: Temperature, Rainfall and Humidity Data of Nilphamari District.

Years	Temperature (centigrade)		Rainfall (mm)	Humidity (%)
	Maximum	Minimum		
2008	32.2	10.0	1881	71.0
2009	33.0	12.3	2140	77.0
2010	33.1	10.2	1526	63.4
2011	21.2	9.3	1821	77.4

Source: BBS, 2011.

4.1.1.4. Water Bodies of Nilphamari District

Teesta, Jamuneshwari, Buri Teesta, Ghagot, Chikni and Dhaigan are the main rivers, flow through this district.

4.1.1.5. Administrative Units of Nilphamari District

The district consists of 6 upazillas, 61 unions, 371 mauzas, 361 villages, 4 paurashavas, 42 wards and 83 mahallas. The upazillas under Nilphamari District are Nilphamari Sadar, Dimla, Domar, Jaldhaka, Kishoreganj and Sayedpur (BBS, 2011). Below the (Table-4.1.1.5) shows the detailed administrative units of Nilphamary district.

Table-4.1.1.5: Detailed Administrative Units of Nilphamari District.

Upazilla	Municipality	Ward	Mahalla	Union	Mauza	Village
Dimla	0	0	0	10	53	53
Domar	1	9	12	10	47	47
Jaldhaka	1	9	15	11	69	61
Kishoreganj	0	0	0	9	51	53
Nilphamari Sadar	1	9	13	15	109	108
Sayedpur	1	15	43	6	42	39
Total	4	42	83	61	371	361

Source: BBS, 2011.

4.1.1.6. Population of Nilphamari District

The district aggregate population is 18, 34,231 of which males are 9, 22,964 and females are 9, 11,267. Religion wise are Muslim 15, 38,916; Hindu 2, 93,385; Buddhist 53; Christian 1,108 and others 769. Indigenous community such as Santal belongs to this district (BBS, 2011). Below the (Table-4.1.1.6) shows the detailed population of Nilphamary district.

Table-4.1.1.5: Detailed Population of Nilphamari District.

Upazilla	Household	Population			Sex ratio(M/F)	Average size of household	Density per sq. km.
		Male	Female	Both sex			
Dimla	63535	142412	141026	283438	101	4.46	867
Domar	58020	125338	124091	249429	101	4.29	1153
Jaldhaka	78994	171466	169206	341672	101	4.30	1122
Kishoreganj	65798	130931	130138	261069	101	3.96	1273
Nilphamari Sadar	97088	219080	216082	435165	101	4.46	1166
Sayedpur	58137	134737	131724	265461	102	4.51	2174
Total	**421572**	**922964**	**911267**	**1834231**	**101**	**4.34**	**1186**

Source: BBS, 2011.

4.1.1.7. Educational Status of Nilphamari District

Among population aged 7 years and over the literacy rate of this district is 44.4 % (Both sex) in which Male 47.6% and Female 41.1% (BBS, 2011).

4.1.1.8. Economic Status of Nilphamari District

The economy of Nilphamari is predominately agricultural. Out of total 384629 households of the district 53.09 % holdings are farms which produce varieties of crops and fruits. Varieties of fish are caught from rivers, beels and paddy fields during rainy season. Besides crops, livestock and poultry are the subsidiary source of household income of the district (BBS, 2011). Non-farm activities also play an important role in economic development of Nilphamari district. There are a total of 47988 establishments in the district in which 118739 persons are engaged in different types of non-farm activities. Female participation in non-farm activities is very poor (7.35%) in Nilphamari district (BBS, 2011).

4.1.1.9. Main Crops of Nilphamari District

The major agricultural crops of Nilphamari district are rice, wheat, jute, pulse, oilseed, vegetable, spice, sugarcane, tobacco, etc. Among rice crops Aman occupies the largest area followed by Aus and Boro. The fruit crops are banana and coconut. The crop which is very commonly grown and is very special of this district is betel nut (BBS, 2011).

4.1.1.10. Transportation System of Nilphamari District

Palanquin, horse carriage, bullock cart, Gaina boat are the traditional transports found in the rural area of Nilphamari District. These means of transport are either extinct or nearly extinct. Now-a-days, all the upazillas are connected with the district headquarters with metaled roads. Bus, minibus, three wheelers ply over the district (BBS, 2011).

4.1.2. Rangpur District

Rangpur is one of the five districts in lower Teesta basin area in Bangladesh.

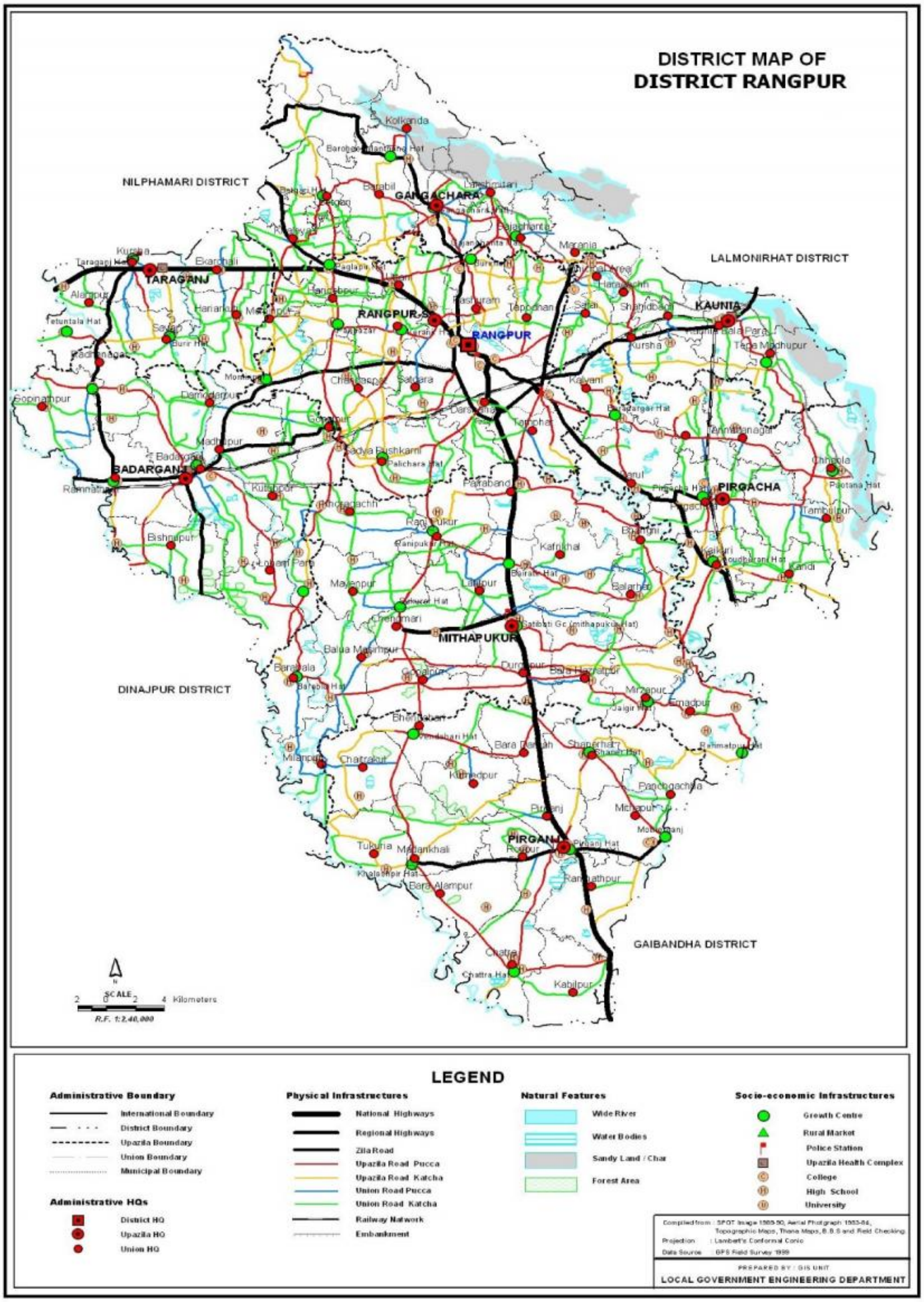
4.1.2.1. Background Information of Rangpur District

Rangpur district was established in 1772. Nothing is definitely known about the origin of the district name. It is said that a representative of Banglar Nawab named Badarjung had a Rang Mahal (meaning house of enjoyment) in this area. The other opinion is that the king of Kamrup had built a Rang Mahal in this area for amusement. This might be the origin of the district name to be Rangpur (BBS, 2011).

4.1.2.2. Geographical Settings of Rangpur District

The district is bounded on the north by Nilphamari and Lalmonirhat districts, on the east by Lalmonirhat, Kurigram and Gaibandha districts, on the south by Gaibandha and Dinajpur districts and on the west by Dinajpur and Nilphamari districts with an area of 2400.56 sq. km (BBS, 2011). The district lies between 25º18˝ and 25º57˝ north latitudes and between 88º56˝ and 89º32˝ east longitudes (Fig–4.1.2.2).

<u>Fig-4.1.2.2: Map of Rangpur District.</u>



Source: Modified by Researcher from LGED District Maps.

4.1.2.3. Temperature and Rainfall of Rangpur District

The Climate of the District is moderate with equable temperature, high humidity and plenty of rainfall. The summer season commences in April and lasts up to June. The monsoon usually sets in early June and continues till the end of September. The winter season sets in early November and lasts up to the end of February. In the months of January and February relatively severe cold is experienced in the District due to its proximity to the Himalayan hills. The minimum and maximum mean annual temperature vary between 6.0°C and 36.3°C. During the monsoon the humidity is very high and remains high until December when it falls sharply to reach a low in February-March. Total annual rainfall of this district is 1932 mm (BBS, 2011). Below the (Table-4.1.2.3) shows year wise temperature, rainfall and humidity data of Rangpur district from year 2008-2011.

Table-4.1.2.3: Temperature, Rainfall and Humidity Data of Rangpur District.

Years	Temperature (centigrade)		Rainfall (mm)	Humidity (%)
	Maximum	Minimum		
2008	32.2	10.4	1907	41.0
2009	33.1	8.8	2217	69.0
2010	41.8	10.5	2102	60.0
2011	36.3	6.0	1932	59.0

Source: BBS, 2011.

4.1.2.4. Water Bodies of Rangpur District

A number of rivers flow through the district. The main rivers are the Teesta, the Jamuneshwari, the Karatoya, the Chikli, the Akhira and the Ghaghat. All the rivers are non-tidal and are not navigable during all seasons except monsoon. The following length of the rivers is about 209 km (130 miles). It occupies an area of 97.78 sq. km (BBS, 2011).

4.1.2.5. Administrative Units of Rangpur District

Rangpur (Town) stands on the bank of the river Ghaghat. The town was turned into a municipality in 1869. The district consists of 8 upazillas, 84 unions, 1197 mauzas, 1492 villages, 3 paurashavas, 33 wards and 197 mahallas. The upazillas under Rangpur District are Badarganj, Gangachara, Kaunia, Rangpur Sadar, Mithapukur, Pirgacha, Pirganj and Taraganj (BBS, 2011). Below the (Table-4.1.2.5) shows the detailed administrative units of Nilphamary district.

Table-4.1.2.5: Detailed Administrative Units of Rangpur District.

Upazilla	Municipality	Ward	Mahalla	Union	Mauza	Village	Depopulated Mauza
Badarganj	1	9	12	10	64	120	1
Gangachara	0	0	0	10	92	128	0
Kaunia	1	9	77	6	80	78	7
Mithapukur	0	0	0	17	310	315	1
Pirgacha	0	0	0	9	170	170	0
Pirganj	0	0	0	15	308	332	3
Rangpur Sadar	1	15	108	12	151	308	12
Taraganj	0	0	0	5	40	41	0
Total	3	33	197	84	1215	1492	24

Source: BBS, 2011.

4.1.2.6. Population of Rangpur District

The district aggregate population is 28, 81,086 of which males are 14, 43,816 and females are 14, 37,270. Religion wise are Muslim 26, 04,263; Hindu 2, 58,684; Buddhist 1863; Christian 6594 and others 9682. Indigenous community such as Santal belongs to this district (BBS, 2011). Below the (Table-4.1.1.6) shows the detailed population of Nilphamary district.

Table-4.1.2.6: Detailed Population of Rangpur District.

Upazilla	Household	Population(000)			Sex ratio(M/F)	Average size of household	Density per sq. km.
		Male	Female	Both sex			
Badarganj	71982	144	143	288	101	3.99	955
Gangachara	73463	150	148	298	102	4.04	1105
Kaunia	56263	113	115	228	98	4.04	1543
Mithapukur	135073	252	256	508	99	3.75	985
Pirgacha	82623	153	160	313	96	3.78	1174
Pirganj	101640	192	193	385	99	3.78	937
Rangpur Sadar	165017	367	351	718	104	4.20	1998
Taraganj	34119	72	71	143	102	4.16	1108
Total	**720180**	**1444**	**1437**	**2881**	**100**	**3.96**	**1200**

Source: BBS, 2011.

4.1.2.7. Educational Status of Rangpur District

Among population aged 7 years and over the literacy rate of this district is 48.5 % (Both sex) in which Male 51.2% and Female 45.9% (BBS, 2011).

4.1.2.8. Economic Status of Rangpur District

The economy of Rangpur is predominately agricultural. Non-farm activities also play an important role in economic development of Rangpur district. Major industries are 3 Garment factories, 703 Rice mills, 215 Steel and Engineering mills, an Aluminum factory, 4 Jute mills, 2 Sugar mills in this district. There are a total of 78842 establishments in the district in which 227149 persons are engaged in different types of non-farm activities. Female participation in non-farm activities is very poor (6.43%) in Nilphamari district (BBS, 2011).

4.1.2.9. Main Crops of Rangpur District

The major agricultural crops of Rangpur district are rice, paddy, wheat, maize, potato, pulse, oilseed, vegetable, spice, sugarcane, tobacco, etc. Among rice crops Aman occupies the largest area followed by Aus and Boro. The fruit crops are banana, mango, jackfruit, papaya, and coconut. The crop which is very commonly grown and is very special of this district is betel nut (BBS, 2011).

4.1.2.10. Transportation System of Rangpur District

Palanquin, horse carriage, bullock cart, Gaina boat are the traditional transports found in the rural area of Rangpur District. These means of transport are either extinct or nearly extinct. Now-a-days, all the upazillas are connected with the district headquarters with metaled roads. Bus, minibus, three wheelers ply over the district (BBS, 2011).

4.2. Upazilla Profile

The selected upazillas from the previously selected districts are:

4.2.1 Dimla upazilla from Nilphamari district, and

4.2.2 Kaunia upazilla from Rangpur district.

4.2.1. Dimla Upazilla

Dimla upazilla is situated in the bank of upstream of Teesta River.

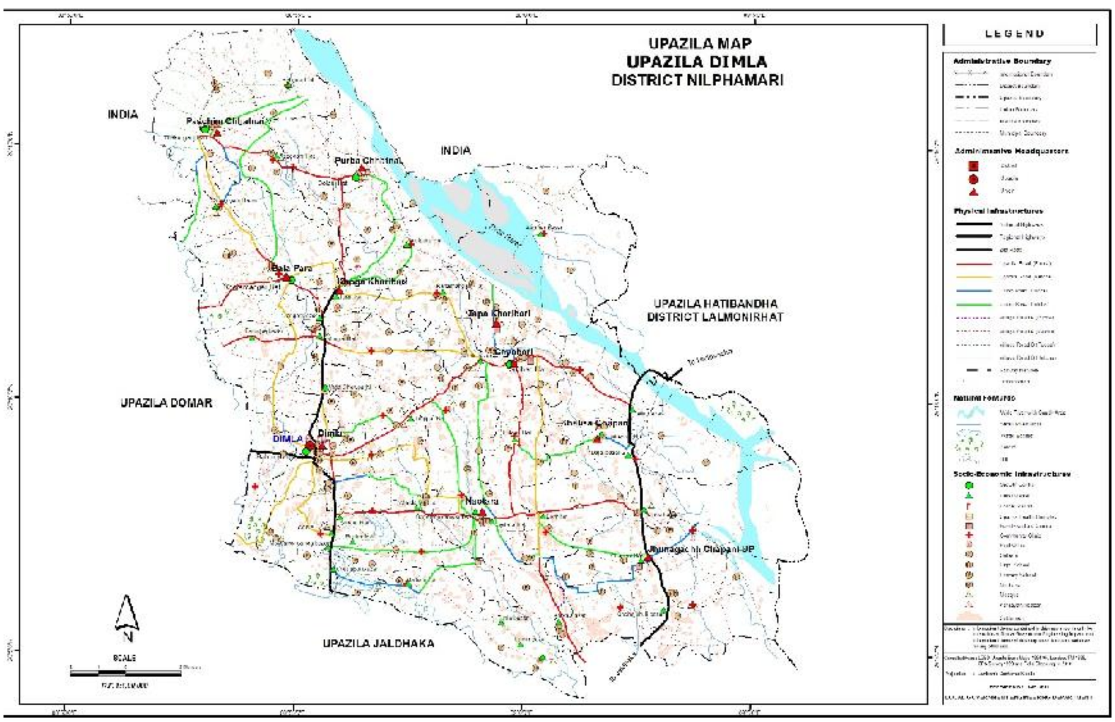
4.2.1.1. Background Information of Dimla Upazilla

Dimla, the second biggest upazilla of Nilphamari district in respect of area, came in to existence in 1857 as a Thana and was upgraded to upazilla in 1984 (BBS, 2011).

4.2.1.2. Geographical Settings of Dimla Upazilla

The upazilla occupies an area of 326.74 sq. km. including 6.41 sq.km. forest area. It is located between 26º05' and 26º17' north latitudes and between 88º52' and 89º06' east longitudes (Fig–4.2.1.2). The upazilla is bounded on the north by West Bengal State of India, east by Hatibandha Upazilla of Lalmonirhat district, south by Jaldhaka Upazilla and west by Domar Upazilla (BBS, 2011).

Fig-4.2.1.2: Map of Dimla Upazilla.



Source: Modified by Researcher from LGED District Maps.

4.2.1.3. Dimla Upazilla at a Glance

Below the (Table – 4.2.1.3) shows demographic, spatial and other attribute information of Dimla upazilla (BBS, 2011).

Table-4.2.1.3: 2011 Census Result of Dimla Upazilla.

Key Indicators	2011
Population Enumerated	
Both Sex	2,83,438
Male	1,42,412
Female	1,41,026
Urban	-
Sub-urban	19,719
Rural	2,63,719
Annual Growth Rate	2.35
Sex Ratio	
Total	101
Urban	-
Sub-urban	104
Rural	101
Households (HH)	
Total	63,535
Urban	-
Sub-urban	4,433
Rural	59,102
Average HH Size	
Total	4.46
Urban	-
Sub-urban	4.43
Rural	4.46
Area sq. km	326.74
Area sq. mile	126.15
Density per sq. km	867
Density per sq. mile	2,247
Urbanization (%)	6.96
Literacy (7 years and above) (%)	
Both Sex	42.2
Male	44.7
Female	39.7
Administrative Unit	
Upazilla	1
Union	10
Mauza	53
Village	53
Paurashava	-
Ward	-
Mahalla	-

Source: BBS, 2011.

4.2.2. Kaunia Upazilla

Kaunia upazilla is situated in the bank of downstream of Teesta River.

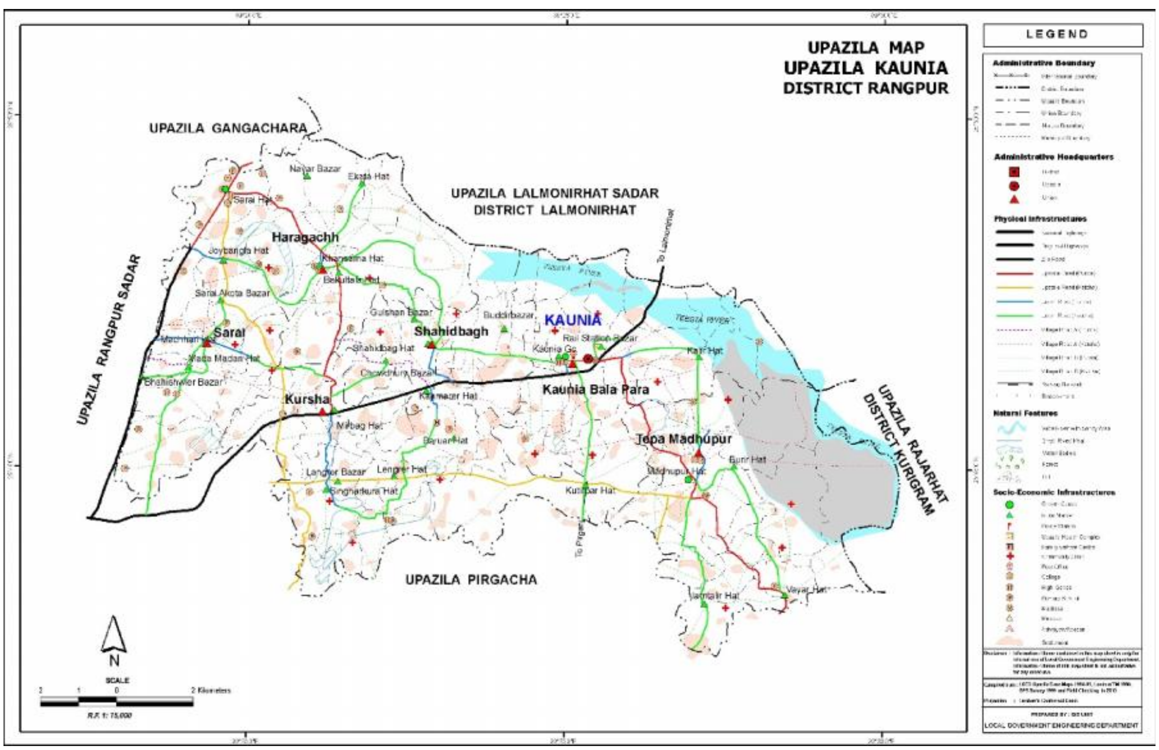
4.2.2.1. Background Information of Kaunia Upazilla

Kaunia came into existence in 1916 as a Thana and was upgraded to upazilla in 1984. The local people are in the opinion that the upazilla derived its name from the name of a prosperous village named Kaunia which was famous for growing ***Kaun*** (one type of grain) in plenty (BBS, 2011).

4.2.2.2. Geographical Settings of Kaunia Upazilla

The upazilla occupies an area of 147.64 sq. km. It is located between 25º42' and 25º50' north latitudes and between 89º18' and 89º30' east longitudes (Fig–4.2.2.2). The upazilla is bounded on the north by Lalmonirhat Sadar upazilla of Lalmonirhat district and Gangachara upazilla, on the east by Lalmonirhat Sadar upazilla of Lalmonirhat district and Rajarhat upazilla of Kurigram district, on the south by Pirgacha upazilla and on the west by Rangpur Sadar upazilla (BBS, 2011).

Fig-4.2.2.2: Map of Kaunia Upazilla.



Source: Modified by Researcher from LGED District Maps.

4.2.2.3. Kaunia Upazilla at a Glance

Below the (Table – 4.2.2.3) shows demographic, spatial and other attribute information of Kaunia upazilla (BBS, 2011).

Table-4.2.2.3: 2011 Census Result of Kaunia Upazilla.

Key Indicators	2011
Population Enumerated	
Both Sex	2,27,805
Male	1,21,701
Female	1,15,104
Urban	61,425
Sub-urban	-
Rural	1,66,380
Annual Growth Rate (%)	0.60
Sex Ratio	
Total	98
Urban	96
Sub-urban	-
Rural	98
Households (HH)	
Total	56,263
Urban	14,714
Sub-urban	-
Rural	41,549
Average HH Size	
Total	4.04
Urban	4.17
Sub-urban	-
Rural	4.00
Area sq. km	147.64
Area sq. mile	57.00
Density per sq. km	1,543
Density per sq. mile	3,996
Urbanization (%)	26.96
Literacy (7 years and above) (%)	
Both Sex	41.9
Male	44.8
Female	39.0
Administrative Unit	
Upazilla	1
Union	6
Mauza	75
Village	78
Paurashava	1
Ward	9
Mahalla	77

Source: BBS, 2011.

4.3. Union Profile

The selected unions from the previously selected upazillas are:

4.3.1 Tepakharibari union from Dimla upazilla of Nilphamari district, and

4.3.2 Tepamadhupur union from Kaunia upazilla of Rangpur district.

4.3.1. Tepakharibari Union

Tepakharibari union is situated in the right bank of upstream of Teesta River.

4.3.1.1. Tepakharibari Union at a Glance

Below the (Table – 4.3.1.1) shows demographic, spatial and other attribute information of Tepakharibari union (BBS, 2011).

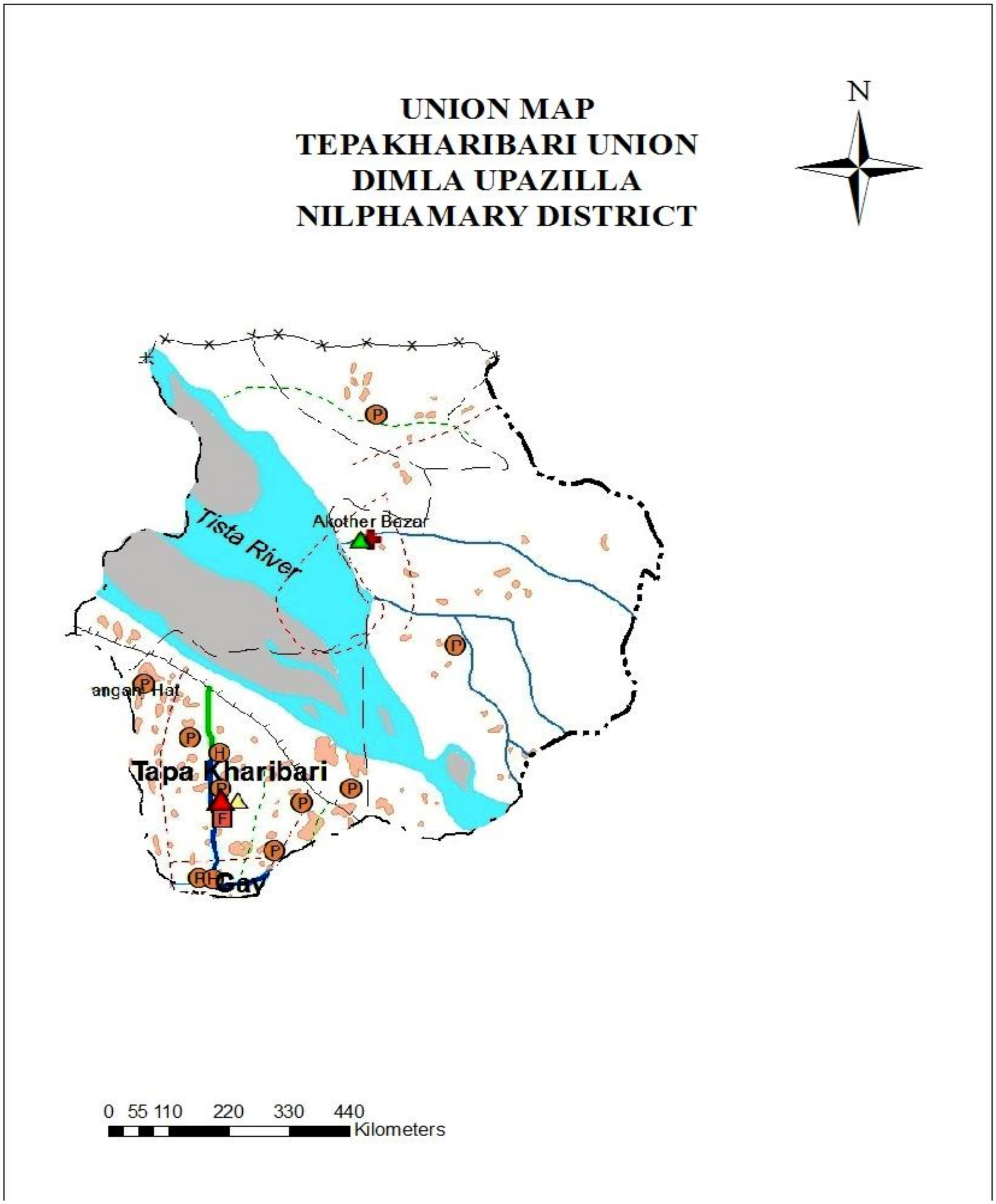
Table-4.3.1.1: 2011 Census Result of Tepakharibari Upazilla.

Key Indicators	**2011**
Area (Acre)	7836
Total Households (HH)	3879
Avg. HH Size	4.7
Population Density (sq. km)	577
Population Total	18284
Male	9271
Female	9013
Sex Ratio	103
Literacy Rate Total	34.0
Male Literacy Rate	36.9
Female Literacy Rate	31.1
Muslim	18011
Hindu	273
Village	4

Source: BBS, 2011.

Tepakharibari union map is shown below in the (Fig – 4.3.1.1).

Fig-4.3.1.1: Map of Tepakharibari Union.



Source: Modified by Researcher from LGED District Maps.

4.3.2. Tepamadhupur Union

Tepamadhupur union is situated in the left bank of downstream of Teesta River.

4.3.2.1. Tepamadhupur Union at a Glance

Below the (Table – 4.3.2.1) shows demographic, spatial and other attribute information of Tepamadhupur union (BBS, 2011).

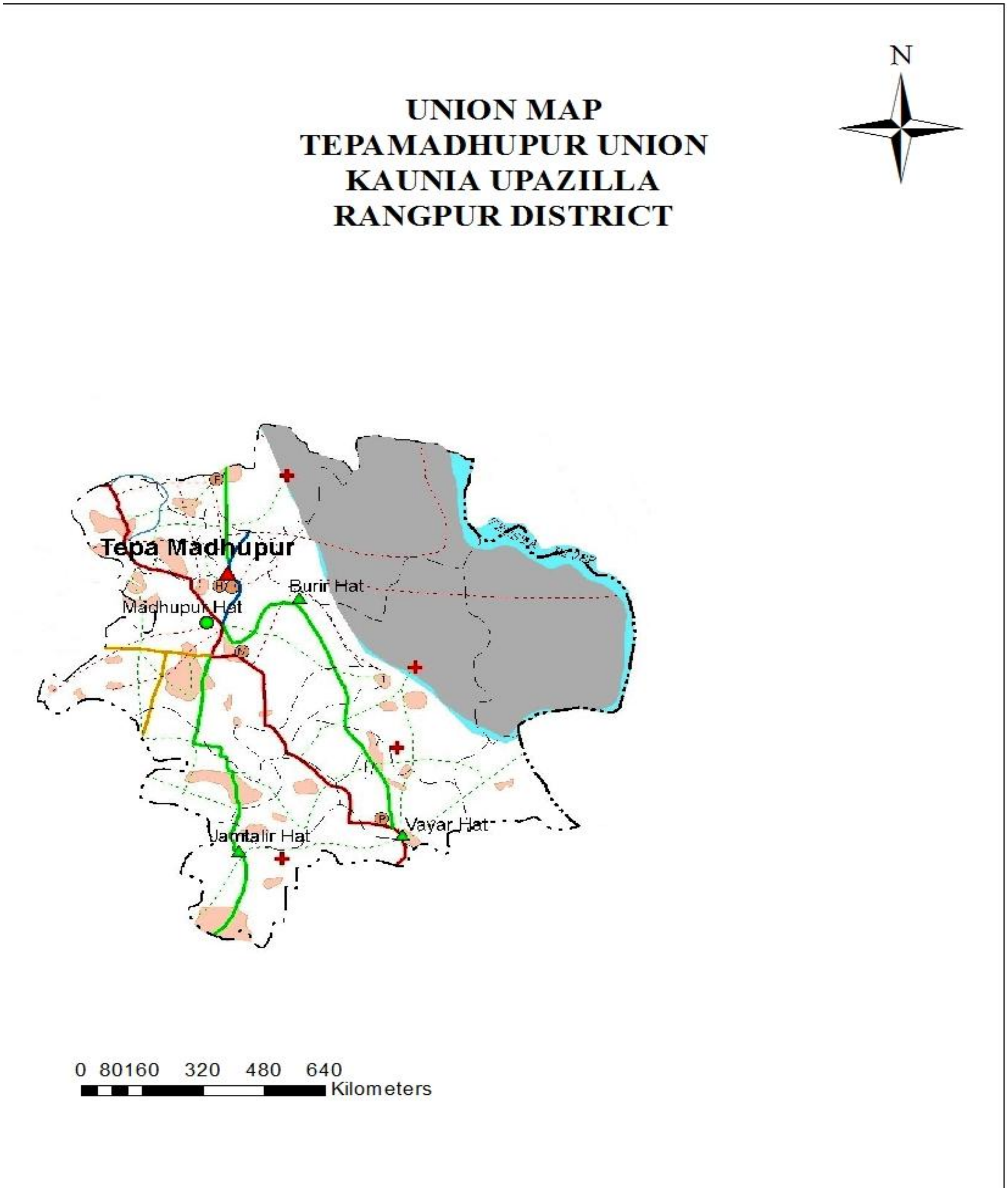
Table-4.3.2.1: 2011 Census Result of Tepamadhupur Upazilla.

Key Indicators	**2011**
Area (Acre)	8149
Total Households (HH)	9179
Avg. HH Size	3.9
Population Density (sq. km)	1081
Population Total	35633
Male	17495
Female	18138
Sex Ratio	96
Literacy Rate Total	38.7
Male Literacy Rate	41.4
Female Literacy Rate	36.2
Muslim	32273
Hindu	3338
Village	13

Source: BBS, 2011.

Tepamadhupur union map is shown below in the (Fig – 4.3.2.1).

Fig-4.3.2.1: Map of Tepamadhupur Union.



Source: Modified by Researcher from LGED District Maps.

4.4. Village Profile

The selected villages from the previously selected upazillas are:

4.4.1 Charkharibari village in Tepakharibari union from Dimla upazilla of Nilphamari district, and

4.4.2 Jigabari village in Tepamadhupur union from Kaunia upazilla of Rangpur district.

4.4.1. Charkharibari Village

Charkharibari village is situated in the right bank of upstream of Teesta River. This village is under Tepakharibari union.

4.4.1.1. Charkharibari Village at a Glance

Below the (Table – 4.4.1.1) shows demographic, spatial and other attribute information of Charkharibari village (BBS, 2011).

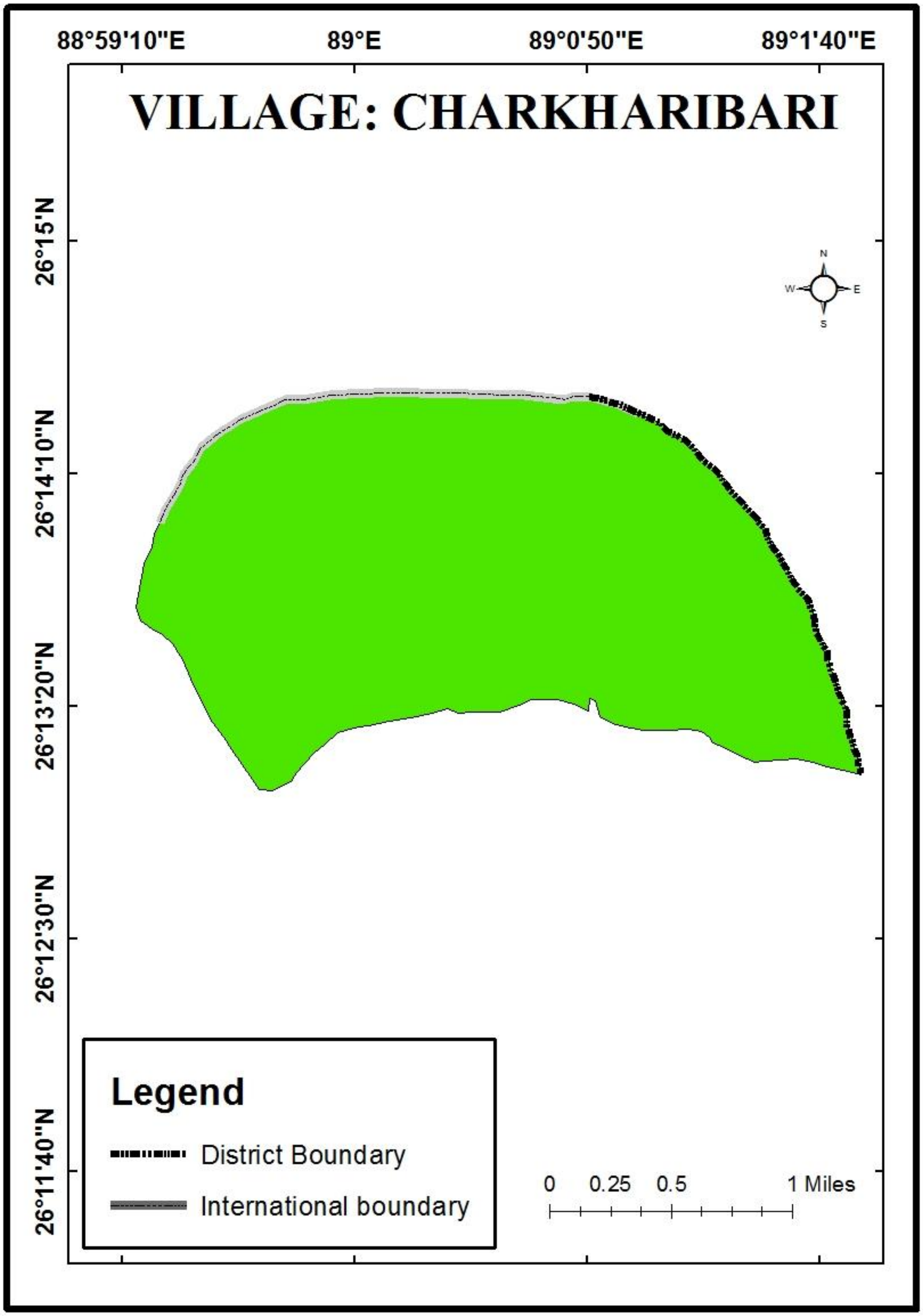
Table-4.4.1.1: 2011 Census Result of Charkharibari Village.

Key Indicators	**2011**
Area (Acre)	-
Total Households (HH)	771
Avg. HH Size	4.8
Population Density (sq. km)	-
Population Total	3722
Male	1850
Female	1872
Sex Ratio	99
Literacy Rate Total	24.2
Male Literacy Rate	25.4
Female Literacy Rate	22.9
Muslim	3722
Hindu	0

Source: BBS, 2011.

Charkharibari village map is shown below in the (Fig – 4.4.1.1).

Fig-4.4.1.1: Map of Charkharibari Village.



Source: Developed by Researcher.

4.4.2. Jigabari Village

Jigabari village is situated in the left bank of upstream of Teesta River. This village is under Tepamadhupur union.

4.4.2.1. Jigabari Village at a Glance

Below the (Table – 4.4.2.1) shows demographic, spatial and other attribute information of Jigabari village (BBS, 2011).

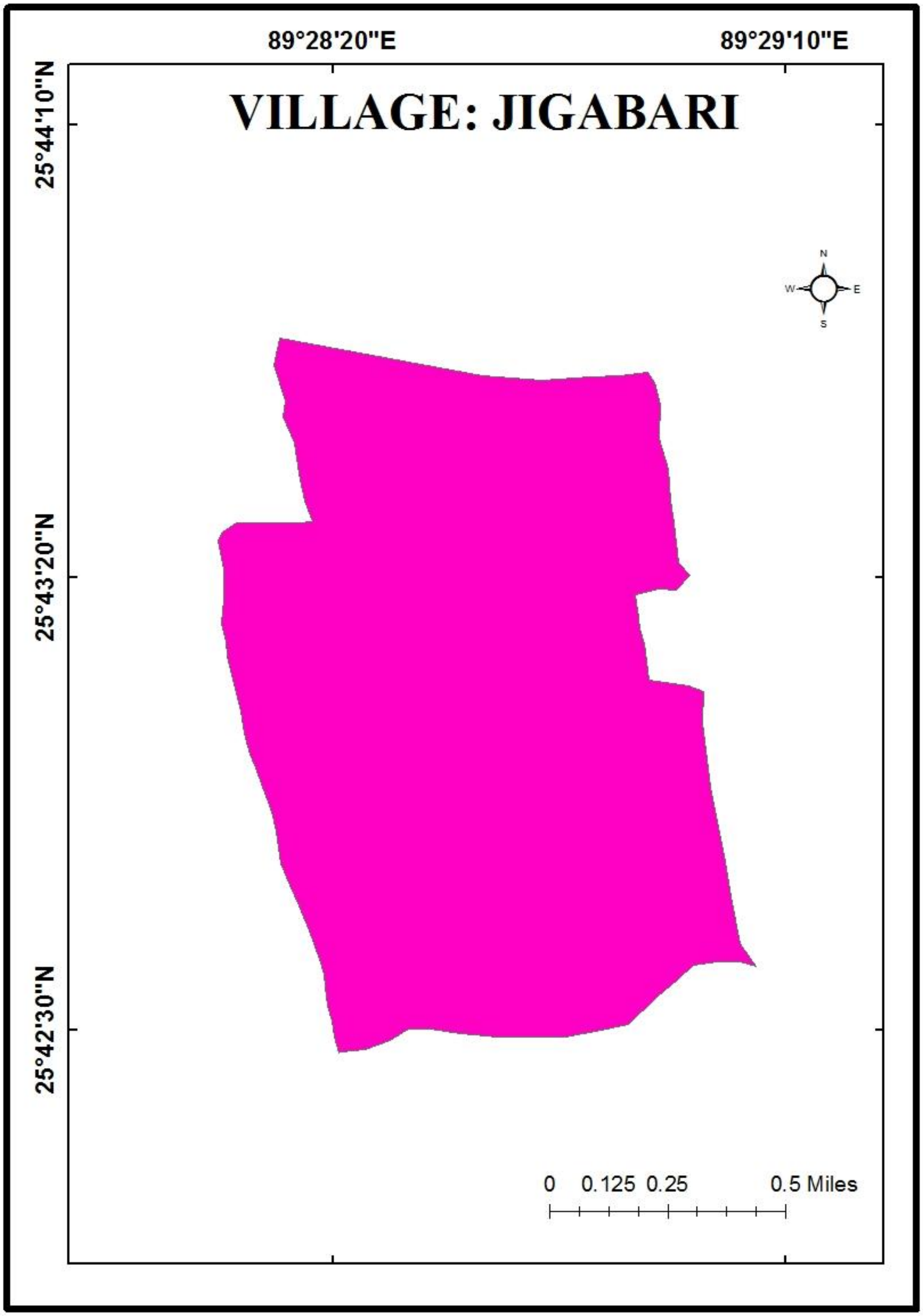
Table-4.4.2.1: 2011 Census Result of Jigabari Village.

Key Indicators	**2011**
Area (Acre)	-
Total Households (HH)	328
Avg. HH Size	3.7
Population Density (sq. km)	-
Population Total	1226
Male	589
Female	637
Sex Ratio	92
Literacy Rate Total	38.4
Male Literacy Rate	42.2
Female Literacy Rate	34.8
Muslim	1183
Hindu	43

Source: BBS, 2011.

Jigabari village map is shown below in the (Fig – 4.4.2.1).

Fig-4.4.2.1: Map of Jigabari Village.



Source: Developed by Researcher.

4.5. Profile of Respondent of the Study Villages

Socio-economic condition of two study villages is heterogeneous in terms of household structure, occupation, employment, economic and social condition etc. These factors have significant influence on people's survival strategy and ability to face disaster.

4.5.1. Age Group

Age of the household heads are classified into four categories: <18, 19-30, 31-60 and >60. Among these categories >18 and 19-30 age group is considered as youth. Other 31-60 and >60 age group is considered as adult. (Table-4.5.1) shows that, 48.4% of total household head in both the study villages falls in the age group of 31-60. Whereas, 47% and 51.8% respondents fall in the same age group in Charkharibari and Jigabari village respectively. Total 25.6% respondents fall in the age group of 19-30 years and Charkharibari and Jigabari village it is 26% and 24.7% respectively in same age group. Household head belongs to the age more than 60 years is 18.3% of total respondents and 19.5% and 15.3% in two study villages respectively. Household head belongs to the age less than 18 years is 7.7% of total respondents and 7.5% and 8.2% in Charkharibari and Jigabari village respectively.

Table-4.5.1: Distribution of Respondents by Age Groups.

Age Group		Study village					
		Charkharibari		Jigabari		Total	
		HH	%	HH	%	HH	%
Youth	<18	15	7.5	7	8.2	22	7.7
	19-30	52	26	21	24.7	73	25.6
Adult	31-60	94	47	44	51.8	138	48.4
	>61	39	19.5	13	15.3	52	18.3
Total		200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

4.5.2. Religion

Negligible cultural differences are found between two study villages because all the respondents in two villages belongs to two different religions. (Table-4.5.2) shows that, 94.1% of total respondents belong to Muslim and 5.9% of total respondents belong to Hindu religion. If we see the village wise distribution, 100% respondent in Charkharibari village belongs to Muslim and only 20% respondent in Jigabari village belongs to Hindu religion.

Table-4.5.2: Distribution of Respondents by Religion.

Religion	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Muslim	200	100	68	80	268	94.1
Hindu	0	0	17	20	17	5.9
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

4.5.3. Gender

Though we try to equal the gender balance in data collection process by ensuring 50% male and 50% female household head (HH) respondent. But, it was not possible to maintain the ration due to pretty less number of female household head. Because, in perspective of Bangladesh female household head is only available if the women is widowed, divorced, separated or husband is externally migrated. In two study villages households are significantly male dominated. (Table-4.5.3) shows that, 79.28% of total household is headed by man. In case of Charkharibari village 88.59% household head is man and in Jigabari village the number is 73.93%. Only 11.41% household in Charkharibari village is headed by female and in Jigabari village the number is 26.07%.

Table-4.5.3: Household Head by Gender.

Gender Category	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Male	177	88.59	63	73.93	240	84
Female	23	11.41	22	26.07	45	16
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

4.5.4. Level of Education

Table 4.5.4 shows level of education of total household members in study villages, in which it is found that 37.74% of sample population were illiterate, 31.23% of sample population completed only primary education, 18.87% of sample population completed secondary education, 10.12% of sample population completed higher secondary education and only 2.04% were graduated. In Charkharibari village 26.63% of sample population completed primary education which is pretty lower than that of Jigabari village which is 40.29%. On the other hand, 19.39% members completed secondary education in Charkharibari village which is slightly higher than Jigabari village which is 17.69%. In Charkharibari village 9.49% of sample population completed higher secondary education which is similar with Jigabari village which is 11.61%.Percentage of illiterate population is a significant proportion of total population in both the villages, which is 43.91% and 25.58% respectively. In case of higher education means, members completed master degree from college or university represents 0.58% in Charkharibari village and 4.83% in Jigabari village. Although the percentage of higher educated people is very low in both the villages but within two villages it is slightly higher in Jigabari village than Charkharibari village. Finally it is observed that, overall in education sector Jigabari village is well ahead of Charkharibari village.

Table-4.5.4: Level of Education of Household Members in the Study Villages.

Level of Education	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Illiterate	301	43.91	87	25.58	388	37.74
Primary Education	183	26.63	138	40.29	321	31.23
Secondary Education	133	19.39	61	17.69	194	18.87
Higher Secondary Education	65	9.49	39	11.61	104	10.12
Graduation	4	0.58	17	4.83	21	2.04
Total	686	100	342	100	1028	100

Source: Field Questionnaire Survey, 2016.

4.5.5. Occupation

Respondents are involved in different occupation in the study villages. Agriculture is the key activity in both the villages. Besides this, fishing, stone collecting, boating and daily labor are major activities for Charkharibari village. In Jigabari village other major activities are daily labor, service and wage earning. (Table-4.5.5.1) shows that, 49.47% respondents are engaged in farming as their main occupation in two study villages followed by daily labor 20.35%. On the other hand, 43.83% respondent in Charkharibari village and 62.29% respondent in Jigabari village are engaged in agriculture as their main occupation, so it is observed that percentage of farmer is quite less in Charkharibari village than that of Jigabari village. Daily labor is 20.52% in Charkharibari village which is almost similar with Jigabari village (19.87%). 19.69% respondent in Charkharibari village are engaged in fishing and stone collecting as their main occupation but in Jigabari village there is no fishing community and stone collecting so the percentage is almost zero. Only 0.48% respondent in Charkharibari village is engaged in service and in Jigabari village this percentage is 13.80%, which is quite higher than Charkharibari village. 13.47% respondent in Charkharibari village are engaged in boating as their main occupation but the Jigabari village is in inland so the percentage is almost zero. The number of businessman is pretty low in both villages and it is 2.01% and 4.04% in Charkharibari and Jigabari village respectively. So after observing both villages it is clear on terms of primary occupation, Charkharibari village is more diversified than Jigabari village.

Table-4.5.5.1: Primary Occupation of Household Head.

Primary Occupation	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Farming	88	43.83	53	62.29	141	49.47
Daily Labor	41	20.52	17	19.87	58	20.35
Fishing and Stone Collecting	39	19.69	0	0	39	13.68
Service	1	0.48	11	13.80	12	4.22
Boating	27	13.47	0	0	27	9.47
Business	4	2.01	4	4.04	8	2.81
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

(Table-4.5.5.2) shows that, 33.68% respondent in both the villages has no secondary or subsidiary occupation. The figure is higher in Charkharibari village (38.31%) than Jigabari village (23.65%), so a major number of respondent have no secondary income source in both the villages. 8.84% respondent in Charkharibari village and 25.37% respondent in Jigabari village are engaged in non-agricultural day labor as their secondary occupation. 18.93% respondent in Charkharibari village and 4.09% respondent in Jigabari village are engaged in fishing, stone collecting and boating as their secondary occupation. 1.29%

respondent in Charkharibari village and 4.33% respondent in Jigabari village are engaged in service as their secondary occupation. 10.31% respondent in Charkharibari village and 14.25% respondent in Jigabari village are engaged in business as their secondary occupation. 15.43% respondent in Charkharibari village and 27.29% respondent in Jigabari village are engaged in rickshaw and van pulling as their secondary occupation. 6.89% respondent in Charkharibari village and 1.02% respondent in Jigabari village are engaged in carpentry as their secondary occupation.

Table-4.5.5.2: Secondary Occupation of Household Head.

Secondary Occupation	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Daily Labor	18	8.84	22	25.37	40	14.03
Fishing, Boating and Stone Collecting	38	18.93	3	4.09	41	14.39
Service	2	1.29	4	4.33	6	2.11
Business	21	10.31	12	14.25	33	11.58
Rickshaw/Van Puller	31	15.43	23	27.29	54	18.95
Carpenter	14	6.89	1	1.02	15	5.26
No Occupation	76	38.31	20	23.65	96	33.68
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

(Table-4.5.5.3) shows that, overall dependent population is 42.80% followed by 32.30% employed and 24.90% unemployed in both the study village. In Charkharibari village employed member is 26.32% and unemployed is 28.29% of total household members and in Jigabari these figures are 44.37% and 18.08% respectively. Average employed member per household is 1.04 and 1.89 in Charkharibari and Jigabari village respectively. Number of unemployed member per household is higher in Charkharibari village than Jigabari village. People fall in the age of less than 18 years and more than 60 years and house wives and also current student who belongs to the age of more than 18 years are considered as dependent population. Percentage of dependent members are slightly higher in Charkharibari village (45.39%) than Jigabari village (37.55%).

Table-4.5.5.3: Employed, Unemployed and Dependent Population.

Category	Study village								
	Charkharibari			Jigabari			Total		
	N	%	Avg./HH	N	%	Avg./HH	N	%	Avg./HH
Employed	180	26.32	1.14	152	44.37	1.89	332	32.30	1.57
Unemployed	194	28.29	1.38	62	18.08	1.07	256	24.90	1.23
Dependent	312	45.39	2.69	128	37.55	2.28	440	42.80	2.49
Total	686	100		342	100		1028	100	

Source: Field Questionnaire Survey, 2016.

4.5.6. Land Ownership and Land-use Type

(Table-4.5.6) shows that, overall landless population is 56.5% and 43.5% have ownership of land. In Charkharibari village landless population is 62.2% and 37.8% have ownership of land. And In Jigabari village landless population is 31.7% and 68.3% have ownership of land. So, in Charkharibari village number of landless people is way more than Jigabari village and the main reason is recently for last four years Charkharibari village is engulfed with high riverbank erosion rate. Overall 5.03% population has homestead land, in Charkharibari village it is 5.61% and 4.41% in Jigabari village. Overall 60.48% population has agricultural land, in Charkharibari village it is 39.55% and 82.65% in Jigabari village. Overall 30.49% population has non-agricultural land, in Charkharibari village it is 54.63% and 5.13% in Jigabari village. Overall 4% population has pond, in Charkharibari village it is 0.21% and 7.81% in Jigabari village. Land ownership combined for both the village is 1.31 Acre per household and 1.71 Acre and 0.89 Acre for Charkharibari and Jigabari village respectively.

Table-4.5.6: Land Ownership and Land-use of Study Villages.

Type of Land-use	Study village (Area in Acre)								
	Charkharibari			Jigabari			Total		
	Yes		No	Yes		No	Yes		No
	Area	%	%	Area	%	%	Area	%	%
Ownership of Land		37.8	62.2		68.3	31.7		43.5	56.5
Homestead Land	4.55	5.61		3.37	4.41		7.92	5.03	
Agricultural Land	32.04	39.55		63.03	82.65		95.07	60.48	

Non-agricultural Land	44	54.63		3.92	5.13		47.92	30.49	
Pond	0.32	0.21		5.96	7.81		6.28	4	
Total	80.91	100		76.28	100		157.19	100	
Avg./HH	1.72			0.89			1.31		

Source: Field Questionnaire Survey, 2016.

4.5.7. Income Pattern of Household

Income of the population are classified into four categories: low (1-3000Tk), lower middle (3001-5000Tk), upper middle (5001-8000Tk) and high (8000Tk+). (Table-4.5.7) shows that, overall 33.34% population has low income and in Charkharibari village it is 39.5% and 18.2% in Jigabari village. Overall 34.74% population has lower middle income and in Charkharibari village it is 37% and 29.7% in Jigabari village. Overall 23.51% population has upper middle income and in Charkharibari village it is 18.5% and 35.7% in Jigabari village. Overall 4.91% population has high income and in Charkharibari village it is 5% and 16.4% in Jigabari village. So it is observed that Jigabari village is more economically stronger than Charkharibari village.

Table-4.5.7: Income Level of Household in the Study Villages.

Income Type	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Low (1-3000Tk)	79	39.5	16	18.2	95	33.34
Lower Middle (3001-5000Tk)	74	37	25	29.7	99	34.74
Upper Middle (5001-8000Tk)	37	18.5	30	35.7	67	23.51
High (8000Tk+)	10	5	14	16.4	14	4.91
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

4.5.8. Housing Condition

(Table-4.5.8) shows that, overall 13.3% population has a housing structure of corrugated iron sheet, cement pillar and bamboo buildup and in Charkharibari village it is 9.6% and 22.5% in Jigabari village, which is way ahead of Charkharibari village. Overall 54.1% population has a housing structure of corrugated iron sheet, thatch and bamboo buildup and in Charkharibari village it is 53% and 55.8% in Jigabari village, which is almost similar and most prominent housing type in both village. Overall 7% population has a housing structure of mud, wood and straw buildup and in Charkharibari village it is 8.9% and 2.9% in Jigabari village. 13.3% population has a housing structure of bamboo, thatch and polythene buildup and in Charkharibari village it is 12.9% and 14.5% in Jigabari village. Overall 7% population is homeless and in Charkharibari village it is 15.6% and 4.3% in Jigabari village, so number of homeless people is pretty high in Charkharibari village than Jigabari village. So overall, Jigabari village has a better housing condition than Charkharibari village.

Table-4.5.8: House Type of the Study Villages.

House Type	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
CI Sheet, Cement Pillar, Wall	19	9.6	19	22.5	38	13.3
Thatch, Bamboo, CI Sheet	106	53	48	55.8	154	54.1
Mud, Wood and Straw	18	8.9	2	2.9	20	7.0
Bamboo, Thatch, Polythene	26	12.9	12	14.5	38	13.3
Homeless	31	15.6	4	4.3	35	12.3
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

4.6. Profile of Drought in the Study Villages

Charkharibari and Jigabari both villages are drought prone area. Broadly agricultural and hydrological drought are prominent in these areas. From 2014 to 2016 within these three years both the villages face drought once a year on an average. But duration and intensity of drought is different between this two study villages.

4.6.1. Drought Month

In both the villages' drought year was same. And as well as drought month is also same and the drought month is March. If we want to see the drought month season wise, we can see that drought season is spring to early summer.

4.6.2. Frequency of Drought

Frequency of drought is different in both villages. On an average in Charkharibari village drought frequency is twice a year. One is agricultural drought and another is hydrological drought and both of these droughts are very acute. On the other hand in Jigabari village the drought frequency is once a year on average. Hydrological drought is very acute in this village and with the help of high efficiency irrigation system like deep tube well impact of agricultural drought had been reduced. So Charkharibari village is more drought affected than Jigabari village.

4.6.3. Duration of Drought

Duration of drought is different in both villages. On an average in Charkharibari village drought duration is 40-45 days with a maximum of 60 days. But in Jigabari village drought duration is 15-20 days with a maximum of 30 days. In Charkharibari village the duration of drought is longer because it is Charland with practically no drought prevention mechanism and almost no pond but in Jigabari village the duration of drought is shorter because it high efficiency irrigation system like deep tube well and has a number of ponds.

4.6.4. Level of Drought

Level and intensity of drought is divided into three categories: Pre-kharif (March-April), Kharif (July-August) and Rabi (November-December). Drought map of Tepakharibari union which includes Charkharibari village and Tepamadhupur union which includes Jigabari village is shown in (Fig-4.6.4.1) and (Fig-4.6.4.2) respectively.

4.6.5. Reason of Drought

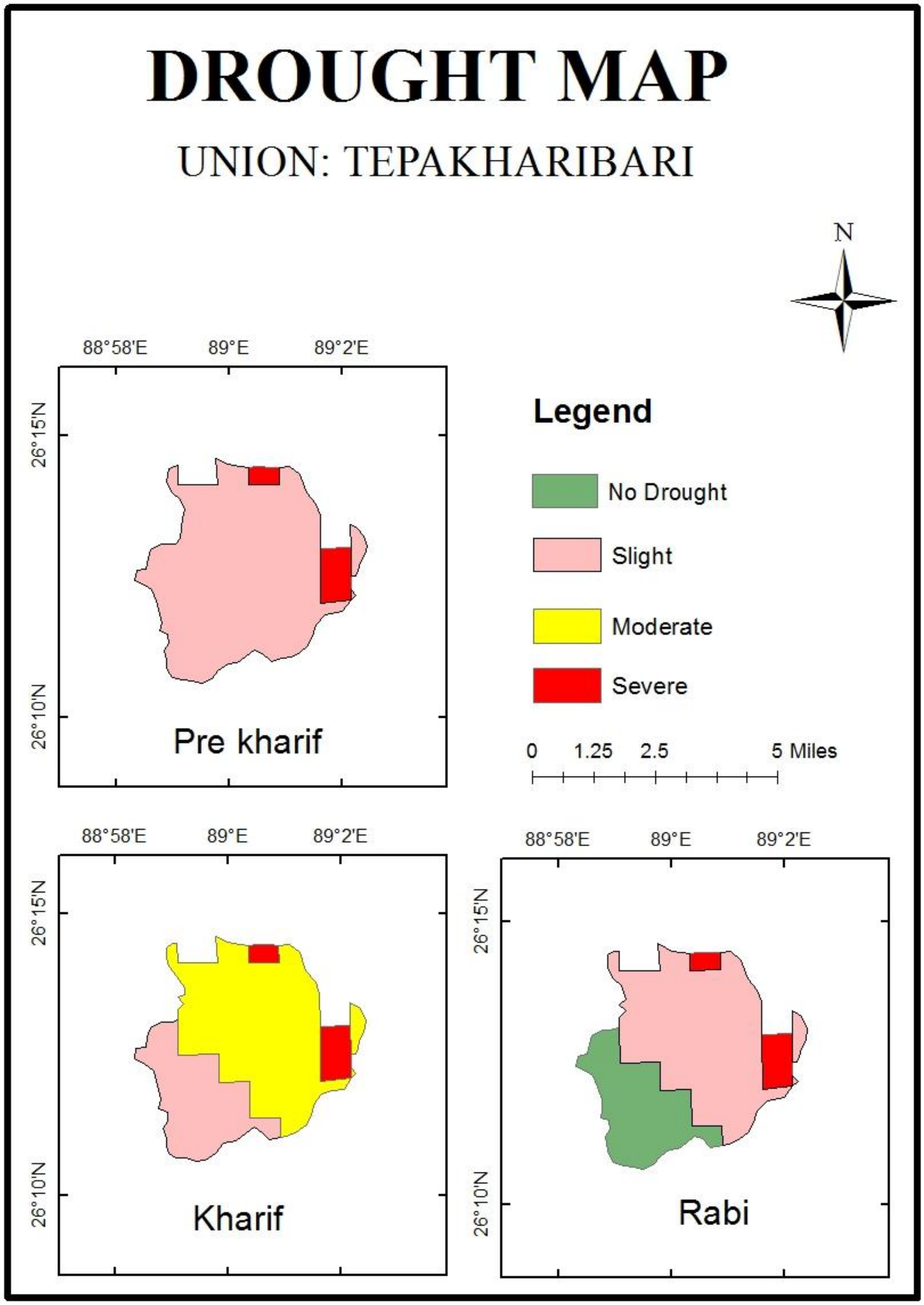
In both Charkharibari and Jigabari village drought reason is almost same but the percent is different. (Table-4.6.5) shows that, main reasons of drought are Teesta barrage, climate change, trans-boundary upstream-downstream water sharing issue and poor water resource management. 38.2% respondent of both village describes that Teesta barrage is the main reason for drought in this region while it is 40.5% and 41.2% in Charkharibari and Jigabari village respectively. 31.3% respondent of both village describes that climate change is the main reason for drought in this region while it is 32.9% and 27.0% in Charkharibari and Jigabari village respectively. 15.1% respondent of both village describes that trans-boundary upstream-downstream water sharing issue is the main reason for drought in this region while it is 16.5% and 11.8% in Charkharibari and Jigabari village respectively. 15.4% respondent of both village describes that poor water resource management is the main reason for drought in this region while it is 16.0% and 14.1% in Charkharibari and Jigabari village respectively. So, it is observed from the table that main reason of drought in Teesta basin is the Teesta barrage and ongoing trans-boundary water sharing complexity.

Table-4.6.5: Reason of Drought.

Reason of Drought	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Teesta Barrage	91	40.5	35	41.2	126	38.2
Climate Change	54	27.0	28	32.9	82	31.3
Trans-Boundary Upstream-Downstream Water Sharing Issue	33	16.5	10	11.8	43	15.1
Poor Water Resource Management	32	16.0	12	14.1	44	15.4
Total	200	100	85	100	285	100

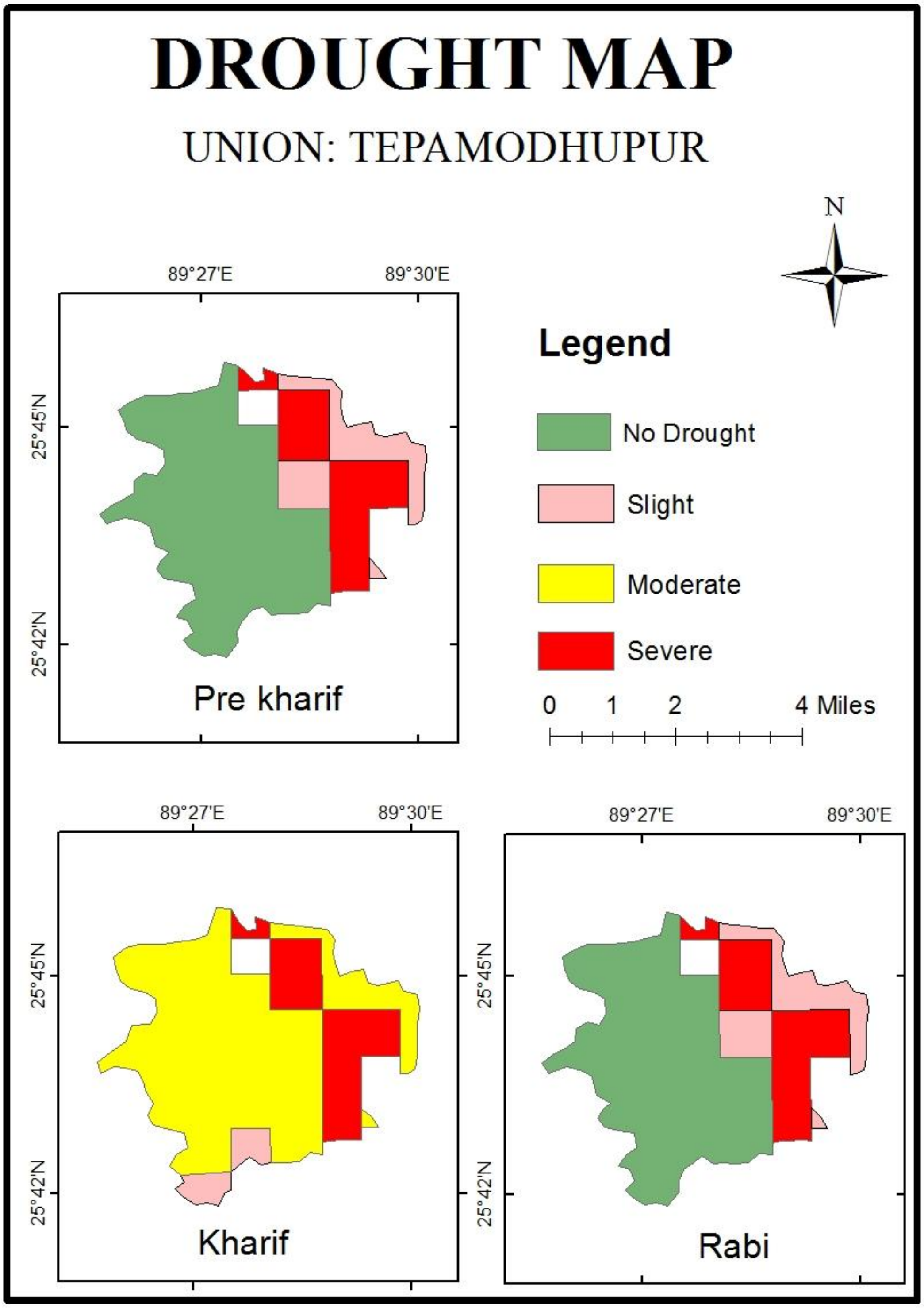
Source: Field Questionnaire Survey, 2016.

Fig-4.6.4.1: Drought Map of Tepakharibari Union.



Source: Developed by Researcher BARC.

Fig-4.6.4.2: Drought Map of Tepamadhupur Union.



Source: Developed by Researcher from BARC.

4.7. Profile of Flood in the Study Villages

Charkharibari and Jigabari both villages are situated in flood prone area, where is a very common phenomenon. Between them Charkharibari village is frequently flooded each for several times. From 2014 to 2016 within these three years Charkharibari village was flooded more than eight times on an average twice a year. Whereas, Jigabari village faced flood almost four times on an average once per year. Similarly frequency and intensity in terms of depth and duration were not same in each year.

4.7.1. Flooding Month

In both the villages' flooding year was same. Charkharibari village is located on the upstream of Teesta barrage whereas, Jigabari village is located in the downstream of Teesta barrage. In Charkharibari village the flooding month is July, but in Jigabari village the flooding month is August. Teesta barrage is a reason for the changes in flooding month between the villages. As we can see, Charkharibari village is in the upstream and before barrage, so it gets affected by flood firstly. But Jigabari village is in the downstream and after barrage, so it gets affected by flood later than Charkharibari village. If we want to see the flooding month season wise, we can see that flooding season is monsoon in Charkharibari village. And in Jigabari village the flooding season is late monsoon and early winter.

4.7.2. Frequency of Flooding

Frequency of flooding is different in both villages. On an average in Charkharibari village flood frequency is twice a year and sometimes it get flooded for more than two times a year. On the other hand in Jigabari village the flood frequency is once a year. So Charkharibari village is more flood prone than Jigabari village.

4.7.3. Duration of Flood

Duration of flooding is different in both villages. On an average in Charkharibari village flood duration is 2-3 days with a maximum of 6 days. But in Jigabari village flood duration is 6-7 days with a maximum of 18 days. In Charkharibari village the flood water flowing because it is Charland with comparatively high elevation but in Jigabari village the water remains stagnant because it is a land locked with a comparative low elevation. Slope is also a factor for the duration of slope. Charkharibari village has comparatively stiff a slope than Jigabari village. Duration of flood also changes according to the location of households within the village. In Charkharibari village witch households are located far from the Teesta river they face flood stagnant days comparatively less than those households which are located on the bank line. And Jigabari village witch households are located in the high lands they face flood stagnant days comparatively less than those households which are located on the low lying parts of the village.

4.7.4. Level and Intensity of Flooding

Level and intensity of flood is divided into three categories: low (2-3 Feet), medium (4-5 Feet) and high (6 Feet+). (Table-4.7.4) shows that, Charkharibari village is engulfed with medium and high level of flood and higher level of flood is increasing rapidly. But in case of Jigabari village low and medium level of flooding is prominent but it also shows an increasing trend towards high flood level.

Table-4.7.4: Level and Intensity of Flooding in Study Villages.

Flood Level	Charkharibari						Jigabari					
	2014		2015		2016		2014		2015		2016	
	f	%	f	%	f	%	f	%	f	%	f	%
Low	0	0	0	0	0	0	57	66.9	46	54.8	32	37.6
Medium	121	60.6	87	43.6	52	26.3	21	24.8	28	32.5	33	38.5
High	79	39.4	113	56.4	148	73.7	7	8.3	11	12.7	20	23.9
Total	200	100	200	100	200	100	85	100	85	100	85	100

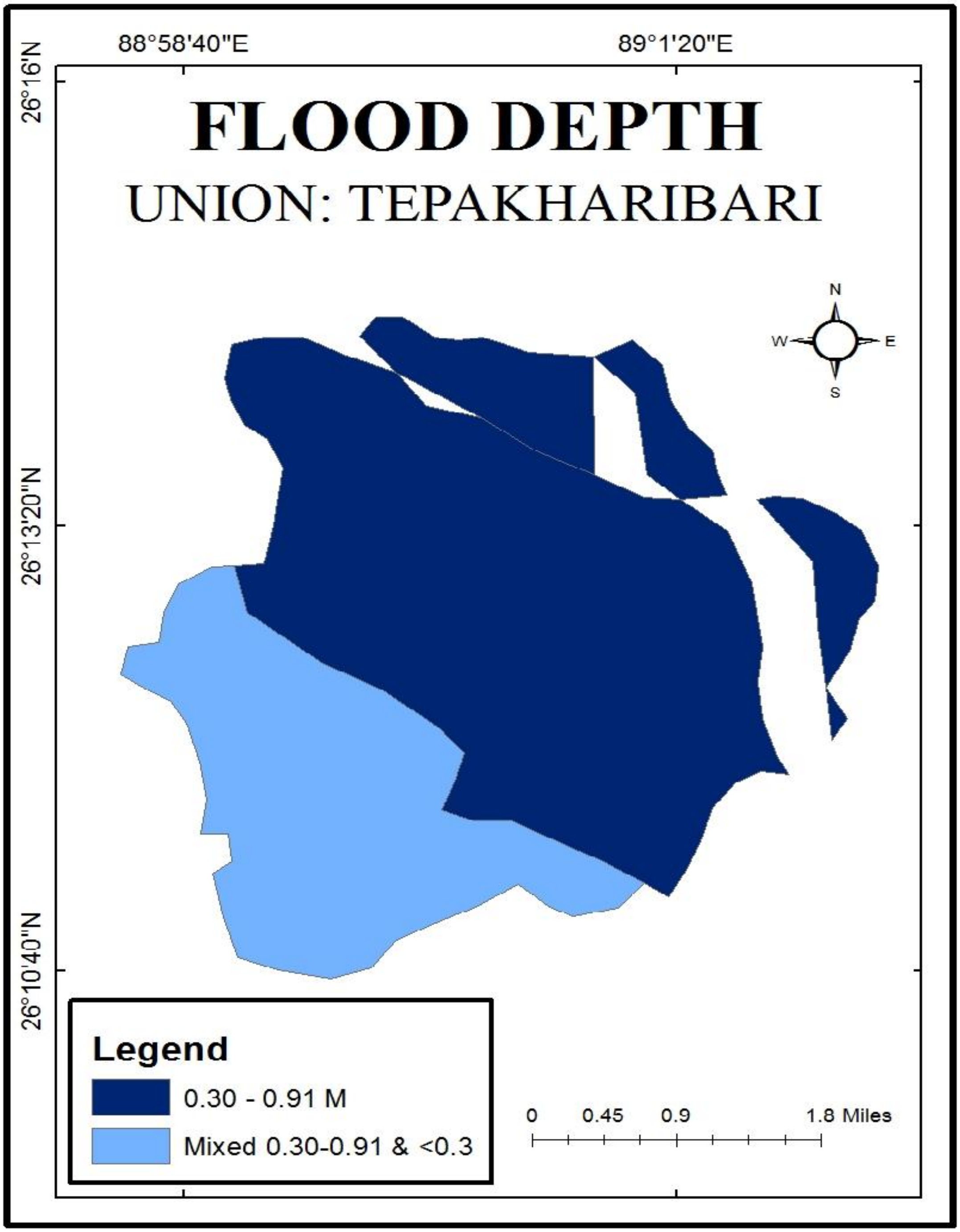
Source: Field Questionnaire Survey, 2016.

Flood depth map of Tepakharibari union which includes Charkharibari village and Tepamadhupur union which includes Jigabari village is shown in (Fig-4.7.4.1) and (Fig-4.7.4.2) respectively.

4.7.5. Nature of Flood

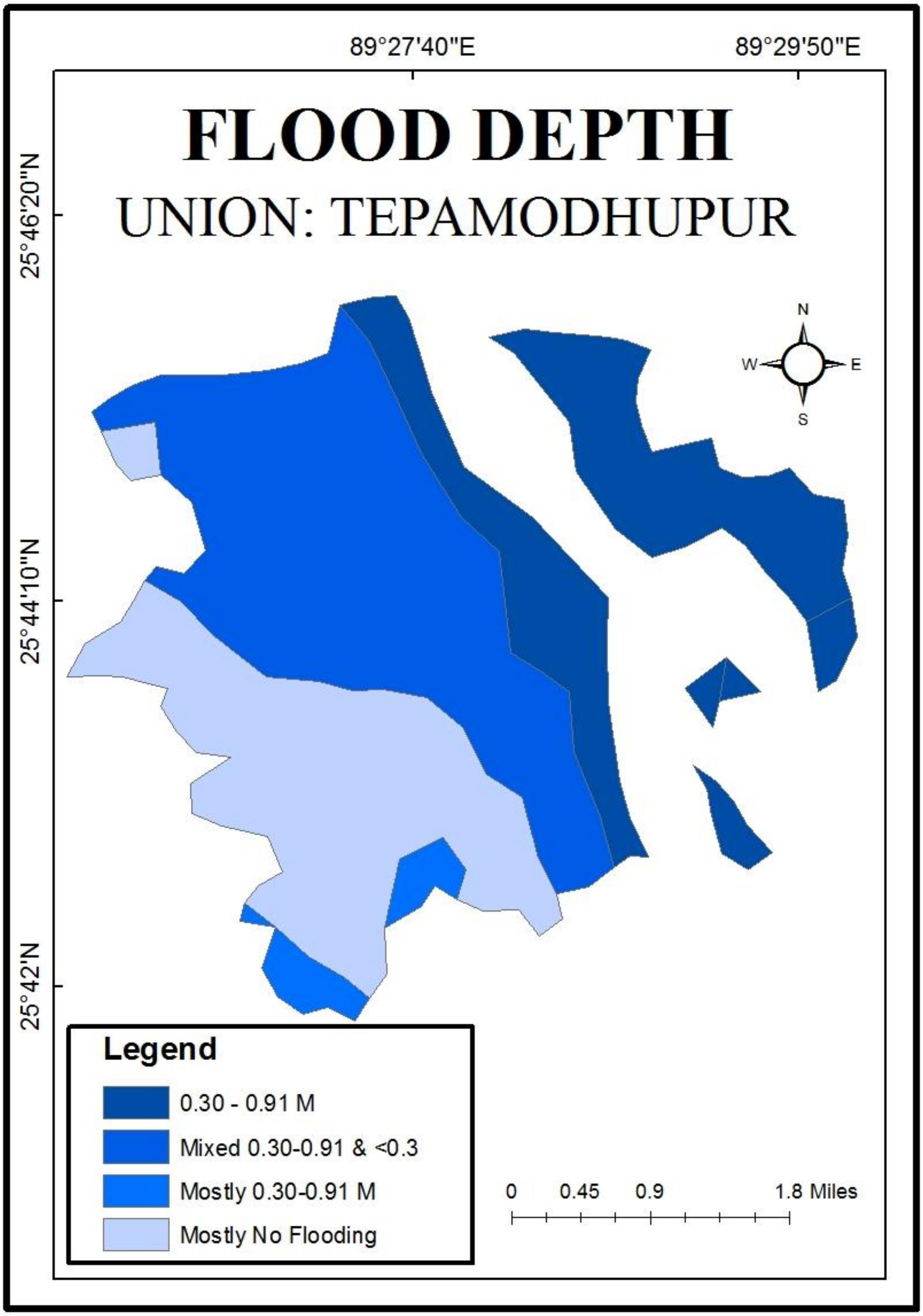
Duration of flooding is different in both villages. In Charkharibari village it is mainly flash flood as a result it is very much destructive in nature. But in Jigabari village the nature of flood is more pluvial or riverine in nature. So, in Jigabari village the flood is combined with river overflow and rainfall. As a result this type of flood has a less impact on infrastructure but very high impact on socio-economic parameters.

Fig-4.7.4.1: Flood Depth Map of Tepakharibari Union.



Source: Developed by Researcher.

Fig-4.7.4.2: Flood Depth Map of Tepamadhupur Union.



Source: Developed by Researcher.

4.7.6. Reason of Flood

In both Charkharibari and Jigabari village flood reason is almost same but the percent is different. (Table-4.7.5) shows that, main reasons of flood are Teesta barrage, climate change, excessive rainfall, trans-boundary upstream-downstream water sharing issue, high siltation rate and poor dredging and snow melt. 21.8% respondent of both village describes that Teesta barrage is the main reason for flood in this region while it is 23.5% and 27.1% in Charkharibari and Jigabari village respectively. 20.6% respondent of both village describes that climate change is the main reason for flood in this region while it is 22.5% and 17.6% in Charkharibari and Jigabari village respectively. 19.3% respondent of both village describes that excessive rainfall is the main reason for flood in this region while it is 22.0% and 17.6% in Charkharibari and Jigabari village respectively. 15.1% respondent of both village describes that trans-boundary upstream-downstream water sharing issue is the main reason for flood in this region while it is 14.0% and 15.3% in Charkharibari and Jigabari village respectively. 13.0% respondent of both village describes that high siltation rate and poor dredging is the main reason for flood in this region while it is 10.0% and 11.8% in Charkharibari and Jigabari village respectively. 10.2% respondent of both village describes that snow melt is the main reason for flood in this region while it is 8.0% and 10.6% in Charkharibari and Jigabari village respectively. So, it is observed from the table that main reason of flood in Teesta basin is the Teesta barrage and climate change has made the situation worse.

Table-4.7.5: Reason of Flood.

Reason of Flood	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Teesta Barrage	47	23.5	23	27.1	80	21.8
Climate Change	45	22.5	15	17.6	60	20.6
Excessive Rainfall	44	22.0	15	17.6	59	19.3
Trans-Boundary Upstream-Downstream Water Sharing Issue	28	14.0	13	15.3	41	15.1
High Siltation Rate And Poor Dredging	20	10.0	10	11.8	30	13.0
Snow Melt	16	8.0	9	10.6	25	10.2
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

Chapter Five

Comparative Vulnerability Analysis

5.1 SWOT Analysis of Charkharibari Village

The SWOT analysis and summary of Charkharibari village is presented in (Table-5.1).

Table 5.1- SWOT Analysis of Charkharibari Village:

INTERNAL FACTORS	
STRENGTHS (+)	WEAKNESSES (-)
1. This village has an international boundary. 2. The village will have a river protection dam. 3. There are plenty of hard rock just beneath the soil. 4. The number of youths are very high in this village. 5. The remaining soil of this village is very fertile. 6. The village has a quite a large number solar powered house.	1. This village is situated in a very unstable Char land. 2. There is no road network in the village. 3. There is only one type of communication system and it is by boat. 4. Due to several active forming Char lands in the river bed the communication system is very remote and time consuming. 5. There is no permanent health care center. 6. There is no permanent educational institutions and thus literacy rate is very low. 7. This village is eroding in different places for last 6 years due to irregular river flow. 8. There is flood shelter center in this village. 9. In present there is not enough flood protection measure in this village. 10. There is no electrical grid in this village. 11. Several NGO's have closed their program in this villages. 12. The remaining agricultural land is filled with 3-4 feet sand. 13. Severe scarcity of drinking water.

	14. Limited types of agricultural crops can be grown. 15. This village don't have any permanent market place. 16. There is no modern high efficiency irrigation system such as deep tube wells.
EXTERNAL FACTORS	
OPPORTUNITIES (+)	**THREATS (-)**
1. Suitable for import-export and other related border market business. 2. A quite large number of unemployed workforce is ready. 3. Planned stone collecting can create a huge workplace for the locals as well as for businessmen. 4. If the combined dam projected could complete earlier then village will be saved from riverbank erosion and flood. 5. Plenty of opportunity for fishing.	1. Increased rate of sand cover in the agricultural field. 2. Rate of riverbank erosion is accelerated due to unplanned stone collection. 3. Number of flash flood has increased. 4. Intensity of flood has increased. 5. Intensity and duration of drought has increased. 6. In summer heat stress has increased. 7. In winter cold wave has increased.

ANALYSIS SUMMARY of Charkharibari Village
Charkharibari village is situated in a charland (Island) which is located on the right bank of Teesta river in Bangladesh. From the SWOT matrix (Table-5.1) of this village we can see that the major strengths of this village are followings. This village is located on the border of India and Bangladesh. In the north of this village is India (Koochbihar district). There is an "India-Bangladesh Combined Teesta Dam Project" is going on. Though part of dam which located in India is already complete but, in Bangladesh part where this village is situated the construction is going on. Till now only 600 ft. of this dam is completed. Another 600 ft. will be complete by the end of 2017. Another important strength is there is plenty of stone just beneath the surface of this village. After digging of 3-4 feet beneath the surface these stones can be easily collectable. A large number of population of this village is youth and adults. Remaining cultivable agricultural land of this village is very fertile. There are a huge number of weakness of this village and they are as follows. Location of this village is unstable. Though this village is situated on a more than 40 years old charland but the charland is still eroding in different places. There is no road network in this village. The only communication system with the inland is by boat which is also very time consuming due to dried up river bed. There is no permanent educational institution in this village. There is only one primary school in this village but right now it has no permanent structure. As a result the literacy rate is very low. There is also no permanent health center in this village. River bank is very active in this village. Presently this village is eroding in 6 different places along the bank line. Almost 85% area of this village has no flood protection. And there is no flood shelter center in this village. There is no electrical grid connection in this village as a result there is no industrial development in this village. And there is no modern high efficiency irrigation system such as deep tube wells in this village. Scarcity of drinking water is severe in this village. Sand cover is severe in this village. The agricultural production is totally uncertain in this village. Most of the agricultural land of this village is one crop land. As a result there is no permanent village market or Hut in this village. Several NGO's have already closed their micro-credit or other development programs in this village. There are several opportunities for this village. They are as follows – this village can be suitable for import-export and other related border market business. A quite large number of unemployed workforce is ready. Planned stone collecting can create a huge workplace for the local inhabitants as well as for businessmen also. If the "India-Bangladesh Combined Teesta Dam Project" could complete earlier, then the village will be saved from riverbank erosion and flood. Fishery based market or industry can be grown here. There are several threats for this village. They are as follows – sand cover rate has increased and it destroys the agricultural land completely. Rate of riverbank erosion has accelerated due to unplanned stone collection. Number of flash flood has increased. Intensity and duration of flash flood has increased also in an alarming rate. During summer season the temperature threshold has increased resulted in severe heat stress. During winter season the temperature threshold has decreased resulted in severe cold wave. Intensity and duration of drought has increased. This is the SWOT analysis summary of Charkharibari village.

Source – Developed by Researcher.

5.2 SWOT Analysis of Jigabari Village

The SWOT analysis and summary of Jigabari village is presented in (Table-5.2).

Table 5.2- SWOT Analysis of Jigabari Village

INTERNAL FACTORS	
STRENGTHS (+)	**WEAKNESSES (-)**
1. This village is a very agriculturally productive area. 2. Literacy rate is more than 70%. 3. A flood protection dam is in the village. 4. Connectivity with the city is good. 5. This village is connected to the national electric grid. 6. There is a semi-permanent medical center. 7. Location of this village is inland. 8. Several NGO's are working in this village. 9. Almost 50% of the agricultural land is very fertile (3 crops). 10. There a number of fresh water ponds in the village.	1. The flood protection dam is highly damaged and has a number of cracks. 2. Almost 50% land of the village in low lying. 3. Flood water remain stagnant in several parts of the village. 4. There is no pucca road network in the village. 5. There is no permanent medical facility in the village. 6. The fresh water ponds are dying. 7. During drought there is severe drinking water problem. 8. During flood villagers get very less or no relief. 9. Number of landless family is around 35-40%. 10. There is arsenic contamination in the ground water. 11. Except agriculture there is almost no other economic activity. 12. This village doesn't have any permanent market place. 13. Limited fishing opportunity.

EXTERNAL FACTORS	
OPPORTUNITIES (+)	**THREATS (-)**
1. Climate and geomorphology is suitable for agricultural production throughout the year. 2. By taking effective measures 50% of the 2 crops land could be converted to 3 crops land. 3. Connectivity with city is good so agro-products can be sold directly to the city. 4. In the high grounds “Indian Bay Leafs – Tejpata” can be cultivated which is highly profitable. 5. Seasonal vegetables can be grown. 6. Agro-based industry can be established.	1. Village is getting more water logged. 2. Level of underground water is falling rapidly. 3. Intensity of flood has increased. 4. Intensity and duration of drought has increased. 5. In summer heat stress has increased. 6. In winter cold wave has increased. 7. Health related problems are relatively high.

ANALYSIS SUMMARY of Jigabari Village
Jigabari village is situated in inland which is located on the left bank of Teesta river in Bangladesh. From the SWOT matrix (Table-5.2) of this village we can see that the major strengths of this village are followings. The village has a flood protection dam. There are a number of educational institutions in this village. This village has stunning literacy rate of more than 70%. There is semi-permanent health care center in this village. This village is directly connected with nearby city and other areas by road. This village is connected with national electrical grid. Several NGO's are working in this area on micro-credit and other programs. The agricultural land is very fertile and more 50% of them is 3 crops. There is a number of fresh water ponds available in this village. This village is engulfed with several problems and they are as follows. The flood protection dam is highly damaged and has a number of cracks and leakage. During flood water enters in the village through these cracks. Almost 50% land of this village is low lying, as a result flood water remain stagnant on those areas. There is no pucca road network in this village. During flood all these Kacha road become inaccessible. The ground water table is declining in an accelerated rate. As a result the fresh water ponds dried up during pre-summer and summer. Drinking water problem get worse on those periods. Number of landless family is around 35-40%. There is severe level of arsenic contamination in the ground water. Except agriculture there is almost no other type of economic activity and fishing opportunity is very limited. During critical climatic stress periods the villagers' doesn't get enough relief. There are several opportunities for this village. They are as follows – the climate and geomorphology is suitable for agricultural production throughout the year. Seasonal vegetables can be grown as side products. Connectivity with nearby city is good so agro-products can be sold directly in the city. In the high ground "Indian Bay Leafs – Tejpata" can be cultivated which is highly profitable. Agro-based industry can be established. By taking effective measures 50% of the 2 crops land can be converted into 3 crops land. There are several threats for this village. They are as follows – several parts of village is getting more water logged. Health related problems are relatively high. Number of flash flood has increased. Intensity and duration of flash flood has increased also in an alarming rate. During summer season the temperature threshold has increased resulted in severe heat stress. During winter season the temperature threshold has decreased resulted in severe cold wave. Intensity and duration of drought has increased. This is the SWOT analysis summary of Jigabari village.

Source – Developed by Researcher.

5.3 Comparative SWOT Analysis of Charkharibari and Jigabari Village

Charkharibari village is a Charland while Jigabari village is inland. Presently there is no fully constructed flood protection dam, on the other hand Jigabari has a flood protection dam. In Charkharibari village there is plenty of excavatable rock but it is absent in Jigabari village. Large working class people is available in Charkharibari village but in Jigabari village the number is quite low. Jigabari village has more cultivable fertile soil than Charkharibari village. Jigabari is more agriculturally productive than Charkharibari village. Transportation system of Jigabari village is far more developed than Charkharibari village. Literacy rate is quite high in Jigabari village than other village. There more fresh water source available in Jigabari village than Charkharibari village. Institutional development and organizational activity is far spread in Jigabari village than Charkharibari village. After comparing the strengths of both village it is clear that Jigabari village is well ahead of Charkharibari village.

Location of Charkharibari village is very unstable while Jigabari village is quite stable. Charkharibari village has no road connectivity but Jigabari village has road connectivity. There is no permanent health center and educational institution in Charkharibari village but Jigabari village has these facilities. There is no national electrical grid connection in Charkharibari village but it presents in Jigabari village. High efficiency irrigation system like deep tube wells are absent in Charkharibari village but it presents in Jigabari village. Sand cover in agricultural land is a very severe problem in Charkharibari village but in Jigabari there is such danger. Arsenic contamination in ground water is very acute in Jigabari village but in Charkharibari village it is low. Different types of economic activity is present in Charkharibari village but in Jigabari village there is limited diversification of economic activity. Low lying land is relatively more in Jigabari village. After comparing the weaknesses of both village it is clear that Charkharibari village is more vulnerable than Jigabari village.

Jigabari village has a very limited or no fishing opportunity but on the other hand Charkharibari village has plenty of fishing opportunity. After a certain period Charkharibari village will be protected from flood. Plenty of non-agro workplace can be created (like stone collecting, border related import-export business and boating) in Charkharibari village but it is not possible in Jigabari village. Agro based industries can be established in Jigabari village but it is not possible in Charkharibari village with current situation. After comparing the opportunities of both village it is clear that Charkharibari village is ahead of Jigabari village.

Sand cover is a great threat in Charkharibari village but it is not in Jigabari village. Riverbank erosion is a great threat in Charkharibari village but it is not in Jigabari village. Other threats are almost similar in both villages but due to locational advantage Jigabari village is comparatively safe than Charkharibari village. After comparing the threats of both village it is clear that Charkharibari village is in more risk than Jigabari village.

5.4 SWOT Matrix Analysis for the Concept Strategy

The SWOT analysis is useful to decide the next step of making the concept strategy accurately. After doing the SWOT analysis, every factor in SWOT can be divided into four categories by using the cross tabulate table to identify it. These are: strength and opportunity, strength and threat, weakness and opportunity, and weakness and threat. Each category will produce different plans based on a combination of conditions and problems. The combination of the positive and negative aspects should be combined so that there are positive aspects to overcome the negative aspects that exist in synergy. The concept strategy of two villages can be seen to the (Table 5.4.1 and 5.4.2).

Table 5.4.1 – The Concept Strategy of Charkharibari Village:

INTERNAL / EXTARNAL	STRENGTH	WEAKNESS
OPPORTUNITY	Due to an international boundary there is plenty of possibility of border related export-import business.	After finishing the dam there is a possibility of improved communication system.
	As the youth rate is very high so there is a ready work force.	After finishing the dam there is a possibility reduced flood affectedness and riverbank erosion.
	Planned stone collecting can create a strong income source.	After finishing the dam there is a possibility of improved educational facility.
	Fishing opportunity can create another large income source.	After finishing the dam there is a possibility of improved health facility.
	After finishing the dam the village can be agriculturally productive because the remaining land is very fertile.	Solar powered irrigation can be helpful to solve the water scarcity problem.
THREAT	Due to an international boundary there is threat of smuggling.	Sand cover is a large threat to agro-production.
	Due to high unemployment rate there is threat of high crime rate.	Increased heat stress in summer coupled with water scarcity could worsen the situation.
	Unplanned stone collecting can accelerated the rate of riverbank erosion.	High riverbank erosion rate would slow the dam construction.
	Illegal fishing equipment can lead to extinction of several local varieties.	Increased intensity of climatic stresses will hamper the possible future economic sectors.

Source – Developed by Researcher.

Table 5.4.2 – The Concept Strategy of Jigabari Village:

INTERNAL / EXTARNAL	STRENGTH	WEAKNESS
OPPORTUNITY	By taking cheap effective measures such as sand filling 50% of the low lying land can be converted into high lands.	Poor condition of the dam will lead to more flood affectedness in near future.
	Agro-based market and industries could be established if the village inter connectivity get improved.	By cheap sand filling from the nearby Teesta river flood water stagnant area can be reduced.
	Because of high literacy rate empowerment efforts and providing knowledge on disaster management would be easy.	35-40% landless family member could be an instant workforce.
	Due to national grid electrical availability urbanization rate in this village will be faster.	Agro-based market and industries will diversify income sector.
	NGO's working in this village can improve health facility.	Low lying areas can be used fish cultivation.
THREAT	Using high efficiency irrigation system like deep tube wells will lead to future underground water scarcity.	Increased heat stress in summer coupled with water scarcity could worsen the situation.
	Due to high literacy rate there is threat of high civil society migration rate.	Increased intensity of climatic stresses will hamper the possible future economic sectors.
	Unequal distribution of agricultural land will cause future severe economic discrimination.	High ground water declination rate would slow the agro-production rate.
	As the ground water is declining rapidly in future this village could turn into a non-agro productive area.	Overall agro-production cost will increase.

Source – Developed by Researcher.

Chapter Six

Critical Moments and Their Coping Strategies

This chapter is focused mainly on the description of identification of drought and flood critical moments. The chapter also includes the description of coping strategies.

6.1. Agricultural Critical Moments and Coping Strategies

Defining agricultural critical moments is a bit of complex process. Identifying critical moments means finding out the stressful period of any sector that is caused by climatic extremes. It is a process of linking vulnerability with temporal dynamism of any particular sector of livelihood. So. Agricultural critical moment identifies the critical agricultural stage, season, month and periods of any agricultural crop. It also identifies what problems are responsible for this moments and what are the strategies to cope with this situations. The major agricultural crops found in my study areas are T.Aus (HYV), Boro (HYV), Wheat, Maize, Onion, Potato and Ground-nut (Peanut). Village wise major crops and their agricultural calendar is shown in (Table-6.1).

Table-6.1: Village Wise Agricultural Crop Calendar of the Study Villages.

Village	Crop	Agricultural Crop Calendar											
		Season											
		Winter		Spring		Summer		Monsoon		Autumn		Late Autumn	
		শীত		বসন্ত		গ্রীষ্ম		বর্ষা		শরৎ		হেমন্ত	
		Month											
		January	February	March	April	May	June	July	August	September	October	November	December
		পৌষ [illegible] ফাল্গুন চৈত্র বৈশাখ জ্যৈষ্ঠ [illegible] শ্রাবণ ভাদ্র আশ্বিন কার্তিক অগ্রহায়ণ পৌষ											
Charkharibari	Maize												
	Onion												
	Ground-nut												
Jigabari	T.Aus (HYV)												
	Boro (HYV)												
	Potato												
Sowing Stage				**Growing and Flowering Stage**					**Harvesting Stage**				

Source: Developed By Researcher.

As this study focused specifically on two climatic stressful period (drought and flood), so two type agricultural critical moment and their coping strategies will be identified. They are:

6.1.1 Drought induced agricultural critical moments and coping strategies, and

6.1.2 Flood induced agricultural critical moments and coping strategies.

6.1.1. Drought Induced Agricultural Critical Moments and Coping Strategies

In both study areas drought affects directly the production of Boro (HYV), Potato, Maize and Onion. Among theses in Charkharibari village drought affected crops are Maize and Onion. (Table-6.1.1.1) shows that, during drought the critical crop stage of Maize is growing and flowering stage. It extends from mid-January to February consists of 25-30 days of dry spell. This period falls in mid-Winter to early-Spring season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by pumping water from the nearby river by using shallow machines. As this shallow machines are diesel powered this coping mechanism adds extra production cost for Maize cultivation. Which ultimately turns into loss for farmers. During drought the critical crop stage of onion is growing and flowering stage. It extends from early-February to late-March consists of 45-60 days of dry spell. This period falls in Late-Winter to mid-Spring season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by pumping water from the nearby river by using shallow machines. As this shallow machines are diesel powered this coping mechanism adds extra production cost for Onion cultivation. Another type of coping strategy is selling crop (Onion) in advance. Those farmers who are unable to afford the costs of shallow machine they usually do this. As the onions are not fully harvested during this stage so the production is not full. Which ultimately turns into loss for farmers.

Table-6.1.1.1: Drought Induced Agricultural Critical Moments and Coping Strategies for Charkharibari Village.

Crop	Agricultural Stage	Month	Season	Period	Problem	Coping Strategy
Maize	Growing and Flowering	Mid-January to February	Mid-Winter to Early-Spring	25-30 Days	Acute Scarcity of Water	Irrigation by Shallow Machines
Onion	Growing and Flowering	Early-February to Late-March	Late-Winter To Mid-Spring	45-60 Days	Acute Scarcity of Water	1. Irrigation by Shallow Machines 2. Selling Crops in Advance

Source: Developed By Researcher.

In Jigabari village drought affected crops are Boro (HYV) and Potato. (Table-6.1.1.2) shows that, during drought the critical crop stage of Boro (HYV) is growing and flowering stage. It extends from mid-February to late-April consists of 50-60 days of dry spell. This period falls in late-Winter through the full-Spring to early-Summer season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by using high efficiency irrigation system like deep tube wells. As these high efficiency irrigation systems use a lot of electricity, so on these periods load shedding gets its peak. Additional electric bills adds extra production cost for Boro (HYV) rice cultivation. Which ultimately turns into loss for farmers. Another serious environmental issue of deep tube well is it affects directly the aquifer layer. And it is observed that during this period ground water table falls drastically. As a result in future this areas can be deserted, as the aquifer is not recharging properly. So, in this case using deep tube wells as a drought coping strategy will have serious consequences in near future. During drought the critical crop stage of potato is growing stage. It extends from mid-January to mid-February consists of 25-30 days of dry spell. This period falls in mid-Winter to early-Spring season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by using high efficiency irrigation system like deep tube wells. Another problem with potato production is in mid-January to late-January the soil temperature gets pretty low and cause a new a type of disease for potato plant. The name of the disease is *Rhizoctoma Solani* and the impact is less potato production. This disease is spreading in a tremendous rate which impacts on drastically fall in yields. Local level farmers try to cope with this problem by using expensive pesticides which adds extra production cost for Potato cultivation. Which ultimately turns into loss for farmers.

Table-6.1.1.2: Drought Induced Agricultural Critical Moments and Coping Strategies for Jigabari Village.

Crop	Agricultural Stage	Month	Season	Period	Problem	Coping Strategy
Boro (HYV)	Growing and Flowering	Mid-February to Late-April	Late-Winter to Early-Summer	50-60 Days	Acute Scarcity of Water	High Efficiency Irrigation System Like Deep Tube Wells
Potato	Growing	Mid-January to February	Mid-January to Mid-February	25-30 Days	1. Acute Scarcity of Water. 2. Spreading of Diseases	1. Irrigation by Deep Tube Wells 2. Using Pesticides

Source: Developed By Researcher.

(Table-6.1.1.3) shows that, 25.6% respondent in both the villages' uses shallow machine as their agricultural drought coping strategy, while the number is 36.5% in Charkharibari village but in Jigabari village the percentage is almost zero because this village is equipped with deep irrigation. 50.9% respondent in both the villages sells their standing crops in advance as their agricultural drought coping strategy, while the number is 63.5% in Charkharibari village and is 21.2% in Jigabari. 23.5% respondent in both the villages' uses deep tube wells as their agricultural drought coping strategy, while the number is 78.8% in Jigabari village but in Charkharibari village the percentage is almost zero because there is electrical grid connection in this village. So, in terms of agricultural coping against drought Jigabari village is ahead than Charkharibari village.

Table-6.1.1.3: Agricultural Coping Strategies against Drought in the Study Villages.

Agricultural Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Irrigation by Shallow Machine	73	36.5	0	0	73	25.6
Selling Crops in Advance	127	63.5	18	21.2	145	50.9

Irrigation by Deep Tube Wells	0	0	67	78.8	67	23.5
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.1.2. Flood Induced Agricultural Critical Moments and Coping Strategies

In both study areas flood affects directly the production of Ground-Nut and T.Aus (HYV). Among theses in Charkharibari village flood affected crops is Ground-Nut. (Table-6.1.2.1) shows that, during flood the critical crop stage of Ground-Nut is sowing stage. It extends from mid-July to early-August consists of 3-7 days of water stagnancy. This period falls in Monsoon (rainy) season. The main problem of this critical period is due to stagnant flood water which causes the perishment of Ground-Nut plants. Still there is no coping strategy for this critical period among the local level farmers. It causes severe yield and economic damage for farmers.

Table-6.1.2.1: Flood Induced Agricultural Critical Moments and Coping Strategies for Charkharibari Village.

Crop	Agricultural Stage	Month	Season	Period	Problem	Coping Strategy
Ground-Nut	Sowing	Mid-July to Early-August	Monsoon	3-7 Days	Stagnant Flood Water	Nil

Source: Developed By Researcher.

In Jigabari village flood affected crop is T.Aus (HYV). (Table-6.1.2.2) shows that, during flood the critical crop stage of T.Aus (HYV) is growing and harvesting stage. It extends from mid-July to mid-August consists of 8-20 days of water stagnancy. This period falls in Monsoon (rainy) season. The main problem of this critical period is due to stagnant flood water which causes the perishment of T.Aus (HYV) plants and after the run-away of flood water the sand cover in the agricultural land. Sand cover or sand living turns the agricultural land into a deserted land immediately. Because due to 3-4 feet of sand cover it is impossible to grow anything on that soil. Type of coping strategy for stagnant water is selling crop (T.Aus - HYV) in advance. But still there is no coping strategy to fight sand cover among the local level farmers.

Table-6.1.2.2: Flood Induced Agricultural Critical Moments and Coping Strategies for Jigabari Village.

Crop	Agricultural Stage	Month	Season	Period	Problem	Coping Strategy
T.Aus (HYV)	Growing and Harvesting	Mid-July to Mid-August	Monsoon	8-20 Days	1. Stagnant Flood Water 2. Sand Cover in the Agricultural Land	1. Selling Crops in Advance 2. Nil

Source: Developed By Researcher.

(Table-6.1.2.3) shows that, 92.6% respondent in both the villages' has no agricultural coping strategy against flood and it is 100% and 75% in Charkharibari and Jigabari village respectively. Only 7.4% people overall and 25% in Jigabari village sells their standing crops in advance as their agricultural flood coping strategy. So, in terms of agricultural coping strategy against flood both the villages is quite insubstantial.

Table-6.1.2.3: Agricultural Coping Strategies against Flood in the Study Villages.

Agricultural Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Selling Crops in Advance	0	0	21	25	21	7.4
Nil	200	100	64	75	264	92.6
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.2. Pecuniary Critical Moments and Coping Strategies

Pecuniary critical moment identifies the critical economical season, month and periods of house hold. It also identifies what problems are responsible for this moments and what are the strategies to cope with this situations. The major economic activities by household found in my study areas are Farming, Fishing, Boating, Stone Collecting, Daily Labor, Service, Business, Rickshaw / Van Puller and carpenter. As this study focused specifically on two climatic stressful period (drought and flood), so two type pecuniary critical moment and their coping strategies will be identified. They are:

6.2.1 Drought induced pecuniary critical moments and coping strategies, and

6.2.2 Flood induced pecuniary critical moments and coping strategies.

6.2.1. Drought Induced Pecuniary Critical Moments and Coping Strategies

In both study areas drought affects directly the income sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.2.1.1) shows that, in both Charkharibari and Jigabari village drought induced pecuniary critical moments extends from late-January to late-March consists of 45-60 days of dry spell. This period falls in mid-Winter to early-Summer season. The main problems of this critical period are lack of agro-based work, acute financial crisis and acute unemployment. Local inhabitants try to cope with these problems during critical stage by temporary migration, borrowing loan, wage earning, by selling properties, by getting debit and by selling labor in advance. They have taken these strategies for just to survive during these critical periods.

Table-6.2.1.1: Drought Induced Pecuniary Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Economic Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Lack of Agro-Based Work, 2. Acute Financial Crisis and 3. Acute Unemployment	Late-January to Late-March	Mid-Winter to Early-Summer	45-60 Days	1. Temporary Migration, 2. Borrowing Loan, 3. Wage Earning, 4. Selling Properties, 5. Getting Debit and 6. Selling Labor in Advance

Source: Developed By Researcher.

(Table-6.2.1.2) shows that, 17.2% respondent in both the villages borrow loan and debit as their pecuniary drought coping strategy, while the number is 17.0% in Charkharibari village and is 17.6% in Jigabari, which is almost same. 24.6% respondent in both the villages sell their properties as their pecuniary drought coping strategy, while the number is 24.5% in Charkharibari village and is 24.7% in Jigabari, which is almost same. 23.5% respondent in both the villages sell their labor in advance and other wage earning jobs as their pecuniary drought coping strategy, while the number is 24.5% in Charkharibari village and is 21.2% in Jigabari, so the number of people who sells their labor in advance is higher in Charkharibari village than that of Jigabari village. 34.7% respondent in both the villages migrate to nearby cities for income as their pecuniary drought coping strategy, while the number is 34.0% in Charkharibari village and is 36.5% in Jigabari, so the number of people who migrate to nearby cities for income is slightly higher in Jigabari village than that of Charkharibari village. So, it is observed that migration to nearby cities is their main pecuniary coping strategy against drought.

Table-6.2.1.2: Pecuniary Coping Strategies against Drought in the Study Villages.

Pecuniary Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Loan and Debit	34	17.0	15	17.6	49	17.2
Selling Properties	49	24.5	21	24.7	70	24.6
Wage Earning and Selling Labor in Advance	49	24.5	18	21.2	67	23.5
Migration	68	34.0	31	36.5	99	34.7
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.2.2. Flood Induced Pecuniary Critical Moments and Coping Strategies

In both study areas flood affects directly the income sector of livelihood and sub-sectors are almost the same. (Table-6.2.2.1) shows that, in both Charkharibari and Jigabari village flood induced pecuniary critical moments extends from early-July to mid-August consists of 5-30 days of flood stagnant water. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are getting water logged due to flood, working area gets flooded, no agro-based work, acute unemployment and acute financial crisis. Local inhabitants try to cope with these problems during critical stage by getting relief, temporary migration, borrowing loan, by fishing, by selling properties, by getting debit, by boating and by selling labor in advance. They have taken these strategies for just to survive during these critical periods.

Table-6.2.2.1: Flood Induced Pecuniary Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Economic Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Water Logged, 2. Working Area gets Flooded, 3. Acute Financial Crisis, 4. No Agro-based Work, and 5. Acute Unemployment	Early-July to Mid-August	Late-Summer to Late-Monsoon	5-30 Days	1. Relief, 2. Temporary Migration, 3. Borrowing Loan, 4. Fishing, 5. Selling Properties, 6. Getting Debit, 7. Boating, and 8. Selling Labor in Advance

Source: Developed By Researcher.

(Table-6.2.2.2) shows that, 23.9% respondent in both the villages get relief their pecuniary flood coping strategy, while the number is 24.5% in Charkharibari village and is 22.4% in Jigabari, so respondents in Charkharibari village get relatively more relief than that of Jigabari village. 21.1% respondent in both the villages borrow loan and debit as their pecuniary flood coping strategy, while the number is 20.5% in Charkharibari village and is 22.4% in Jigabari, so respondents in Jigabari village borrow relatively more loan and debit than that of Jigabari village. 37.5% respondent in both the villages use fishing as their pecuniary flood coping strategy, while the number is 38.5% in Charkharibari village and is 35.2% in Jigabari, so respondents in Charkharibari village do fishing as their flood pecuniary coping strategy than that of Jigabari village. 17.5% respondent in both the villages occupy boating as their pecuniary flood coping strategy, while the number is 16.5% in Charkharibari village and is 20.0% in Jigabari. But selling property is not an active flood induced pecuniary coping strategy. So, it is observed that fishing is their main pecuniary coping strategy against flood.

Table-6.2.2.2: Pecuniary Coping Strategies against Flood in the Study Villages.

Pecuniary Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Relief	49	24.5	19	22.4	68	23.9
Loan and Debit	41	20.5	19	22.4	60	21.1
Fishing	77	38.5	30	35.2	107	37.5
Boating	33	16.5	17	20	50	17.5
Selling Properties	0	0	0	0	0	0
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.3. Nutritional Critical Moments and Coping Strategies

Nutritional critical moment identifies the critical food shortage season, month and periods of house hold. It also identifies what problems are responsible for this moments and what are the strategies to cope with this situations. In both the villages the maximum number of food groups consumed per day is three meals per day. But the number of meal intake changes significantly during critical climatic stress periods. As this study focused specifically on two climatic stressful period (drought and flood), so two type nutritional critical moment and their coping strategies will be identified. They are:

6.3.1 Drought induced nutritional critical moments and coping strategies, and

6.3.2 Flood induced nutritional critical moments and coping strategies.

6.3.1. Drought Induced Nutritional Critical Moments and Coping Strategies

In both study areas drought affects directly the victual sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.3.1.1) shows that, in both Charkharibari and Jigabari village drought induced nutritional critical moments extends from late-January to early-March consists of 30-45 days of dry spell. This period falls in late-Winter to early-Summer season. The main problems of this critical period are lack of cereal, lack of cooking materials and acute food shortage. Local inhabitants try to cope with these problems during critical stage by change in number of main meal intake, borrowing loan to buy food grain, borrowing food from other household, selling properties and borrowing food from shop by debit. Local inhabitants have taken this coping strategies just to survive during these critical days.

Table-6.3.1.1: Drought Induced Nutritional Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Nutritional Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Lack of Food Cereals, 2. Lack of Cooking Materials and 3. Acute Food Shortage	Late-January to Early-March	Late-Winter to Early-Summer	30-45 Days	1. Change in Number of Main Meal Intake, 2. Borrowing Loan to buy Food Grain, 3. Borrowing Food from Other Household, 4. Selling Properties and 5. Borrowing Food from Shop by Debit

Source: Developed By Researcher.

(Table-6.3.1.2) shows that, 33.7% respondent in both the villages changes their number of main meal intake as their nutritional drought coping strategy, while the number is 35.0% in Charkharibari village and is 30.6% in Jigabari, so the number of people who changes their number of main meal intake is higher in Charkharibari village than that of Jigabari village. 26.0% respondent in both the villages borrow food grain from other household as debit as their nutritional drought coping strategy, while the number is 26.5% in Charkharibari village and is 24.7% in Jigabari, which is almost same. 17.5% respondent in both the villages sell their property and wage labor as their nutritional drought coping strategy, while the number is 17.5% in Charkharibari village and is 17.6% in Jigabari, which is almost same. 22.8% respondent in both the villages living on begging as their nutritional drought coping strategy, while the number is 21.0% in Charkharibari village and is 27.1% in Jigabari. So, it is observed that changes in number of main meal intake is their main nutritional coping strategy against drought.

Table-6.3.1.2: Nutritional Coping Strategies against Drought in the Study Villages.

Nutritional Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Change in Number of Main Meal Intake	70	35.0	26	30.6	96	33.7
Borrowing Food from Other Household	53	26.5	21	24.7	74	26.0
Selling Properties and Wage Labor	35	17.5	15	17.6	50	17.5
Loan, Debit and Begging	42	21.0	23	27.1	65	22.8
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.3.2. Flood Induced Nutritional Critical Moments and Coping Strategies

In both study areas flood affects directly the victual sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.3.2.1) shows that, in both Charkharibari and Jigabari village flood induced nutritional critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are lack of cereal, lack of cooking materials, lack of fodder and acute food shortage. Local inhabitants try to cope with these problems during critical stage by getting relief, change in number of main meal intake, by fishing, borrowing loan to buy food grain, borrowing food from other household, selling properties and borrowing food from shop by debit. Local inhabitants have taken this coping strategies just to survive during these critical days.

Table-6.3.2.1: Flood Induced Nutritional Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Nutritional Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Lack of Food Cereals, 2. Lack of Cooking Materials, 3. Lack of Fodder and 3. Acute Food Shortage	Early-July to Mid-August	Late-Summer to Late-Monsoon	25-30 Days	1. Relief, 2. Change in Number of Main Meal Intake, 3. Borrowing Loan to buy Food Grain, 4. Borrowing Food from Other Household, 5. Selling Properties, 6. Fishing, and 6. Borrowing Food from Shop by Debit

Source: Developed By Researcher.

(Table-6.3.2.2) shows that, 25.8% respondent in both the villages changes their number of main meal intake as their nutritional flood coping strategy, while the number is 21.0% in Charkharibari village and is 27.1% in Jigabari, so the number of people who changes their number of main meal intake is higher in Jigabari village than that of Charkharibari village. 14.5% respondent in both the villages use relief as their nutritional flood coping strategy, while the number is 17.5% in Charkharibari village and is 17.6% in Jigabari, which is almost same. 30.7% respondent in both the villages living on begging, loan and debit as their nutritional flood coping strategy, while the number is 35.0% in Charkharibari village and is 30.6% in Jigabari. 29.0% respondent in both the villages borrow food grain from other household as debit as their nutritional flood coping strategy, while the number is 26.5% in Charkharibari village and is 24.7% in Jigabari. So, it is observed that borrowing food and loan is their main nutritional coping strategy against flood.

Table-6.3.1.2: Nutritional Coping Strategies against Flood in the Study Villages.

Nutritional Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Relief	35	17.5	15	17.6	50	14.5
Change in Number of Main Meal Intake	42	21.0	23	27.1	65	25.8
Loan, Debit and Begging	70	35.0	26	30.6	96	30.7
Borrowing Food from Other Household	53	26.5	21	24.7	74	29.0
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.4. Aqua Paucity Critical Moments and Coping Strategies

Aqua paucity critical moment identifies the critical water shortage season, month and periods of house hold. Water scarcity includes both drinking water and household uses water. It also identifies what problems are responsible for this moments and what are the strategies to cope with this situations. In both the villages on an average every household member consumes 3 liters of drinking water and uses 45 liters of water for daily household purpose, but this amount drastically falls during critical climatic stressful moments. They have to survive on only average 1 liter of drinking water and 5-7 liter for daily household purpose. As this study focused specifically on two climatic stressful period (drought and flood), so two type aqua paucity critical moment and their coping strategies will be identified. They are:

6.4.1 Drought induced aqua paucity critical moments and coping strategies, and
6.4.2 Flood induced aqua paucity critical moments and coping strategies.

6.4.1. Drought Induced Aqua Paucity Critical Moments and Coping Strategies

In both study areas drought affects directly the aquatic sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.4.1.1) shows that, in both Charkharibari and Jigabari village drought induced aquatic critical moments extends from late-January to mid-March consists of 45-60 days of dry spell. This period falls in late-Winter to mid-Summer season. The main problems of this critical period are acute shortage of drinking water, scarcity of daily use water. Local inhabitants try to cope with these problems during critical stage by drinking unhygienic water from river, lessening their water usage. Local inhabitants have taken this coping strategies just to survive during these critical days. But by drinking unhygienic river water they got affected by different diseases.

Table-6.4.1.1: Drought Induced Aqua Paucity Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Aquatic Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Acute Shortage of Drinking Water, and 2. Scarcity of Daily Use Water	Late-January to Mid-March	Late-Winter to Mid-Summer	45-60 Days	1. Drinking Unhygienic Water From River, and 2. Lessening Water Usage.

Source: Developed By Researcher.

(Table-6.4.1.2) shows that, 40.0% respondent in both the villages' collects safe water from far places as their aqua paucity drought coping strategy, while the number is 40.5% in Charkharibari village and is 38.8% in Jigabari, which is almost same. 31.2% respondent in both the villages drinks river water as their aqua paucity drought coping strategy, while the number is 31.5% in Charkharibari village and is 30.6% in Jigabari, which is almost same. 28.8% respondent in both the villages drinks contaminated water as their aqua paucity drought coping strategy, while the number is 28.0% in Charkharibari village and is 30.6%

in Jigabari, which is also almost same. So, it is observed that collecting safe water from far places is their main aqua paucity coping strategy against drought.

Table-6.4.1.2: Aqua Paucity Coping Strategies against Drought in the Study Villages.

Aqua Paucity Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Collecting Safe Water from Far Places	81	40.5	33	38.8	114	40.0
Drinking River Water	63	31.5	26	30.6	89	31.2
Drinking Contaminated Water	56	28.0	26	30.6	82	28.8
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.4.2. Flood Induced Aqua Paucity Critical Moments and Coping Strategies

In both study areas flood affects directly the aquatic sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.4.2.1) shows that, in both Charkharibari and Jigabari village flood induced aquatic critical moments extends from early-July to mid-August consists of 30-40 days of dry spell. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are acute shortage of drinking water, scarcity of safe daily use water. Local inhabitants try to cope with these problems during critical stage by drinking and using unhygienic flood water from river. But by drinking and using unhygienic flood river water they got affected by different diseases. Local inhabitants have taken this coping strategies just to survive during these critical days.

Table-6.4.2.1: Flood Induced Aqua Paucity Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Aquatic Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Acute Shortage of Drinking Water, and 2. Scarcity of Safe Daily Use Water	Early-July to Mid-August	Late-Summer to Late-Monsoon	30-40 Days	1. Drinking and Using Unhygienic Flood Water From River.

Source: Developed By Researcher.

(Table-6.4.2.2) shows that, 25.9% respondent in both the villages' collects safe water from far places as their aqua paucity flood coping strategy, while the number is 33.0% in Charkharibari village and is 30.6% in Jigabari, which is slightly higher in Charkharibari village than that of Jigabari village. 45.3% respondent in both the villages drinks river flood water as their aqua paucity flood coping strategy, while the number is 40.5% in Charkharibari village and is 44.7% in Jigabari, which is slightly higher in Jigabari village than that of Charkharibari village. 28.8% respondent in both the villages drinks contaminated water as their aqua paucity flood coping strategy, while the number is 26.5% in Charkharibari village and is 24.7% in Jigabari, which is almost same. So, it is observed that drinking river flood water is their main aqua paucity coping strategy against flood.

Table-6.4.2.2: Aqua Paucity Coping Strategies against Flood in the Study Villages.

Aqua Paucity Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Collecting Safe Water from Far Places	66	33.0	26	30.6	82	25.9
Drinking Flood River Water	81	40.5	38	44.7	129	45.3
Drinking Contaminated Water	53	26.5	21	24.7	74	28.8
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.5. Health Critical Moments and Coping Strategies

Health critical moment identifies the critical disease prone season, month and periods of house hold. It also identifies what problems are responsible for this moments and what are the strategies to cope with this situations. In both the villages the maximum number of households are affected by several diseases throughout the year. But the situation get worse during critical climatic stressful moments. As this study focused specifically on two climatic stressful period (drought and flood), so two type health critical moment and their coping strategies will be identified. They are:

6.5.1 Drought induced health critical moments and coping strategies, and

6.5.2 Flood induced health critical moments and coping strategies.

6.5.1. Drought Induced Health Critical Moments and Coping Strategies

In both study areas drought affects directly the health sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.5.1.1) shows that, in both Charkharibari and Jigabari village drought induced health critical moments extends from late-January to late-March consists of 45-60 days of dry spell. This period falls in mid-Winter to early-Summer season. The main problems of this critical period are pox, black fever, skin disease, jaundice, women's' menstrual related problems and heat stroke. Local inhabitants try to cope with these problems during critical stage by managing somewhat medical facility that is available to them.

Table-6.5.1.1: Drought Induced Health Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	Health Problems	Month	Season	Period	Coping Strategy
Charkharibari and Jigabari	1. Pox, 2. Black Fever, 3. Skin Diseases, 4. Jaundice, 5. Menstrual Related Problems and 6. Heat Stroke.	Late-January to Late-March	Mid-Winter to Early-Summer	45-60 Days	Local Inadequate Medical Facilities

Source: Developed By Researcher.

(Table-6.5.1.2) shows that, 37.9% respondent in both the villages' goes to local (LMF) village doctor as their health drought coping strategy, while the number is 38.0% in Charkharibari village and is 37.6% in Jigabari, which is almost same. 30.5% respondent in both the villages' goes to Kobiraj as their health drought coping strategy, while the number is 30.0% in Charkharibari village and is 31.8% in Jigabari, which is almost same. 14.4% respondent in both the villages' goes to Govt. and NGO health center as their health drought coping strategy, while the number is 15.0% in Charkharibari village and is 12.9% in Jigabari, which is slightly higher in Charkharibari village than that of Jigabari village. 17.2% respondent in both the villages' has no (Nil) health drought coping strategy, while the number is 17.0% in Charkharibari village and is 17.6% in Jigabari, which is almost same. So, it is observed that getting treatment from local (LMF) village doctor is their main health coping strategy against drought.

Table-6.5.1.2: Health Coping Strategies against Drought in the Study Villages.

Health Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Local Village Doctor (LMF)	76	38.0	32	37.6	108	37.9
Kobiraj	60	30.0	27	31.8	87	30.5
Govt. and NGO Health Center	30	15.0	11	12.9	41	14.4
Nil	34	17.0	15	17.6	49	17.2
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

6.5.2. Flood Induced Health Critical Moments and Coping Strategies

In both study areas flood affects directly the health sector of livelihood and other related sub-sectors with almost same intensity. (Table-6.5.2.1) shows that, in both Charkharibari and Jigabari village flood induced health critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are several water borne diseases, women's' menstrual related problems, fever and skin diseases. Local inhabitants try to cope with these problems during critical stage by sometimes getting medical relief and by managing somewhat medical facility that is available to them. But due to flood stagnant water most of the times it gets impossible to connect with the health centers.

Table-6.5.2.1: Flood Induced Health Critical Moments and Coping Strategies for Charkharibari and Jigabari Village.

Village	**Health Problems**	**Month**	**Season**	**Period**	**Coping Strategy**
Charkharibari and Jigabari	1. Several Water Borne Diseases, 2. Women's' Menstrual Related Problems, 3. Fever	Early-July to Mid-August	Late-Summer to Late-Monsoon	25-30 Days	1.Medical Relief, and 2. Local Inadequate Medical Facilities.

	and 4. Skin Diseases.				

Source: Developed By Researcher.

(Table-6.5.2.2) shows that, 35.1% respondent in both the villages' goes to local (LMF) village doctor as their health flood coping strategy, while the number is 35.0% in Charkharibari village and is 35.3% in Jigabari, which is almost same. 28.4% respondent in both the villages' goes to Kobiraj as their health flood coping strategy, while the number is 29.0% in Charkharibari village and is 27.1% in Jigabari, which is almost same. 18.2% respondent in both the villages' goes to Govt. and NGO health center as their health flood coping strategy, while the number is 18.5% in Charkharibari village and is 17.6% in Jigabari, which is also almost same. 18.3% respondent in both the villages' has no (Nil) health flood coping strategy, while the number is 17.5% in Charkharibari village and is 20.0% in Jigabari, which is slightly higher in Jigabari village than that of Charkharibari village. So, it is observed that getting treatment from local (LMF) village doctor is their main health coping strategy against flood.

Table-6.5.2.2: Health Coping Strategies against Flood in the Study Villages.

Health Coping Strategy	Study village					
	Charkharibari		Jigabari		Total	
	N	%	N	%	N	%
Local Village Doctor (LMF)	70	35.0	30	35.3	100	35.1
Kobiraj	58	29.0	23	27.1	81	28.4
Govt. and NGO Health Center	37	18.5	15	17.6	52	18.2
Nil	35	17.5	17	20.0	52	18.3
Total	200	100	85	100	285	100

Source: Field Questionnaire Survey, 2016.

Chapter Seven

Assessment of Coping Capacity

Flood and drought both are natural climatic extreme event which occur every year in Teesta basin. Local people try to cope with these situations with their own knowledge, resources and occasionally getting external support from government and non-governmental organizations. Coping capacity is a complex process which is highly linked with several other physical and socio-economic variables. In this following chapter we will try to find out linkage between some selected variables such as income level, education level, occupation type, drought characteristics, and flood characteristics with coping capacity to understand the dynamic process of coping capacity.

7.1. Assessment of Drought Coping Capacity

Inhabitants' drought induced critical periods and coping capacity during those periods are highly linked with income level, occupation type and education level of the inhabitants. Generally the illiterate, poor and marginal sector of any community has less coping capacity (Chan, 1996).

7.1.1. Assessment of Income Level and Drought Coping capacity

According to the field data per month income of household head is classified into four categories: low (1-3000Tk), lower middle (3001-5000Tk), upper middle (5001-8000Tk) and high (8000Tk+). From (Table-4.5.7) it is observed that most (34.74%) of the total surveyed household sits in the category of lower middle (3001-5000Tk) and second most (33.34%) of the total surveyed household sits in the category of low (1-3000Tk). So, two third of the total sampled household belongs to low and lower middle income category. As per the concept of coping capacity, high income tends to great coping capacity. Comparison between two study villages, people in Charkharibari village seems to be poorer than people of Jigabari village. As income profile of household is a crucial factor for less coping capacity against drought, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against drought. Below in the (Table-7.1.1) shows the correlation between income level and drought coping capacity. From that table it is observed that there is significant correlation between income level and different sectorial drought coping capacity.

Table-7.1.1: Correlation between Income Level and Drought Coping Capacity.

		Income Level	Agricultural Drought Coping capacity	Pecuniary Drought Coping capacity	Nutritional Drought Coping capacity	Aqua Paucity Drought Coping capacity	Health Drought Coping capacity
Income Level	Pearson Correlation	1	.694**	.839**	.889**	.874**	.878**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	285	285	285	285	285	285
Agricultural Drought Coping capacity	Pearson Correlation	.694**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Drought Coping capacity	Pearson Correlation	.839**	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Drought Coping capacity	Pearson Correlation	.889**	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Drought Coping capacity	Pearson Correlation	.874**	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Drought Coping capacity	Pearson Correlation	.878**	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	285	285	285	285	285	285

Note: **. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.1.1.1. Income Level and Agricultural Drought Coping capacity

(Table-7.1.1) shows that, correlation between income level and agricultural drought coping capacity is highly significant. In (Table-7.1.1.1) shows Chi-square test between income level and agricultural drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly significant. High efficiency irrigation system like deep tube wells as an agricultural drought coping strategy is only possible for relatively high income group which is only found among the respondents of Jigabari village (Table-6.1.1.3). People belongs to lower middle and upper middle income group tend to sell their standing crops earlier as an agricultural drought coping strategy. So, if the income is higher, then they have multiple agricultural drought coping strategy rather than only selling their crops in advance.

Table-7.1.1.1: Impact of Income Level on Agricultural Drought Coping Capacity.

Income Level		Agricultural Drought Coping Capacity			Total
		Irrigation By Shallow Machine	Selling Crops In Advance	Irrigation By Deep Tube Wells	
Low (1-3000Tk)	HH	73	22	0	95
	% of Total	25.6%	7.7%	0.0%	33.3%
Lower Middle (3001-5000Tk)	HH	0	76	23	99
	% of Total	0.0%	26.7%	8.1%	34.7%
Upper Middle (5001-8000Tk)	HH	0	37	30	67
	% of Total	0.0%	13.0%	10.5%	23.5%
High (8000Tk+)	HH	0	10	14	24
	% of Total	0.0%	3.5%	4.9%	8.4%
Total	HH	73	145	67	285
	% of Total	25.6%	50.9%	23.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6			

Source: Field Questionnaire Survey, 2016.

7.1.1.2. Income Level and Pecuniary Drought Coping capacity

(Table-7.1.1) shows that, correlation between income level and pecuniary drought coping capacity is highly significant. In (Table-7.1.1.2) shows Chi-square test between income level and pecuniary drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. Getting loan and debit and selling properties as a pecuniary drought coping strategy is highly adopted by the low and lower middle income group is mostly found among the respondents of Charkharibari village (Table-6.2.1.2). On the other hand migration and wage earning as a pecuniary drought coping strategy is generally adopted by lower middle, upper middle and high income group. So, people with relatively higher income level usually don’t sell their properties as a pecuniary drought coping strategy. They migrate temporarily for outsourcing during these critical moments.

Table-7.1.1.2: Impact of Income Level on Pecuniary Drought Coping Capacity.

Income Level		Pecuniary Drought Coping Capacity				Total
		Loan And Debit	Selling Properties	Wage Earnings And Selling Labor In Advance	Migration	
Low (1-3000Tk)	HH	49	46	0	0	95
	% Of Total	17.2%	16.1%	0.0%	0.0%	33.3%
Lower Middle (3001-5000Tk)	HH	0	24	54	21	99
	% Of Total	0.0%	8.4%	18.9%	7.4%	34.7%
Upper Middle (5001-8000Tk)	HH	0	0	13	54	67
	% Of Total	0.0%	0.0%	4.6%	18.9%	23.5%
High (8000Tk+)	HH	0	0	0	24	24
	% Of Total	0.0%	0.0%	0.0%	8.4%	8.4%
Total	HH	49	70	67	99	285
	% Of Total	17.2%	24.6%	23.5%	34.7%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 9				

Source: Field Questionnaire Survey, 2016.

7.1.1.3. Income Level and Nutritional Drought Coping capacity

(Table-7.1.1) shows that, correlation between income level and nutritional drought coping capacity is highly significant. In (Table-7.1.1.3) shows Chi-square test between income level and nutritional drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. People with lower income usually change their number of main meal intake as a nutritional drought coping capacity and majority respondents of Charkharibari village adopted this strategy (Table-6.3.1.2).

Table-7.1.1.3: Impact of Income Level on Nutritional Drought Coping Capacity.

Income Level		Nutritional Drought Coping Capacity				Total
		Change In Number Of Main Meal Intake	Borrowing Food From Other Household	Selling Properties and Wage Labor	Loan, Debit and Begging	
Low (1-3000Tk)	HH	86	9	0	0	95
	% of Total	30.2%	3.2%	0.0%	0.0%	33.3%
Lower Middle (3001-5000Tk),	HH	10	59	30	0	99
	% of Total	3.5%	20.7%	10.5%	0.0%	34.7%
Upper Middle (5001-8000Tk)	HH	0	6	20	41	67
	% of Total	0.0%	2.1%	7.0%	14.4%	23.5%
High (8000Tk+)	HH	0	0	0	24	24
	% of Total	0.0%	0.0%	0.0%	8.4%	8.4%

Total	HH	96	74	50	65	285
	% of Total	33.7%	26.0%	17.5%	22.8%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 9				

Source: Field Questionnaire Survey, 2016.

7.1.1.4. Income Level and Aqua Paucity Drought Coping capacity

(Table-7.1.1) shows that, correlation between income level and aquatic drought coping capacity is highly significant. In (Table-7.1.1.4) shows Chi-square test between income level and aquatic drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. People with relatively lower income generally drinks contaminated water as their aquatic drought coping capacity. But, people who belongs to upper middle and high income group collects safe water from far places as their aquatic drought coping capacity. So, people with relatively higher income level usually don't drink contaminated water which mostly found in Jigabari village.

Table-7.1.1.4: Impact of Income Level on Aqua Paucity Drought Coping Capacity.

Income Level		Aqua Paucity Drought Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking River Water	Drinking Contaminated Water	
Low (1-3000Tk)	HH	0	0	95	95
	% of Total	0.0%	0.0%	33.3%	33.3%
Lower Middle (3001-5000Tk)	HH	19	71	9	99
	% of Total	6.7%	24.9%	3.2%	34.7%
Upper Middle (5001-8000Tk)	HH	49	18	0	67
	% of Total	17.2%	6.3%	0.0%	23.5%
High (8000Tk+)	HH	24	0	0	24
	% of Total	8.4%	0.0%	0.0%	8.4%
Total	HH	73	89	104	285
	% of Total	32.3%	31.2%	36.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6			

Source: Field Questionnaire Survey, 2016.

7.1.1.5. Income Level and Health Drought Coping capacity

(Table-7.1.1) shows that, correlation between income level and health drought coping capacity is highly significant. In (Table-7.1.1.5) shows Chi-square test between income level and health drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. People with relatively lower income generally don't have anything as their health drought coping capacity. Lower middle and upper middle income group usually goes to village doctor (LMF) and get Kobiraji treatment as their health drought coping capacity. On the other people who belongs to higher income group usually goes to the far Govt. and Non-Govt. health centers. So, people with relatively higher income level usually get proper medical facilities during their drought induced critical health periods.

Table-7.1.1.5: Impact of Income Level on Health Drought Coping Capacity.

Income Level		Health Drought Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
Low (1-3000Tk)	HH	0	3	0	92	95
	% of Total	0.0%	1.1%	0.0%	32.3%	33.3%
Lower Middle (3001-5000Tk)	HH	16	66	17	0	99
	% of Total	5.6%	23.2%	6.0%	0.0%	34.7%
Upper Middle (5001-8000Tk)	HH	25	18	24	0	67
	% of Total	8.8%	6.3%	8.4%	0.0%	23.5%
High (8000Tk+)	HH	0	0	24	0	24
	% of Total	0.0%	0.0%	8.4%	0.0%	8.4%
Total	HH	41	87	65	116	285
	% of Total	14.4%	30.5%	22.8%	32.3%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 9				

Source: Field Questionnaire Survey, 2016.

7.1.2. Assessment of Education Level and Drought Coping capacity

According to the field data educational status of household head is classified into five categories: illiterate, primary, SSC, HSC and graduate. Comparison between two study villages, people in Charkharibari village seems to be less educationally qualified than people of Jigabari village (Table-4.5.4). As educational status of a person have a great deal of influence on his/her lifestyle and different socio-economic sectors. So, educational profile of household can be a crucial factor for less coping capacity against drought, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against drought. Below in the (Table-7.1.2) shows the correlation between education level and drought coping capacity. From that table it is observed that there is significant correlation between education level and different sectorial drought coping capacity.

Table-7.1.2: Correlation between Education Level and Drought Coping Capacity.

		Education Level	Agricultural Drought Coping capacity	Pecuniary Drought Coping capacity	Nutritional Drought Coping capacity	Aqua Paucity Drought Coping capacity	Health Drought Coping capacity
Education Level	Pearson Correlation	1	.547**	.849**	.905**	.905**	.926**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	285	285	285	285	285	285
Agricultural Drought Coping capacity	Pearson Correlation	.547**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Drought Coping capacity	Pearson Correlation	.849**	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Drought Coping capacity	Pearson Correlation	.905**	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Drought Coping capacity	Pearson Correlation	.905**	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Drought Coping capacity	Pearson Correlation	.926**	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.1.2.1. Education Level and Agricultural Drought Coping capacity

(Table-7.1.2) shows that, correlation between education level and agricultural drought coping capacity is highly significant. In (Table-7.1.2.1) shows Chi-square test between education level and agricultural drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 8, which is highly significant. Highly educated percentage of population usually don't sell their standing crops earlier as their agricultural drought coping capacity, which is observed in (table-6.1.13). But overall in both study villages educational status was pretty poor. So they don't understand the long-term bad impact of deep tube well irrigation system and they use it as their agricultural drought coping strategy.

Table-7.1.2.1: Impact of Education Level on Agricultural Drought Coping Capacity.

Education Level		Agricultural Drought Coping Capacity			Total
		Irrigation By Shallow Machine	Selling Crops In Advance	Irrigation By Deep Tube Wells	
Illiterate	HH	73	33	4	110
	% of Total	25.6%	11.6%	1.4%	38.6%
Primary	HH	0	53	34	87
	% of Total	0.0%	18.6%	11.9%	30.5%
SSC	HH	0	39	15	54
	% of Total	0.0%	13.7%	5.3%	18.9%
HSC	HH	0	19	10	29
	% of Total	0.0%	6.7%	3.5%	10.2%
Graduation	HH	0	1	4	5
	% of Total	0.0%	0.4%	1.4%	1.8%
Total	HH	73	145	67	285
	% of Total	25.6%	50.9%	23.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 8			

Source: Field Questionnaire Survey, 2016.

7.1.2.2. Education Level and Pecuniary Drought Coping capacity

(Table-7.1.2) shows that, correlation between education level and pecuniary drought coping capacity is highly significant. In (Table-7.1.2.2) shows Chi-square test between education level and pecuniary drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 12, which is highly significant. Highly educated percentage of population usually don’t loan and debit or work as day labor and they usually sell their properties also. Instead they prefer temporary migration for outsourcing as their pecuniary drought coping strategy which is found in Jigabari village (Table-6.2.1.2). On the other hand illiterate people and people with limited educational knowledge usually get loan and debit, as they don’t completely understand getting loan will financial help them temporarily but it will weak there future economic progress. So, people with relatively higher educational knowledge usually not fall in debt during their drought induced critical pecuniary periods.

Table-7.1.2.2: Impact of Education Level on Pecuniary Drought Coping Capacity.

Education Level		Pecuniary Drought Coping Capacity				Total
		Loan And Debit	Selling Properties	Wage Earnings And Selling Labor In Advance	Migration	
Illiterate	HH	49	56	5	0	110
	% of Total	17.2%	19.6%	1.8%	0.0%	38.6%
Primary	HH	0	14	62	11	87
	% of Total	0.0%	4.9%	21.8%	3.9%	30.5%
SSC	HH	0	0	0	54	54
	% of Total	0.0%	0.0%	0.0%	18.9%	18.9%
HSC	HH	0	0	0	29	29
	% of Total	0.0%	0.0%	0.0%	10.2%	10.2%
Graduation	HH	0	0	0	5	5
	% of Total	0.0%	0.0%	0.0%	1.8%	1.8%
Total	HH	49	70	67	99	285
	% of Total	17.2%	24.6%	23.5%	34.7%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 12				

Source: Field Questionnaire Survey, 2016.

7.1.2.3. Education Level and Nutritional Drought Coping capacity

(Table-7.1.2) shows that, correlation between education level and nutritional drought coping capacity is highly significant. In (Table-7.1.2.3) shows Chi-square test between education level and nutritional drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. Illiterate people usually change their number in main meal intake as their nutritional drought coping capacity which is very high in Charkharibari village (Table-6.3.1.2). While the well-educated percentage don't adopt these type of adaptive capacity.

Table-7.1.2.3: Impact of Educational Level on Nutritional Drought Coping Capacity.

Education Level		Nutritional Drought Coping Capacity				Total
		Change in Number of Main Meal Intake	Borrowing Food From other HH	Selling Properties and Wage Labor	Loan, Debit and Begging	
Illiterate	HH	92	18	0	0	110
	% of Total	32.3%	6.3%	0.0%	0.0%	38.6%
Primary	HH	4	56	27	0	87
	% of Total	1.4%	19.6%	9.5%	0.0%	30.5%
SSC	HH	0	0	23	31	54
	% of Total	0.0%	0.0%	8.1%	10.9%	18.9%
HSC	HH	0	0	0	29	29
	% of Total	0.0%	0.0%	0.0%	10.2%	10.2%
Graduation	HH	0	0	0	5	5
	% of Total	0.0%	0.0%	0.0%	1.8%	1.8%
Total	HH	96	74	50	65	285
	% of Total	33.7%	26.0%	17.5%	22.8%	100.0%

χ^2 - Test	Sig. Value = 0.000, *df* = 12

Source: Field Questionnaire Survey, 2016.

7.1.2.4. Education Level and Aqua Paucity Drought Coping capacity

(Table-7.1.2) shows that, correlation between education level and aquatic drought coping capacity is highly significant. In (Table-7.1.2.4) shows Chi-square test between education level and aquatic drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 8, which is highly significant. Illiterate people usually and people with low educational knowledge usually drink contaminated water and river water as their aquatic drought coping strategy. On the hand educated people collects safe water from far places as their aquatic drought coping strategy, because they drinking contaminated will harm their health condition.

Table-7.1.2.4: Impact of Education Level on Aqua Paucity Drought Coping Capacity.

Education Level		Aqua Paucity Drought Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking River Water	Drinking Contaminated Water	
Illiterate	HH	0	7	103	110
	% of Total	0.0%	2.5%	36.1%	38.6%
Primary	HH	0	76	11	87
	% of Total	0.0%	26.7%	3.9%	30.5%
SSC	HH	48	6	0	54
	% of Total	16.8%	2.1%	0.0%	18.9%
HSC	HH	29	0	0	29
	% of Total	10.2%	0.0%	0.0%	10.2%
Graduation	HH	5	0	0	5
	% of Total	1.8%	0.0%	0.0%	1.8%
Total	HH	82	89	114	285
	% of Total	28.8%	31.2%	40.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 8			

Source: Field Questionnaire Survey, 2016.

7.1.2.5. Education Level and Health Drought Coping capacity

(Table-7.1.2) shows that, correlation between education level and health drought coping capacity is highly significant. In (Table-7.1.2.5) shows Chi-square test between education level and health drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 12, which is highly significant. Illiterate people usually don't have any drought induced health coping capacity but sometimes they go to Kobiraj for their treatment, as they usually don't understand their medical status completely. On the other educated people usually don't go to village doctor (LMF) and Kobiraj, instead they go the far Govt. and Non-Govt. health centers for proper medical treatment. So, people with relatively higher educational knowledge usually get proper medical facilities during their drought induced critical health periods.

Table-7.1.2.5: Impact of Education Level on Health Drought Coping Capacity.

Education Level		Health Drought Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
Illiterate	HH	0	12	0	98	110
	% of Total	0.0%	4.2%	0.0%	34.4%	38.6%
Primary	HH	10	72	5	0	87
	% of Total	3.5%	25.3%	1.8%	0.0%	30.5%
SSC	HH	15	3	36	0	54
	% of Total	5.3%	1.1%	12.6%	0.0%	18.9%
HSC	HH	0	0	29	0	29
	% of Total	0.0%	0.0%	10.2%	0.0%	10.2%
Graduation	HH	0	0	5	0	5
	% of Total	0.0%	0.0%	1.8%	0.0%	1.8%
Total	HH	25	87	75	98	285
	% of Total	8.8%	30.6%	26.2%	34.4%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 12				

Source: Field Questionnaire Survey, 2016.

7.1.3. Assessment of Occupation and Drought Coping capacity

According to the field data occupation type of household head is classified into six categories: farming, non-agro labor, service, business, fishing, stone collecting, and boating. From (Table-4.5.5.1) it is observed that, comparison between two study villages, people in Charkharibari village seems to be more occupationally diversified qualified than people of Jigabari village. But in terms of economically more beneficial occupation Jigabari village is well ahead of Charkharibari village. As per the concept of coping capacity, stable occupational sector tends to great coping capacity. As occupation type of household is a crucial factor for less coping capacity against drought, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against drought. Below in the (Table-7.1.3) shows the correlation between occupation and drought coping capacity. From that table it is observed that there is significant correlation between occupation and different sectorial drought coping capacity.

Table-7.1.3: Correlation between Occupation and Drought Coping Capacity.

		Occupation Type	Agricultural Drought Coping capacity	Pecuniary Drought Coping capacity	Nutritional Drought Coping capacity	Aqua Paucity Drought Coping capacity	Health Drought Coping capacity
Occupation Type	Pearson Correlation	1	.258**	.775**	.851**	.831**	.919**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	285	285	285	285	285	285
Agricultural Drought Coping capacity	Pearson Correlation	.258**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Drought Coping capacity	Pearson Correlation	.775**	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Drought Coping capacity	Pearson Correlation	.851**	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Drought Coping capacity	Pearson Correlation	.831**	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Drought Coping capacity	Pearson Correlation	.919**	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.1.3.1. Occupation and Agricultural Drought Coping capacity

(Table-7.1.3) shows that, correlation between occupation and agricultural drought coping capacity is highly significant. In (Table-7.1.3.1) shows Chi-square test between occupation and agricultural drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 10, which is highly significant. It is observed from the table people who are active in agricultural sector such as farmer and agro-labor they preferred irrigation by shallow machine and other high efficiency irrigation system like deep tube wells as their agricultural drought coping strategy. On the other hand people who works in non-agro sector tends to sell their crops in advance as their agricultural drought coping strategy. So, people who works in agricultural sector prefers different irrigation methods as their agricultural drought coping strategy because they have that knowledge.

Table-7.1.3.1: Impact of Occupation on Agricultural Drought Coping Capacity.

Occupation Type		Agricultural Drought Coping capacity			Total
		Irrigation by Shallow machine	Selling Crops in Advance	Irrigation by Deep Tube wells	
Farming	HH	73	33	35	141
	% of Total	25.6%	11.6%	12.3%	49.5%
Daily labor	HH	0	41	17	58
	% of Total	0.0%	14.4%	6.0%	20.4%
Fishing and Stone collecting	HH	0	39	0	39
	% of Total	0.0%	13.7%	0.0%	13.7%
Service	HH	0	1	11	12
	% of Total	0.0%	0.4%	3.9%	4.2%
Boating	HH	0	27	4	31
	% of Total	0.0%	9.5%	1.4%	10.9%
Business	HH	0	4	0	4
	% of Total	0.0%	1.4%	0.0%	1.4%
Total	HH	73	145	67	285
	% of Total	25.6%	50.9%	23.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 10			

Source: Field Questionnaire Survey, 2016.

7.1.3.2. Occupation and Pecuniary Drought Coping capacity

(Table-7.1.3) shows that, correlation between occupation and pecuniary drought coping capacity is highly significant. In (Table-7.1.3.2) shows Chi-square test between occupation and pecuniary drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 15, which is highly significant. It is observed that farmers and business men usually doesn't migrate, rather they borrow loan and debit as their pecuniary drought coping strategy. On the other hand non-agro occupants such as daily labor, fisher man, boat man they usually migrate to nearby cities as their pecuniary drought coping strategy. So, it is clear that occupation type highly influence the pecuniary drought coping capacity.

<u>Table-7.1.3.2: Impact of Occupation on Pecuniary Drought Coping Capacity.</u>

Occupation Type		Pecuniary Drought Coping capacity				Total
		Loan and Debit	Selling Properties	Wage earnings and selling labor in advance	Migration	
Farming	HH	49	70	22	0	141
	% of Total	17.2%	24.6%	7.7%	0.0%	49.5%
Daily labor	HH	0	0	42	16	58
	% of Total	0.0%	0.0%	14.7%	5.6%	20.4%
Fishing and Stone collecting	HH	0	0	3	36	39
	% of Total	0.0%	0.0%	1.1%	12.6%	13.7%
Service	HH	0	0	0	12	12
	% of Total	0.0%	0.0%	0.0%	4.2%	4.2%
Boating	HH	0	0	0	31	31
	% of Total	0.0%	0.0%	0.0%	10.9%	10.9%
Business	HH	4	0	0	0	4
	% of Total	1.4%	0.0%	0.0%	0.0%	1.4%
Total	HH	53	70	67	95	285
	% of Total	18.6%	24.6%	23.5%	33.3%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 15				

Source: Field Questionnaire Survey, 2016.

7.1.3.3. Occupation and Nutritional Drought Coping capacity

(Table-7.1.3) shows that, correlation between occupation and nutritional drought coping capacity is highly significant. In (Table-7.1.3.3) shows Chi-square test between occupation and nutritional drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 15, which is highly significant. It is observed from the table people who are active in agricultural sector such as farmer and agro-labor they preferred changing the number of main meal intake as their nutritional drought coping strategy. On the other hand non-agro occupants such as business man, daily labor, fisher man, boat man they usually borrow loan to buy food grain and get debit as their nutritional drought coping strategy. So, it is pretty clear that, agro and non-agro occupation holder's nutritional drought coping capacity and strategy is different.

Table-7.1.3.3: Impact of Occupation on Nutritional Drought Coping Capacity.

Occupation Type		Nutritional Drought Coping capacity				Total
		Change in Number of Main Meal Intake	Borrowing Food from Other Household	Selling Properties and Wage labor	Loan, Debit and Begging	
Farming	HH	96	39	6	0	141
	% of Total	33.7%	13.7%	2.1%	0.0%	49.5%
Daily labor	HH	0	35	15	8	58
	% of Total	0.0%	12.3%	5.3%	2.8%	20.4%
Fishing and Stone collecting	HH	0	0	29	10	39
	% of Total	0.0%	0.0%	10.2%	3.5%	13.7%
Service	HH	0	0	0	12	12
	% of Total	0.0%	0.0%	0.0%	4.2%	4.2%
Boating	HH	0	0	0	31	31
	% of Total	0.0%	0.0%	0.0%	10.9%	10.9%
Business	HH	0	0	0	4	4
	% of Total	0.0%	0.0%	0.0%	1.4%	1.4%
Total	HH	96	74	50	65	285
	% of Total	33.7%	26.0%	17.5%	22.8%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 15				

Source: Field Questionnaire Survey, 2016.

7.1.3.4. Occupation and Aqua Paucity Drought Coping capacity

(Table-7.1.3) shows that, correlation between occupation and aquatic drought coping capacity is highly significant. In (Table-7.1.3.4) shows Chi-square test between occupation and aquatic drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 10, which is highly significant. Low income generating occupation holders such as farmers, fishermen, boatmen, day labors usually drinks river water and contaminated water as their aquatic drought coping strategy. On the other hand relatively high income generating occupations such as servicemen and businessmen usually doesn't drink river water or other contaminated water rather they collect safe drinkable water from far places. So, it is pretty clear that, agro and non-agro occupation holder's aquatic drought coping capacity and strategy is different.

Table-7.1.3.4: Impact of Occupation on Aqua Paucity Drought Coping Capacity.

Occupation Type		Aqua Paucity Drought Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking River Water	Drinking Contaminated Water	
Farming	HH	0	27	114	141
	% of Total	0.0%	9.5%	40.0%	49.5%
Daily labor	HH	0	47	11	58
	% of Total	0.0%	16.5%	3.9%	20.4%
Fishing and Stone collecting	HH	0	15	24	39
	% of Total	0.0%	5.3%	8.4%	13.7%
Service	HH	12	0	0	12
	% of Total	4.2%	0.0%	0.0%	4.2%
Boating	HH	0	31	0	31
	% of Total	0.0%	10.9%	0.0%	10.9%
Business	HH	4	0	0	4
	% of Total	1.4%	0.0%	0.0%	1.4%
Total	HH	16	120	149	285
	% of Total	5.6%	42.2%	52.3%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 10			

Source: Field Questionnaire Survey, 2016.

7.1.3.5. Occupation and Health Drought Coping capacity

(Table-7.1.3) shows that, correlation between occupation and health drought coping capacity is highly significant. In (Table-7.1.3.5) shows Chi-square test between occupation and health drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 15, which is highly significant. Low income generating occupation holders such as farmers, fishermen, boatmen, day labors usually go to local village doctors (LMF) and Kobiraj as their health related drought coping strategy. On the other hand relatively high income generating occupations such as servicemen and businessmen usually go to far Govt. and non-governmental health facility centers.

Table-7.1.3.5: Impact of Occupation on Health Drought Coping Capacity.

Occupation Type		Health Drought Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
Farming	HH	108	33	0	0	141
	% of Total	37.9%	11.6%	0.0%	0.0%	49.5%
Daily labor	HH	0	47	11	0	58
	% of Total	0.0%	16.5%	3.9%	0.0%	20.4%
Fishing and Stone collecting	HH	0	7	30	2	39
	% of Total	0.0%	2.5%	10.5%	0.7%	13.7%
Service	HH	0	0	12	0	12
	% of Total	0.0%	0.0%	4.2%	0.0%	4.2%
Boating	HH	0	0	0	31	31
	% of Total	0.0%	0.0%	0.0%	10.9%	10.9%

Business	HH	0	0	4	0	4
	% of Total	0.0%	0.0%	1.4%	0.0%	1.4%
Total	HH	108	87	57	33	285
	% of Total	37.9%	30.5%	20.0%	11.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 15				

Source: Field Questionnaire Survey, 2016.

7.1.4. Assessment of Drought Frequency and Drought Coping capacity

According to the field data drought frequency in the study area is classified into two categories: drought once per year and drought twice per year. It is observed that on an average Charkharibari village gets drought affected twice per year and Jigabari village gets drought affected once per year. As per the concept of coping capacity, less disaster frequency tends to higher coping capacity. If drought frequency is a crucial factor for less coping capacity against drought, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against drought. Below in the (Table-7.1.4) shows the correlation between drought frequency and drought coping capacity. From that table it is observed that there is moderately significant correlation between drought frequency and different sectorial drought coping capacity.

Table-7.1.4: Correlation between Drought Frequency and Drought Coping Capacity.

		Drought Frequency	Agricultural Drought Coping capacity	Pecuniary Drought Coping capacity	Nutritional Drought Coping capacity	Aqua Paucity Drought Coping capacity	Health Drought Coping capacity
Drought Frequency	Pearson Correlation	1	-.753**	-.004	-.066	-.024	.002
	Sig. (2-tailed)		.000	.946	.267	.690	.977
	N	285	285	285	285	285	285
Agricultural Drought Coping capacity	Pearson Correlation	-.753**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Drought Coping capacity	Pearson Correlation	-.004	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.946	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Drought Coping capacity	Pearson Correlation	-.066	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)	.267	.000	.000		.000	.000
	N	285	285	285	285	285	285
	Pearson Correlation	-.024	.508**	.916**	.932**	1	.946**

Aqua Paucity Drought Coping capacity	Sig. (2-tailed)	.690	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Drought Coping capacity	Pearson Correlation	.002	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)	.977	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.1.4.1. Drought Frequency and Agricultural Drought Coping capacity

(Table-7.1.4) shows that, correlation between drought frequency and agricultural drought coping capacity is highly significant. In (Table-7.1.4.1) shows Chi-square test between drought frequency and agricultural drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 2, which is highly significant. It is observed from the table that if the area gets drought affected once a year then irrigation by shallow machine can be an agricultural drought coping strategy but if the area gets drought affected twice per year then high efficiency irrigation systems like deep tube wells is the main agricultural drought coping strategy.

Table-7.1.4.1: Impact of Drought Frequency on Agricultural Drought Coping Capacity.

Drought Frequency		Agricultural Drought Coping capacity			Total
		Irrigation by Shallow machine	Selling Crops in Advance	Irrigation by Deep Tube wells	
1	HH	67	18	0	85
	% of Total	23.5%	6.3%	0.0%	29.8%
2	HH	0	127	73	200
	% of Total	0.0%	44.6%	25.6%	70.2%
Total	HH	67	145	73	285
	% of Total	23.5%	50.9%	25.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 2			

Source: Field Questionnaire Survey, 2016.

7.1.4.2. Drought Frequency and Pecuniary Drought Coping capacity

(Table-7.1.4) shows that, correlation between drought frequency and pecuniary drought coping capacity is highly insignificant. In (Table-7.1.4.2) shows Chi-square test between drought frequency and pecuniary drought coping capacity. Chi-square (χ^2) test result also shows that Sig. Value is 0.940 and *df* = 3, which is highly insignificant.

Table-7.1.4.2: Impact of Drought Frequency on Pecuniary Drought Coping Capacity.

Drought Frequency		Pecuniary Drought Coping capacity				Total
		Loan and Debit	Selling Properties	Wage earnings and selling labor in advance	Migration	
1	HH	15	21	18	31	85
	% of Total	5.3%	7.4%	6.3%	10.9%	29.8%
2	HH	34	49	49	68	200
	% of Total	11.9%	17.2%	17.2%	23.9%	70.2%
Total	HH	49	70	67	99	285
	% of Total	17.2%	24.6%	23.5%	34.7%	100.0%
χ^2 - Test		Sig. Value = 0.940, *df* = 3				

Source: Field Questionnaire Survey, 2016.

7.1.4.3. Drought Frequency and Nutritional Drought Coping capacity

(Table-7.1.4) shows that, correlation between drought frequency and nutritional drought coping capacity is highly insignificant. In (Table-7.1.4.3) shows Chi-square test between drought frequency and nutritional drought coping capacity. Chi-square (χ^2) test result also shows that Sig. Value is 0.710 and *df* = 3, which is highly insignificant.

Table-7.1.4.3: Impact of Drought Frequency on Nutritional Drought Coping Capacity.

Drought Frequency		Nutritional Drought Coping capacity				Total
		Change in Number of Main Meal Intake	Borrowing Food from Other Household	Selling Properties and Wage labor	Loan, Debit and Begging	
1	HH	26	21	15	23	85
	% of Total	9.1%	7.4%	5.3%	8.1%	29.8%
2	HH	70	53	35	42	200
	% of Total	24.6%	18.6%	12.3%	14.7%	70.2%
Total	HH	96	74	50	65	285
	% of Total	33.7%	26.0%	17.5%	22.8%	100.0%
χ^2 - Test		Sig. Value = 0.710, *df* = 3				

Source: Field Questionnaire Survey, 2016.

7.1.4.4. Drought Frequency and Aqua Paucity Drought Coping capacity

(Table-7.1.4) shows that, correlation between drought frequency and aquatic drought coping capacity is highly insignificant. In (Table-7.1.4.4) shows Chi-square test between drought frequency and aquatic drought coping capacity. Chi-square (χ^2) test result also shows that Sig. Value is 0.906 and *df* = 2, which is highly insignificant.

Table-7.1.4.4: Impact of Drought Frequency on Aqua Paucity Drought Coping Capacity.

Drought Frequency		Aqua Paucity Drought Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking River Water	Drinking Contaminated Water	
1	HH	33	26	26	85
	% of Total	11.6%	9.1%	9.1%	29.8%
2	HH	81	63	56	200
	% of Total	28.4%	22.1%	19.6%	70.2%
Total	HH	114	89	82	285
	% of Total	40.0%	31.2%	28.8%	100.0%
χ^2 - Test		Sig. Value = 0.906, *df* = 2			

Source: Field Questionnaire Survey, 2016.

7.1.4.5. Drought Frequency and Health Drought Coping capacity

(Table-7.1.4) shows that, correlation between drought frequency and health drought coping capacity is highly insignificant. In (Table-7.1.4.5) shows Chi-square test between drought frequency and health drought coping capacity. Chi-square (χ^2) test result also shows that Sig. Value is 0.969 and *df* = 15, which is highly insignificant.

Table-7.1.4.5: Impact of Drought Frequency on Health Drought Coping Capacity.

Drought Frequency		Health Drought Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
1	HH	32	27	11	15	85
	% of Total	11.2%	9.5%	3.9%	5.3%	29.8%
2	HH	76	60	30	34	200
	% of Total	26.7%	21.1%	10.5%	11.9%	70.2%
Total	HH	108	87	41	49	285
	% of Total	37.9%	30.5%	14.4%	17.2%	100.0%
χ^2 - Test		Sig. Value = 0.969, *df* = 3				

Source: Field Questionnaire Survey, 2016.

7.1.5. Assessment of Drought Duration and Drought Coping capacity

According to the field data drought duration in the study areas is classified into three categories: <20 days, 21-45 days and 46+ days. It is observed that on an average in Charkharibari village drought duration is around 40-50 days and in Jigabari village it 15-20 days. As per the concept of coping capacity, less disaster duration tends to higher coping capacity. If duration of drought is a crucial factor for less coping capacity against drought, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against drought. Below in the (Table-

7.1.5) shows the correlation between drought duration and drought coping capacity. From that table it is observed that there is moderately significant correlation between drought duration and different sectorial drought coping capacity.

Table-7.1.5: Correlation between Drought Duration and Drought Coping Capacity.

		Drought Duration	Agricultural Drought Coping capacity	Pecuniary Drought Coping capacity	Nutritional Drought Coping capacity	Aqua Paucity Drought Coping capacity	Health Drought Coping capacity
Drought Duration	Pearson Correlation	1	-.509**	.062	-.040	.028	.036
	Sig. (2-tailed)		.000	.299	.505	.636	.546
	N	285	285	285	285	285	285
Agricultural Drought Coping capacity	Pearson Correlation	-.509**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Drought Coping capacity	Pearson Correlation	.062	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.299	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Drought Coping capacity	Pearson Correlation	-.040	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)	.505	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Drought Coping capacity	Pearson Correlation	.028	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)	.636	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Drought Coping capacity	Pearson Correlation	.036	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)	.546	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.1.5.1. Drought Duration and Agricultural Drought Coping capacity

(Table-7.1.5) shows that, correlation between drought duration and agricultural drought coping capacity is highly significant. In (Table-7.1.5.1) shows Chi-square test between drought duration and agricultural drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 4, which is highly significant. If the drought stays less than 20 days then people usually don't sell their crop in advance as an agricultural drought coping strategy. But if the drought prolonged more than 20 days or for a much higher period then irrigation is not the only solution, they also sell their crop in advance as an agricultural drought coping strategy.

Table-7.1.5.1: Impact of Drought Duration on Agricultural Drought Coping Capacity.

Drought Duration		Agricultural Drought Coping capacity			Total
		Irrigation by Shallow machine	Selling Crops in Advance	Irrigation by Deep Tube wells	
<20	HH	44	15	0	59
	% of Total	15.4%	5.3%	0.0%	20.7%
20-45	HH	48	83	23	154
	% of Total	16.8%	29.1%	8.1%	54.0%
46+	HH	25	47	25	72
	% of Total	8.8%	16.5%	8.8%	25.3%
Total	HH	117	145	48	285
	% of Total	41.0%	50.9%	16.9%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 4			

Source: Field Questionnaire Survey, 2016.

7.1.5.2. Drought Duration and Pecuniary Drought Coping capacity

(Table-7.1.5) shows that, correlation between drought duration and pecuniary drought coping capacity is highly insignificant. In (Table-7.1.5.2) shows Chi-square test between drought duration and pecuniary drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.145 and *df* = 6, which is highly insignificant.

Table-7.1.5.2: Impact of Drought Duration on Pecuniary Drought Coping Capacity.

Drought Duration		Pecuniary Drought Coping capacity				Total
		Loan and Debit	Selling Properties	Wage earnings and selling labor in advance	Migration	
<20	HH	13	11	13	22	59
	% of Total	4.6%	3.9%	4.6%	7.7%	20.7%
20-45	HH	31	36	38	49	154
	% of Total	10.9%	12.6%	13.3%	17.2%	54.0%
46+	HH	5	23	16	28	72
	% of Total	1.8%	8.1%	5.6%	9.8%	25.3%
Total	HH	49	70	67	99	285
	% of Total	17.2%	24.6%	23.5%	34.7%	100.0%
χ^2 - Test		Sig. Value = 0.145, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.1.5.3. Drought Duration and Nutritional Drought Coping capacity

(Table-7.1.5) shows that, correlation between drought duration and nutritional drought coping capacity is highly insignificant. In (Table-7.1.5.3) shows Chi-square test between drought duration and nutritional drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.040 and *df* = 6, which is moderately significant. If the drought prolonged for a longer period then peoples nutritional coping capacity decreases and it leads to borrowing and getting loan rather than only change in number of main meal intake.

Table-7.1.5.3: Impact of Drought Duration on Nutritional Drought Coping Capacity.

Drought Duration		Nutritional Drought Coping capacity				Total
		Change in Number of Main Meal Intake	Borrowing Food from Other Household	Selling Properties and Wage labor	Loan, Debit and Begging	
<20	HH	16	15	9	19	59
	% of Total	5.6%	5.3%	3.2%	6.7%	20.7%
20-45	HH	55	41	34	24	154
	% of Total	19.3%	14.4%	11.9%	8.4%	54.0%
46+	HH	25	18	7	22	72
	% of Total	8.8%	6.3%	2.5%	7.7%	25.3%
Total	HH	96	74	50	65	285
	% of Total	33.7%	26.0%	17.5%	22.8%	100.0%
χ^2 - Test		Sig. Value = 0.040, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.1.5.4. Drought Duration and Aqua Paucity Drought Coping capacity

(Table-7.1.5) shows that, correlation between drought duration and aquatic drought coping capacity is highly insignificant. In (Table-7.1.5.4) shows Chi-square test between drought duration and aquatic drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.242 and *df* = 4, which is highly insignificant.

Table-7.1.5.4: Impact of Drought Duration on Aqua Paucity Drought Coping Capacity.

Drought Duration		Aqua Paucity Drought Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking River Water	Drinking Contaminated Water	
<20	HH	21	19	19	59
	% of Total	7.4%	6.7%	6.7%	20.7%
20-45	HH	67	51	36	154
	% of Total	23.5%	17.9%	12.6%	54.0%
46+	HH	26	19	27	72
	% of Total	9.1%	6.7%	9.5%	25.3%
Total	HH	114	89	82	285
	% of Total	40.0%	31.2%	28.8%	100.0%
χ^2 - Test		Sig. Value = 0.242, *df* = 4			

Source: Field Questionnaire Survey, 2016.

7.1.5.5. Drought Duration and Health Drought Coping capacity

(Table-7.1.5) shows that, correlation between drought duration and health drought coping capacity is highly insignificant. In (Table-7.1.5.5) shows Chi-square test between drought duration and health drought coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.319 and *df* = 6, which is highly insignificant.

Table-7.1.5.5: Impact of Drought Duration on Health Drought Coping Capacity.

Drought Duration		Health Drought Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
<20	HH	20	20	7	12	59
	% of Total	7.0%	7.0%	2.5%	4.2%	20.7%
20-45	HH	63	47	25	19	154
	% of Total	22.1%	16.5%	8.8%	6.7%	54.0%
46+	HH	25	20	9	18	72
	% of Total	8.8%	7.0%	3.2%	6.3%	25.3%
Total	HH	108	87	41	49	285
	% of Total	37.9%	30.5%	14.4%	17.2%	100.0%
χ^2 - Test		Sig. Value = 0.319, df = 6				

Source: Field Questionnaire Survey, 2016.

7.2. Assessment of Flood Coping Capacity

Inhabitants' flood induced critical periods and coping capacity during those periods are highly linked with income level, occupation type and education level of the inhabitants. Generally the illiterate, poor and marginal sector of any community has less coping capacity (Chan, 1996).

7.2.1. Assessment of Income Level and Flood Coping capacity

According to the field data per month income of household head is classified into four categories: low (1-3000Tk), lower middle (3001-5000Tk), upper middle (5001-8000Tk) and high (8000Tk+). From (Table-4.5.7) it is observed that most (34.74%) of the total surveyed household sits in the category of lower middle (3001-5000Tk) and second most (33.34%) of the total surveyed household sits in the category of low (1-3000Tk). So, two third of the total sampled household belongs to low and lower middle income category. As per the concept of coping capacity, high income tends to great coping capacity. Comparison between two study villages, people in Charkharibari village seems to be poorer than people of Jigabari village. As income profile of household is a crucial factor for less coping capacity against flood, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against flood. Below in the (Table-7.2.1) shows the correlation between income level and flood coping capacity. From that table it is observed that there is significant correlation between income level and different sectorial flood coping capacity.

Table-7.2.1: Correlation between Income Level and Flood Coping Capacity.

		Income Level	Agricultural Flood Coping capacity	Pecuniary Flood Coping capacity	Nutritional Flood Coping capacity	Aqua Paucity Flood Coping capacity	Health Flood Coping capacity
Income Level	Pearson Correlation	1	.247**	.870**	.856**	.852**	.872**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	285	285	285	285	285	285
Agricultural Flood Coping capacity	Pearson Correlation	.247**	1	.378**	.377**	.347**	.305**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Flood Coping capacity	Pearson Correlation	.870**	.378**	1	.928**	.892**	.906**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Flood Coping capacity	Pearson Correlation	.856**	.377**	.928**	1	.930**	.894**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Flood Coping capacity	Pearson Correlation	.852**	.347**	.892**	.930**	1	.924**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Flood Coping capacity	Pearson Correlation	.872**	.305**	.906**	.894**	.924**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.2.1.1. Income Level and Agricultural Flood Coping capacity

(Table-7.2.1) shows that, correlation between income level and agricultural flood coping capacity is highly significant. In (Table-7.2.1.1) shows Chi-square test between income level and agricultural flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 3, which is highly significant. People belongs to lower middle and upper middle income group tend to sell their standing crops earlier as an agricultural flood coping strategy which is mostly found among the respondents of Charkharibari village

(Table-6.1.1.3). So, if the income is higher, then they have multiple agricultural flood coping strategy rather than only selling their crops in advance.

Table-7.2.1.1: Impact of Income Level on Agricultural Flood Coping Capacity.

Income Level		Agricultural Flood Coping capacity		Total
		Selling Crops in Advance	Nil	
Low (1-3000Tk)	Count	16	79	95
	% of Total	5.6%	27.7%	33.3%
Lower Middle (3001-5000Tk)	Count	5	94	99
	% of Total	1.8%	33.0%	34.7%
Upper Middle (5001-8000Tk)	Count	0	67	67
	% of Total	0.0%	23.5%	23.5%
High (8000Tk+)	Count	0	24	24
	% of Total	0.0%	8.4%	8.4%
Total	Count	21	264	285
	% of Total	7.4%	92.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 3		

Source: Field Questionnaire Survey, 2016.

7.2.1.2. Income Level and Pecuniary Flood Coping capacity

(Table-7.2.1) shows that, correlation between income level and pecuniary flood coping capacity is highly significant. In (Table-7.1.1.2) shows Chi-square test between income level and pecuniary flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. Getting relief, loan and debit and selling properties as a pecuniary flood coping capacity is highly adopted by the low and lower middle income group which is mostly found among the respondents of Charkharibari village (Table-6.2.1.2). On the other fishing and boating as a pecuniary flood coping strategy is generally adopted by lower middle, upper middle and high income group. So, people with relatively higher income level usually don't depend on relief and loan as a pecuniary flood coping strategy. They migrate temporarily to other activities for outsourcing during these critical moments.

Table-7.2.1.2: Impact of Income Level on Pecuniary Flood Coping Capacity.

Income Level		Pecuniary Flood Coping capacity				Total
		Relief	Loan and Debit	Fishing	Boating	
Low (1-3000Tk)	Count	65	30	0	0	95
	% of Total	22.8%	10.5%	0.0%	0.0%	33.3%
Lower Middle (3001-5000Tk)	Count	3	30	66	0	99
	% of Total	1.1%	10.5%	23.2%	0.0%	34.7%
Upper Middle (5001-8000Tk)	Count	0	0	41	26	67
	% of Total	0.0%	0.0%	14.4%	9.1%	23.5%

High (8000Tk+)	Count	0	0	0	24	24
	% of Total	0.0%	0.0%	0.0%	8.4%	8.4%
Total	Count	68	60	107	50	285
	% of Total	23.9%	21.1%	37.5%	17.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 9				

Source: Field Questionnaire Survey, 2016.

7.2.1.3. Income Level and Nutritional Flood Coping capacity

(Table-7.2.1) shows that, correlation between income level and nutritional flood coping capacity is highly significant. In (Table-7.2.1.3) shows Chi-square test between income level and nutritional flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. People with lower income usually depends on food relief and change their number of main meal intake as a nutritional flood coping capacity and majority respondents of Charkharibari village adopted this strategy (Table-6.3.1.2).

Table-7.2.1.3: Impact of Income Level on Nutritional Flood Coping Capacity.

Income Level		Nutritional Flood Coping Capacity				Total
		Relief	Change In Number of Main Meal Intake	Loan, Debit and Begging	Borrowing Food from other Household	
Low (1-3000Tk)	Count	50	43	2	0	95
	% of Total	17.5%	15.1%	0.7%	0.0%	33.3%
Lower Middle (3001-5000Tk)	Count	0	22	71	6	99
	% of Total	0.0%	7.7%	24.9%	2.1%	34.7%
Upper Middle (5001-8000Tk)	Count	0	0	23	44	67
	% of Total	0.0%	0.0%	8.1%	15.4%	23.5%
High (8000Tk+)	Count	0	0	0	24	24
	% of Total	0.0%	0.0%	0.0%	8.4%	8.4%
Total	Count	50	65	96	74	285
	% of Total	17.5%	22.8%	33.7%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 9				

Source: Field Questionnaire Survey, 2016.

7.2.1.4. Income Level and Aqua Paucity Flood Coping capacity

(Table-7.2.1) shows that, correlation between income level and aquatic flood coping capacity is highly significant. In (Table-7.2.1.4) shows Chi-square test between income level and aquatic flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly significant. People with relatively lower income generally drinks contaminated water as their aquatic flood coping strategy. But, people who belongs to upper middle and high income group collects safe water from far places as their aquatic flood coping capacity. So, people with relatively higher income level usually don't drink contaminated water which mostly found in Jigabari village.

Table-7.2.1.4: Impact of Income Level on Aqua Paucity Flood Coping Capacity.

Income Level		Aqua Paucity Flood Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking Flood River Water	Drinking contaminated water	
Low (1-3000Tk)	Count	0	13	82	95
	% of Total	0.0%	4.6%	28.8%	33.3%
Lower Middle (3001-5000Tk)	Count	10	83	6	99
	% of Total	3.5%	29.1%	2.1%	34.7%
Upper Middle (5001-8000Tk)	Count	44	23	0	67
	% of Total	15.4%	8.1%	0.0%	23.5%
High (8000Tk+)	Count	24	0	0	24
	% of Total	8.4%	0.0%	0.0%	8.4%
Total	Count	78	119	88	285
	% of Total	27.3%	41.8%	30.9%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6			

Source: Field Questionnaire Survey, 2016.

7.2.1.5. Income Level and Health Flood Coping capacity

(Table-7.2.1) shows that, correlation between income level and health flood coping capacity is highly significant. In (Table-7.1.2.5) shows Chi-square test between income level and health flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 9, which is highly significant. People with relatively lower income generally don't have anything as their health flood coping capacity. Lower middle and upper middle income group usually goes to village doctor (LMF) and get Kobiraji treatment as their health flood coping strategy. On the other people who belongs to higher income group usually goes to the far Govt. and Non-Govt. health centers. So, people with relatively higher income level usually get proper medical facilities during their flood induced critical health periods.

Table-7.2.1.5: Impact of Income Level on Health Flood Coping Capacity.

Income Level		Health Flood Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
Low (1-3000Tk)	Count	0	9	0	86	95
	% of Total	0.0%	3.2%	0.0%	30.2%	33.3%
Lower Middle (3001-5000Tk)	Count	14	60	25	0	99
	% of Total	4.9%	21.1%	8.8%	0.0%	34.7%
	Count	28	12	27	0	67

Upper Middle (5001-8000Tk)	% of Total	9.8%	4.2%	9.5%	0.0%	23.5%
High (8000Tk+)	Count	4	0	20	0	24
	% of Total	1.4%	0.0%	7.0%	0.0%	8.4%
Total	Count	46	81	72	86	285
	% of Total	16.1%	28.4%	25.3%	30.2%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 9				

Source: Field Questionnaire Survey, 2016.

7.2.2. Assessment of Education Level and Flood Coping capacity

According to the field data educational status of household head is classified into five categories: illiterate, primary, SSC, HSC and graduate. Comparison between two study villages, people in Charkharibari village seems to be less educationally qualified than people of Jigabari village (Table-4.5.4). As educational status of a person have a great deal of influence on his/her lifestyle and different socio-economic sectors. So, educational profile of household can be a crucial factor for less coping capacity against flood, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against flood. Below in the (Table-7.2.2) shows the correlation between education level and flood coping capacity. From that table it is observed that there is significant correlation between education level and different sectorial flood coping capacity.

Table-7.2.2: Correlation between Education Level and Flood Coping Capacity.

		Education Level	Agricultural Flood Coping capacity	Pecuniary Flood Coping capacity	Nutritional Flood Coping capacity	Aqua Paucity Flood Coping capacity	Health Flood Coping capacity
Education Level	Pearson Correlation	1	.280**	.874**	.844**	.874**	.912**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	285	285	285	285	285	285
Agricultural Flood Coping capacity	Pearson Correlation	.280**	1	.378**	.377**	.347**	.305**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Flood Coping capacity	Pearson Correlation	.874**	.378**	1	.928**	.892**	.906**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Flood Coping capacity	Pearson Correlation	.844**	.377**	.928**	1	.930**	.894**
	Sig. (2-tailed)	.000	.000	.000		.000	.000

	N	285	285	285	285	285	285
Aqua Paucity Flood Coping capacity	Pearson Correlation	.874**	.347**	.892**	.930**	1	.924**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Flood Coping capacity	Pearson Correlation	.912**	.305**	.906**	.894**	.924**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.2.2.1. Education Level and Agricultural Flood Coping capacity

(Table-7.2.2) shows that, correlation between education level and agricultural flood coping capacity is highly significant. In (Table-7.2.2.1) shows Chi-square test between education level and agricultural flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 4, which is highly significant. Illiterate percentage of population usually sell their standing crops earlier as their agricultural flood coping strategy. But overall in both study villages the agricultural flood coping capacity is mostly nil.

Table-7.2.2.1: Impact of Education Level on Agricultural Flood Coping Capacity.

Education Level		Agricultural Flood Coping capacity		Total
		Selling Crops in Advance	Nil	
Illiterate	Count	21	89	110
	% of Total	7.4%	31.2%	38.6%
Primary	Count	0	87	87
	% of Total	0.0%	30.5%	30.5%
SSC	Count	0	54	54
	% of Total	0.0%	18.9%	18.9%
HSC	Count	0	29	29
	% of Total	0.0%	10.2%	10.2%
Graduation	Count	0	5	5
	% of Total	0.0%	1.8%	1.8%
Total	Count	21	264	285
	% of Total	7.4%	92.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 4		

Source: Field Questionnaire Survey, 2016.

7.2.2.2. Education Level and Pecuniary Flood Coping capacity

(Table-7.2.2) shows that, correlation between education level and pecuniary flood coping capacity is highly significant. In (Table-7.2.2.2) shows Chi-square test between education level and pecuniary flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 12, which is highly significant. Highly educated percentage of population usually don't depend on relief, loan and debit or work as day labor and they usually sell their properties also. Instead they prefer temporary migration of occupation such as fishing and boating for outsourcing as their pecuniary flood coping strategy. On the other hand illiterate people and people with limited educational knowledge usually depend highly on relief and getting loan and debit, as they don't completely understand getting loan will financial help them temporarily but it will weak there future economic progress, and distribution of relief is still unequal. So, people with relatively higher educational knowledge usually not fall in debt during their flood induced critical pecuniary periods.

Table-7.2.2.2: Impact of Education Level on Pecuniary Flood Coping Capacity.

Education Level		Pecuniary Flood Coping capacity				Total
		Relief	Loan and Debit	Fishing	Boating	
Illiterate	Count	68	42	0	0	110
	% of Total	23.9%	14.7%	0.0%	0.0%	38.6%
Primary	Count	0	18	69	0	87
	% of Total	0.0%	6.3%	24.2%	0.0%	30.5%
SSC	Count	0	0	38	16	54
	% of Total	0.0%	0.0%	13.3%	5.6%	18.9%
HSC	Count	0	0	0	29	29
	% of Total	0.0%	0.0%	0.0%	10.2%	10.2%
Graduation	Count	0	0	0	5	5
	% of Total	0.0%	0.0%	0.0%	1.8%	1.8%
Total	Count	68	60	107	50	285
	% of Total	23.9%	21.1%	37.5%	17.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 12				

Source: Field Questionnaire Survey, 2016.

7.2.2.3 Education Level and Nutritional Flood Coping capacity

(Table-7.2.2) shows that, correlation between education level and nutritional flood coping capacity is highly significant. In (Table-7.2.2.3) shows Chi-square test between education level and nutritional flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 12, which is highly significant. Illiterate people usually change their number in main meal intake and depends on food relief as their nutritional flood coping capacity, while the well-educated percentage don't adopt these type of adaptive capacity.

Table-7.2.2.3: Impact of Educational Level on Nutritional Flood Coping Capacity.

Education Level		Nutritional Flood Coping capacity				Total
		Relief	Change in Number of Main meal Intake	Loan, Debit and Begging	Borrowing Food from other Household	
Illiterate	Count	50	49	11	0	110

	% of Total	17.5%	17.2%	3.9%	0.0%	38.6%
Primary	Count	0	16	71	0	87
	% of Total	0.0%	5.6%	24.9%	0.0%	30.5%
SSC	Count	0	0	14	40	54
	% of Total	0.0%	0.0%	4.9%	14.0%	18.9%
HSC	Count	0	0	0	29	29
	% of Total	0.0%	0.0%	0.0%	10.2%	10.2%
Graduation	Count	0	0	0	5	5
	% of Total	0.0%	0.0%	0.0%	1.8%	1.8%
Total	Count	50	65	96	74	285
	% of Total	17.5%	22.8%	33.7%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 12				

Source: Field Questionnaire Survey, 2016.

7.2.2.4. Education Level and Aqua Paucity Flood Coping capacity

(Table-7.2.2) shows that, correlation between education level and aquatic flood coping capacity is highly significant. In (Table-7.2.2.4) shows Chi-square test between education level and aquatic flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 8, which is highly significant. Illiterate people usually and people with low educational knowledge usually drink contaminated water and river water as their aquatic flood coping strategy. On the hand educated people collects safe water from far places as their aquatic flood coping strategy, because they drinking contaminated will harm their health condition.

Table-7.2.2.4: Impact of Education Level on Aqua Paucity Flood Coping Capacity.

Education Level		Aqua Paucity Flood Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking Flood River Water	Drinking contaminated water	
Illiterate	Count	0	22	88	110
	% of Total	0.0%	7.7%	30.9%	38.6%
Primary	Count	0	83	4	87
	% of Total	0.0%	29.1%	1.4%	30.5%
SSC	Count	40	14	0	54
	% of Total	14.0%	4.9%	0.0%	18.9%
HSC	Count	29	0	0	29
	% of Total	10.2%	0.0%	0.0%	10.2%
Graduation	Count	5	0	0	5
	% of Total	1.8%	0.0%	0.0%	1.8%
Total	Count	74	119	92	285
	% of Total	26.0%	41.8%	32.2%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 8			

Source: Field Questionnaire Survey, 2016.

7.2.2.5. Education Level and Health Flood Coping capacity

(Table-7.2.2) shows that, correlation between education level and health flood coping capacity is highly significant. In (Table-7.2.2.5) shows Chi-square test between education level and health flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 12, which is highly significant. Illiterate people usually don't have any flood induced health coping strategy but sometimes they go to Kobiraj for their treatment, as they usually don't understand their medical status completely. On the other educated people usually don't go to village doctor (LMF) and Kobiraj, instead they go the far Govt. and Non-Govt. health centers for proper medical treatment. So, people with relatively higher educational knowledge usually get proper medical facilities during their flood induced critical health periods.

Table-7.2.2.5: Impact of Education Level on Health Flood Coping Capacity.

Education Level		Health Flood Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
Illiterate	Count	0	18	0	92	110
	% of Total	0.0%	6.3%	0.0%	32.3%	38.6%
Primary	Count	8	63	16	0	87
	% of Total	2.8%	22.1%	5.6%	0.0%	30.5%
SSC	Count	18	0	36	0	54
	% of Total	6.3%	0.0%	12.6%	0.0%	18.9%
HSC	Count	0	0	29	0	29
	% of Total	0.0%	0.0%	10.2%	0.0%	10.2%
Graduation	Count	0	0	5	0	5
	% of Total	0.0%	0.0%	1.8%	0.0%	1.8%
Total	Count	26	81	86	92	285
	% of Total	9.1%	28.4%	30.2%	32.3%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 12				

Source: Field Questionnaire Survey, 2016.

7.2.3. Assessment of Occupation and Flood Coping capacity

According to the field data occupation type of household head is classified into six categories: farming, non-agro labor, service, business, fishing, stone collecting, and boating. From (Table-4.5.5.1) it is observed that, comparison between two study villages, people in Charkharibari village seems to be more occupationally diversified qualified than people of Jigabari village. But in terms of economically more beneficial occupation Jigabari village is well ahead of Charkharibari village. As per the concept of coping capacity, stable occupational sector tends to great coping capacity. As occupation type of household is a crucial factor for less coping capacity against flood, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against flood. Below in the (Table-7.2.3) shows the correlation between occupation and flood coping capacity. From that table it is observed that there is significant correlation between occupation and different sectorial flood coping capacity.

Table-7.2.3: Correlation between Occupation and Flood Coping Capacity.

		Occupation Type	Agricultural Flood Coping capacity	Pecuniary Flood Coping capacity	Nutritional Flood Coping capacity	Aqua Paucity Flood Coping capacity	Health Flood Coping capacity
Occupation Type	Pearson Correlation	1	.222**	.823**	.784**	.811**	.903**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	285	285	285	285	285	285
Agricultural Flood Coping capacity	Pearson Correlation	.222**	1	.378**	.377**	.347**	.305**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Flood Coping capacity	Pearson Correlation	.823**	.378**	1	.928**	.892**	.906**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Flood Coping capacity	Pearson Correlation	.784**	.377**	.928**	1	.930**	.894**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Flood Coping capacity	Pearson Correlation	.811**	.347**	.892**	.930**	1	.924**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Flood Coping capacity	Pearson Correlation	.903**	.305**	.906**	.894**	.924**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.2.3.1. Occupation and Agricultural Flood Coping capacity

(Table-7.2.3) shows that, correlation between occupation and agricultural flood coping capacity is highly significant. In (Table-7.2.3.1) shows Chi-square test between occupation and agricultural flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 5, which is highly significant. It is observed from the table people who are active in agricultural sector such as farmer and agro-labor they preferred selling crops in an early stage as their agricultural flood coping strategy. On the other hand people who works in non-agro sector tends to have no effective coping strategy, as they are not directly linked with agricultural sector. So, people who works in agricultural sector prefers selling crops in an early stage as their agricultural flood coping strategy because they have that knowledge.

Table-7.2.3.1: Impact of Occupation on Agricultural Flood Coping Capacity.

Occupation Type		Agricultural Flood Coping capacity		Total
		Selling Crops in Advance	Nil	
Farming	Count	21	120	141
	% of Total	7.4%	42.1%	49.5%
Daily labor	Count	0	58	58
	% of Total	0.0%	20.4%	20.4%
Fishing and Stone Collecting	Count	0	39	39
	% of Total	0.0%	13.7%	13.7%
Service	Count	0	12	12
	% of Total	0.0%	4.2%	4.2%
Boating	Count	0	31	31
	% of Total	0.0%	10.9%	10.9%
Business	Count	0	4	4
	% of Total	0.0%	1.4%	1.4%
Total	Count	21	264	285
	% of Total	7.4%	92.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 5		

Source: Field Questionnaire Survey, 2016.

7.2.3.2. Occupation and Pecuniary Flood Coping capacity

(Table-7.2.3) shows that, correlation between occupation and pecuniary flood coping capacity is highly significant. In (Table-7.2.3.2) shows Chi-square test between occupation and pecuniary flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 15, which is highly significant. It is observed that farmers and business men usually doesn’t migrate, rather they depends highly on relief and borrow loan and debit as their pecuniary flood coping strategy. On the other hand non-agro occupants such as daily labor, fisher man, boat man they usually migrate to other economic activities as their pecuniary flood coping strategy. After when the critical flood moment is over they came back to their previous occupations. So, it is clear that occupation type highly influence the pecuniary flood coping capacity.

Table-7.2.3.2: Impact of Occupation on Pecuniary Flood Coping Capacity.

Occupation Type		Pecuniary Flood Coping capacity				Total
		Relief	Loan and Debit	Fishing	Boating	
Farming	Count	68	58	15	0	141
	% of Total	23.9%	20.4%	5.3%	0.0%	49.5%
Daily labor	Count	0	2	54	2	58
Fishing and Stone collecting	Count	0	0	38	1	39
	% of Total	0.0%	0.0%	13.3%	0.4%	13.7%
Service	Count	0	0	0	12	12
	% of Total	0.0%	0.0%	0.0%	4.2%	4.2%
Boating	Count	0	0	0	31	31
	% of Total	0.0%	0.0%	0.0%	10.9%	10.9%
Business	Count	0	0	0	4	4
	% of Total	0.0%	0.0%	0.0%	1.4%	1.4%
Total	Count	68	60	107	50	285
	% of Total	23.9%	21.1%	37.5%	17.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 15				

Source: Field Questionnaire Survey, 2016.

7.2.3.3. Occupation and Nutritional Flood Coping capacity

(Table-7.2.3) shows that, correlation between occupation and nutritional flood coping capacity is highly significant. In (Table-7.2.3.3) shows Chi-square test between occupation and nutritional flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 15, which is highly significant. It is observed from the table people who are active in agricultural sector such as farmer and agro-labor they preferred changing the number of main meal intake and depends highly on food relief as their nutritional flood coping strategy. On the other hand non-agro occupants such as business man, daily labor, fisher man, boat man they usually borrow loan to buy food grain and get debit as their nutritional flood coping strategy. So, it is pretty clear that, agro and non-agro occupation holder's nutritional flood coping capacity and strategy is different.

Table-7.2.3.3: Impact of Occupation on Nutritional Flood Coping Capacity.

Occupation Type		Nutritional Flood Coping capacity				Total
		Relief	Change in Number of Main meal Intake	Loan, Debit and Begging	Borrowing Food from Other Household	
Farming	Count	50	65	26	0	141
	% of Total	17.5%	22.8%	9.1%	0.0%	49.5%
Daily labor	Count	0	0	52	6	58
	% of Total	0.0%	0.0%	18.2%	2.1%	20.4%
Fishing and Stone collecting	Count	0	0	18	21	39
	% of Total	0.0%	0.0%	6.3%	7.4%	13.7%
Service	Count	0	0	0	12	12
	% of Total	0.0%	0.0%	0.0%	4.2%	4.2%
Boating	Count	0	0	0	31	31
	% of Total	0.0%	0.0%	0.0%	10.9%	10.9%
Business	Count	0	0	0	4	4
	% of Total	0.0%	0.0%	0.0%	1.4%	1.4%
Total	Count	50	65	96	74	285
	% of Total	17.5%	22.8%	33.7%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, df = 15				

Source: Field Questionnaire Survey, 2016.

7.2.3.4. Occupation and Aqua Paucity Flood Coping capacity

(Table-7.2.3) shows that, correlation between occupation and aquatic flood coping capacity is highly significant. In (Table-7.2.3.4) shows Chi-square test between occupation and aquatic flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 10, which is highly significant. Low income generating occupation holders such as farmers, fishermen, boatmen, day labors usually drinks river water and contaminated water as their aquatic flood coping strategy. On the other hand relatively high income generating occupations such as servicemen and businessmen usually doesn't drink river water or other contaminated water rather they collect safe drinkable water from far places. So, it is pretty clear that, agro and non-agro occupation holder's aquatic flood coping capacity and strategy is different.

Table-7.2.3.4: Impact of Occupation on Aqua Paucity Flood Coping Capacity.

Occupation Type		Aqua Paucity Flood Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking Flood River Water	Drinking contaminated water	
Farming	Count	12	49	80	141
	% of Total	4.3%	17.2%	28.0%	49.5%
Daily labor	Count	0	52	6	58
	% of Total	0.0%	18.2%	2.1%	20.4%
	Count	0	18	21	39

Fishing and Stone collecting	% of Total	0.0%	6.3%	7.4%	13.7%
Service	Count	12	0	0	12
	% of Total	4.2%	0.0%	0.0%	4.2%
Boating	Count	0	20	11	31
	% of Total	0.0%	7.4%	3.5%	10.9%
Business	Count	4	0	0	4
	% of Total	1.4%	0.0%	0.0%	1.4%
Total	Count	28	139	118	285
	% of Total	9.9%	49.1%	41.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 10			

Source: Field Questionnaire Survey, 2016.

7.2.3.5. Occupation and Health Flood Coping capacity

(Table-7.2.3) shows that, correlation between occupation and health flood coping capacity is highly significant. In (Table-7.2.3.5) shows Chi-square test between occupation and health flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 15, which is highly significant. Low income generating occupation holders such as farmers, fishermen, boatmen, day labors usually go to local village doctors (LMF) and Kobiraj as their health related flood coping strategy. On the other hand relatively high income generating occupations such as servicemen and businessmen usually go to far Govt. and non-governmental health facility centers.

Table-7.2.3.5: Impact of Occupation on Health Flood Coping Capacity.

Occupation Type		Health Flood Coping Capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
Farming	Count	100	41	0	0	141
	% of Total	35.1%	14.4%	0.0%	0.0%	49.5%
Daily labor	Count	0	40	16	2	58
	% of Total	0.0%	14.0%	5.6%	0.7%	20.4%
Fishing and Stone collecting	Count	0	0	36	3	39
	% of Total	0.0%	0.0%	12.6%	1.1%	13.7%
Service	Count	0	0	0	12	12
	% of Total	0.0%	0.0%	0.0%	4.2%	4.2%
Boating	Count	0	0	0	31	31
	% of Total	0.0%	0.0%	0.0%	10.9%	10.9%
Business	Count	0	0	0	4	4
	% of Total	0.0%	0.0%	0.0%	1.4%	1.4%
Total	Count	100	81	52	52	285
	% of Total	35.1%	28.4%	18.2%	18.2%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 15				

Source: Field Questionnaire Survey, 2016.

7.2.4. Assessment of Flood Frequency and Flood Coping capacity

According to the field data flood frequency in the study area is classified into three categories: flood once per year, flood twice per year and flood more than twice per year. It is observed that on an average Charkharibari village gets flood affected more than twice per year and Jigabari village gets flood affected once per year. As per the concept of coping capacity, less disaster frequency tends to higher coping capacity. If flood frequency is a crucial factor for less coping capacity against flood, hence the inhabitants in Charkharibari village are more vulnerable than Jigabari village, which is could lead them to lesser coping capacity against flood. Below in the (Table-7.2.4) shows the correlation between flood frequency and flood coping capacity. From that table it is observed that there is moderately significant correlation between flood frequency and different sectorial drought coping capacity.

Table-7.2.4: Correlation between Flood Frequency and Flood Coping Capacity.

		Flood Frequency	Agricultural Flood Coping capacity	Pecuniary Flood Coping capacity	Nutritional Flood Coping capacity	Aqua Paucity Flood Coping capacity	Health Flood Coping capacity
Flood Frequency	Pearson Correlation	1	.380**	-.096	-.008	-.089	-.082
	Sig. (2-tailed)		.000	.107	.899	.133	.165
	N	285	285	285	285	285	285
Agricultural Flood Coping capacity	Pearson Correlation	.380**	1	.378**	.377**	.347**	.305**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Flood Coping capacity	Pearson Correlation	-.096	.378**	1	.928**	.892**	.906**
	Sig. (2-tailed)	.107	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Flood Coping capacity	Pearson Correlation	-.008	.377**	.928**	1	.930**	.894**
	Sig. (2-tailed)	.899	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Flood Coping capacity	Pearson Correlation	-.089	.347**	.892**	.930**	1	.924**
	Sig. (2-tailed)	.133	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Flood Coping capacity	Pearson Correlation	-.082	.305**	.906**	.894**	.924**	1
	Sig. (2-tailed)	.165	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).
Source: Field Questionnaire Survey, 2016.

7.2.4.1. Flood Frequency and Agricultural Flood Coping capacity

(Table-7.2.4) shows that, correlation between flood frequency and agricultural flood coping capacity is highly significant. In (Table-7.2.4.1) shows Chi-square test between flood frequency and agricultural flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 2, which is highly significant. It is observed from the table that if the area gets flood affected once a year then selling crops in advance can be an agricultural flood coping strategy but if the area gets flood affected twice per year then there is no coping capacity.

Table-7.2.4.1: Impact of Flood Frequency on Agricultural Flood Coping Capacity.

Flood Frequency		Agricultural Flood Coping capacity		Total
		Selling Crops in Advance	Nil	
1	Count	21	64	85
	% of Total	7.4%	22.5%	29.8%
2	Count	0	74	74
	% of Total	0.0%	26.0%	26.0%
2+	Count	0	126	126
	% of Total	0.0%	44.2%	44.2%
Total	Count	21	264	285
	% of Total	7.4%	92.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 2		

Source: Field Questionnaire Survey, 2016.

7.2.4.2. Flood Frequency and Pecuniary Flood Coping capacity

(Table-7.2.4) shows that, correlation between flood frequency and pecuniary flood coping capacity is highly insignificant. In (Table-7.2.4.2) shows Chi-square test between flood frequency and pecuniary flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly significant. So, if there is more flood frequency there will be multiple pecuniary flood coping strategy like fishing, boating and getting loan etc.

Table-7.2.4.2: Impact of Flood Frequency on Pecuniary Flood Coping Capacity.

Flood Frequency		Pecuniary Flood Coping capacity				Total
		Relief	Loan and Debit	Fishing	Boating	
1	Count	19	19	30	17	85
	% of Total	6.7%	6.7%	10.5%	6.0%	29.8%

2	Count	13	19	18	24	74
	% of Total	4.6%	6.7%	6.3%	8.4%	26.0%
2+	Count	36	22	59	9	126
	% of Total	12.6%	7.7%	20.7%	3.2%	44.2%
Total	Count	68	60	107	50	285
	% of Total	23.9%	21.1%	37.5%	17.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.2.4.3. Flood Frequency and Nutritional Flood Coping capacity

(Table-7.2.4) shows that, correlation between flood frequency and nutritional flood coping capacity is highly insignificant. In (Table-7.2.4.3) shows Chi-square test between flood frequency and nutritional flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly significant. So, if there is more flood frequency there will be multiple nutritional flood coping strategy like relief, change in number of main meal intake, borrow food by debit and getting loan to buy food grain etc.

Table-7.2.4.3: Impact of Flood Frequency on Nutritional Flood Coping Capacity.

Flood Frequency		Nutritional Flood Coping capacity				Total
		Relief	Change in Number of Main meal Intake	Loan, Debit and Begging	Borrowing Food from Other Household	
1	Count	15	23	26	21	85
	% of Total	5.3%	8.1%	9.1%	7.4%	29.8%
2	Count	13	10	27	24	74
	% of Total	4.6%	3.5%	9.5%	8.4%	26.0%
2+	Count	22	32	43	29	126
	% of Total	7.7%	11.2%	15.1%	10.2%	44.2%
Total	Count	50	65	96	74	285
	% of Total	17.5%	22.8%	33.7%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.2.4.4. Flood Frequency and Aqua Paucity Flood Coping capacity

(Table-7.2.4) shows that, correlation between flood frequency and aquatic flood coping capacity is highly insignificant. In (Table-7.2.4.4) shows Chi-square test between flood frequency and aquatic flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 4, which is highly significant. If there is more flood frequency then people doesn't have any other choice than drinking river flood water and other contaminated water.

Table-7.2.4.4: Impact of Flood Frequency on Aqua Paucity Flood Coping Capacity.

Flood Frequency		Aqua Paucity Flood Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking Flood River Water	Drinking contaminated water	
1	Count	26	38	21	85
	% of Total	9.1%	13.3%	7.4%	29.8%
2	Count	13	37	24	74
	% of Total	4.6%	13.0%	8.4%	26.0%
2+	Count	53	44	29	126
	% of Total	18.6%	15.4%	10.2%	44.2%
Total	Count	92	119	74	285
	% of Total	32.3%	41.8%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 4			

Source: Field Questionnaire Survey, 2016.

7.2.4.5 Flood Frequency and Health Flood Coping capacity

(Table-7.2.4) shows that, correlation between flood frequency and health flood coping capacity is highly insignificant. In (Table-7.2.4.5) shows Chi-square test between flood frequency and health flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly significant. If there is more flood frequency then peoples' health flood coping capacity falls drastically.

Table-7.2.4.5: Impact of Flood Frequency on Health Flood Coping Capacity.

Flood Frequency		Health Flood Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
1	Count	30	23	15	17	85
	% of Total	10.5%	8.1%	5.3%	6.0%	29.8%
2	Count	16	34	0	24	74
	% of Total	5.6%	11.9%	0.0%	8.4%	26.0%
2+	Count	54	24	37	11	126
	% of Total	18.9%	8.4%	13.0%	3.9%	44.2%
Total	Count	100	81	52	52	285
	% of Total	35.1%	28.4%	18.2%	18.2%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.2.5. Assessment of Flood Duration and Flood Coping capacity

According to the field data flood duration in the study areas is classified into three categories: <3 days, 3-7 days and 7+ days. It is observed that on an average in Charkharibari village drought duration is around 2-5 days and in Jigabari village it 7-10 days. As per the concept of coping capacity, less disaster duration tends to higher coping capacity. If duration of flood is a crucial factor for less coping capacity against flood, hence the inhabitants in Jigabari village are more vulnerable than Charkharibari village, which is could lead them to lesser coping capacity against flood. Below in the (Table-7.2.5) shows the correlation between flood duration and flood coping capacity. From that table it is observed that there is moderately significant correlation between flood duration and different sectorial flood coping capacity.

Table-7.2.5: Correlation between Flood Duration and Flood Coping Capacity.

		Flood Duration	Agricultural Flood Coping capacity	Pecuniary Flood Coping capacity	Nutritional Flood Coping capacity	Aqua Paucity Flood Coping capacity	Health Flood Coping capacity
Flood Duration	Pearson Correlation	1	-.384**	.023	-.034	.007	.021
	Sig. (2-tailed)		.000	.698	.566	.906	.725
	N	285	285	285	285	285	285
Agricultural Flood Coping capacity	Pearson Correlation	-.384**	1	.378**	.377**	.347**	.305**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	285	285	285	285	285	285
Pecuniary Flood Coping capacity	Pearson Correlation	.023	.378**	1	.928**	.892**	.906**
	Sig. (2-tailed)	.698	.000		.000	.000	.000
	N	285	285	285	285	285	285
Nutritional Flood Coping capacity	Pearson Correlation	-.034	.377**	.928**	1	.930**	.894**
	Sig. (2-tailed)	.566	.000	.000		.000	.000
	N	285	285	285	285	285	285
Aqua Paucity Flood Coping capacity	Pearson Correlation	.007	.347**	.892**	.930**	1	.924**
	Sig. (2-tailed)	.906	.000	.000	.000		.000
	N	285	285	285	285	285	285
Health Flood Coping capacity	Pearson Correlation	.021	.305**	.906**	.894**	.924**	1
	Sig. (2-tailed)	.725	.000	.000	.000	.000	
	N	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.2.5.1. Flood Duration and Agricultural Flood Coping capacity

(Table-7.2.5) shows that, correlation between flood duration and agricultural flood coping capacity is highly significant. In (Table-7.2.5.1) shows Chi-square test between flood duration and agricultural flood coping capacity. Chi-square (χ^2) test result shows that Sig.

Value is 0.000 and *df* = 4, which is highly significant. If the flood stays less than 3 days then people usually don't have any agricultural flood coping strategy. But if the flood prolonged more than 7 days or for a much higher period then they sell their crop in advance as an agricultural flood coping strategy.

Table-7.2.5.1: Impact of Flood Duration on Agricultural Flood Coping Capacity.

Flood Duration		Agricultural Flood Coping capacity		Total
		Selling Crops in Advance	Nil	
<3	Count	0	165	165
	% of Total	0.0%	57.9%	57.9%
3-7	Count	3	42	45
	% of Total	1.1%	14.7%	15.8%
7+	Count	18	57	75
	% of Total	6.3%	20.0%	26.3%
Total	Count	21	264	285
	% of Total	7.4%	92.6%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 2		

Source: Field Questionnaire Survey, 2016.

7.2.5.2. Flood Duration and Pecuniary Flood Coping capacity

(Table-7.2.5) shows that, correlation between flood duration and pecuniary flood coping capacity is highly insignificant. In (Table-7.2.5.2) shows Chi-square test between flood duration and pecuniary flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly insignificant. So, if there is more flood prolonged days then there will be multiple pecuniary flood coping strategy like fishing, boating and getting loan etc.

Table-7.2.5.2: Impact of Flood Duration on Pecuniary Flood Coping Capacity.

Flood Duration		Pecuniary Flood Coping capacity				Total
		Relief	Loan and Debit	Fishing	Boating	
<3	Count	39	35	64	27	165
	% of Total	13.7%	12.3%	22.5%	9.5%	57.9%
3-7	Count	13	8	16	8	45
	% of Total	4.6%	2.8%	5.6%	2.8%	15.8%
7+	Count	16	17	27	15	75
	% of Total	5.6%	6.0%	9.5%	5.3%	26.3%
Total	Count	68	60	107	50	285
	% of Total	23.9%	21.1%	37.5%	17.5%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.2.5.3. Flood Duration and Nutritional Flood Coping capacity

(Table-7.2.5) shows that, correlation between flood duration and nutritional flood coping capacity is highly insignificant. In (Table-7.2.5.3) shows Chi-square test between flood duration and nutritional flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly significant. If the flood prolonged for a longer period then peoples nutritional coping capacity decreases and it leads to borrowing and getting loan rather than only change in number of main meal intake.

Table-7.2.5.3: Impact of Flood Duration on Nutritional Flood Coping Capacity.

Flood Duration		Nutritional Flood Coping capacity				Total
		Relief	Change in Number of Main meal Intake	Loan, Debit and Begging	Borrowing Food from Other Household	
<3	Count	28	35	58	44	165
	% of Total	9.8%	12.3%	20.4%	15.4%	57.9%
3-7	Count	9	10	15	11	45
	% of Total	3.2%	3.5%	5.3%	3.9%	15.8%
7+	Count	13	20	23	19	75
	% of Total	4.6%	7.0%	8.1%	6.7%	26.3%
Total	Count	50	65	96	74	285
	% of Total	17.5%	22.8%	33.7%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.2.5.4. Flood Duration and Aqua Paucity Flood Coping capacity

(Table-7.2.5) shows that, correlation between flood duration and aquatic flood coping capacity is highly insignificant. In (Table-7.2.5.4) shows Chi-square test between flood duration and aquatic flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 4, which is highly significant. So, if there is more flood prolonged days then people doesn't have any other choice than drinking river flood water and other contaminated water.

Table-7.2.5.4: Impact of Flood Duration on Aqua Paucity Flood Coping Capacity.

Flood Duration		Aqua Paucity Flood Coping capacity			Total
		Collecting Safe Water from Far Places	Drinking Flood River Water	Drinking contaminated water	
<3	Count	54	67	44	165
	% of Total	18.9%	23.5%	15.4%	57.9%
3-7	Count	16	18	11	45
	% of Total	5.6%	6.3%	3.9%	15.8%
7+	Count	22	34	19	75
	% of Total	7.7%	11.9%	6.7%	26.3%

Total	Count	92	119	74	285
	% of Total	32.3%	41.8%	26.0%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 4			

Source: Field Questionnaire Survey, 2016.

7.2.5.5 Flood Duration and Health Flood Coping capacity

(Table-7.2.5) shows that, correlation between flood duration and health flood coping capacity is highly insignificant. In (Table-7.2.5.5) shows Chi-square test between flood duration and health flood coping capacity. Chi-square (χ^2) test result shows that Sig. Value is 0.000 and *df* = 6, which is highly insignificant. So, if there is more flood prolonged days then peoples' health flood coping capacity falls drastically.

Table-7.2.5.5: Impact of Flood Duration on Health Flood Coping Capacity.

Flood Duration		Health Flood Coping capacity				Total
		LMF	Kobiraj	Govt. and NGO Health Center	Nil	
<3	Count	57	49	31	28	165
	% of Total	20.0%	17.2%	10.9%	9.8%	57.9%
3-7	Count	17	12	7	9	45
	% of Total	6.0%	4.2%	2.5%	3.2%	15.8%
7+	Count	26	20	14	15	75
	% of Total	9.1%	7.0%	4.9%	5.3%	26.3%
Total	Count	100	81	52	52	285
	% of Total	35.1%	28.4%	18.2%	18.2%	100.0%
χ^2 - Test		Sig. Value = 0.000, *df* = 6				

Source: Field Questionnaire Survey, 2016.

7.3. Priority and Needs Assessment During and After Drought Induced Critical Moments

Priority and needs are assessed here in this study based on people's perception. Mostly the problems people faced during and after drought and based on these they prioritize their needs. The needs assessed in this study during drought for both the villages includes supply of drinking water, supply of household water, supply of food and health service.

Based on the overall WAI value in (Table-7.3.1), drinking water supply ranked first priority, irrigation water supply ranked second priority, food supply ranked third priority, and health service ranked fourth priority. In case of individual village ranking of first two priorities are same. In both Charkharibari village and Jigabari village drinking water supply ranked first and irrigation water supply ranked second. But in Charkharibari village food supply ranked third and it ranked fourth in Jigabari village. And in Charkharibari village health service ranked fourth while it is third in Jigabari village.

Table-7.3.1: Priority and Needs assessment During Drought in the Study Villages.

Needs	Charkharibari						Jigabari						Total	
	R1	R2	R3	R4	WAI	Priority	R1	R2	R3	R4	WAI	Priority	WAI	Priority
Drinking Water Supply	88	48	34	30	0.886	1	45	19	11	10	0.794	1	0.778	1
Irrigation Water Supply	23	93	46	38	0.801	2	17	39	9	20	0.665	2	0.647	2
Food Supply	40	30	81	49	0.785	3	13	12	42	18	0.486	4	0.329	3
Health Service	49	29	39	83	0.691	4	10	15	23	37	0.389	3	0.281	4
Correlations	r = 0.89													

Note: R = Rank, WAI = Weighted Average Index
Source: Field Questionnaire Survey, 2016.

Similarly like as during drought, needs are assessed for after drought situation also. To assess needs after drought in both the villages criteria considered are drinking water supply, irrigation water supply, food relief, job creation, agricultural loan. Based on the overall WAI value in (Table-7.3.2), in both the villages' agricultural loan ranked first priority, irrigation water supply ranked second priority, job creation ranked third priority, drinking water supply ranked fourth priority and food relief ranked fifth priority. In case of individual village ranking of in Charkharibari village agricultural loan ranked first priority, irrigation water supply ranked second priority, drinking water supply ranked third priority, food relief ranked fourth priority and job creation ranked fifth priority. On the other hand in case of Jigabari village irrigation water supply ranked first priority, agricultural loan ranked second priority, job creation ranked third priority, drinking water supply ranked fourth priority and food relief ranked fifth priority.

Table-7.3.2: Priority and Needs assessment After Drought in the Study Villages.

Needs	Charkharibari							Jigabari							Total	
	R1	R2	R3	R4	R5	WAI	Priority	R1	R2	R3	R4	R5	WAI	Priority	WAI	Priority
Agricultural Loan	73	19	35	39	34	0.874	1	35	9	10	14	17	0.764	2	0.709	1
Irrigation Water Supply	21	79	29	37	34	0.659	2	7	41	20	2	15	0.860	1	0.863	2
Job Creation	28	33	81	31	27	0.381	5	12	8	39	19	7	0.597	3	0.439	3
Drinking Water Supply	32	43	27	68	30	0.432	3	10	14	17	43	1	0.438	4	0.421	4
Food Relief	46	26	28	25	75	0.397	4	21	13	0	7	45	0.284	5	0.327	5
Correlations	r = 0.93															

Note: R = Rank, WAI = Weighted Average Index
Source: Field Questionnaire Survey, 2016.

7.4. Priority and Risk Assessment During and After Flood Critical Moments

Priority and needs are assessed here in this study based on people's perception. Mostly the problems people faced during and after flood and based on these they prioritize their needs. The needs assessed in this study during flood for both the villages includes supply of drinking water, supply of food, temporary shelter, health service, boats for communication. Based on the overall WAI value in (Table-7.4.1), drinking water supply ranked first priority, food supply ranked second priority, boats ranked third priority, temporary shelter ranked fourth priority and health service ranked fifth priority. In case of individual village, in Charkharibari village drinking water supply ranked first priority, boats ranked second priority, temporary shelter ranked third priority, food supply ranked fourth priority and health service ranked fifth priority. On the other hand in case of Jigabari village drinking water supply ranked first priority, boats ranked second priority, food supply ranked third priority, health service ranked fourth priority and temporary shelter ranked fifth priority.

Table-7.4.1: Priority and Needs assessment During Flood in the Study Villages.

Needs	Charkharibari							Jigabari							Total	
	R1	R2	R3	R4	R5	WAI	Priority	R1	R2	R3	R4	R5	WAI	Priority	WAI	Priority
Drinking Water Supply	75	41	33	20	31	0.854	1	40	11	8	14	12	0.860	1	0.839	1
Boats	20	74	28	50	28	0.632	2	8	43	7	13	14	0.764	2	0.711	2
Food Supply	25	38	79	29	29	0.381	4	19	10	37	15	4	0.597	3	0.459	3
Temporary Shelter Ranked	37	26	30	71	36	0.429	3	11	9	18	33	14	0.438	4	0.423	4

Health Service	43	21	30	30	76	0.317	5	7	12	15	10	41	0.284	5	0.335	5
Correlations	r = 0.78															

Note: R = Rank, WAI = Weighted Average Index

Source: Field Questionnaire Survey, 2016.

Similarly like as during flood, needs are assessed for after flood situation also. To assess needs after flood in both the villages criteria considered are drinking water supply, food relief, job creation, reconstruction of house, distribution of agricultural holdings and distribution of loans. Based on the overall WAI value in (Table-7.4.2), repairing house ranked first priority, food relief ranked second priority, drinking water supply ranked third priority, distribution of agricultural holdings ranked fourth priority, distribution of loans ranked fifth priority and job creation ranked sixth priority. In case of individual village, in Charkharibari village repairing house ranked first priority, distribution of loans ranked second priority, food relief ranked third priority, drinking water supply ranked fourth priority, distribution of agricultural holdings ranked fifth priority and job creation ranked sixth priority. On the other hand in case of Jigabari village food relief ranked first priority, distribution of agricultural holdings ranked second priority, repairing house ranked third priority, distribution of loans ranked fourth priority, drinking water supply ranked fifth priority and job creation ranked sixth priority.

Table-7.4.2: Priority and Needs assessment After Flood in the Study Villages.

Needs	Charkharibari								Jigabari								Total	
	R 1	R 2	R 3	R 4	R 5	R 6	WAI	Priority	R 1	R 2	R 3	R 4	R 5	R 6	WAI	Priority	WAI	Priority
Repairing House	73	19	35	39	34	19	0.872	1	35	9	10	14	17	01	0.559	3	0.837	1
Food Relief	21	79	29	37	34	33	0.574	3	7	41	20	2	15	8	0.861	1	0.625	2
Drinking Water Supply	28	33	81	31	27	43	0.471	4	12	8	39	19	7	14	0.337	5	0.548	3
Distribution Of Agricultural Holdings	32	43	27	68	30	26	0.395	5	10	14	17	43	1	13	0.619	2	0.483	4
Distribution Of Loans Ranked	46	26	28	25	75	43	0.658	2	21	13	0	7	45	8	0.439	4	0.316	5
Job Creation	32	43	27	68	30	79	0.276	6	12	8	39	19	12	41	0.290	6	0.281	6
Correlations	r = 0.89																	

Note: R = Rank, WAI = Weighted Average Index

Source: Field Questionnaire Survey, 2016.

7.5. Hypothesis Tested to Understand Drought Coping Capacity

In the present study to measure the drought induced critical moment coping capacity of people, some variables have been selected; such as income, education, occupation, drought frequency and drought duration. These have considered as independent factors, which has influence on drought induced critical moment coping capacity. These are presented in (Table-7.5).

Table-7.5: Summary of Chi-square Test Result Related to Peoples Drought Induced Critical Moment Coping Capacity in the Study Villages.

Sl.	Null Hypothesis	Significant Value	Remark
1	There is no significant relationship between income level and agricultural drought coping capacity.	0.000**	H_1 Accepted
2	There is no significant relationship between income level and pecuniary drought coping capacity.	0.000**	H_1 Accepted
3	There is no significant relationship between income level and nutritional drought coping capacity.	0.000**	H_1 Accepted
4	There is no significant relationship between income level and aqua paucity drought coping capacity.	0.000**	H_1 Accepted
5	There is no significant relationship between income level and health drought coping capacity.	0.000**	H_1 Accepted
6	There is no significant relationship between education level and agricultural drought coping capacity.	0.000**	H_1 Accepted
7	There is no significant relationship between education level and pecuniary drought coping capacity.	0.000**	H_1 Accepted
8	There is no significant relationship between education level and nutritional drought coping capacity.	0.000**	H_1 Accepted
9	There is no significant relationship between education level and aqua paucity drought coping capacity.	0.000**	H_1 Accepted
10	There is no significant relationship between education level and health drought coping capacity.	0.000**	H_1 Accepted
11	There is no significant relationship between occupation and agricultural drought coping capacity.	0.000**	H_1 Accepted
12	There is no significant relationship between occupation and pecuniary drought coping capacity.	0.000**	H_1 Accepted
13	There is no significant relationship between occupation and nutritional drought coping capacity.	0.000**	H_1 Accepted
14	There is no significant relationship between occupation and aqua paucity drought coping capacity.	0.000**	H_1 Accepted
15	There is no significant relationship between occupation and health drought coping capacity.	0.000**	H_1 Accepted

16	There is no significant relationship between drought frequency and agricultural drought coping capacity.	0.000**	H_1 Accepted
17	There is no significant relationship between drought frequency and pecuniary drought coping capacity.	0.940**	H_0 Accepted
18	There is no significant relationship between drought frequency and nutritional drought coping capacity.	0.710**	H_0 Accepted
19	There is no significant relationship between drought frequency and aqua paucity drought coping capacity.	0.906**	H_0 Accepted
20	There is no significant relationship between drought frequency and health drought coping capacity.	0.969**	H_0 Accepted
21	There is no significant relationship between drought duration and agricultural drought coping capacity.	0.000**	H_1 Accepted
22	There is no significant relationship between drought duration and pecuniary drought coping capacity.	0.145**	H_0 Accepted
23	There is no significant relationship between drought duration and nutritional drought coping capacity.	0.040**	H_1 Accepted
24	There is no significant relationship between drought duration and aqua paucity drought coping capacity.	0.242**	H_0 Accepted
25	There is no significant relationship between drought duration and health drought coping capacity.	0.319**	H_0 Accepted

Note: **. χ^2 - Test is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

7.6. Hypothesis Tested to Understand Flood Coping Capacity

In the present study to measure the flood induced critical moment coping capacity of people, some variables have been selected; such as income, education, occupation, flood frequency and flood duration. These have considered as independent factors, which has influence on flood induced critical moment coping capacity. These are presented in (Table-7.6).

Table-7.6: Summary of Chi-square Test Result Related to Peoples Flood Induced Critical Moment Coping Capacity in the Study Villages.

Sl.	Null Hypothesis	Significant Value	Remark
1	There is no significant relationship between income level and agricultural flood coping capacity.	0.000**	H_1 Accepted
2	There is no significant relationship between income level and pecuniary flood coping capacity.	0.000**	H_1 Accepted
3	There is no significant relationship between income level and nutritional flood coping capacity.	0.000**	H_1 Accepted
4	There is no significant relationship between income level and aqua paucity flood coping capacity.	0.000**	H_1 Accepted

5	There is no significant relationship between income level and health flood coping capacity.	0.000**	H_1 Accepted
6	There is no significant relationship between education level and agricultural flood coping capacity.	0.000**	H_1 Accepted
7	There is no significant relationship between education level and pecuniary flood coping capacity.	0.000**	H_1 Accepted
8	There is no significant relationship between education level and nutritional flood coping capacity.	0.000**	H_1 Accepted
9	There is no significant relationship between education level and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
10	There is no significant relationship between education level and health flood coping capacity.	0.000**	H_1 Accepted
11	There is no significant relationship between occupation and agricultural flood coping capacity.	0.000**	H_1 Accepted
12	There is no significant relationship between occupation and pecuniary flood coping capacity.	0.000**	H_1 Accepted
13	There is no significant relationship between occupation and nutritional flood coping capacity.	0.000**	H_1 Accepted
14	There is no significant relationship between occupation and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
15	There is no significant relationship between occupation and health flood coping capacity.	0.000**	H_1 Accepted
16	There is no significant relationship between drought frequency and agricultural flood coping capacity.	0.000**	H_1 Accepted
17	There is no significant relationship between drought frequency and pecuniary flood coping capacity.	0.000**	H_1 Accepted
18	There is no significant relationship between drought frequency and nutritional flood coping capacity.	0.000**	H_1 Accepted
19	There is no significant relationship between drought frequency and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
20	There is no significant relationship between drought frequency and health flood coping capacity.	0.000**	H_1 Accepted
21	There is no significant relationship between drought duration and agricultural flood coping capacity.	0.000**	H_1 Accepted
22	There is no significant relationship between drought duration and pecuniary flood coping capacity.	0.000**	H_1
23	There is no significant relationship between drought duration and nutritional flood coping capacity.	0.000**	H_1 Accepted
24	There is no significant relationship between drought duration and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
25	There is no significant relationship between drought duration and health flood coping capacity.	0.000**	H_1 Accepted

Note: **. χ^2 - Test is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

Chapter Eight

Institutional Risk Management

As drought and flood occurs every year cyclically in lower Teesta basin there are some institutional mechanism in the study area. The focus of this chapter is assessing the institutional drought and flood risk management mechanism in the study area.

8.1. Assessment of Institutional Drought Risk Management

To assess institutional drought management mechanism drought aid scenario, existing institutional drought risk management measures and effectiveness of these measures will be discussed.

8.1.1. Evaluation of Drought Aid Scenario

Drought aid scenario will be evaluated by measuring drought relief availability, drought relief type and drought relief provider.

8.1.1.1. Availability of Drought Relief, Type and Provider

(Table-8.1.1.1) shows that in both villages there is no drought relief program. As a result there is no category of relief and no relief provider.

Table-8.1.1.1: Availability of Drought relief, Types of Relief and Relief Provider.

Drought Relief	Study village											
	Charkharibari				Jigabari				Total			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Relief Availability	0	0	200	100	0	0	85	100	0	0	285	100
Relief Type	-	-	-	-	-	-	-	-	-	-	-	-
Relief Provider	-	-	-	-	-	-	-	-	-	-	-	-

**Note: (-) = Nil.

Source: Field Questionnaire Survey, 2016.

8.1.1.2. Inaccessibility of Drought Relief and Reason

There is no accessibility to drought relief in both Charkharibari and Jigabari village. The main reason of inaccessibility to drought relief is there is no drought relief program and committee.

8.1.2. Evaluation of Institutional Drought Risk Management Measures

To evaluate institutional drought risk management measures existence of emergency drought management committee and their working area will be discussed. By doing this we will be able evaluate the mechanism of institutional drought management.

8.1.2.1. Existence of Emergency Drought Management Committee

(Table-8.1.2.1) shows that in both villages there is no emergency drought management committee. Though there is a combined disaster management committee in the union level in both villages. But this committee doesn't play any role to manage drought risk in the selected study areas.

Table-8.1.2.1: Existence of Emergency Drought Management Committee.

Emergency Drought Relief Committee	Study village											
	Charkharibari				Jigabari				Total			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Exist	0	0	200	100	0	0	85	100	0	0	285	100

Source: Field Questionnaire Survey, 2016.

8.1.2.2. Endeavour Zone of Emergency Drought Management Committee

As there is no emergency drought management committee exist so, there is no working area of this committee.

8.1.3. Evaluation of Effectiveness of Drought Management Approaches

Indigenous people of the study areas adopted several approaches to cope with drought. In this section most effective approach will be identified. And the non-effectiveness of other approaches will also be evaluated.

8.1.3.1. Most Effective Drought Management Approach

(Table-8.1.3.1) shows that in both Charkharibari and Jigabari village most effective drought management approaches are almost same, but the percentage of each approach is different in village. 61.75% of total respondents diversify their agricultural production as their most effective drought management approach and 38.25% of total respondents uses high efficiency irrigation method as their most effective drought management approach. If we see the village wise distribution, 77.5% respondent in Charkharibari village diversify their agricultural production as their most effective drought management approach but it is 24.7% in Jigabari village. And 22.5% respondent in Charkharibari village uses high efficiency irrigation method as their most effective drought management approach and the number is 75.3% in Jigabari village. Chi-square test result shows that Sig. value is 0.018 and *df* = 2, which is highly significant. That means, there is significant difference between two villages in case of most effective drought management approach.

Table-8.1.3.1: Most Effective Drought Management Approach in the Study Villages.

Most Effective Drought Management Approach	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Agricultural Diversion	155	77.5	21	24.7	176	61.75
High Efficiency Irrigation System	45	22.5	64	75.3	109	38.25
Total	200	100	85	100	285	100
χ^2 - Test	Sig. Value = 0.018, *df* = 2					

Source: Field Questionnaire Survey, 2016.

8.1.3.2. Reason for Non-effectiveness of Other Drought Management Approaches

(Table-8.1.3.2) shows the main reasons for non-effectiveness of other drought management approaches. Major barriers of institutional drought management are; lack of technical capacity, lack of political will, lack of funding, lack of local awareness, other priorities, lack of communication and information flow, and adverse situation.

Table-8.1.3.2: Reason for Non-effectiveness of Other Drought Management Approaches in the Study Villages.

Barriers of Institutional Drought Management	Study village									
	Charkharibari (%) of N					Jigabari (%) of N				
	0.20	0.40	0.60	0.80	1.00	0.20	0.40	0.60	0.80	1.00
Lack of Technical capacity	22.5	37.0	40.5	0.0	0.0	0.0	24.0	35.4	40.6	0.0
Lack of Political Will	0.0	8.5	29.0	45.5	17.0	11.6	28.8	42.8	16.8	0.0
Lack of Funding	5.2	33.4	21.6	40.8	0.0	0.0	8.5	29.0	45.5	17.0
Lack of Local Awareness	37.0	30.5	5.0	8.5	19.0	7.1	2.9	15.5	29.0	45.5
Other Priorities	7.1	2.9	15.5	29.0	45.5	10.0	11.9	28.5	42.3	7.3

Lack of Communication and Information Flow	0.0	17.0	12.2	48.0	22.8	3.4	6.6	25.2	49.3	15.5
Adverse Situation	32.5	47.5	30.0	0.0	0.0	23.0	37.0	17.2	11.8	10.0

Note: Ranking (0.20 = No Important, 0.40 = Less Important, 0.60 = Somewhat Important, 0.80 = Important, 1.00 = Very Important). N = Sample Size (Charkharibari = 200 and Jigabari = 85).

Source: Field Questionnaire Survey, 2016.

8.2. Assessment of Institutional Flood Risk Management

To assess institutional flood management mechanism flood aid scenario, existing institutional flood risk management measures and effectiveness of these measures will be discussed.

8.2.1. Evaluation of Flood Aid Scenario

Flood aid scenario will be evaluated by measuring flood relief availability, flood relief type and flood relief provider.

8.2.1.1. Availability of Flood Relief, Type and Provider

(Table-8.2.1.1) shows that overall 57.5% respondent receives flood relief in both village. In case of village wise 61.5% respondent of Charkharibari village gets flood relief, while it is 48.2% in Jigabari village. So, in terms of flood relief availability Charkharibari village is well ahead of Jigabari village. Chi-square test result shows sig. value = 0.038 and *df* = 1 which is significant.

Table-8.2.1.1: Availability of Flood Relief in the Study Villages.

Flood Relief	Study village											
	Charkharibari				Jigabari				Total			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Relief Availability	123	61.5	77	38.5	41	48.2	44	51.8	164	57.5	121	42.5
χ^2 - Test	Sig. Value = 0.038, *df* = 1											

Source: Field Questionnaire Survey, 2016.

(Table-8.2.1.2) shows that overall 25.3% respondent receives flood relief from governmental organizations in both village. In case of village wise 25.5% respondent of Charkharibari village gets flood relief from governmental organizations, while it is 24.8% in Jigabari village. 39.3% respondent receives flood relief from NGO in both village. In case of village wise 40.0% respondent of Charkharibari village gets flood relief from NGO, while it is 37.6% in Jigabari village. 35.4% respondent receives flood relief from volunteers in both village. In case of village wise 34.5% respondent of Charkharibari village gets flood relief from volunteers, while it is 37.6% in Jigabari village. So, NGO's are the major flood relief provider among them in both study village. So, in terms of flood relief provider Charkharibari village and Jigabari village is almost same. Chi-square test result shows sig. value = 0.876 and *df* = 2 which is also highly insignificant.

Table-8.2.1.2: Flood Relief Provider in the Study Villages.

Relief Provider	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Govt.	51	25.5	21	24.8	72	25.3
NGO	80	40.0	32	37.6	112	39.3
Volunteer	69	34.5	32	37.6	101	35.4
Total	200	100	85	100	285	100
χ^2 - Test	Sig. Value = 0.876, *df* = 2					

Source: Field Questionnaire Survey, 2016.

(Table-8.2.1.3) shows that overall 67.4% respondent receives food as flood relief in both village. In case of village wise 67.5% respondent of Charkharibari village gets food as flood relief, while it is 67.1% in Jigabari village. 8.1% respondent receives water as flood relief in both village. In case of village wise 7.5% respondent of Charkharibari village gets water as flood relief, while it is 9.4% in Jigabari village. 9.8% respondent receives medicine as flood relief in both village. In case of village wise 10.0% respondent of Charkharibari village gets medicine as flood relief, while it is 9.4% in Jigabari village. And, 14.7% respondent receives money as flood relief in both village. In case of village wise 15.0% respondent of Charkharibari village gets money as flood relief, while it is 14.1% in Jigabari village. So, food and money are the major flood relief types among them in both study village. So, in terms of flood relief type Charkharibari village and Jigabari village is almost same. Chi-square test result shows sig. value = 0.955 and *df* = 3 which is also highly insignificant.

Table-8.2.1.3: Types of Flood Relief Provided in the Study Villages.

Relief Type	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%

Food	135	67.5	57	67.1	192	67.4
Water	15	7.5	8	9.4	23	8.1
Medicine	20	10.0	8	9.4	28	9.8
Money	30	15.0	12	14.1	42	14.7
Total	200	100	85	100	285	100
χ^2 - Test	Sig. Value = 0.955, *df* = 3					

Source: Field Questionnaire Survey, 2016.

8.2.1.2. Inaccessibility of Flood Relief and Reason

(Table-8.2.1.4) shows that 73.3% respondent didn't get flood relief because it was not distributed among them in both village. In case of village wise 73.5% respondent of Charkharibari village respondent didn't get flood relief because it was not distributed among them, while it is 72.9% in Jigabari village. And, 26.7% respondent didn't get flood relief because there was not enough relief for all of them in both village. In case of village wise 26.5% respondent of Charkharibari village respondent didn't get flood relief because there was not enough relief for all of them, while it is 27.1% in Jigabari village. So, non-equal distribution is the main inaccessibility reason among them in both study village. So, in terms inaccessibility reason of flood relief type Charkharibari village and Jigabari village is almost same. Chi-square test result shows sig. value = 0.922 and *df* = 1 which is also highly insignificant.

Table-8.2.1.4: Inaccessibility Reason of Flood Relief in the Study Villages.

Reason	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Not Distributed	147	73.5	62	72.9	209	73.3
Not Enough Relief	53	26.5	23	27.1	76	26.7
Total	200	100	85	100	285	100
χ^2 - Test	Sig. Value = 0.922, *df* = 1					

Source: Field Questionnaire Survey, 2016.

8.2.2. Evaluation of Institutional Flood Risk Management Measures

To evaluate institutional flood risk management measures existence of emergency flood management committee and their working area will be discussed. By doing this we will be able evaluate the mechanism of institutional flood management.

8.2.2.1. Existence of Emergency Flood Management Committee

(Table-8.2.2.1) shows that in both Charkharibari and Jigabari village there is emergency flood management committee.

Table-8.2.2.1: Existence of Emergency Flood Management Committee in the Study Villages.

Existence	Study village											
	Charkharibari				Jigabari				Total			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Flood Mng. Cmt.	200	100	0	0	85	100	0	0	285	100	0	0

Source: Field Questionnaire Survey, 2016.

8.2.2.2. Endeavour Zone of Emergency Flood Management Committee

(Table-8.2.2.2) shows that major working areas of emergency flood management committees are taking prevention measures for upcoming flood, taking mitigation measures for upcoming flood, long term plan to overcome deep rooted problems, combined management approach, and building awareness among the inhabitants. Below is the sector wise percentage for both villages.

Table-8.2.2.2: Working Area of Emergency Flood Management Committee in the Study Villages.

Working Area	Study village									
	Charkharibari (%) of N					Jigabari (%) of N				
	1	2	3	4	5	1	2	3	4	5
Taking Prevention Measures for Upcoming Flood	23.5	37.5	39.0	0.0	0.0	12.5	44.0	17.0	10.0	16.5
Taking Mitigation Measures for Upcoming Flood	15.5	31.5	28.0	25.0	0.0	15.5	31.5	18.0	15.0	20.0
Long Term Plan to Overcome Deep Rooted Problems	22.5	34.0	27.0	10.0	6.5	3.5	37.5	39.0	10.0	10.0
Combined Management Approach	10.0	12.0	34.5	38.0	5.5	20.0	12.0	24.5	28.0	15.5
Building Awareness Among the Inhabitants	13.5	37.5	29.0	8.0	12.0	10.0	22.0	24.5	28.0	15.5

Note: Ranking (1=No, 2=Occasionally, 3=Sometimes, 4=Often, and 5=Very Often). N = Sample Size (Charkharibari = 200 and Jigabari = 85).

Source: Field Questionnaire Survey, 2016.

8.2.3. Evaluation of Effectiveness of Flood Management Approaches

Indigenous people of the study areas adopted several approaches to cope with flood. In this section most effective approach will be identified. And the non-effectiveness of other approaches will also be evaluated.

8.2.3.1. Most Effective Flood Management Approach

(Table-8.2.3.1) shows that in both Charkharibari and Jigabari village most effective drought management approach is almost same, and it is raising plinth of the house.

Table-8.2.3.1: Most Effective Flood Management Approach in the Study Villages.

Most Effective Flood Management Approach	Study village					
	Charkharibari		Jigabari		Total	
	HH	%	HH	%	HH	%
Raising Plinth of the House	200	100	85	100	85	100

Source: Field Questionnaire Survey, 2016.

8.2.3.2. Reason for Non-effectiveness of Other Flood Management Approaches

(Table-8.1.3.2) shows the main reasons for non-effectiveness of other flood management approaches. Major barriers of institutional flood management are; lack of technical capacity, lack of political will, lack of funding, lack of local awareness, other priorities, lack of communication and information flow, and adverse situation.

Table-8.1.3.2: Reason for Non-effectiveness of Other Flood Management Approaches in the Study Villages.

Barriers of Institutional Flood Management	Study village									
	Charkharibari (%) of N					Jigabari (%) of N				
	0.20	0.40	0.60	0.80	1.00	0.20	0.40	0.60	0.80	1.00
Lack of Technical capacity	37.0	30.5	5.0	8.5	19.0	7.1	2.9	15.5	29.0	45.5
Lack of Political Will	7.1	2.9	15.5	29.0	45.5	10.0	11.9	28.5	42.3	7.3
Lack of Funding	0.0	17.0	12.2	48.0	22.8	3.4	6.6	25.2	49.3	15.5
Lack of Local Awareness	32.5	47.5	30.0	0.0	0.0	23.0	37.0	17.2	11.8	10.0
Other Priorities	22.5	37.0	40.5	0.0	0.0	0.0	24.0	35.4	40.6	0.0
Lack of Communication and Information Flow	0.0	8.5	29.0	45.5	17.0	11.6	28.8	42.8	16.8	0.0
Adverse Situation	5.2	33.4	21.6	40.8	0.0	0.0	8.5	29.0	45.5	17.0

Note: Ranking (0.20 = No Important, 0.40 = Less Important, 0.60 = Somewhat Important, 0.80 = Important, 1.00 = Very Important). N = Sample Size (Charkharibari = 200 and Jigabari = 85).

Source: Field Questionnaire Survey, 2016.

Chapter Nine

Summary, Recommendation and Conclusion

This chapter intends to summarize the findings, presents recommendations and conclusions.

9.1. Summary of Findings

This study examines the physical and socio-economic profile of study areas, profile of drought and flood in the study areas, vulnerability analysis of the study areas, identify drought and flood induced critical moments and their coping strategies, impact of assets on coping capacities, and present scenario of institutional drought and flood management.

9.1.1. Profile of Drought and Flood in Lower Teesta Basin, Study Area and Respondents.

In north-western part of Bangladesh in lower Teesta basin area, people repeatedly confronted by natural catastrophe almost every year such as drought and flood. After the construction of two barrages in Gozaldoba and Dalia on Teesta river drought and flood occurs almost every year. Intensity and frequency of these calamities are also increasing in an alarming rate, which caused serious damage to livelihoods and economy of this area. Both the study villages Charkharibari and Jigabari are located in lower Teesta basin area which is equally drought and flood area. Charkharibari village is situated on Charland that is located on the right bank of upstream of lower Teesta river. Jigabari village is situated on inland that is located on the left bank of downstream of lower Teesta river. Households are male dominated in both villages. Major economic activities are farming, fishing, boating, wage earning and small business. Jigabari village is ahead of Charkharibari village in terms of employment, education, health, connectivity and other utility services. In both villages land holding size is pretty small with a significant number of landless people. The agricultural cropping pattern is quite in different in both villages.

9.1.2. Vulnerability Findings by SWOT Analysis

Between the two villages severity of drought and flood is higher in Charkharibari village. Presently there is no fully constructed flood protection dam, on the other hand Jigabari has a flood protection dam. In Charkharibari village there is plenty of excavatable rock but it is absent in Jigabari village. Large working class people is available in Charkharibari village but in Jigabari village the number is quite low. Jigabari village has more cultivable fertile soil than Charkharibari village. Jigabari is more agriculturally productive than Charkharibari village. Transportation system of Jigabari village is far more developed than Charkharibari village. Literacy rate is quite high in Jigabari village than other village. There more fresh water source available in Jigabari village than Charkharibari village. Institutional development and organizational activity is far spread in Jigabari village than Charkharibari village. After comparing the strengths of both village it is clear that Jigabari village is well ahead of Charkharibari village. Location of Charkharibari village is very unstable while Jigabari village is quite stable. Charkharibari village has no road connectivity but Jigabari village has road connectivity. There is no permanent health center and educational institution in Charkharibari village but Jigabari village has these facilities. There is no national electrical grid connection in Charkharibari village but it presents in Jigabari village. High efficiency irrigation system like deep tube wells are absent in Charkharibari village but it presents in Jigabari village. Sand cover in agricultural land is a very severe problem in Charkharibari village but in Jigabari there is such danger. Arsenic contamination in ground water is very acute in Jigabari village but in Charkharibari village it is low. Different types of economic activity is present in Charkharibari village but in Jigabari village there is limited diversification of economic activity. Low lying land is relatively more in Jigabari village. After comparing the weaknesses of both village it is clear that Charkharibari village is more vulnerable than Jigabari village. Jigabari village has a very limited or no fishing opportunity but on the other hand Charkharibari village has plenty of fishing opportunity. After a certain period Charkharibari village will be protected from flood. Plenty of non-agro workplace can be created (like stone collecting, border related import-export business and boating) in Charkharibari village but it is not possible in Jigabari village. Agro based industries can be established in Jigabari village but it is not possible in Charkharibari village with current situation. After comparing the opportunities of both village it is clear that Charkharibari village is ahead of Jigabari village. Sand cover is a great threat in Charkharibari village but it is not in Jigabari village. Riverbank erosion is a great threat in Charkharibari village but it is not in Jigabari village. Other threats are almost similar in both villages but due to locational advantage Jigabari village is comparatively safe than Charkharibari village. After comparing the threats of both village it is clear that Charkharibari village is in more risk than Jigabari village.

9.1.3. Identification of Drought and Flood Induced Critical Moments and Their Coping Strategies

Assessment of agricultural critical moment shows, in both study areas drought affects directly the production of Boro (HYV), Potato, Maize and Onion. Among theses in Charkharibari village drought affected crops are Maize and Onion. During drought the critical crop stage of Maize is growing and flowering stage. It extends from mid-January to February consists of 25-30 days of dry spell. This period falls in mid-Winter to early-Spring season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by pumping water from the nearby river by using shallow machines. During drought the critical crop stage of onion is growing and flowering stage. It extends from early-February to late-March consists of 45-60 days of dry spell. This period falls in Late-Winter to mid-Spring season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by pumping water from nearby river by using shallow machines. Another type of coping strategy is selling crop (Onion) in advance. In Jigabari village drought affected crops are Boro (HYV) and Potato. During drought the critical crop stage of Boro (HYV) is growing and flowering stage. It extends from mid-February to late-April consists of 50-60 days of dry spell. This period falls in late-Winter through the full-Spring to early-Summer season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by using high efficiency irrigation system like deep tube wells. During drought the critical crop stage of potato is growing stage. It extends from mid-January to mid-February consists of 25-30 days of dry spell. This period falls in mid-Winter to early-Spring season. The main problem of this critical period is acute scarcity of water. Local level farmers try to cope with this problem during critical stage by using high efficiency irrigation system like deep tube wells. Another problem with potato production is in mid-January to late-January the soil temperature gets pretty low and cause a new a type of disease for potato plant. The name of the disease is *Rhizoctoma Solani* and the impact is less potato production. This disease is spreading in a tremendous rate which impacts on drastically fall in yields. Local level farmers try to cope with this problem by using expensive pesticides which adds extra production cost for Potato cultivation. In both study areas flood affects directly the production of Ground-Nut and T.Aus (HYV). Among theses in Charkharibari village flood affected crops is Ground-Nut. During flood the critical crop stage of Ground-Nut is sowing stage. It extends from mid-July to early-August consists of 3-7 days of water stagnancy. This period falls in Monsoon (rainy) season. The main problem of this critical period is due to stagnant flood water which causes the perishment of Ground-Nut plants. Still there is no coping strategy for this critical period among the local level farmers. In Jigabari village flood affected crop is T.Aus (HYV). During flood the critical crop stage of T.Aus (HYV) is growing and harvesting stage. It extends from mid-July to mid-August consists of 8-20 days of water stagnancy. This period falls in Monsoon (rainy) season. The main problem of this critical period is due to stagnant flood water which causes the perishment of T.Aus (HYV) plants and after the run-away of flood water the sand cover in the agricultural land. Sand cover or sand living turns the agricultural land into a deserted land immediately. Because due to 3-4 feet of sand cover it is impossible to grow anything on that soil. Type of coping strategy for stagnant water is selling crop (T.Aus - HYV) in advance. But still there is no coping strategy to fight sand cover among the local level farmers.

Assessment of pecuniary critical moment shows, in both study areas drought affects directly the income sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village drought induced pecuniary critical moments extends from late-January to late-March consists of 45-60 days of dry spell. This period falls in mid-Winter to early-Summer season. The main problems of this critical period are lack of agro-based work, acute financial crisis and acute unemployment. Local inhabitants try to cope with these problems during critical stage by temporary migration, borrowing loan, wage earning, by selling properties, by getting debit and by selling labor in advance. In both study areas flood affects directly the income sector of livelihood and sub-sectors are almost the same. In both Charkharibari and Jigabari village flood induced pecuniary critical moments extends from early-July to mid-August consists of 5-30 days of flood stagnant water. This period falls in late-Summer to late-Monsoon (rainy) season.

The main problems of this critical period are getting water logged due to flood, working area gets flooded, no agro-based work, acute unemployment and acute financial crisis. Local inhabitants try to cope with these problems during critical stage by getting relief, temporary migration, borrowing loan, by fishing, by selling properties, by getting debit, by boating and by selling labor in advance.

Assessment of nutritional critical moment shows, in both study areas drought affects directly the victual sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village drought induced nutritional critical moments extends from late-January to early-March consists of 30-45 days of dry spell. This period falls in late-Winter to early-Summer season. The main problems of this critical period are lack of cereal, lack of cooking materials and acute food shortage. Local inhabitants try to cope with these problems during critical stage by change in number of main meal intake, borrowing loan to buy food grain, borrowing food from other household, selling properties and borrowing food from shop by debit. In both study areas flood affects directly the victual sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village flood induced nutritional critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are lack of cereal, lack of cooking materials, lack of fodder and acute food shortage. Local inhabitants try to cope with these problems during critical stage by getting relief, change in number of main meal intake, by fishing, borrowing loan to buy food grain, borrowing food from other household, selling properties and borrowing food from shop by debit.

Assessment of aqua paucity critical moment shows, in both study areas drought affects directly the aquatic sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village drought induced aquatic critical moments extends from late-January to mid-March consists of 45-60 days of dry spell. This period falls in late-Winter to mid-Summer season. The main problems of this critical period are acute shortage of drinking water, scarcity of daily use water. Local inhabitants try to cope with these problems during critical stage by drinking unhygienic water from river, lessening their water usage. In both study areas flood affects directly the aquatic sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village flood induced aquatic critical moments extends from early-July to mid-August consists of 30-40 days of flooding. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are acute shortage of drinking water, scarcity of safe daily use water. Local inhabitants try to cope with these problems during critical stage by drinking and using unhygienic flood water from river.

Assessment of health critical moment shows, in both study areas drought affects directly the health sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village drought induced health critical moments extends from late-January to late-March consists of 45-60 days of dry spell. This period falls in mid-Winter to early-Summer season. The main problems of this critical period are pox, black fever, skin disease, jaundice, women's' menstrual related problems and heat stroke. Local inhabitants try to cope with these problems during critical stage by managing somewhat medical facility that is available to them. In both study areas flood affects directly the health sector of livelihood and other related sub-sectors with almost same intensity. In both Charkharibari and Jigabari village flood induced health critical moments extends from early-July to mid-August consists of 25-30 days of during and after flood stagnant water. This period falls in late-Summer to late-Monsoon (rainy) season. The main problems of this critical period are several water borne diseases, women's' menstrual related problems, fever and skin diseases. Local inhabitants try to cope with these problems during critical stage by sometimes getting medical relief and by managing somewhat medical facility that is available to them.

9.1.4. Impact of Assets on Coping Capacities

Assessment of drought and flood induced critical moments and their coping capacities show that Charkharibari village has more problems but less coping capacities than Jigabari village. Assessment of coping capacity as dependable factor with income, education, occupation, drought frequency, drought duration, flood frequency and flood duration as independent factors shows significant correlation and relationship between them (Table-9.1.4). Correlation analysis and Chi-square test was done to find the results.

Table-9.1.4: Summary of Chi-square Test Result of Coping Capacities and Needs.

Sl.	Null Hypothesis	Significant Value	Remark
1	H_0: There is no significant relationship between income level and agricultural drought coping capacity.	0.000**	H_1 Accepted
2	H_0: There is no significant relationship between income level and pecuniary drought coping capacity.	0.000**	H_1 Accepted
3	H_0: There is no significant relationship between income level and nutritional drought coping capacity.	0.000**	H_1 Accepted
4	H_0: There is no significant relationship between income level and aqua paucity drought coping capacity.	0.000**	H_1 Accepted
5	H_0: There is no significant relationship between income level and health drought coping capacity.	0.000**	H_1 Accepted
6	H_0: There is no significant relationship between education level and agricultural drought coping capacity.	0.000**	H_1 Accepted
7	H_0: There is no significant relationship between education level and pecuniary drought coping capacity.	0.000**	H_1 Accepted
8	H_0: There is no significant relationship between education level and nutritional drought coping capacity.	0.000**	H_1 Accepted
9	H_0: There is no significant relationship between education level and aqua paucity drought coping capacity.	0.000**	H_1 Accepted
10	H_0: There is no significant relationship between education level and health drought coping capacity.	0.000**	H_1 Accepted
11	H_0: There is no significant relationship between occupation and agricultural drought coping capacity.	0.000**	H_1 Accepted
12	H_0: There is no significant relationship between occupation and pecuniary drought coping capacity.	0.000**	H_1 Accepted
13	H_0: There is no significant relationship between occupation and nutritional drought coping capacity.	0.000**	H_1 Accepted
14	H_0: There is no significant relationship between occupation and aqua paucity drought coping capacity.	0.000**	H_1 Accepted
15	H_0: There is no significant relationship between occupation and health drought coping capacity.	0.000**	H_1 Accepted
16	H_0: There is no significant relationship between drought frequency and agricultural drought coping capacity.	0.000**	H_1 Accepted

17	H_0: There is no significant relationship between drought duration and agricultural drought coping capacity.	0.000**	H_1 Accepted
18	H_0: There is no significant relationship between drought duration and nutritional drought coping capacity.	0.040**	H_1 Accepted
19	H_0: There is no significant relationship between income level and agricultural flood coping capacity.	0.000**	H_1 Accepted
20	H_0: There is no significant relationship between income level and pecuniary flood coping capacity.	0.000**	H_1 Accepted
21	H_0: There is no significant relationship between income level and nutritional flood coping capacity.	0.000**	H_1 Accepted
22	H_0: There is no significant relationship between income level and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
23	H_0: There is no significant relationship between income level and health flood coping capacity.	0.000**	H_1 Accepted
24	H_0: There is no significant relationship between education level and agricultural flood coping capacity.	0.000**	H_1 Accepted
25	H_0: There is no significant relationship between education level and pecuniary flood coping capacity.	0.000**	H_1 Accepted
26	H_0: There is no significant relationship between education level and nutritional flood coping capacity.	0.000**	H_1 Accepted
27	H_0: There is no significant relationship between education level and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
28	H_0: There is no significant relationship between education level and health flood coping capacity.	0.000**	H_1 Accepted
29	H_0: There is no significant relationship between occupation and agricultural flood coping capacity.	0.000**	H_1 Accepted
30	H_0: There is no significant relationship between occupation and pecuniary flood coping capacity.	0.000**	H_1 Accepted
31	H_0: There is no significant relationship between occupation and nutritional flood coping capacity.	0.000**	H_1 Accepted
32	H_0: There is no significant relationship between occupation and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
33	H_0: There is no significant relationship between occupation and health flood coping capacity.	0.000**	H_1 Accepted
34	H_0: There is no significant relationship between drought frequency and agricultural flood coping capacity.	0.000**	H_1 Accepted
35	H_0: There is no significant relationship between drought frequency and pecuniary flood coping capacity.	0.000**	H_1 Accepted

36	H_0: There is no significant relationship between drought frequency and nutritional flood coping capacity.	0.000**	H_1 Accepted
37	H_0: There is no significant relationship between drought frequency and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
38	H_0: There is no significant relationship between drought frequency and health flood coping capacity.	0.000**	H_1 Accepted
39	H_0: There is no significant relationship between drought duration and agricultural flood coping capacity.	0.000**	H_1 Accepted
40	H_0: There is no significant relationship between drought duration and pecuniary flood coping capacity.	0.000**	H_1
41	H_0: There is no significant relationship between drought duration and nutritional flood coping capacity.	0.000**	H_1 Accepted
42	H_0: There is no significant relationship between drought duration and aqua paucity flood coping capacity.	0.000**	H_1 Accepted
43	H_0: There is no significant relationship between drought duration and health flood coping capacity.	0.000**	H_1 Accepted

Note: **. χ^2 - Test is significant at the 0.01 level (2-tailed).
Source: Field Questionnaire Survey, 2016.

9.1.5 Assessment of Institutional Drought and Flood Risk Management

For institutional drought risk management, in both villages there is no drought relief program. As a result there is no category of relief and no relief provider. In both villages there is no emergency drought management committee. Though there is a combined disaster management committee in the union level in both villages. But this committee doesn't play any role to manage drought risk in the selected study areas. In both Charkharibari and Jigabari village most effective drought management approaches are almost same. They are diversify their agricultural production and use of high efficiency irrigation method. The main reasons for non-effectiveness of other drought management approaches is other priorities and lack of political will.

For institutional flood risk management, in both villages there is flood relief program. NGO's are main flood relief provider. Main relief item is food and money. In both villages there is emergency flood management committee. Their main working area is make people prepare for next flood to optimize risk. And building awareness among them. In both Charkharibari and Jigabari village most effective flood management approach is raising plinth of the house. The main reasons for non-effectiveness of other flood management approaches are lack of funding, political will and communication.

9.2. Recommendations

Based on this study the following sets of recommendations for drought and flood management are outlined.

9.2.1. Recommendations for Drought Management

Based on this study the following sets of recommendations for drought management are outlined. These recommendations are applicable for both Charkharibari and Jigabari village.

A). Long and Short-Term Drought Management

Drought management requires selection of the most appropriate combination of long-term and short-term actions with reference to the vulnerability of the specific sectorial needs and to drought intensity. Major long-term and short-term actions are as follows (Table-9.2.1).

Table-9.2.1: Long-term and Short-term Drought Management.

Category	Type of Actions	
	Long-term	Short-term
Demand Reduction	▪ Economic incentives for water saving. ▪ Dry crops in place of irrigated crops. ▪ Water recycling.	▪ Public information for water saving. ▪ Restrictions of irrigation crops. ▪ Mandatory rationing.
Water Supply Increase	▪ Reuse of treated wastewater. ▪ Inter-basin water sharing. ▪ Building water reservoirs. ▪ Construction of farm ponds. ▪ Control of seepage losses.	▪ Improvement of existing water system deficiency. ▪ Use of additional sources. ▪ Use of ground water reservoirs. ▪ Increased diversion by relaxing ecological or recreational use constraints.
Impact Minimization	▪ Educational activities for drought preparedness. ▪ Reallocation of water resources based on water quality requirements. ▪ Development of early warning systems. ▪ Insurance programs.	▪ Temporary reallocation of water resources. ▪ Public aids to compensate income losses. ▪ Tax reduction or delay of payment deadline. ▪ Public aid for crop insurance.

Source: Developed by Researcher.

B). Appoint A Drought Management Committee with Bottom-Up Approach

A key political leader initiates the drought planning process through appointment of a drought management committee Depending on the level of government developing the plan, this could be the chairman or member of the union parishad. The committee has two purposes. First, the committee supervises and coordinates development of the plan. Second, after the plan is developed and during times of drought when the plan is activated, the committee coordinates actions, implements mitigation and response programs, and makes policy recommendations to the top level.

C). Seek Stakeholder Participation and Resolve Conflict

Social, economic, and environmental values often clash as competition for scarce water resources intensifies. Therefore, committee members must identify all citizen groups (stakeholders) that have a stake in drought planning and their interests. These groups must be involved early and continuously for fair representation and effective drought management and planning.

D). Integrate Science and Policy

An essential aspect of the planning process is integrating the science and policy of drought management. The policy maker's understanding of the scientific issues and technical constraints involved in addressing problems associated with drought is often limited. Likewise, scientists generally have a poor understanding of existing policy constraints for responding to the impacts of drought. In many cases, communication and understanding between the science and policy communities must be enhanced if the planning process is to be successful.

E). Raising Awareness of the Value of Indigenous Knowledge

Local knowledge about drought is mostly invisible. Knowledge is largely passed down orally and rarely recorded, especially beyond local languages. The identification and recognition of local practice require participatory approaches, which presents its own challenges. Therefore, potentially highly replicable experiences are not easily accessible, even to interested practitioners outside these communities or countries. This impedes testing and validation as well as the dissemination of local practices.

F). Rain Water Storing

Rain water collection and storing in rainy season can be a very good way to meet the daily household needs in the dry season.

G). Supplemental Irrigation

Supplemental irrigation is the opposite of full or conventional irrigation. In the latter, the principal source of moisture is fully controlled irrigation water, and highly variable limited precipitation is only supplementary. Supplemental irrigation is dependent on the precipitation of a basic source of water for the crop. Water for supplemental irrigation comes mainly from surface sources, but shallow groundwater aquifers increasingly are being used. Among non-conventional water resources that have potential for the future, such as treated sewage water-harvesting is also important.

9.2.2. Recommendations for Flood Management

Based on this study the following sets of recommendations for flood management are outlined.

a). Needs of Embankment

In river erosive Charkharibari village most of the time flood occurred suddenly due to the unavailability of embankment. So, ongoing embankment project need to be maximized because it would protect the village from future erosion and flooding. And in case of Jigabari villages the cracks and fault need to be repaired immediately to protect the river from flood which caused by the seepage in the dam.

b). Plinth Rising of the Property

Plinth raising of the house is not enough. But if the property is raised with homestead gardening facility then it will be helpful. The house will be equipped with all kind of essential facilities like safe drinking water source, raised kitchen, shelter for livestock, and raised separate toilet facility for male and female respectively. The property can be powered by either solar electricity or grid line electricity. Plinth raising can be easily done by pumping sand from the river. Approximately the costing will be 3000/= Tk. per 1000 sq. feet for plinth raising of the property. It is equally applicable to both Charkharibari and Jigabari village.

c). Practice of Indigenous Knowledge

Indigenous knowledge has prospect of being applied in the household level, such as making Macha in the house to keep utensils from getting wet during flood time.

d). Integrate Science and Policy

An essential aspect of the planning process is integrating the science and policy of flood management. The policy maker's understanding of the scientific issues and technical constraints involved in addressing problems associated with flood is often limited. Likewise, scientists generally have a poor understanding of existing policy constraints for responding to the impacts of flood. In many cases, communication and understanding between the science and policy communities must be enhanced if the planning process is to be successful.

e). Appoint A Flood Management Committee with Bottom-Up Approach

A key political leader initiates the flood planning process through appointment of a flood management committee Depending on the level of government developing the plan, this could be the chairman or member of the union parishad. The committee has two purposes. First, the committee supervises and coordinates development of the plan. Second, after the plan is developed and during times of flood when the plan is activated, the committee coordinates actions, implements mitigation and response programs, and makes policy recommendations to the top level.

9.3. Conclusion

Based on the analysis and the findings of this research, following conclusions are drawn. In lower Teesta basin area, people repeatedly confronted by natural catastrophe almost every year such as drought and flood. In terms of vulnerability Charkharibari village is more vulnerable than Jigabari village. But there are more opportunities for Charkharibari village than Jigabari village. So, drought and flood induced critical periods are more acute in Charkharibari village. And coping capacity against these critical periods are highly influenced by income, occupation, education, frequency and duration of hazards. Peoples' demands varies during and after these critical periods. However it is evident that proper dissemination of information regarding early warning and assistance from governmental as well as non-governmental organizations can significantly improve the coping capacity of people.

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