Situation Assessment Report
In
S-W Coastal Region of Bangladesh

JUNE 2009

Printing supported by:

Comprehensive Disaster Management Programme
Ministry of Disaster Management and Relief

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Livelihood Adaptation to Climate Change Project

(BGD/01/004/01/99)

SITUATION ASSESSMENT REPORT

IN

S-W COASTAL REGION OF BANGLADESH

(JUNE, 2009)

Food and Agriculture Organization of the United Nations (FAO)

Department of Agricultural Extension (DAE)

Acknowledgements

The present study on livelihoods adaptation was conducted under the project Livelihood Adaptation to Climate Change, project phase-II (LACC-II), a sub-component of the Comprehensive Disaster Management Programme (CDMP), funded by UNDP, EU and DFID which is being implemented by the Department of Agricultural Extension (DAE) with technical support of the Food and Agriculture Organization (FAO), UN.

The Project Management Unit is especially thankful to Dr Stephan Baas, Lead Technical Advisor (Environment, Climate Change and Bioenergy Division (NRC), FAO, Rome) and Dr Ramasamy Selvaraju, Environment Officer (NRC Division, FAO, Rome) for their overall technical guidance and highly proactive initiatives. The final document and the development of the project outputs are direct results of their valuable insights received on a regular basis.

The inputs in the form of valuable information provided by Field Officers (Monitoring) of four coastal Upazilas proved very useful in compiling the report. The reports of the upazilas are very informative and well presented.

In the course of the study, the discussions with a number of DAE officials at central and field level were found insightful. In devising the fieldwork the useful contributions from the DAE field offices in four study upazilas and in district offices of Khulna and Pirojpur was significant. The cooperation with the responsible SAAOs in four upazilas was also highly useful.

The finalization of the study report has benefited from the valuable inputs, comments and suggestions received from various agencies such as DAE, Climate Change Cell, SRDI (Central and Regional offices), and others. The report prepared by CEGIS for drought prone areas during 2006 helped in developing the present document.

The study would not have been possible without the valuable feed back and information received from community people, as well as UP and UDMC representatives who participated with great enthusiasm during various meetings, group discussions, KIIs etc. The valuable inputs in the form of experience shared by numerous respected village persons proved to be of much help and very useful. The PMU team is highly indebted to the local people of the study villages. Useful participation of various line agency representatives in the upazila and district level workshops is also greatly acknowledged.

Acronyms

ADM	Agricultural Disaster Management
AEZ	Agro-ecological Zone
B. Aman	Broadcast Aman
B. Aus	Broadcast Aus
BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BDNAPA	Bangladesh National Adaptation Programmes of Action
BMD	Bangladesh Meteorological Department
BMDA	Barind Multipurpose Development Authority
BUET	Bangladesh University of Engineering & Technology
BWDB	Bangladesh Water Development Board
CBO	Community Based Organization
CCC	Climate Change Cell
CDMP	Comprehensive Disaster Management Programme
CEGIS	Center for Environmental and Geographic Information Services
CFAB	Climate Forecast Application in Bangladesh
cm	Centimeter
CPP	Cyclone Preparedness Programme
CRA	Community Risk Analysis
DAE	Department of Agricultural Extension
DEFRA	Department for Environment, Food & Rural Affairs (UK)
DEM	Digital Elevation Model
DFID	Department for International Development
DMB	Disaster Management Bureau
DMC	Disaster Management Committee
DoE	Department of Environment
DoF	Department of Fisheries
DPHE	Department of Public Health Engineering
DRAS	Drought Assessment Framework
EGIS	Environment and GIS Support Project for Water Sector Planning (now CEGIS)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAP	Flood Action Plan

FFWC	Flood Forecasting and Warning Center
FGD	Focus Group Discussion
GEF	Global Environment Facility
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
HYV	High Yielding Variety
IRS	Indian Remote Sensing Satellite
ICM	Integrated Crop Management
IPM	Integrated Pest Management
IPCC	Inter Governmental Panel for Climate Change
ISPAN	Irrigation Support Project for Asia and the Near East
ITDG	Intermediate Technology Development Group
IWM	Institute of Water Modelling
KII	Key Informant Interviews
LACC	Livelihood Adaptation to Climate Change project
LANDSAT	Land Satellite
LDCs	Least Developed Countries
LGED	Local Government Engineering Department
LMP	Livelihood Monitoring Project (a CARE project)
LTC	Lead Technical Consultant
LTU	Lead Technical Unit
MDMR	Ministry of Disaster Management and Relief (now MoFDM)
MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forests
MoFDM	Ministry of Food and Disaster Management (earlier MDMR)
MoWR	Ministry of Water Resources
MPO	Master Plan Organization
NAPA	National Adaptation Programmes of Action
NCA	Net Cultivable Area
NCM	National Component Manager
NDMC	National Disaster Management Council
NGO	Non Government Organizations
NIR	Net Irrigation Requirement
NPD	National Project Director
NRC (division)	Environment, Climate Change and Bioenergy Division of FAO

NWMPP	National Water Management Plan Project
NWRD	National Water Recourses Database
PRA	Participatory Rural Appraisal
PRECIS	Providing REgional Climates for Impacts Studies (Regional Climate Modelling System)
PMU	Project Management Unit
REB	Rural Electrical Board
RVCC	Reducing Vulnerability to Climate Change (A CARE-SIDA project)
SAAO	Sub Assistant Agriculture Officer (earlier called Block Supervisor)
SLF	Sustainable Livelihoods Framework
SOD	Standing Orders on Disaster
SRDI	Soil Research Development Institute
SSDP	Support to the Strengthening of Disaster Preparedness in Agricultural Sector
T-Aman	Transplanted Aman
TAR	Third Assessment Report
UNFCCC	United Nations Framework Convention on Climate Change
UAO	Upazila Agricultural Officer
UDMC	Upazila Disaster Management Committee
UNDP	United Nations Development Programme...
UNO	Upazila *Nirbahi* (Executive) Officer
UP	Union Parishad
WARPO	Water Resources Planning Organization

LOCAL BANGLA TERMINOLOGY USED

Amin **:** A village level government employee dealing with land records

Boro : Irrigated winter rice

Gher : Water body for shrimp cultivation

Imam : The Muslim priest

Kharif- I : Early monsoon cropping season

Kharif- II : Monsoon cropping season

Rabi : Winter cropping season

T. Aman : Transplanted Aman (Monsoon rice)

T. Aus : Transplanted Aus (Early monsoon rice)

Bawali : Wood cutter in the Sundarbans Forest

Rhishi : A marginalized hindu community who work on leather and other instruments

Kal boishkhi : Nor'wester

Monds : Unit used for weight (approximately about 40 Kgs)

Khals : Small canal filled with water and use for fish rearing and navigation

Mohajon : Local money lender

Beel : Natural perennial lake or depression

Barind :The largest Pleistocene era pysiographic unit in Bangladesh and the Bengal Basin. It is fragmented, being made up of several separate sections in the northeastern part of the country, covering a total area of approximately 7,770 km² of mostly old alluvium

Mouja : A small unit under union parishad used for the land measurement and tax collection

Ghats : Platform/dock at the river side used for anchorage of ferry or other purposes

Union Parishad : Local self government system at union level.

Net cultivated area : Arable and actual land area brought under cultivation in a particular period or one year.

Gross cultivated area : Cultivable land that includes cultivated and fallow, waste lands.

Fallow land : Arable land remain empty i.e. without crop fro certain period/season

Executive Summary

The present study is an integral part of the "Livelihood Adaptation to Climate Change (LACC) Project", a subcomponent of the national "Comprehensive Disaster Management Programme (CDMP)", funded by UNDP, DFID and the EU. The project, being implemented by the Department of Agricultural Extension, MoA, with technical support from the Food and Agriculture Organization, UN, aims to strengthen disaster risk reduction management and climate change adaptation capacities for sustainable livelihoods and food security in agriculture (the rural sectors including crops, livestock, fisheries and forestry) and other key factors of rural livelihoods in the drought prone and coastal regions of Bangladesh.

The study is composed of a livelihood systems assessment, a vulnerable groups profiling and a study on livelihood adaptation practices and technologies to climate hazard and long-term climate change in the coastal regions of south-western Bangladesh. The study has been carried out in four selected upazilas - Dacope, Terokhada, Bhandaria and Nazirpur – of two districts: Khulna and Pirojpur.

The specific objectives and activities of the study were to

- describe the physio-geographic environment and framework conditions of the study areas,
- assess local perceptions of climate hazard, past and present climate risk/impact,
- livelihood systems and establish livelihood profiles of the major vulnerable groups considering household categories,
- investigate current and past adaptive responses and coping strategies of the vulnerable groups to risks in particular climate risk, and
- review the mandates, actual roles and capacities of communities and local institutions/organizations (including local government agencies and self-help groups) in disaster prevention and preparedness, as well as the services they offer and the resources they have.

The study found that the people of the study area hold various perceptions towards the current and past risks. People perceive that the current climate in the area has been behaving differently from the past years: The seasonal cycle has changed, and the impacts of natural and also of different anthropogenic hazards have become more frequent and prominent. Increased salinity, scarcity of fresh water, soil erosion and deterioration, land degradation, water contamination, pest and disease incidences, increase in average temperature, increase in intensity and frequency of natural disasters like floods and cyclones have adversely affected almost each and every section of the society in the

coastal region. A major portion of the land, which was once productive, remains fallow today. The local people perceive that these changes have not only enormously reduced the crop and fish production, but also deteriorated the overall environment in the study area.

The study profiles the major livelihood groups in the area. It was observed that the livelihoods are severely affected by climatic and non climatic changes. For example, the increased salinity of both soil and water has seriously affected all livelihood resources, in particular. agriculture, fishery, livestock and forestry. The increase in frequency and intensity of natural disasters, i.e. floods and cyclones, has made it difficult for the local people to secure their livelihood. In addition to natural factors, several anthropogenic factors (e.g. electricity failure, high price of agricultural input, social barriers) remain the major form of vulnerability for the farmers, fishers and other livelihood sections of the society. Due to a large portion of land lying fallow, the wage laborers face unemployment and are forced to migrate in search of employment. Petty traders find difficulties in getting buyers on a regular basis. In comparison to men, women are more vulnerable due to various reasons. The study tried to identify some gender specific vulnerability in the study area and found that the women are more vulnerable to disaster and climate risk due to gender inequalities in various social, economic and political institutions. Large businesses and rich farmers were found vulnerable by a lesser degree. However, during natural calamities like droughts, floods, cyclones etc. this group also becomes vulnerable to some extent as their business and assets get damaged. But due to better access to assets, this group is not considered severely vulnerable to changing climatic conditions.

The study revealed that the local people have evolved many local adaptive practices to deal with the difficult climatic conditions. As scarcity of fresh water and deteriorating soil conditions are the major problems, most of the adaptive practices in the area are related to water and soil management. The adaptive practices identified in the study area include excavation of small/mini ponds and canals, the Sarjan method, crop diversification and adjustments, short duration fresh water fish culture etc. Different government departments and NGOs are helping the local people in adapting to changing climatic conditions. The study found that the benefits of these adaptive practices vary: some are promising, some bring limited success and others have only a low efficacy in severe variable climatic conditions.

The study identified and reviewed the institutional setting in which the vulnerable groups are trying to cope with and adapt to deteriorating climatic conditions. A number of institutions like local government agencies, international and national NGOs, CBOs, informal and private bodies etc. were found to be operating in the area. The institutional assessment found that many of these agencies along with carrying out usual developmental activities are also involved in disaster and climate risk

management. The main weakness identified is the lack of proper coordination mechanism among these agencies. As a consequence, there is a lot of overlapping and mismanagement. In few cases the activities carried do not meet the needs of the vulnerable groups and thus are not socially acceptable and sustainable.

To conclude, the present study found that climate change along with a number of other anthropogenic factors is responsible for the increased vulnerability of the coastal area's rural population, particularly their livelihoods. Scientific findings and forecast models predict that the situation is going to further deteriorate in the near future. Limitations of existing coping strategies with regard to climate change will make the rural livelihoods of the area more vulnerable, leading to food insecurity. The study's findings suggest that there is urgent need to look for climate change adaptation and disaster risk management strategies (both long and short term) and integrate them into the ongoing developmental planning. The main recommendations include i) awareness raising and capacity building of all stakeholders, including the local community ii) adjustment/alteration of agricultural practices (e.g., setting up appropriate cropping patterns and selection of suitable crop species), iii) pay appropriate attention to other livelihood sectors like fishery, livestock and forestry, iv) creation of alternative livelihood opportunities, v) appropriate and suitable action and raising awareness by government and other agencies to do away with the social and legal barriers, vi) develop a proper coordination mechanism among governmental and non-governmental agencies working in the region, and last but not the least vii) responding to climatic risks with adaptive measures wherever possible (such as water and soil resources management).

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1. INTRODUCTION

1.1 Background

Bangladesh, due to its geo-physical position and socio-economical context is prone to several types of natural disasters. The occurrence of natural disaster is of particular significance for the coastal region of the country. The people of this area have been suffering from a number of intense and even more frequent hazards like salinity, cyclones, storm surges, floods, water logging etc. The recurring hazards are leaving lives and livelihood of the coastal community in peril and have severe impacts on every sector, agriculture being the worst affected.

Climate Change is adding a new dimension to community risks and vulnerabilities to natural disasters, especially in coastal regions. The combination of already frequent natural hazards and high vulnerability coupled with expected climate change impacts, like increase in temperature and sea level rise, bears the risk of inundating a major part of the landmass along the coast within the first half of this century. In addition to direct land loss due to inundation, climate change is expected to increase the severity and frequency of weather-related natural hazards, such as storms, high rainfalls, floods, droughts, salinity, soil degradation and erosion, and heat-waves (IPCC Fourth Assessment Report), posing a direct threat to agriculture and allied sectors.

The impacts of climate change on agriculture production represent a particular threat for food security in Bangladesh. Agriculture in Bangladesh is already under pressure mainly due to an increase in demand for food, as well as to depletion of land and water resources. Higher temperatures and water stress due to heat would result in decline in vegetation and agricultural production. By 2050, dry season rainfall is expected to decrease by 37%, increasing the risks of droughts[1]. Though monsoon rainfall is expected to increase by 28%, intermittent dry and wet spells cannot be ruled out. High intense rainfall would result in increased flooding and sedimentation of flood plains, making them less productive. On top of that, encroaching salinity, as result of sea level rise and other factors will further degrade agricultural areas.

The coastal region in Bangladesh, including the estuaries and islands adjacent to the land-water-interface from the south-west to the south-east is under significant threat due to climatic changes.

The coastal area of Bangladesh is about 710 km long and extends along the Bay of Bengal. It has been divided into three sub regions – Western (Khulna, Pirojpur, Patuakhali), Central (Barisal, Barguna, Noakhali) and Eastern (Chittagong). Heavily sediment-laden river water with very little salinity meets with the high saline seawater at the coastal area and creates a unique ecosystem that has given rise to a variety of agricultural and social system.

The combination of several factors, such as monsoon rain, enormous run off and sea level rise due to monsoon wind and the tide creates a hydrological zone, which often floods the coastal region, particularly in the eastern and central region. Along with flooding, increased salinity (both in water and soil), soil erosion and soil nutrient deficiency, water logging, land degradation, crop damage due to cyclones and storm surges, river siltation and erosion etc. have adversely affected agriculture and allied livelihood sectors in the coastal region of Bangladesh.

In this context, the Livelihood Adaptation to Climate Change (LACC) project, a sub-component of the Comprehensive Disaster Management Programme (CDMP), is being implemented by the Department of Agricultural Extension (DAE), with technical support from the Food and Agriculture Organization of the UN (FAO). The project launched its operation in 2005 with the objective to reduce the impact of climate change risks in agriculture and allied sectors. In its 1st phase the project worked in the north-west drought prone *Barind* tract. In the 2nd phase (LACC-II) the project has extended its activities to the south-western coastal regions. In the coastal region two districts, namely Khulna and Pirojpur, have been selected, and since February, 2008 the project activities are being implemented in four upazilas of these two districts.

According to the Project Implementation Approach, the situational assessment of the pilot upazilas is the first task to be carried out, in order to collect basic information about the communities' vulnerability to climate risks and the factors determining their vulnerability, as well as to identify and assess existing adaptive responses to climatic risks by the local population. In line with this approach, the 2nd phase of the project (LACC-II) began with a situational assessment study, which has been carried out in three unions of all four upazilas of the Khulna and Pirojpur districts. The study has been completed in the months of July and August 2008.

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[1] Ministry of Environment and Forest, 2002. Initial Communication under the United Nations Framework Convention on Climate Change.

This report outlines the background, objectives, study process, methods, findings and recommendations made on the basis of the situation assessment in these south-west coastal districts of Bangladesh.

1.2 Objectives of the study

The major objectives of the Situation Assessment were to appraise livelihood vulnerability of community people, which has been exacerbated by the current problems and future risks posed by climate change, and identifies the local adaptive and coping responses to the changing climatic conditions.

Specifically, the study intended to

- describe the physio-geographic environment and framework conditions of the study areas;
- assess local perceptions of climatic hazards and past and present climate risks and associated impacts;
- study livelihood systems and establish livelihood profiles of the major vulnerable groups;
- investigate about current and past (30 years) adaptive responses and coping strategies of the vulnerable groups to particular climatic risks;
- review the mandates, actual roles and capacities of communities and local institutions/organizations (including local government agencies and self-help groups) in disaster prevention and preparedness, as well as the services they offer and resources they have.

2. METHODOLOGY

The assessment process was developed and adapted from the Community Risk Analysis (CRA) guidelines used by CDMP and using the overall structure of the CEGIS report "Livelihood System Assessment, Vulnerable Group Profiling and Livelihood Adaptation Study, 2005". A tailored version of the CRA was followed in facilitating sessions at the union and upazila levels to assess the region specific situation.

2.1 The assessment process

The assessment was aimed at developing the baseline and identifying adaptation options for the community people of the study area. The assessment activities were carried out in four major steps (Figure: 2-1). The methodological measures adopted in the study are shown in Table- 2.1.

Figure-2-1: Steps of assessment activities

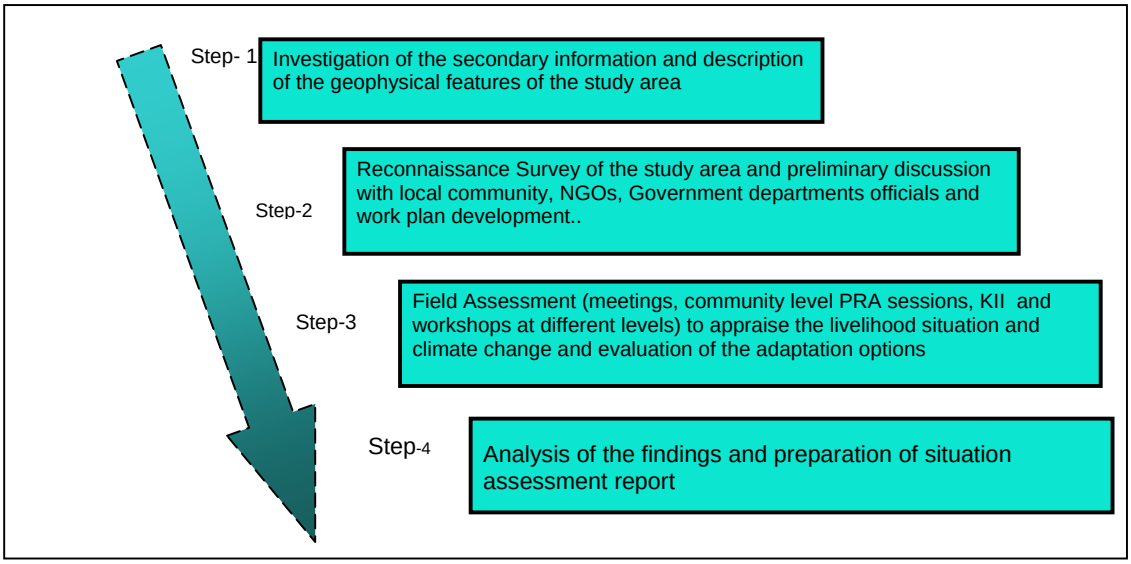


Table-2.1: - Issues, methods and data sources

Sl. No.	Objectives	Analytical issues	Methods/tools used	Data source
1	Review of secondary information	- Physiography - Rainfall - Salinity	Secondary data review	SRDI, DPHE, DAE, BBS, BARI, BRRI,

		- Soils - Ground water salinity - Agriculture land use - Major crops - Land types - Major cropping systems		CARE, BMD etc.
2	PRA to assess local perceptions of climate hazard, past and present climate risk/ impact and perception about future climatic risks	- Local perceptions of climatic hazards - Local perceptions of impacts of various climatic risks/hazards in the present situation	- Community level PRA sessions - Interviews	Primary field data.
3	Study Livelihood and livelihood profiles	The livelihood resources available and being practiced.	KII, PRA sessions supplemented by secondary information.	Primary and secondary data.
3	Local Climate Change adaptations and Coping mechanism	Climate risk associated problems and their coping mechanism	Community level PRA sessions	Primary field data
4	Institutional assessment	identify the role and capacities of the community, local institutions, organizations to cope and adapt to the changing climate and also disaster risk management interventions	- Community level PRA sessions -Interviews - Union and Upazila level meetings & workshops	Primary field data

2.2: Investigation of the secondary information and data

The study started with the review of the secondary information from different sources to understand the background context of the study area. Secondary information and data on socio-economic, geographic, weather and climatic conditions were collected from union, upazila, district and other national sources in order to understand the local context and background. This information and data were collected, reviewed and analyzed at the beginning and at various stages of the assessment.

The main sources of the information have been Union Parishad, Union and Upazila Land offices, DAE, SRDI, DoF, DLS, DoE, DPHE, FFWC/BWDB, CCC, BMD, CARE etc. In addition, documents like *"NAPA", CEGIS-LACC-I_Vulnerability Assessment Report", "CEGIS-FAO Vulnerability Analysis of Major Livelihood Groups in the Coastal Zone Report", "ICZM Coastal Zone Study Reports, Soil Salinity in Bangladesh 2000"* and other relevant reports were consulted.

2.3: Reconnaissance survey and preliminary discussions

The Field Officers (Monitoring) of the respective upazilas made reconnaissance visits of the study area, including the study villages and had preliminary discussions with different stakeholders, including local community, elite persons, local NGOs/CBOs representatives etc. Separate introductory discussions were held with DAE local officials, i.e. UAO and SAAOs. The main outcomes were:

- Preliminary idea about the study area
- Identification of the study villages
- Identification of the major vulnerable groups
- Identification of the meeting, field session and workshop locations.
- First hand identification of groups and persons for KII.

The study ultimately helped and guided in preparing a work plan for carrying out the subsequent detailed activities, which were shared with the project management unit and finalized.

2.4 Field Assessment

A field assessment was carried out using different tools and techniques like meetings, community level PRA sessions, KII and workshops at different levels mainly to appraise the livelihood

situation, assess climate change related risks, evaluate of the adaptation options and assess the institutional capacity at local and regional levels of different governmental organizations and NGOs.

2.4.1 Selection of the study area

During the project inception at the upazila level, the working areas for the project were identified on the basis of specific criteria developed by the project in close consultation with the upazila DAE authorities and others concerned. Under each upazila, three unions were selected, where the project activities and interventions were started accordingly. Representation from each and every section of the society was ensured, while carrying out the assessment exercise in the selected unions. The selection of the unions was based on the following criteria:

- Unions doing activities supported/facilitated by DAE and other allied departments.
- Unions having an active Disaster Management Committee (DMC).
- Unions having received support from other projects/initiatives like Coastal Afforestation programme, Drainage/Polder Rehabilitation programmes, IPM/ICM clubs/schools, farmer organizations/clubs, others.
- Unions which are not overassisted by the SIDR rehabilitation programme/activities
- Unions which are particularly vulnerable due to major hazards related to climate change and other environmental reasons.

2.4.2. Tools and techniques:

Different Participatory Rural Appraisal (PRA) tools and techniques were used for various sessions and activities of the assessment (see Box). The tools and techniques were used for vulnerable group profiling and seasonal variation of livelihoods of the community people and their income generation activities. Different hazards , climatic risks and risks associated problems stocking the community livelihoods including agriculture, livestock, fisheries and forest sectors as well as coping mechanism of the local people were identified using these tools.

Assessment tools and techniques

- Review of secondary information
- Key Informant Interview (KII)
- Focus Group Discussion (FGD)
- Small group works
- Story telling and experience sharing
- Mapping exercises for social and hazard mapping
- Seasonal Calendar for plotting cropping and hazard
- Ranking and scoring

2.4.3. Selection of the study participants

Before the start of the study in the unions itself, the study participants were identified by the project staff in close consultation with the local DAE officials and the union representatives. A general principle was followed in the selection process so that farmers, fishers etc. of all categories and representation from the community in general were included as study participants. The selection primarily focused on overall representation, and secondly on gathering a cross-sectoral view on vulnerability and adaptation measures of the area concerned. In particular, the following categories of participants were selected for the assessment:

- Union Parishad Chairperson
- UDMC Members
- Farmers and fishermen
- Female representative
- Teacher/Imam
- Trader
- Local elite
- Surveyor/*Amins* etc

In addition, the following categories of persons from upazila level participated:

- Officers from DAE, DLS, DoF and Forest Department
- Officers of other concerned departments like rural development officer
- Representatives from NGOs
- Union Chairperson
- Farmer representatives
- BARI and scientists from other research organizations

2.4.4..Activity-wise categories of participants in PRA sessions:

The assessment study was intended to collect information and data that represent various sectors and cover various socio-economic groups of the community. The representative/s from all sections of the community, in particular the farming communities, were involved in the entire process (Table: 2-2).

Table: 2-2– Activity-wise categories of participants

Sl. No.	**Method/activities**	**Category of participants**	**Facilitators**
1	Focus Group	-Farmer	Respective Sub

	Discussions (FGD), Preparing Livelihood seasonal calendar, Hazards seasonal calendar	-Teacher -Imam -Fisher - Local level representative -UDMC member -Local resource person -Women representative -Representatives from water use group -Public representative	Assistant Agriculture Officers (SAAOs), Field Officers-Monitoring (FO-M)
2	Social mapping, hazard mapping, identification of vulnerable sectors & vulnerable areas	-Farmer -Teacher -Imam -Fisher -UDMC member -Local resource person -Women representative -Amin -Public representative -Surveyor	Respective SAAOs, FO-M
3	Hazards history & their impacts, hazard-associated risks for agriculture & allied sectors, local coping mechanisms & their institutional assessment	-Farmer -Teacher -Imam -Fisher -UDMC member -Local resource person -Women representative - Local livestock and fishery department official -Rep. from water use group- -Public representatives.-	Respective SAAOs, FO-M
4	Vulnerable group profiling, hazard-	-Farmer -Teacher	Respective SAAOs, FOM

	associated risks for agriculture & forest sectors, local coping mechanisms & their institutional assessment	-Imam -Fisher -UDMC member -Local resource person -Women representative -Amin -Public representative -Surveyor	

2.5. Livelihood group profiling:

The exercise was carried out using the following steps and methods:

- Classification and profiling of the livelihood groups were done primarily through FGD and ranking exercises.
- Characteristics of various livelihood groups were recognized using small group discussion among the study participants.
- Seasonal and year round occupation of various livelihood groups were then identified and expanded by using a seasonal calendar.

2.6 Hazard, vulnerability and risk analysis

A list of the major local climatic and environmental hazards and the frequency of their occurrence was generated through a brainstorming session of the participants. Afterwards a hazard-seasonal-calendar was prepared by the participants, showing the occurrence of the hazards throughout the year. Concerning vulnerability and the risks, a perceptions assessment of the participants was done by taking their opinion, about the occurrence, frequency, intensity of the hazards and the impact on livelihoods of the local people. An open discussion addressed, how the hazards could pose a risk to the livelihood of the people, the agricultural production and its management.

2.7 Appraisal of adaptation and coping measures

A number of workshops at union and upazila levels were organized, where question and answer exercises were conducted to appraise the locally used adaptation and coping measures. Techniques like brainstorming sessions, experience sharing, story telling etc. were used in the

workshops to identify, review and authenticate the adaptation and coping options being practiced by the community to cope with climate vulnerability and change and natural disasters.

Key informant interviews were carried out with various stakeholders (including the community and professionals) to further enrich the information gathered during the workshops, discussion meetings and from other sources and processes. This exercise was carried out in each union, where an open ended and informal discussion was held with local knowledgeable persons, who are conversant with the environmental and socio-economic conditions and other aspects of the study area.

At the end of the process, a list of adaptation options was generated taking all sectors into consideration.

2.8 Institutional analysis

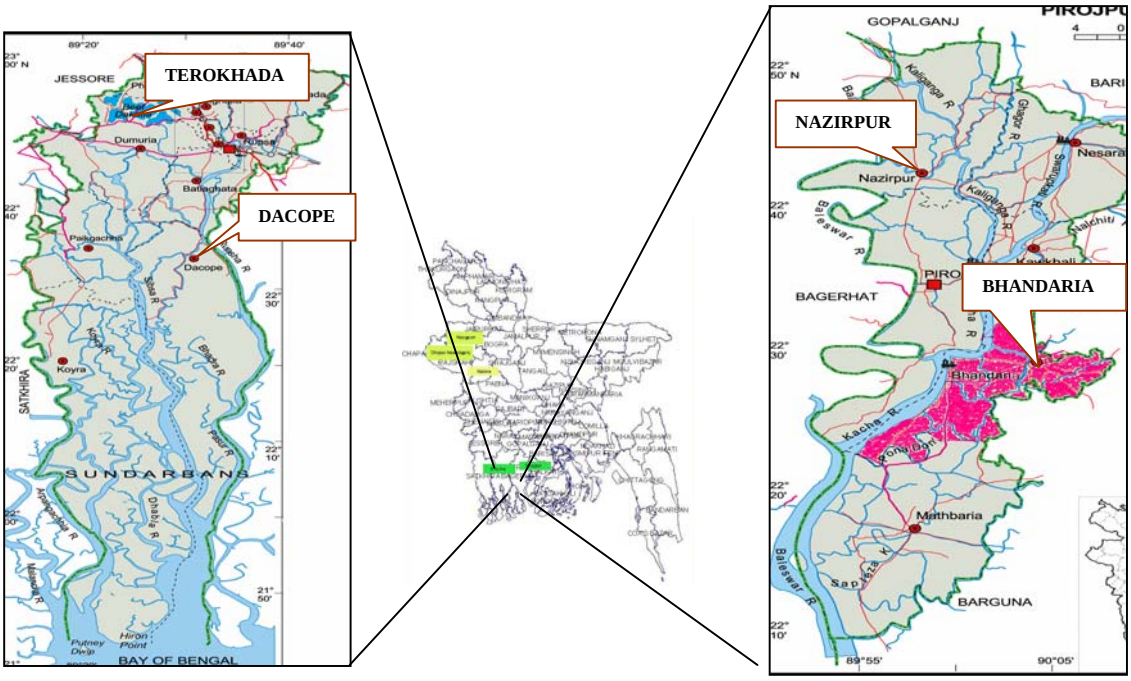
In order to identify the mandates, responsibilities, capacities and limitations of the institutions involved, an institutional analysis was performed in both union and upazila sessions. A listing of of the government departments, institutes, non-governmental organizations and CBOs was done, followed by an open discussion. Special emphasis was given to understand the role the institutions can play in reducing the livelihood risks and in planning and implementing adaptation activities.
The framework of activities and processes followed is summarized in Annex-I.

3: PHYSIOGRAPHIC SETTING

3.1 Geographical locations of the study area

The study area is situated in the south-western coastal region of the country and lies between 22°29'04" and 22°56′30″ north latitude and between 89°30'4" and 90°4′88″ east longitude. It covers the Upazilas of Terokhada and Dacope of Khulna district and Bhandaria and Nazirpur upazilas of Pirojpur district. The location of the study area is shown Figure-3-1.

Figure-3-1: Map of the study areas



3.2 Sources of the data and the information

To describe the physio-geography of the study area, secondary data and information were collected from a number of organizations and institutions and subsequently analyzed, including reports and information from the district and upazila levels from the DAE, the Land Department, the Forest Department, the Bangladesh Water Development Board (BWDB), the Bangladesh Meteorological Department (BMD), the Climate Change Cell, the Bangladesh Bureau of Statistics (BBS) and the Soil Resource and Development Institute (SRDI) . The main sources of data/ information are summarized in the table below:

Table 3.1- Source of secondary data/ information

Information	**Source**
Climatic data	BMD, Khulna Meteorological Center, Climate Change Cell, MoEF
Sea level data	Climate Change Cell, ADPC
Agricultural information	DAE - HQ and DAE Upazila offices
Census data	Upazila Statistic Departments
Salinity data	SRDI – Dhaka and Regional offices and Upazila Fishery Department
Soil status	SRDI (including regional offices), Upazila Agriculture offices
Union based socio-economic information	Union Councils

3.3 General physiography and hydrology of the study area

The coastal zone of Bangladesh, the largest delta of the world, is under a continuous process of active delta development and morphological changes by the Ganges-Brahmaputra-Meghna (GBM) river system. The coastal region is marked by a vast network of river systems and deltaic tidal channels, ever dynamic estuary and interaction of large quantities of fresh water that are discharged by the major river systems. In addition to the coastal plains, there are 30 offshore islands that are subject to strong wind and tidal interactions throughout the year and are inhabited by a large number of people. The Coastal Zone Policy uses three indicators for determining the landward boundaries of the coastal zone of Bangladesh: influence of tidal waters, salinity intrusion and cyclones/storm surges (Ministry of Water Resources, 2005).

Five main physiographic units cover the entire coastal area of Bangladesh, namely Ganges river floodplain, Ganges tidal floodplain, Young Meghna estuarine floodplain, Chittagong coastal tidal floodplain and Peat basins.

The present study area mainly consists of Gangetic flood plain and tidal floodplains and falls under Agro-Ecological Zones (AEZ) 11, 12, 13 and 14. The main soil types of the region are non-calcareous to dark gray and non-saline to seasonally saline with a loamy clayey texture. A small area of Nazirpur Upazila also contains peat soil. The maximum average temperature of the area varies between 26 °C and 36 °C during the months of March and August and between 13 °C and 15 °C during the rest of the year. The average rainfall is about 1500 mm, but most of the rainfall

occurs only during the Monsoon. The general physiography of the four study area upazilas is discussed subsequently.

3.3.1 Dacope upazila

Dacope upazila is one of the Southern upazilas in the Khulna district and is surrounded by the Batiaghata upazila of the Khulna district in the North, the Rampal upazila of the Bagerhat district in the East, the Sundarbans (a tidal halophytic mangrove forest) in the South and the Paikegacha upazila of the Khulna district in the West. It is situated at 22°34′20″ north latitude and 89°30′40″ east longitude. The total area of the upazila is 285.57 square kilometers, out of which the area of broad rivers is 33.54 sq. km. Dacope upazila belongs to Gangakatal Alluvial land. The total population of the upazila is 168,772, and the population density is 493/sq. km. For administration, the upazila consists of 9 unions and 25 moujas.

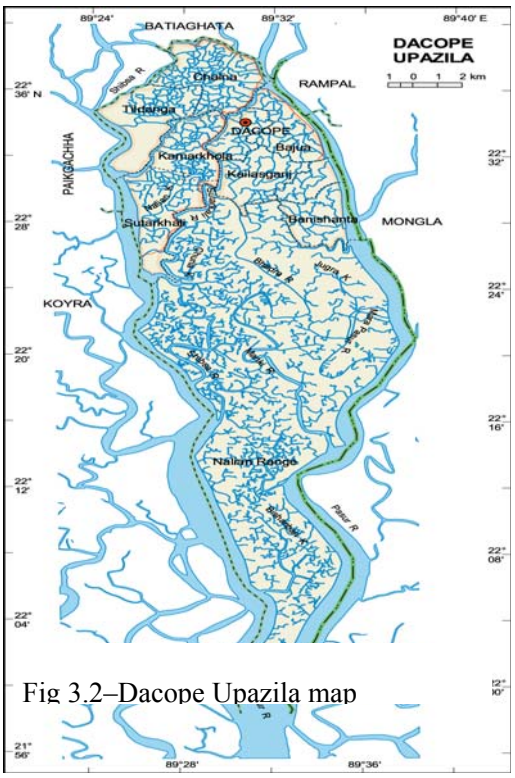


Fig 3.2–Dacope Upazila map

The average of the maximum temperature in the upazila is 41.7 °C and the minimum average is 20.4 °C. The monthly rainfall varies from 6 to 371 mm. As the whole upazila is surrounded with embankment, tidal water usually enters into the land through sluice gates controlled by a committee authorized by BWDB. However, in case of heavy rainfall during the rainy season, the area is waterlogged, and it takes the water several days to flow down to the rivers connected to the bay. The soil of the area is mainly clay loam. Further details of land forms and soil are given in the Upazila soil maps in Annex II.

3.3.2 Terokhada upazila

Terokhada upazila is one of the Northern upazilas in Khulna district and surrounded by the Kalia upazila of the Narail district in the North and in the East, Rupsha upazila of Khulna district in the South and the Chitalmari upazila of the Bagerhat district in the West. It is situated at 22°56′30″ north latitude and 89°40′10″ east longitude. The distance of Terokhada upazila from Khulna town is about 20 kilometers. The total area of the upazila is 189.48 square kilometers, out of which

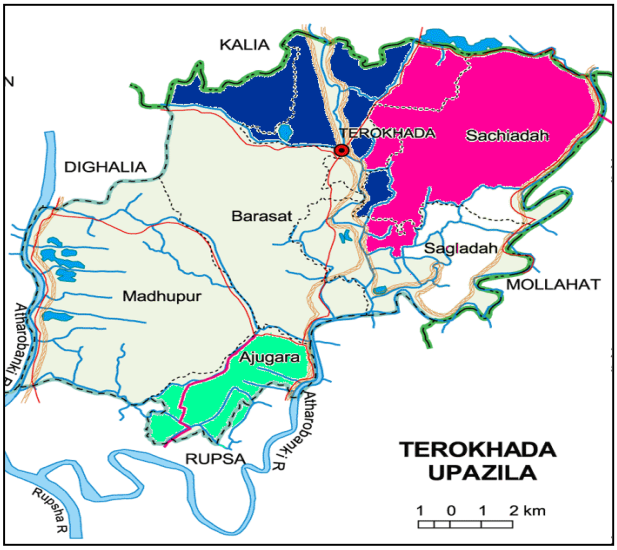


Fig 3.3– Terokhada Upazila map showing study area unions

broad rivers cover 24.54 sq. km. The total population of the Upazila is 126418 with a population density of 667persons/sq.km. For administration, the Upazila consists of six unions and 100 moujas.

The maximum average temperature in the upazila is 41.7 °C, the minimum average is 20.2 °C. The monthly total rainfall varies from 6 to 366 mm. Terokhada upazila mainly consists of floodplain and medium high land. A large area of the upazila, especially in the north-eastern part, is covered by large water bodies commonly called *beel*. Part of the Terokhada upazila is surrounded with embankment, and in the south-western part tidal water usually enters into the land through sluice gate, controlled by a committee authorized by BWDB. The land within the embankment usually goes under water in the rainy season and gets waterlogged temporally. The soils of the area are clay and clay loam. Further details of land forms and soil are given in the Upazila soil maps in Annex II.

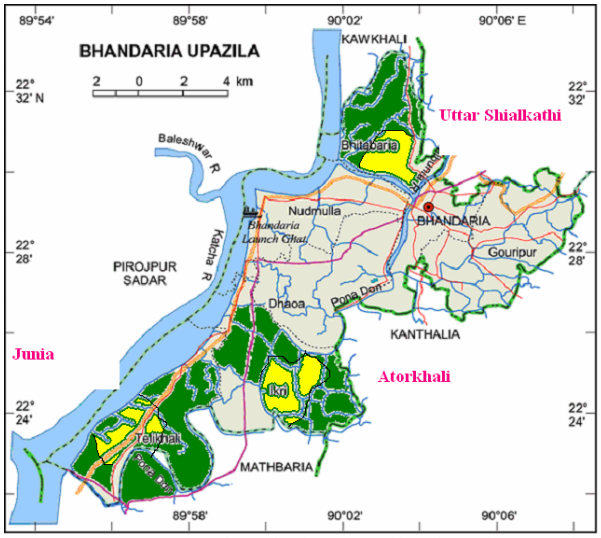


Fig-3.4 Map of Bhandaria Upazila showing study area

3.3.3 Bhandaria upazila

Bhandaria upazila of the Pirojpur district is situated in the South-Western part of the district headquarter. It is surrounded by the Kawkhali and Rajapur upazilas of the Jhalokathi district in the North, the Rajapur and Kathalia upazilas of the Jhalokathi district in the East, Mothbaria in the South and Pirojour sadar and Kawkhali of the Pirojpur district in the West. The upazila is situated between 22°22′ and 22°34’ north latitudes and 89°54′ and

90°08′ east longitudes. The total population of the upazila is 145233 with a population density of 943 per sq. km. For administration, the Upazila consists of 7 unions and 37 moujas.

The maximum average temperature in the upazila is 41.1°C, the minimum average is 19.4°C. The total monthly rain fall varies from 5 mm to 421 mm. The area is comprised mainly of two physiographic features, the lower Ganges floodplain and the southern coastal floodplain. During the high tide, the southern part of the upazila is flooded. However, the flood water recedes within 24 hours time. The majority of the land is constituted by flood plain and coastal soil. The Southern part of the upazila is affected by varying degrees of salinity, and in the winter season the crops grown suffer due to increased salinity. The soil of the upazila is mostly loam and clay loam with variation among the unions. Further details of land forms and soil are given in the Upazila soil maps in Annex II.

3.3.4 Nazirpur upazila

Nazirpur upazila, situated in the North-West of the Pirojpur district, is surrounded by the Tungipara and Kotalipara upazilas of the Gopalgonj district and the Uzirpur upazila of the Barisal district in the North; Banaripara upazila under Barisal district and Nesarabad upazila of Pirojpur district in the East; the Kanchua and Chitolmari upazilas of the Bagerhat district and the Sadar upazila of the Pirojpur district in the South. It is situated between 22°40' and 22°52' north latitude and 89°52' and 90°30' east longitude. The area of the upazila is 233.65 sq. km. and consists of 8 unions and 67 moujas. The total population of the upazilas is 166,014, with a population density of 728 per sq. km.

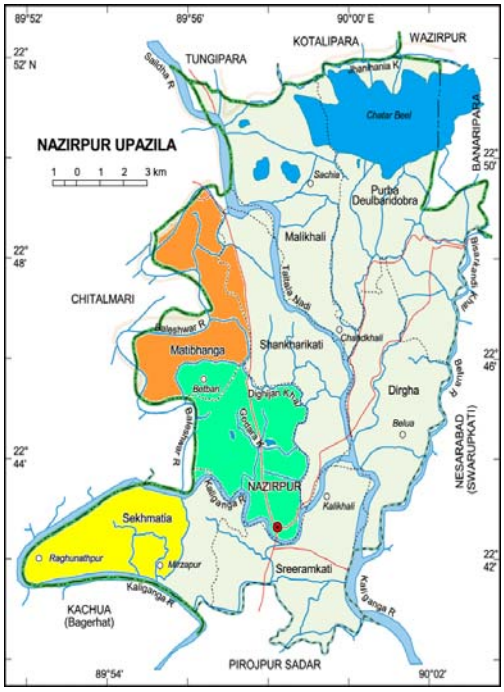


Fig 3.5 - Map of Nazirpur Upazila showing study area unions

The maximum average temperature in the upazila is 33.8 °C, the minimum average is 20 °C. The monthly total rainfall varies from 5 to 423 mm. The Upazila is mainly comprised of the lower Ganges floodplain. The land of the upazila is constituted by flood plain soil and peat soil in the upper Western part. Soil and water of the Nazirpur upazila are affected by various degrees of salinity, and floods are a common phenomenon here.

Further details of land forms and soil are given in the Upazila soil maps in Annex II.

3.4. Land and soils

The study area consists of three major physiographic features: the Ganges flood plain, tidal flood plain and partly marshy land. The Ganges flood Plain is characterized by high and low flood plains. The low flood plain area is subjected to flooding in the monsoon season and some lower area is water logged even during dry periods. Through a network of tidal creeks and drainage channels the tidal flood inundates the soil and impregnates it with soluble salts, thus rendering the topsoil and subsoil saline. Part of the area in the Dacope, Terokhada and Nazirpur upazilas is marshy land, locally called *Zolabhumi,* characterized by peat soil at some places. Some portion of this marshy land remains under water throughout the year.

3.4.1. General Characteristics -

The land of the study area mainly consists of four categories: high land, medium high land, medium low land and low land. The distribution of these four categories of land in the upazilas is shown in Table 3.2

Table 3.2: Distribution of land categories within the study area upazilas

Name of Upazila	**High land (ha)**	**Medium High Land (ha)**	**Medium Low land (ha)**	**Low land (ha)**	**TOTAL (ha)**
Nazirpur	610	3728	7530	5879	17747
Terokhada	416	4080	12870	3807	21935 (miscellaneous-1216 Ha)
Bhandaria	775	2244	5956	0	8975
Dacope	390	22652	?	?	23042

As mentioned above the major portion of the area consists of the Ganges flood plain and the Ganges tidal flood plain. The soil characteristics of these two regions are quite different (see Table 3.3).

Table 3.3: The general soil characteristics of the two main regions comprising the study area upazilas.

Characteristics	**Ganges Flood Plain (Upazila)**	**Ganges Tidal Flood Plain (Upazila)**
Study area coverage	Part of Terokhada and Nazirpur upazilas.	Dacope and parts of the other three upazilas
Soil reaction	pH value – 7.3 to 8.0	pH value – 4.6 to 7.9
Total Nitrogen	Generally low to medium. Ranging from 0.11% to 0.16%. The poor N status of salt affected soil is due to high cropping intensity and inadequate application of organic manure.	Varying from low to high. Ranging from 0.07% to 0.38%. The poor N status of salt affected soil is due to high cropping intensity, inadequate application of organic manure and high volatilization of ammonium nitrogen.
Phosphorous	Deficient in Phosphorous. Varies from 3.34 to 22.52 mg/gm soil.	More deficient in Phosphorous. Varies from 0.95 to 21.13 mg/gm soil.
Potassium	Deficient in Potassium, ranging from 0.02 to 0.15 meq/100 gm soil.	Varying from very low to very high, ranging from 0.03 to 7.20 meq/1 00 gm soil.
Sulphur	Varying from low to high, ranging from 15 to 73.9 ppm. Regular inundation with tidal water may be cause of higher S content.	Varying from medium to very high, ranging from 24 to 514 ppm. Regular inundation with tidal water may be cause of higher S content. More S content in land inundated with saline water.
Micronutrients	Appreciable amount of micronutrients such as Cu, Fe and Mn, but deficient in Zn.	Appreciable amount of micronutrients such as Cu, Fe, B and Mn, but deficient in Zn. Zn varies from 0.09 to 1.58.

3.4.2. The Soil Map:

The soil maps of the four upazilas in Annex II provide details about land and soil characteristics along with the area covered. Table 3.4 below summarizes the data contained in the soil maps,

which were procured from SRDI and translated from Bangla with the help of a soil scientist of SRDI.

Table 3.4: The main characteristics of land and soil in the project area upazilas (based on the SRDI map index)

Land/ Soil Characteristics/ Upazilas	Land Type	Drainage of surface water in Rabi	Available moisture	Soil Texture	pH	Drainage of water	Salinity
Dacope	Medium to high Land	Early to normal	Low to medium	Clay, Clay loam and Loam	Neutral to slightly alkaline	Poorly drained	Low to very high
Terokhada	Medium Low land to medium High land	Early to very Late	Low to medium, in some cases high	Clay, clay loam and Organic silt	Neutral-slightly alkaline to slightly acidic	Poorly to very poorly drained	Non saline to medium saline
Bhandaria	Medium to High Land	Very early to Late	Low to medium in some places high	Clay, Clay loam and Loam	Neutral-slightly alkaline to slightly acidic	Poorly to very poorly drained	Not mentioned
Nazirpur	Medium low land to High land	Very early to very late	Low to medium	Clay,/Clay loam/organic soil	Neutral-slightly alkaline to slightly acidic	Poorly to very poorly drained	Slight saline

3.4.3 Soil sample analysis of project demonstration sites:

To get more location specific details about the soil quality, soil samples from different LACC demonstration sites of the four study area upazilas were analyzed at regional SRDI laboratories (September 2008). The location of these sample sites and the detailed soil analysis results are given separately for each Upazila in Annex III. The analysis reports are summarized in Table 3.5.

As evident form the analysis results the soils from the four upazilas are somewhat different in characteristics and in general deficient in micronutrients. In general

- The organic matter in the soil samples is very low, varying form 1.57 to 3.7 %.
- The nitrogen percentage varies from 0.112 to 0.18. In some samples, e.g. in Terokhada, it is high at 0.662.
- Most of the soil samples are very deficient in potassium content, varying from 0.15 to 0.45 µg/mg soil.

- The Sulphur content in the soil samples varies from medium to high, except in Dacope, where the Sulphur content is very high i.e. > 360 µg/mg soil. The main reason may be regular land inundation with tidal water.
- Like other nutrients, the phosphorous content in the soil samples is low, except in Terokhada, where samples show phosphorous content varying from 8.3 to 30 microgram/mg.
- As far as the soil reaction of the soil samples are concerned, most of the soil samples are slightly alkaline, except in Bhandaria, where few samples are of slightly acidic nature. The high pH of the soil leads to nutrient deficiency in the soils.
- The salinity in the soil samples varies from low to very high. Whereas the soil samples from Nazirpur and Bhandaria are low to medium saline, the soil samples collected from Dacope have very high salt content. Just before the Kharif II season, in most of the soil samples the soil salinity measured is almost double in comparison to soil salinity measured in October, before Rabi season.

Table 3.5 Summary of soil sample analysis from project demonstration sites

Soil Characteristics/ Upazilas	Organic material (%)	Nitrogen (%)	Potassium (me/100gms)	Sulphur (µg/mg soil)	Phosphorous (µg/ mg soil)	pH	Salinity (ds/ m)
Dacope	2.0 to 3.0	0.12 to 0.16	0.15 to 0.30	360+	6 to 15	Neutral to slight alkaline	Very high- in June month double than in October (vary from 7.5 to 18.97)
Terokhada	1.7 to 3.7	0.09 to 0.662	0.15 to 1.58	23 to 73	8.3 to 30	Neutral to alkaline	Less to medium saline (0.75 to 11.7)
Bhandaria	1.9 to 3.4	0.112 to 0.170	0.12 to 0.45	14.2 to 156	2 to 20.2	Slightly acidic to alkaline	Low to medium (0.62 to 5.53- only fro Rabi season)
Nazirpur	1.6 to 3.6	0.103 to 0.182	0.15 to 0.28	11.5 to 195.3	6 to 13.6	Slightly alkaline	Low to medium (0.64 to 7.16)

3.4 Agro-Ecological Characteristics:

The study area falls under the agro-ecological zones 11, 12, 13 and 14 (Figure. 3.6). A major portion of the study area districts suffers from different agro-ecological constraints like floods, river erosion, tidal surge, inundation etc. (Figure 3.7). Their main characteristics are shown in Table 3.6.

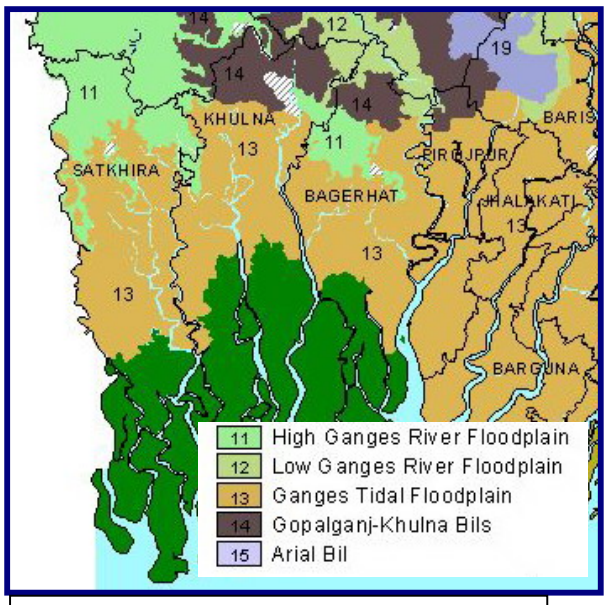


Fig-3.6 Agro-ecological zones of the study area

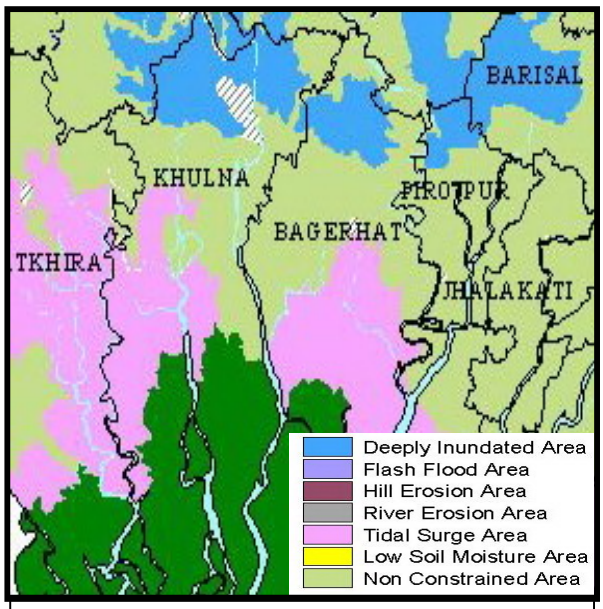


Fig- 3.7 Agro-ecologically constrained area

Table 3.6: Agro-ecological zones of study area upazilas and respective land and soil characteristics

Agro ecological zones	**Upazilas of study area**	**Characteristics**
AEZ- 11- High Ganges river Flood Plain	Terokhada	**Land type**-High land, Medium high land and Medium low land. **Soil** – Clay loam, loam and clay. Organic matter- Medium, organic matter contains decomposed grass and others hydrotropic plant. **Soil fertility class**: Nitrogen very high Phosporous- Medium Sulphur- Low- medium Zinc- Low **Suitable crops**: Boro (HYV), wheat (Rabi), Til (seas am), jute, broadcast aus (local improved), Indian spinach, broadcast aman, (Kharif-I), T. aman (local improved/ HYV) (Kharif-II)
AEZ 12- Low Ganges River Flood Plain	Nazirpur,	**Land type:** Medium high and medium low **Soil texture:** Clay and clay loam **Organic matter:** Medium **Soil fertility class:** Nitrogen-Very low-low Phosphorus-Low-medium Potassium-Medium- optimum Sulphur- Low-medium Zinc- Low-medium **Suitable crops:** Pulse, wheat, Boro(HYV), Broadcast Aus (local improved), jute(tosa), transplant aman (HYV), green

		manure etc
AEZ 13-Ganges Tidal flood Plain	Terokhada, Bhandaria, Nazirpur and Dacope	**Land type:** Medium high **Soil texture:** Loamy **Organic matter:** Medium **Soil fertility class:** Nitrogen-Very low-low Phosphorus- very Low-low Potassium- Optimum-high Sulphur- Optimum-high Zinc- Low-medium **Suitable crops:** Wheat, Boro rice, mungbean, grass pea, chili, bean tomato, mustard, onion, water melon, cowpea (Rabi), Aus(HYV), indian spinach, amaranth (Kharif-I), Transplant aman(local improved), T. aman (HYV), gourd, chili etc (Kharif-II).
AEZ 14 Gopal ganj Khulna Bils	Nazirpur and Terokhada	**Land type:** Medium high and medium low **Soil texture:** Clay **Organic matter:** Medium **Soil fertility class:** Nitrogen-Optimum-high Phosphorus- Low Potassium - Optimum Sulphur- High Zinc- Low **Suitable crops:** Boro(HYV), wheat (Rabi), Til, jute, broadcast aus(local improved), Indian spinach, broadcast aman, (Kharif-I), T. aman(local improved/ HYV) (Kharif-II)

3.6. Soil Salinity:

3.6.1. Soil Salinity in the project upazilas:

Soil and water salinity have been identified as major climatic hazards in the study area, having direct adverse impact on crop production, fishery and livestock. In view of the severity of the problem, a detailed analysis of primary and secondary data collected from different sources has been carried out.

In general, the coastal saline soils occur in the river deltas in a strip of land of a few to 180 km width along the sea coast (Fig- 3.8). In the study area the upstream withdrawal of the Ganges water has increased salinity in the tidal river, decreased surface water availability in the rivers and canals, lowered ground water table and reduced soil moisture content. The degree of salinity in coastal regions varies widely with area and season, depending on availability of fresh water, intensity of tidal flooding and nature of movement of saline ground water. The salinity is causing unfavorable environmental and hydrological situations restricting crop production throughout the

year and other adverse impact on fishery and livestock sectors. The fresh drinking water is also getting scarce in the region due to increased salinity.

In the study area upazilas the problem of salinity in general is very severe and increasing with time. As per the SRDI report- "Soil Salinity in Bangladesh- 2000", published in Nov. 2003, the saline areas of Bangladesh have been classified in five salinity mapping units, depending on salinity content (i.e. S1 to S5, S5 being the most saline). The soil salinity-mapping units along with coverage area of the four study area upazilas are shown in Table-3.6 and Fig-3.9.

The figures in Table-3.7 indicate that among the four study area upazilas Dacope is worst affected by soil salinity, with more than 80% soil suffering from various degrees of salinity. In the upazila above 28% soil is of worst quality, falling under soil salinity unit S5. The second worst affected upazila of the study area is Terokhada, where 61% of the soil falls under salinity unit/category/class S1 to S3. The Nazirpur and Bhandaria, upazilas of the Pirojpur district, also suffer from salinity, but less in comparison to that of Khulna.

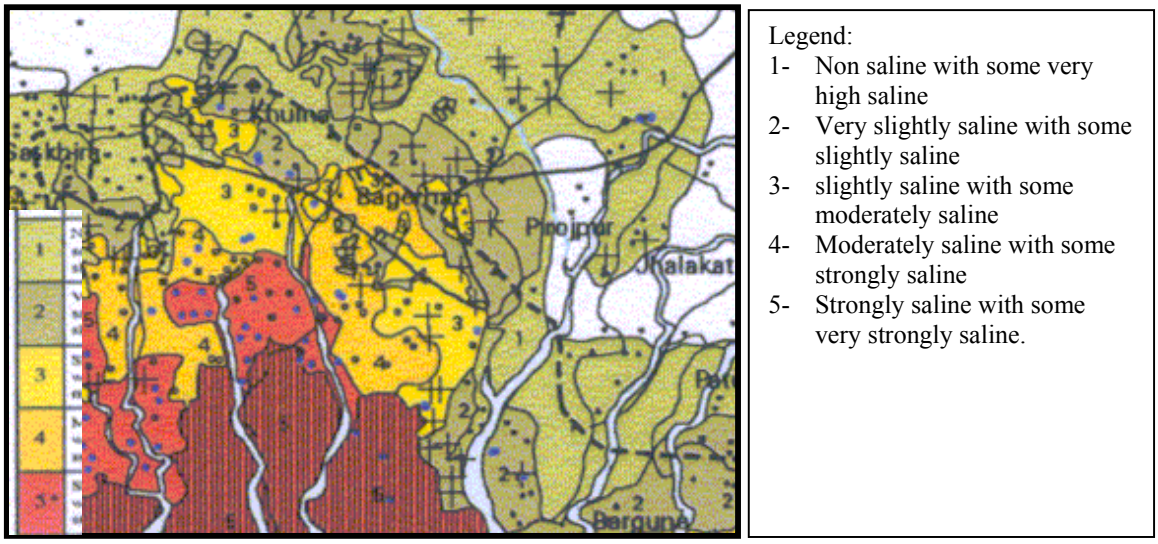


Fig 3.8 General Soil salinity map of study area and surroundings (Source: Climate Change Cell)

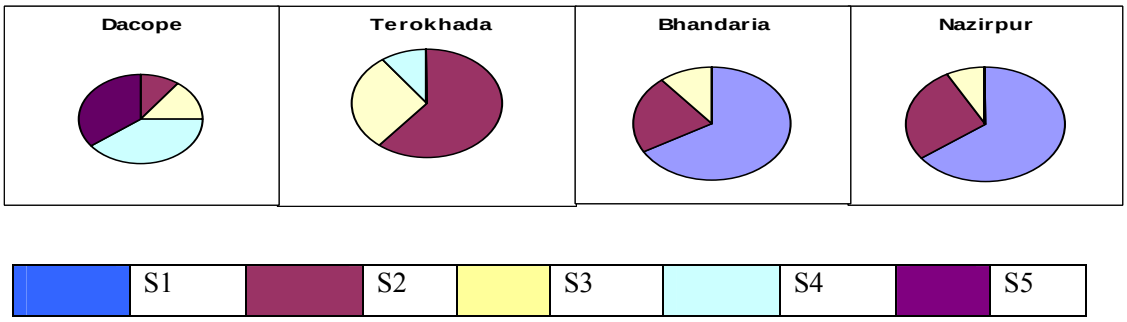


Fig 3.9: Salinity unit (S1 to S5) wise covered area in the four upazilas

Table: 3.7 Soil Salinity map units of four study area upazilas and covered areas

SN	Name of Upazila	Total area (hectare)	Total saline area (hec)	%	Salinity unit (dS/m) wise area distribution (in hectares)				
					S1	S2	S3	S4	S5
					2.0-4.0	4.1-8.0	8.1-12.0	12.1-16.0	>16.1
1	Dacope	28,557	22760	80	0	2280	3410	9100	7970
2	Terokhada	18,769	11410	61	6920	3340	1150	0	0
3	Bhandaria	15,443	4820	31	3220	1070	540	0	0
4	Nazirpur	22897	5590	20	3600	1530	450	0	0

3.7. Recent increase in soil salinity

The most significant observation made in the SRDI report on salinity is the increasing soil salinity trend. According to the figures mentioned in the report, about 0.17 million hectares new land has been affected by various degrees of soil salinity between 1973 and 2000. Due to several reasons, like fresh river water withdrawal from upstream, introduction of brackish water shrimp cultivation, faulty management of sluice gates, regular tidal water flooding in unpolded area, capillary upward movement of soluble salts due to presence of high saline ground water table at shallower depth etc. soil salinity has increased considerably in the study area upazilas. The table 3.8 below shows the increasing salinity trend in the study area districts Khulna and Pirojpur between 1973 and 2000.

Table –3.8: Comparison of soil salinity status between 1973 and 2000 in study area districts (area in 000' hectares) (Source: SRDI report- 2000).

District	**Total Salt affected area (000'ha)**		**Area covered under different soil salinity unit class**								**Salinity Increase over three decades**	
			S1 2.0-40dS/m		S2 4.1-8.0dS/m		S3* & S4 8.1-16.0dS/m		S5 >16.0dS/m		Area	%
	1973	2000	1973	2000	1973	2000	1973	2000	1973	2000	(000'ha)	
Khulna	120	145.3	3.9	28.8	92.5	37.32	13	59.49	9.8	19.61	25.21	21
Pirojpur	20.3	28.64	18.4	19.2	1.9	6.05	0	2.43	0	0	8.34	41

The data in Table-3.8 show an increase in the soil salinity at alarming rate in the two districts during three decades: The main observations are -

- More than 25,000 hectares of additional land in Khulna and more than 8,000 hectares in Pirojpur got affected by salinity.
- More than 24,000 hectares of land, which was non-saline during 1973, has converted into S1 soil salinity category in Khulna district alone.
- In Khulna, there has also been a large increase in the area with S3, S4 and S5 soil salinity units. Around 55,000 hectares of land which was earlier categorized as S2 has become more saline during this period.
- In Pirojpur, between 1973 and 2000 around 2420 hectares of area has been converted into areas with soil salinity units S3 and S4. In addition there has been large increase in the area (more than 4000 hectare) of S2 unit.

3.7.1. Future Projection (increase in salt affected area) –

If the current alarming rate of soil becoming affected by salinity continues, a large area will get affected with soil salinity in both the districts in near future (see Table- 3.9 and Figure- 3.10).

Table-3.9 Future projection about salt affected area in Khulna and Pirojpur districts (based on the rate shown in Table-3.8)

District	Salt affected area in 2000	Increase in salt affected area rate in 5 years (%)	Salt affected area in 2010	Salt affected area in 2015	Salt affected area in 2020	Salt affected area in 2025
Khulna	120	3.5	128.4	132.6	136.8	141.0
Pirojpur	20.3	7	22.8	24.6	25.68	27.1

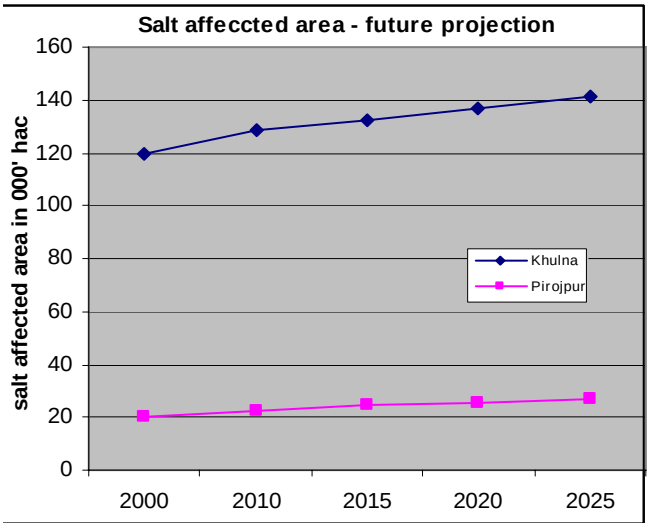


Figure-3.10 Future projection of land affected by salinity in Khulna and Pirojpur
(Source: SRDI Report)

The above prediction is also supported by the area specific field data of soil salinity from Terokhada upazila, which has clearly shown an increase in soil salinity during the last eight years, especially in the months of November to June (Table-3.10). As evident form the data, the maximum increase in soil salinity is observed during the dry season (January to June) (Figure-3.11).

Table-3.10 Soil salinity content from soil samples of Terokhada Upazila for the last eight years (in ds/m)

Year	Jan	Feb	March	April	May	June	Jul- Oct	Nov	Dec
2008	0.8	1.2	3.2	4.3	4.8	1.2	Very less saline	0.3	0.9
2007	1.0	1.2	3.1	3.9	4.6	1.3		0.3	0.6
2006	1.2	1.3	2.9	4.0	4.7	1.2		0.3	0.9
2005	0.9	1.1	2.8	3.8	4.6	0.9		0.2	0.8
2004	0.5	1.0	2.6	3.8	4.5	1.1		0.3	0.6
2003	0.9	0.9	2.5	3.9	4.2	1.0		-	0.4
2002	0.4	0.9	2.5	3.8	4.0	1.0		-	0.4
2001	0.3	0.8	2.2	3.5	4.0	0.8		-	-
2000	0.2	0.8	2.3	3.5	3.9	0.8		-	-

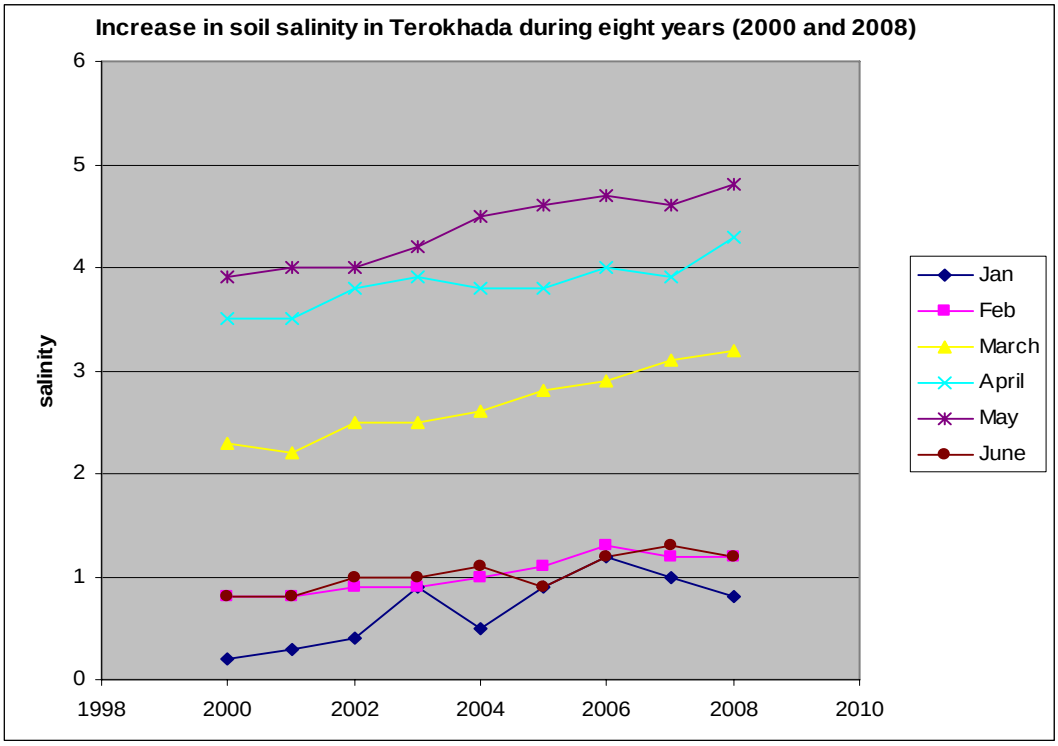


Fig 3.11: The soil salinity data collected from regional office SRDI for the last eight years from Terokhada show increase (60 to 70%) in soil salinity during the dry season (between January and June)

Though no specific information is available about the project sites regarding salinity increase, the general perception of the community is that the salinity has increased tremendously during the last twenty to thirty years. It is a common observation among the farmers and other rural community members that land which used to be fertile in the past has turned into barren due to salinity. The high salinity is also very much evident from the soil samples collected from the LACC project demonstration sites.

3. 8. Floods and water inundation

The study area is part of the flood plain and the risk of flooding always prevails. Due to the close proximity to the coast of Dacope and Bhandaria Upazilas the flood water from these upazilas usually flows down to the sea quickly. However, during the months when the upward pressure of water from the sea due to the high tides or upsurge coincides with upstream flood water, the flood water inundates the region for a longer period. As a result of the large numbers of rivers in both the study area districts, some parts of the area are vulnerable to water logging in the monsoon

period and saline intrusion in the following months. In the study area, most of the lands are medium high land and medium low land. The land area flooded at various degrees during Monsoon in all the four study area upazilas is shown in the following table (Table 3.11).

Table-3.11 Area of flooded land in the four study area upazilas

Name of Upazila	**Never flooded area (ha)**	**Flooded < 90 cm (ha)**	**Flooded between 90 and 180 cm (ha)**	**Flooded >180 cm (ha)**
Nazirpur	610	3728	7530	5879
Terokhada	416	4080	12870	3807
Bhandaria	775	2244	5956	0
Dacope	390	22652	0	0

As evident from the above table, a major portion of the land in the study area is flooded during Monsoon. The flood water remains in the area for quite a long period (in some areas up to December) and starts receding only once Monsoon is over. The percentage of land affected by inundation by flood water receding water in the study area districts is shown in Table-3.12.

Table-3.12 Percentage of flooded land and water receding between October and December in the study area districts of Khulna and Pirojpur:

District	% of flooded land		Flood water receding (in % area inundated)		
	Flooded up to 90 cm	Flooded >90cm	Within Oct.	Nov to Mid-Dec.	Late Dec.
Khulna	70	25	9	61	30
Pirojpur	75	16	21	20	59

3.9 Surface and Groundwater situation

The surface water bodies in the regions are in the form of rivers, canals, ponds, beels and shrimp ponds. Perennial water bodies, quite numerous, are used as alternative sources of irrigation water during the dry periods. Canals are generally connected to the rivers during monsoon season, which preserves water mostly in the monsoon season. In the region there are some government owned ponds which are leased for fishing and also serve for irrigation during the dry season. All

the upazilas have small and big rivers spread all over the region, which in most of the cases are connected with sea water and are affected by low and high water tides. In all the upazilas saline water intrusion is controlled to enter the agriculture land by using sluice gates.

The quality of the surface water in general is good during the wet season. However, in the dry season more than 50% surface water is of poor quality (SRDI-2000). In the study area, the Dacope and Bhandaria upazilas surface water bodies are worst affected by salinity. The water logging is another major problem in the region. Among the study area upazilas the situation is worst in Terokhada and Nazirpur upazila, where more than 76% and 60-70% respectively of the area is low lying and flooded by water depth of more than 90 cm. . In Dacope and Bhandaria upazila also large parts of the land are water logged. In Terokhada upazilas most of the rivers and rivulets are shallowed due to high rate of siltation and are flooded even with small water discharge.

The ground water table level in the study area is not uniform and varies from upazila to upazila. In most cases groundwater is of poor quality and usually unsuitable for crop irrigation. The SRDI report "Soil Salinity in Bagladesh-2000" indicates that on an average ten percent of the ground water is of good quality, 10% is of medium and the remaining 80% is of poor quality. The deep tube well ground water in the region is usually good in quality (78% good, 16% medium and 6% poor quality). Despite deep ground water being of good quality, the high costs for establishing deep tube wells does not make it feasible source of irrigation.

Not only for irrigation, pure drinking water is scarce, especially in Dacope and Bhandaria upazilas, and the community has to depend on rainwater harvesting or purification of the river, canal and pond water for making it drinkable. In areas near to the sea coast, the underground water is polluted by sea water intrusion. This intrusion of saline water is common in many villages of Dacope upazila.

3.10. Water salinity

Along with the soil, the surface as well as ground water in the study area upazilas is also adversely affected by salinity. The surface water in the areas mainly comprises river and canal water, and water in shrimp cultivation fields, locally called 'Gher'. The main characteristics of the surface and ground water mentioned in the SRDI report are:

- In general almost all the river/canal water in the region is extremely saline in dry season and not suitable for irrigation.

- In dry season, on average 48% of the river/canal water samples are of good quality, 6% are of marginal quality and 56% are of poor quality.
- Chemical data indicates that almost all the *gher* water is of poor quality.
- On average, 10% ground water samples at shallow depth are of good quality, 10% are of marginal quality and 80% are of poor quality.
- On average, 78% shallow tube well water samples are of good quality, 16% are of marginal quality and 6% of poor quality.
- On average, 63% deep tube well water samples are of good quality, 37% are of marginal quality and no deep tube well is found of poor quality.

In the study area, the water salinity problem is most evident in Dacope, Bhandaria and Terokhada upazilas. The water salinity is maximum in the months of March, April and May and is decreasing once the Monsoon has started. Salinity test results of river water from Dacope and Bhandaria upazilas collected during the months of March and April is given in Table-3.13. They show that the degree of surface water salinity differs from area to area. The Rupsa River is showing maximum salinity during this period, whereas water of the Ponakhal river of Bhandaria is not much affected.

Table-3.13 Water salinity analysis data from four river sites of Dacope and Bhandaria upazilas (water sample collected during the months of March and April, from January 1999 to December 2008 for Khulna and from January 2002 to December 2007 for Pirojpur.

River	**Union/ upazila**	**Salinity (ds/m)**	**Comments**
Rupsa river	Jhalgate/ Dacope	13.1- 19.4	Very harmful
Kacha river	Telikhali / Bhandaria	3.27	Very harmful
Kacha river	Nodmula / Bhandaria	2.45- 2.60	Harmful
Pona khal	Ikri / Bhandaria	0.62	Safe

The surface water in most of the water bodies in Terokhada upazila is affected by salinity during dry season. Table-3.14 shows the salinity of the water samples collected from different rivers/ canals of Terokhada upazila during dry season.

Table-3.14 Surface water salinity in Terokhada

Source of water	**Sample collection area**	**EC (DS/m)**	**Salinity classes**
Chittra river	Terokhada	1.0	Not very harmful
Chittra river	Kodla	1.5	Not very harmful

Atharobaki river	Harikhali	2.9	harmful
Atharobaki river	Kamarul	1.1	Not very harmful
Atai river	Kola	3.7	More harmful
Atai river	Kola	2.9	harmful
Bashkhali canel water	Kola	3.5	More harmful

The quality of ground water is also very much affected by salinity in the study area upazilas. Table 3.15 provides the results of water samples collected from Terokhada upazila and gives an idea of the ground water salinity.

Table 3.15.-Ground water salinity of Terokhada upazila

Source of water	**Sample collection area**	**Sl no for water sample**	**EC (DS/m)**	**Salinity class**
Deep tube well water	Madhupur Bazar	58	3.5	More harmful
Deep tube well water	Terokhada	59	2.5	Harmful
Deep tube well water	Kodla	60	1.0	Not very harmful
Ground water	Katingga	8	0.8	Not very harmful
Ground water	Atlia	12	1.3	Not very harmful
Ground water	Malikpur	32	2.8	Harmful

3.11. Recent increase in water salinity-

The increase in surface water salinity during the last years is a common observation of the affected people in the study area. This perception is confirmed by the water sample analysis data from the study area districts. However, the increase in water salinity is not uniform across time and space (see Table-3.16 and Table-3.17). The tables indicate the water salinity data from two main rivers of the region in different years and different months. The analysis of salinity data indicates:

- Water salinity data of the last ten years from the Jhalgate site of Rupsa River, Dacope upazila (Table-3.16) clearly indicate remarkable changes in water salinity (much higher during the dry months, i.e from December till June).
- During the last ten years the water salinity in the Rupsa River has increased more than double in the dry months.
- In Rupsa River during the year 1999, the salinity in the month of February was almost negligible, but in 2008 the river water salinity is quite high during the same month.

- Although the water salinity in Kacha River in Bhandaria is comparatively low in general, during the month of March and April it crosses the safety limit to be useful for irrigation and other purposes.
- The water salinity data for the last six years from the *Kacha* River, *Charkhali* ferryghat of Bhandaria upazila, (Table-3.17) also show an increasing trend in salinity, especially during the months of March of April.

The water sample analysis of river Pashur, Dacope upazila, launch ghat for the last nine years also show increasing trend in water salinity, though not so prominent.

Table-3.16 Last ten year water salinity data from Rupsa River – district Khulna (technical Report of SRDI) in Ds/m

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	1.7	7.9	13.1	19.4	22.0	4.1	0.4	0.5	0.25	0.38	0.5	0.7
2007	1.0	4.6	15.5	22.2	27.7	4.9	0.3	0.5	0.2	0.4	0.5	0.8
2006	0.8	3.9	14.7	23.3	24.9	0.4	0.4	0.3	0.6	0.4	0.5	0.6
2005	0.6	3.2	9.0	13.5	21.8	14.4	0.32	0.39	-	-	0.45	0.53
2004	0.4	2.9	11.3	16.4	25.5	0.6	-	-	-	0.3	0.4	0.5
2003	1.6	3.6	13.7	12.7	20.3	6.4	0.3	-	-	0.31	0.9	0.5
2002	0.4	1.4	7.4	18.1	17.1	0.3	0.3	0.2	0.3	-	-	-
2001	0.4	1.2	6.5	11.2	14.6	0.3	-	0.3	0.3	0.3	0.3	0.3
2000	0.4	1.2	6.3	10.7	14.3	0.2	-	0.2	0.3	0.3	0.3	0.3
1999	0.4	1.1	6.2	10.5	14.4	0.3	-	-	0.3	0.3	0.3	0.3

Table-3.17 River water salinity for six years for Charkhali ferryghat, Kacha River, Bhandaria, Pirojpur (Ds/m)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2007	0.81	0.89	2.45	2.6	1.05	0.63						
2006	0.66	0.94	1.05	1.2	0.75	0.58	0.32	0.26	0.23	0.2	0.38	0.62
2005	0.98	1.25	1.3	1.82	1.15	0.82	0.33	0.3	0.24	0.26	0.35	0.52
2004	1.15	1.24	1.33	1.48	0.96	0.53	0.4	0.32	0.26	0.24	0.28	0.65
2003	1.1	1.15	1.2	1.36	0.61	0.48	0.33	0.28	0.21	0.3	0.37	0.88
2002	0.94	1.2	1.32	0.85	0.92	0.6	0.38	0.3	0.24	0.22	0.45	0.72

3.12 Tidal effect

The effect of the tides is manifested in a regular alteration in rise and fall of the water level of the sea and the tidal channels and creeks. The high tides from the twelfth to full moon or moonless periods and from the first and fifth day of the lunar fortnight inundate the coastal area. The high tide during the summer rises up to 1.3 meter above ground level. On the East coast of the Sundarbans, the highest tide could inundate the lands with depth up to 2.0 meters in the absence of bunds.

3.13. Agriculture land use

The agricultural land use and cropping patterns of the study area are generally dominated by the rice crop and other crops suitable to the coastal and saline soil. The agricultural practices of the upazilas are largely determined by the hydro-meteorological characteristics, geographical location and over all coastal features like soil and water salinity, tidal flow, upsurge etc. As a consequence, a large portion of cultivable land remains either fallow or used for single crop.

Similar to the standard cropping seasons of the country, the study upazilas have three cropping seasons in an annual crop calendar i.e. *Rabi* (October – February), *Kharif-I* (February – June) and *Kharif-II* (June – October). In *Kharif–I* season *Transplanted Aus* (T. Aus) rice is the main crop and farmers usually cultivate local varieties, but the coverage of the HYV varieties is increasing steadily. Farmers prepare the seed bed near the pond or canal side where they can get fresh irrigation water. In some year's, if the monsoon rain begins late, the transplantation is delayed and the farmers have to incur yield losses. *Kharif-II* season is dominated by rain fed *T. Aman* rice that covers more than 80% of the area. In Dacope and other upazilas, transplantation of the *T. Aman* continues until the end of September and sometimes beginning of October. Such delay is caused by the slow recession of floodwater. During *Rabi* season, a small amount of land is cultivated with high yielding irrigated *Boro* rice, where ground water irrigation facilities are available. In such areas about 10-15% of the land is used to grow petty cash crops like potato, sweet potato, mustard, sesame, pulses, watermelon and other types of vegetables. In some areas of Bhandaria and Nazirpur farmers build seasonal dams across the local canals towards the end of the Kharif-II season to preserve fresh water for subsequent irrigation for the Rabi crops.

Rice is the major crop of the area cultivated throughout three seasons like *aus* in early monsoon, *aman* in monsoon and *boro* in winter of the year. Other crops are also cultivated but some lands are left fallow for few months in the year. The present main agricultural land use in these areas is listed below:

- Fallow-fallow-transplanted aman.
- Fallow-broadcasted aus/transplanted aus-transplanted aman.
- Wheat/chickpea/mustard-broadcasted aus/jute-transplanted aman.
- Fallow-mixed broadcasted aus and aman.
- Boro-fallow-transplanted aman.
- Grass pea-broadcasted aman.

- Sugarcane/banana/turmeric.
- Boro-deep water transplanted aman/ broadcasted aman.
- Rabi crops-fallow-transplanted aman.
- Boro-fallow-fallow.

Rabi crops include lentil, mustard, gram, khesari, linseed, watermelon, felon, chili, wheat, sweet potato, potato, sunflower, cowpea, onion, garlic, aram, Rabi vegetables and HYV and local boro. Some annual and perennial crops such as banana and sugarcane are also cultivated. Recently HYV/local boro cultivation has been practiced followed by sweet water shrimp, such as lobster in considerable area of peat basin. Besides Rabi crops transplanted aman, broadcasted aus and aman, seasame, jute are the major crops of the region. The land use pattern of all four upazilas, categorized as single, double and triple cropped area is shown in following Table- 3.18 (area in hectares).

The data in Figure-3.12 and Table 3.18 indicates:

- Most of the land in all four upazilas is used for double cultivation. In Dacope about 74% of the land is double cropped, followed by Nazirpur, Bhandaria and Terokhada. In these three upazilas more than 50% of the land is used for double cropping.
- The agriculture land use is lower in Bhandaria and Terokhada upazilas, where about 40-45% of the land is under single cropping pattern. During other seasons the land remains fallow due to various reasons.
- There is limited agriculture land area in Dacope and Bhandaria upazilas where farmers could cultivate three crops in a year.
- The situation is comparatively better in Nazirpur upazila, where about 25% land is used for triple cropping and more than 50 % for double cropping.

Table-3.18: Single, double and triple cropped cultivable land distribution in four upazilas

UPAZILA	Single cropped	Double Cropped	Triple Cropped
Dacope	5265	13910	580
Terokhada	8954	13206	2430
Bhandaria	4251	5510	260
Nazirpur	3500	9900	4152

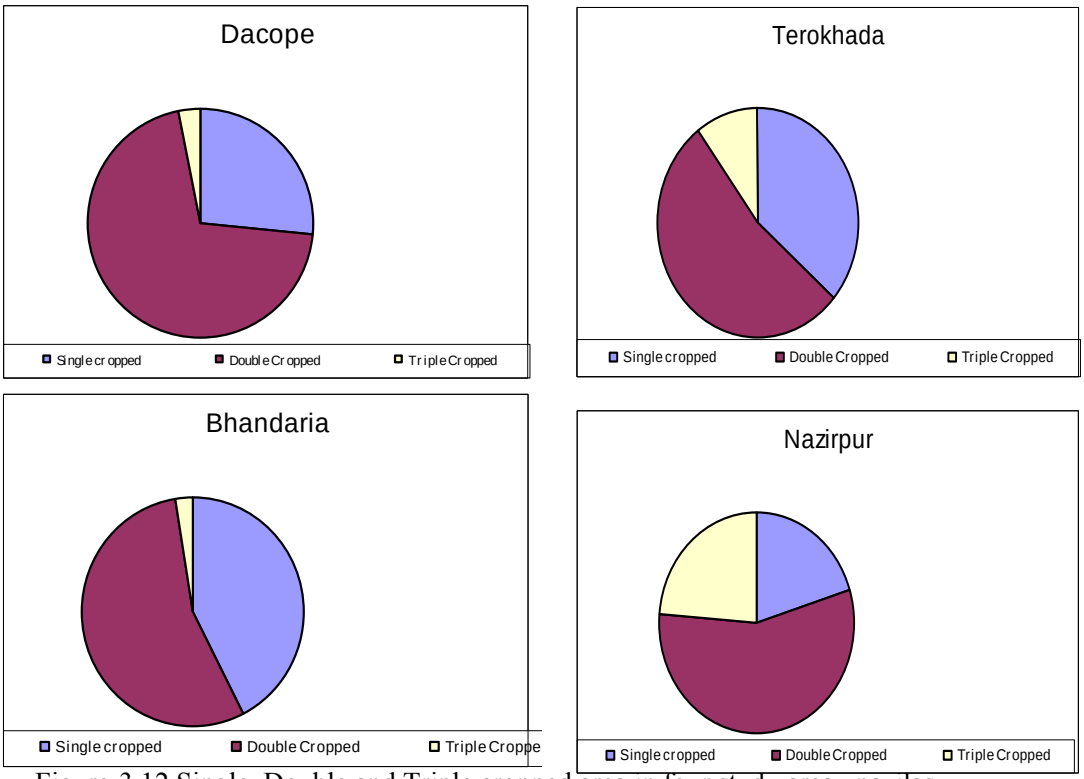


Figure-3.12 Single, Double and Triple cropped area in four study area upazilas

3.13.1. Change in land use pattern:

In the study area land use pattern is changing with time. In the Nazirpur area the farmers adopted new patterns, as for example they were cultivating one or 2 crops per year (10-20 years ago), but now they are cultivating 3 crops in a year. While previously most of their land was unutilized or fallow in the Rabi/Boro season, they are now applying new or changed agricultural practices, such as cultivation of boro rice, grass pea after T. Aman harvesting, mung bean after grass pea harvesting, potato cultivation by zero tillage, tomato, brinjal and other vegetable cultivation at large scale and in homestead area. They also increasingly apply the *Sarjon method*, which means they cultivate rice, fish and vegetables simultaneously in one unit area. This practice is very

common in this area and in fact one suitable adaptation option. In some areas the farmers practice floating vegetable gardening, on water bodies using water hyacinth and other raw materials to grow vegetables seedlings. So, the farmers of this area have started to change their cultivation practices as well as land use patterns to face and adapt to negative impacts of climate change and other socio- economic factors.

The analysis of the figures of land use pattern during the last twenty years in the Pirojpur district and its project upazila Bhandaria, enlisted below, illustrates the change in agriculture land use pattern.

Table-3.19: Change in land use pattern in total Pirojpur district and its upazila Bhandaria (between 1984 and 2005)

Description	Pirojpur district			Bhandaria upzila		
	1984	1996	2005	1984	1996	2005
Number of holdings	132499	154403	196233	18818	21234	23960
Number of Agricultural Laborers	40647	39711	27880	5516	4578	3066
Homestead area (acre)	9124	9120	10360	1792	1047	1139
Net cultivated area (acre)	217882	207156	218881	30408	27340	25718
Gross cultivated area (acre)	259203	243450	240999	39496	28406	32840
Cropped area (HYV aus) (acre)	20417	8552	7783	400	893	778.3
Cropped area (HYV aman) (acre)	4895	8877	10398	204	561	657
Cropped area (HYV Boro) (acre)	6093	14178	24107	87	15	26

- The total number of land holdings increased in the Pirojpur district as a whole and as well as in the Bhandaria upazila, indicating much pressure on land resources.
- There is a significant decrease in agriculture labour force both in Pirojpur and Bhandaria.
- The net cultivated area remained almost same in the district whereas in the Bhandaria upazila it has decreased in comparison to 1984.
- The gross cultivated area has decreased both at upazila and district level in comparison to 1984.
- The homestead area in the overall district has slightly increased, whereas in the Bhandaria upazila it has decreased a little.
- There has been a decrease in the overall HYV Aus cropped area and an increase in HYV cropped Aman cropped area. The HYV Boro cropped area has also increased in the Pirojpur district.

3.14. Problems related to fallow land:

As discussed above, a large part of the cultivable land in the area remains fallow in different cropping seasons due to various reasons. The season wise fallow land distribution of all the four upazila is shown in Table- 3.20 and Figure- 3.13.

As evident from the table, the maximum land remains fallow in Dacope upazila followed by Bhandaria. The area of fallow land varies from season to season and region to region. In Dacope and Bhandaria upazila most of the cultivable land remains fallow during Rabi season, whereas in Terokhada it is during Kharif II and in Nazirpur during Kharif I. Topographically, the medium low land is the area that remains fallow most of the time.

Table – 3.20: Fallow land distribution in different cropping seasons in the project upazilas

UPAZILA	**Kharif I**	**Kharif II**	**Rabi**
Dacope	7162	675	18628
Terokhada	1135	2334	1260
Bhandaria	2924	145	5674
Nazirpur	2230	1240	550

Figure-3.13: Graphs showing fallow land distribution during different cropping seasons in four study area upazilas

3.14.1. Reasons for land lying fallow-

The main reasons for cultivable land lying fallow in the area are listed in the following.

a. Fallow lands during Rabi season: main reasons

- Poor water holding capacity of the soil
- Scarcity of irrigation water due to siltation of canals and rivers
- In most of the cases, early tide water inundates fields with mung bean, chili, sesame, and ground nut crops during fruit setting and causes damages to theses crops. Farmers therefore are not interested to cultivate these crops and thus let the land remain fallow.
- A large percentage of land remains inundated by tide water starting from the months of April and May to December.
- There is a risk of extreme tide water inundation and highest water level in the month of August. Farmers cultivate local T. Aman late and harvest up to the middle of January. Therefore, there is little scope to cultivate Rabi crops.
- Due to the short winter duration, there is little scope for winter crop cultivation.

- Salinity of river/canals increases in the months of March and April and the water is not suitable for irrigation.

b. Fallow lands during Kharif-I & kharif-II season: main reasons

- T. Aus cultivated in medium high & low lands is inundated before ripening and damaged by tide water.
- In this area, farmers cultivate T. Aus and T. Aman by tide water or rain water. If they fail to transplant in due time with tide water, they have to wait for 15 days and lands remains fallow.
- There are only 60-70 days in between Boro and T. Aman rice; there is no scope for Rabi crops production.

c. Socio-economic reasons

- Faulty land leasing patterns.
- Land used as grazing grounds for free grazing of animals is another important reason of fallow lands in Rabi season.
- Lack of technological knowledge (modern cultivation methods, HYV crop varieties, fertilizer management).

3.14.2. Possibility to cultivate fallow lands

- There is scope to cultivate *Khesary*/pulse crop in high lands as relay crops, which could cover a large land area during Rabi season.
- In the project areas, farmers cultivate local varieties of mung bean, sweet potato, chilli, okra, sweet gourd, white gourd, water melon, khira, tomato, red amaranth etc immediately after harvesting of T. Aman. So, there is scope to introduce improved, more salinity resilient varieties of the above crops such as Bari mung-5, 6, BINA mung-5, BARI sweet potato-4,5, 7, BARI Morich-1, BARI tomato-2,3 BARI lalshak-1.
- Introduction of modern technologies of crop production, including appropriate irrigation facilities, as well as ICM/IPM can enhance the productivity of crops cultivated in land otherwise left fallow.
- By constructing small check dams in the month of November, saline and tide water intrusion may be restricted and land may be used for cultivation.
- In the Fallow—T. Aus—T. Aman and T. Aus-T. Aman—Relay with *Khesary* (grass pea) pattern, there is scope to introduce HYV such as BR3, BR26 & 27 instead of local varieties.

- Irrigation management in T, Aus season can also ensure timely transplanting and harvesting of T. Aus which ultimately reduces the fallow land areas in Rabi season.
- The use of the Sarjan method may also reduce the fallow land area to some extent.

3.15 Climatic parameters

The different climatic parameters like temperature, rainfall, humidity, wind speed etc. of the study area as a whole can be summarized as follows:

- The mean annual total rainfall of the study area varies between 1400 and 1500mm, whereas dry season rainfall is only 18 to22% of the mean annual rainfall.
- Annual total evapo-transpiration in the study area varies between 1245 and 1350 mm.
- The mean annual temperature is around 25^0C and varies between 16 and 35 ^{0}C. Highest temperatures are generally observed in the months of April and May (39 °C) and lowest in the month of January (7 °C).
- The relative humidity remains high throughout the year. It ranges from 60% to 90%; it is highest in the rainy season and lowest in the dry season. Mean annual humidity is around 72% and sunshine hours range between 6.5 and 7 hours.
- Mean wind speed is 90kpd and high wind speed (155kpd) is observed in the months of May and June. Sudden gusty wind in the months of April-May sometimes causes damage to sesame, sweet gourd, water melon and *boro* crops.
- The area is subject to tidal bore, and occasionally large areas become flooded with saline water. Storm effects are normally smaller in the northern parts of the Sunderbans due to dense vegetation and absence of crops and settlements.
- Evaporation is highest between March and May and lowest between December and January. Evaporation is higher than the rainfall during the period of November till April.

3.16 Long term changes in climatic parameters:

There are about 36 BMD hydro-meteorological data collection stations in Bangladesh to collect rainfall, temperature, evaporation and sunshine duration data. In the study area here is a station in Khulna. However, long term data from the Khulna station is available only in raw form. The nearest stations, for which cleaned climatic data is available, are Jessore and Chandpur. In the report prepared by BUET for Climate Change Cell, MoEF ("*Characterizing Long-term changes*

of Bangladesh Climate in context of Agriculture and Irrigation, March, 2008"), a detailed analysis of the climatic data has been made for eight stations, including Jessore and Chandpur. The main findings of the analysis in the context of these two stations are summarized in the succeeding text.

3.16.1. Changes in Rainfall Pattern - To see the long term trends in mean rainfall, the data available (1961-2001) is divided in two halves, each with 21 years of record, i.e.1960-1980 and 1981-2001 (Annex IV Table I and Figure 3.14). The results indicate:

- Monsoon rainfall has decreased at both stations.
- The mean rainfall in winter has increased at Jessore (the 1960-80 data for Chandpur is not available for winter rainfall) in the second half of the available time series compared to the first half.
- The summer, the critical period for rainfall, is also showing an increasing trend at both stations.
- The linear trends in rainfall per decade for both the stations at different seasons for the entire time series (1960-2001) are shown in Annex IV (Table II). The decadal trend was estimated by multiplying the annual trend with the number of years. It is clear from the table that there is an increasing trend in rainfall at both the stations during the summer and winter. There is a general decreasing trend at both the places for the monsoon.
- The monthly rainfalls (Annex IV, table III and Figure 3.15) show a decreasing trend for the monsoon during earlier months of the season and an increasing trend during the later months. The main observations made for the monthly rainfall are:
    - For the month of May there has been an increasing trend at both stations.
    - For the months of June and July, which are the months of high rainfall, there has been a decreasing trend at both stations.
    - For the month of September there has been an increasing trend at Jessore and a decreasing trend at Chandpur.

This intra-year variability in the trends suggests that monsoons may have weakened in the earliest months of the season and strengthened during the later months. The transplanting of the Aman rice during the period of mid – July to mid- August could be delayed or negatively affected by this shift in rainfall pattern.

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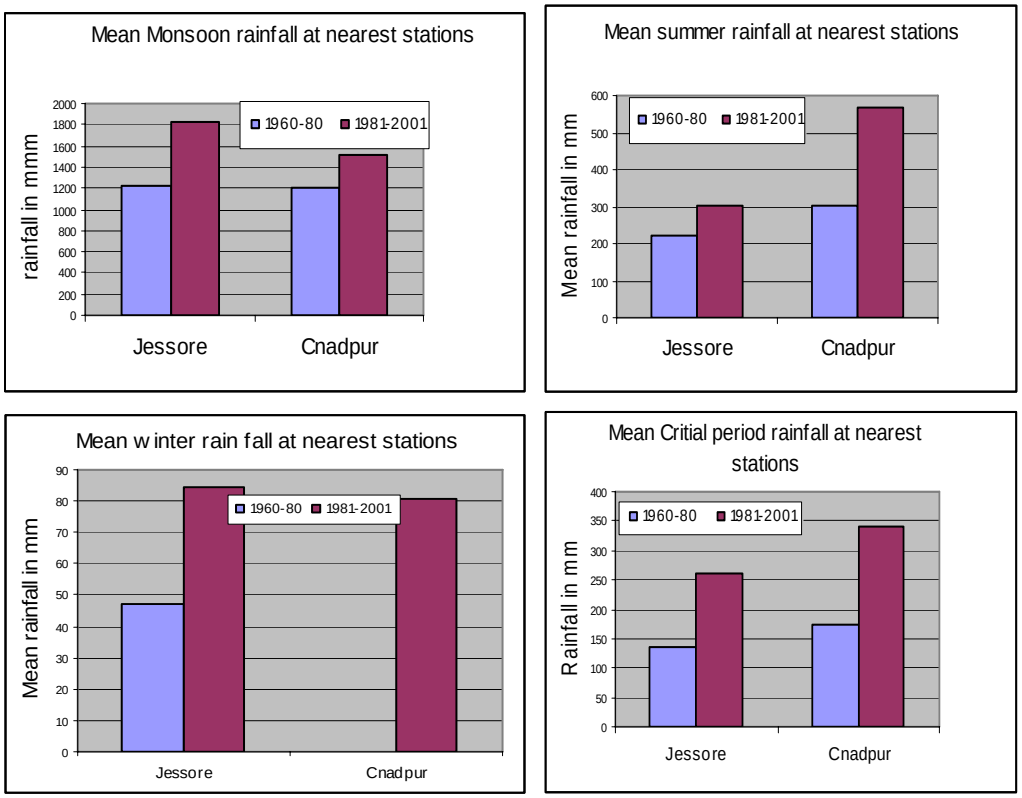


Fig 3.14- Comparison of different rainfall data at two neighboring stations of the study area (Source- Climate Change Cell)

This could negatively affect the Aman rice production in the region.

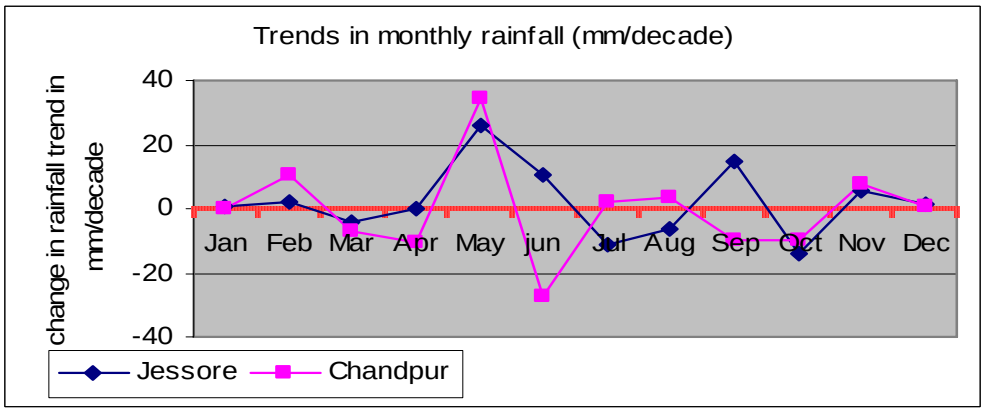


Fig- 3.15: Trend in monthly rainfall at the two stations near the study area. The red line shows the normal rainfall (Source- based on information from Climate Change Cell).

3.16.2. Trend in Temperature- To understand the trend in temperature, the Climate Change Cell report analyzed the trend (change from the normal) in 10- days average of maximum and minimum temperatures (Annex IV,Table IV and Figures 3.16 and 3.17). The results indicate the following:

- There is an increasing trend in the maximum temperature during the summer but a decreasing trend in winter maximum temperature at both stations.
- At Jessore the trend is increasing from March to December and decreasing during the months of January, February and March.
- At Chandpur, the trend is increasing from June to December (except during September, whereit has been decreasing slightly).
- The trend during winter in general is negative (except little increases during February, March and April).

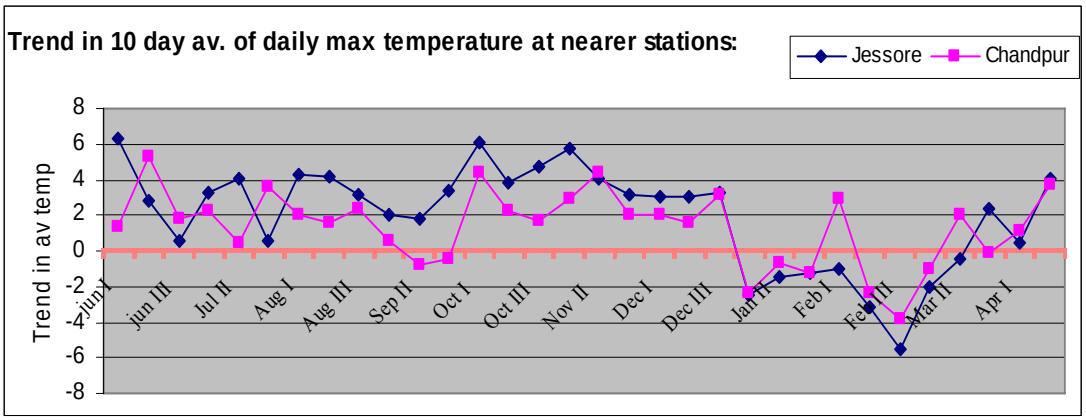


Figure 3.16: Trend in 10 days average of daily maximum temperature in different months at two neighbouring stations of Jessore and Chandpur. The red line in the centre show the normal temperature during the months; X-axis: trend in average temperature and Y – axis: months (Source- based on information from Climate Change Cell)

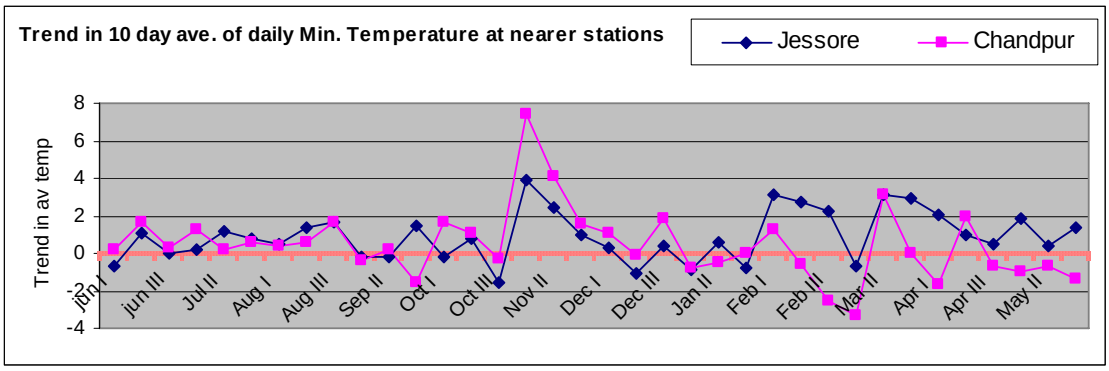


Figure 3.17: Trend in 10 days average of daily minimum temperature in different months at two neighbouring stations of Jessore and Chandpur. The red line in the centre show the normal temperature during different months; X-axis: trend in average temperature and Y- axis: Months (Source- based on information from Climate Change Cell)

3.16.3. Sunshine- To get an idea about the sunshine duration trend, the available records were divided into three time spans: 1961-75, 1976-90 and 1990-06. The average sunshine duration during each of these time spans for each of 36 ten-day periods was calculated and for Jessore it is shown in Figure-3.18. The figures indicate a decrease in sunshine duration at Jessore from 8.99 hours a day to 5.84 hours a day in the span of forty years (1961-75 and 1991-2006).

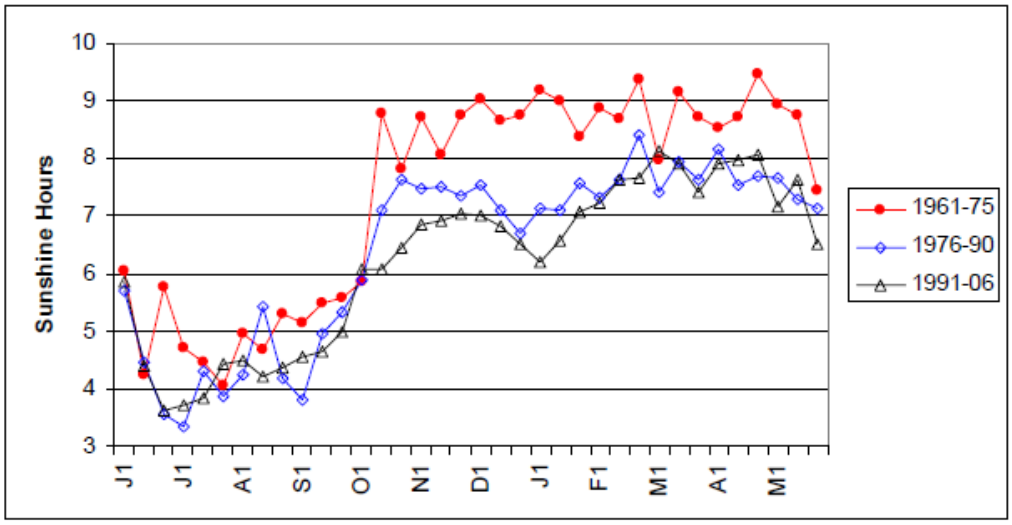


Fig- 3.18 Average ten days sunshine duration (in hrs/day) in three different time spans at Jessore (Source–Climate Change Cell)

3.16.4. Evaporation- To see the long term changes in evaporation, the available data was divided into two periods, i.e. 1964-80 and 1981-98. The average decadal evaporation at Jessore for both periods indicates that the evaporation rate is generally decreasing (Figure 3.19), the reason for which may be the reduction in sunshine duration.

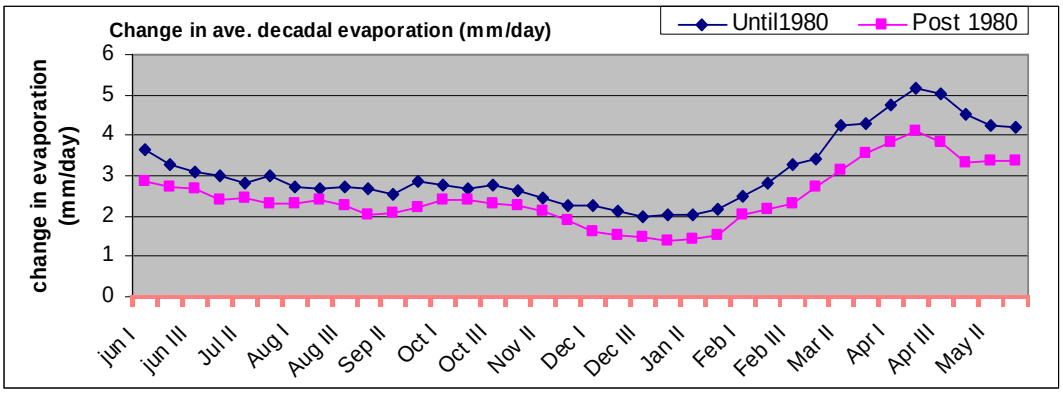


Figure: 3.19: The change in average decadal evaporation in mm/day before 1980 and post 1980; X axis: change in evaporation and Y- axis: months (Source-based on information from Climate Change Cell).

4- CLIMATE CHANGE IMPACT IN COASTAL REGIONS OF BANGLADESH

After having looked at the changes in climatic parameters in the last decades the present Chapter provides a synoptic analysis of various types of future anticipated risks that are likely affect at different timescales the country in general and the coastal areas of Bangladesh where the LACC-II pilot areas are situated. Data and information from various secondary sources of related parameters at regional, national and sub-national scales are reviewed for framing the future anticipated risks of the LACC-II project pilot areas.

There is a host of studies available that talks about the future and anticipated climatic risks of Bangladesh and the coastal zone in a generic manner but often these publications are based on a limited number of original research studies. Therefore, the present Chapter focuses on a "core set only recently published original research works". Some of the data that are published from authentic sources are thereby used in this Chapter.

For understanding the patters of rainfall and temperature in future contexts the "Preparation of Look-up Table and generation of PRECIS scenarios for Bangladesh (November, 2008)" study report submitted by Bangladesh University of Engineering and Technology (BUET) is consulted with other relevant reports. This report is also published jointly from the Climate Change Cell (CCC), DoE. The UK IDS supported ORCHID report titled "Piloting Climate Risk Screening in DFID Bangladesh: Detailed Research Publication (IDS: April 2007) is also consulted for bringing some additional latest information.

The Sea Level Rise (SLR) and water salinity related information are adopted from a latest available (June 2007) study titled "Investigating the Impact of Relative Sea-Level Rise on Coastal Communities and their Livelihoods in Bangladesh" UK Department for Environment Food and Rural Affairs carried out by two lead Bangladesh government trust agencies: Institute of Water Modeling (IWM) and Center for Environment and Geographic Information Services (CEGIS).

4.1 Analysis of future anticipated risks

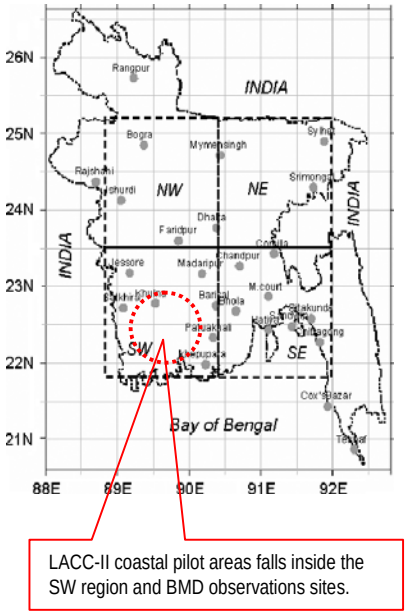
4.1.1 Rainfall and Temperature

The regional climate modeling system PRECIS (Providing REgional Climates for Impacts Studies) has recently been run to project the future rainfall and temperature situations. In a recent study carried out by BUET (BUET, Nov. 2008) projections for rainfall and temperature in 2030, 2031, 2050, 2051, 2070 and 2071 have been generated using ECHAM4 SRES A2 emission scenarios as the model input. PRECIS model run has provided results for the whole country based on the BMD observation areas and region. The LACC-II project pilot upazilas fall under the Southwest Region (SW) from this grid thereby the results can justified for the pilot upazilas (see graph).

Rainfall

The PRECIS model sets a figure of 6.78 mm/d for the annual average rainfall in the baseline period (1961-1990) in the country. PRECIS model results indicate that the annual average rainfall in year 2030 will be 6.93 mm/d, in year 2050 it will be 6.84 mm/d, and 7.17 mm/d in the year 2070.

An important finding was that in Bangladesh, the average rainfall during monsoon and post-monsoon periods will increase whereas in dry season it will remain close to historical amount. Rainfall during the pre-monsoon period is anticipated to fluctuate in different years as well.



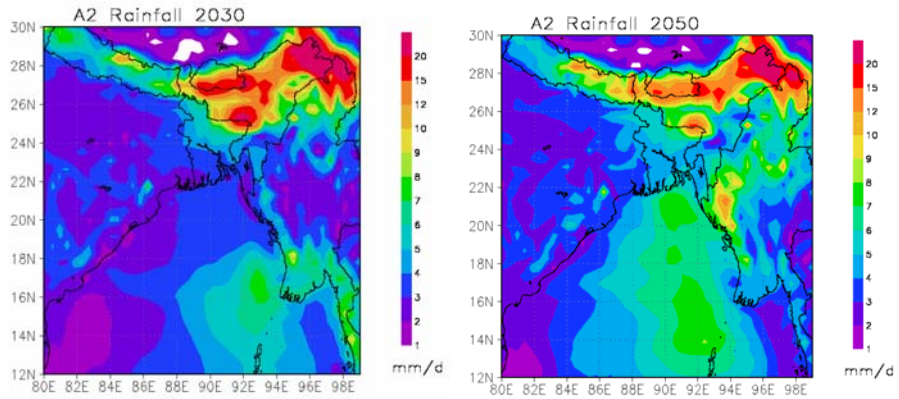
The PRECIS model outputs indicated that the monsoon rainfall will increase in all years and from 2051 to onwards its surplus amount is large. It will remain almost same in 2030 and 2050. Importantly, large amount of rainfall is projected in August for all years except its deficit in 2030.

In terms of percentage of changes of rainfall from the observed baseline period, this is likely to increase about 4% (in 2030), 2.3% (in 2050) and 6.7 % (in 2070) in the country in general. Some of the model results are shown in Table 4-1 and Figure 4-1.

Table 4-1. Summary of changes of rainfall (%) in the SW region (for LACC-II area) compared to 1961-1990

	2030					2050					2070				
	DJF	MAM	JJAS	ON	**Ann.**	DJF	MAM	JJAS	ON	**Ann.**	DJF	MAM	JJAS	ON	**Ann.**
SW	-3.6	-2.9	-5.5	19.8	**2.0**	-4.1	-6.3	-5.8	17.0	**0.2**	1.3	7.7	3.9	17.7	**7.6**
BD	-8.7	4.1	3.8	16.6	**4.0**	-4.7	-3.5	3.0	14.5	**2.3**	1.8	7.4	4.6	13.2	**6.7**

Source: Adapted from BUET (Nov.2008). **Note:** LACC-II coastal upazilas fall under SW region.



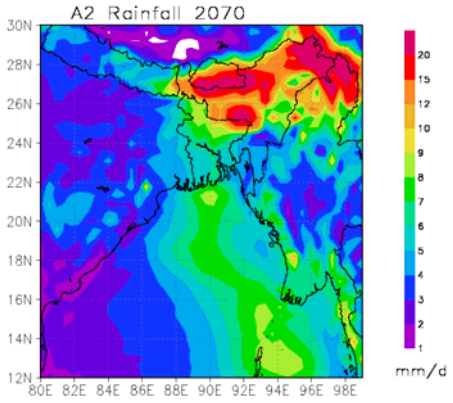


Figure 4-1 (three figures). A2 (SRES A2 Emission) rainfall scenarios generated by PRECIS in year 2030, 2050 and 2070 (Source: BUET, Nov. 2008).

Temperature

The monthly average maximum temperature in the country, as per the latest PRECIS model results, are expected to change from -1.2°C (baseline year 1961-1990) to 4.7 °C in 2030, to 2.5 °C in 2050 and to 3.0 °C in 2070. Maximum temperature have been projected to increase during monsoon period and to decrease in other periods.

On the other hand, monthly average minimum temperature will increase in all periods and vary from 0.3 to 2.4 °C in 2030, from 0.2 to 2.3 °C in 2050 and from -0.6 to 3.3 °C in 2070. Large increase of temperature is the clear indication of global warming. The observed period (years 1961-1990) was considered as baseline for all temperature parameters under the PRECIS modeling.

The projected results for the maximum and minimum temperature (°C) in various months, anticipated changes (%) in three projected years and in areas (BD compared with SW) are shown in comparison with the observed baseline period below (Tables 4-2 and 4-3). The model run scenarios for the maximum temperature in three future scenarios are also shown graphically (Figure 4-2).

Table 4-2. Projected maximum and minimum temperature (°C) with observed values.

	Observed Temperature (°C) in baseline period (1961-1990)		**Projected Temperature (°C)**					
			2030		**2050**		**2070**	
	Max. temp.	**Min. temp.**	**Max. temp.**	**Min. temp.**	**Max. temp.**	**Min. temp.**	**Max. temp.**	**Min. temp.**
DJF	26.66	14.11	26.64	14.76	26.73	14.70	26.73	14.55
MAM	32.48	22.44	32.27	23.65	32.25	23.78	32.16	24.08
JJAS	31.16	24.44	32.45	27.22	32.05	27.48	32.18	27.67
ON	30.07	21.13	29.62	21.83	29.72	22.32	29.64	22.15
Annual	30.18	21.14	30.48	22.31	30.38	22.51	30.39	22.57

Source: Adapted from BUET (Nov.2008).

Table 4-3. Summary of changes of temperatures in SW region (for LACC-II area) compared to 1961-1990

		2030					2050					2070				
		DJF	MAM	JJAS	ON	**Ann.**	DJF	MAM	JJAS	ON	**Ann.**	DJF	MAM	JJAS	ON	**Ann.**
Maximum Temperature Change (°C)	**SW**	-0.12	0.09	0.30	-0.90	**-0.06**	-0.23	0.21	0.07	-0.95	**-0.14**	-0.35	0.06	0.26	-0.85	**-0.13**
	BD	-0.03	0.16	0.23	-0.52	**0.02**	-0.05	0.27	0.10	-0.44	**0.01**	-0.08	0.20	0.20	-0.50	**0.02**
Minimum Temperature Change (°C)	**SW**	0.01	0.40	0.62	0.33	**0.36**	-0.25	0.35	0.76	0.90	**0.43**	-0.59	0.71	1.45	0.29	**0.56**
	BD	0.13	0.48	0.64	0.05	**0.37**	-0.03	0.52	0.74	0.44	**0.44**	-0.19	0.86	1.30	0.24	**0.64**

Source: Adapted from BUET (Nov.2008). **Note:** LACC-II coastal upazilas fall under SW region.

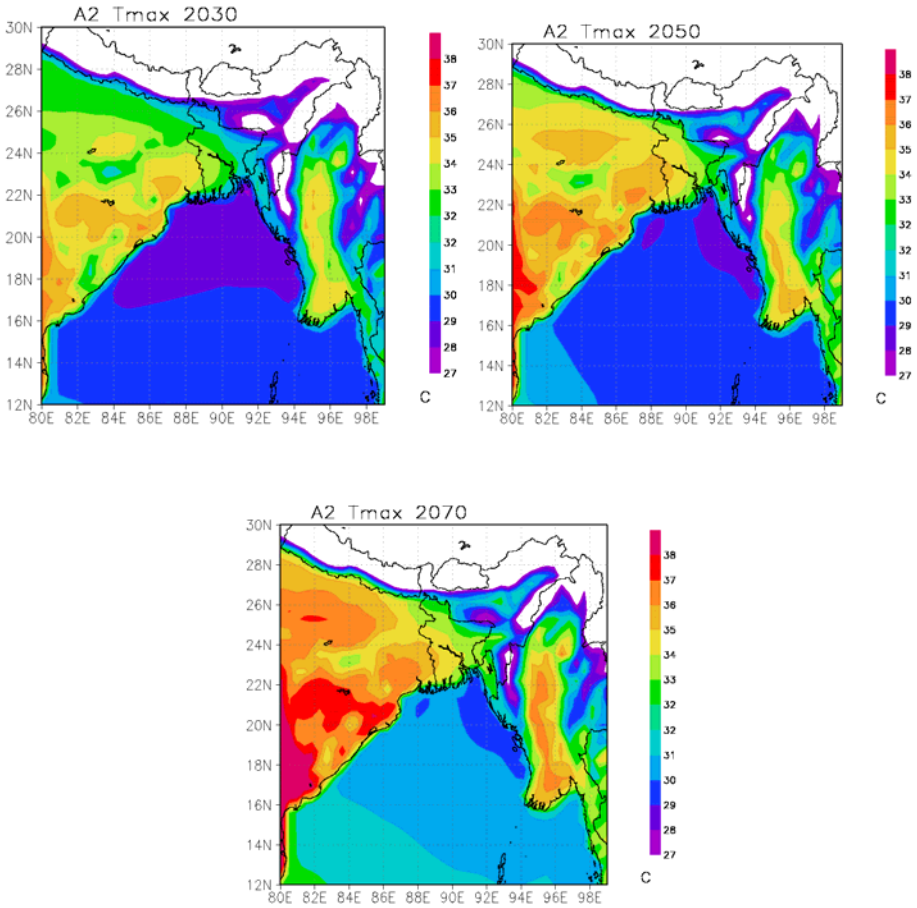


Figure 4-2 (three figures). A2 (SRES A2 Emission) maximum temperature scenarios generated by PRECIS in year 2030, 2050 and 2070 (Source: BUET, Nov. 2008).

One of the major conclusions from the PRECIS results is that the variation of rainfall and temperature (maximum and minimum) in a location over Bangladesh and in a particular month is much larger than the seasonal or annual average. The model result diagrams can be compared with the reference of the baseline period specified in Table 4-3.

4.1.1 Sea Level Rise (SLR)

The threat of sea level rise spans an enormous range of possible impacts ranging from relatively small and manageable to catastrophic in the country. Bangladesh has been identified as one amongst 27 countries, which are the most vulnerable to the impacts of global warming induced accelerated sea level rise.

A study carried out by the UK Department for Environment Food and Rural Affairs (DEFRA, June 2007) has made a detailed assessment of the potential impacts of relative sea-level rise (resulting from global climate change, changes in river-flow and coastal development) on coastal populations, socio-economic impacts on livelihoods of coastal communities of Bangladesh. The study has considered the sea level rise, changes in intensity of cyclones and precipitation for both low (B1) and high (A2) greenhouse gas emission scenarios according to the 3rd IPCC predictions.

The study area covers the LACC-II project pilot areas and the conclusions are significant for the four pilot upazilas of the project. Some of the physical impacts of SLR identified for the Bangladesh coast are as follows:

Table 4-4. Projected Inundated Area (more than 30cm) in the coastal districts for different SLR

District	**Total Area (km^2)**	**Baseline year 2005 (km^2)**	**Inundation area for SLR (km^2)**			
			2080 B1 [15cm]	2050 A2 [27cm]	2080 A2 [62cm]	2080 A2 [62cm+10%rainfall]
Khulna	4394	2137	2219	2380	2459	2465
Pirojpur	1308	735	858	940	1034	1071
All coastal districts	47194	17240	18685	19722	21839	22717

Source: Adapted from DEFRA (June, 2007)

Projected inundation results for the anticipated SLR 15cm (B1 scenario), 27cm (A2 scenario) and 62cm (A2 scenario) are shown in Figure 4.3. In all scenarios, the LACC-II project pilot upazilas are likely to be inundated due to sea level rise.

DEFRA study results showed that about 13% more area (469,000 ha) will be inundated in monsoon due to 62cm sea level rise for high emission scenario A2 in addition to the inundated area in base condition (following Table-4.5). The most vulnerable areas are the areas without polders like Patuakhali, Pirojpur, Barisal, Jhalakati, Bagerhat, Narail. Due to increased rainfall in addition to 62cm sea level rise, the inundated area will be increased and about 16% (551,500 ha) more area will be inundated in the year 2080. On the contrary, in the dry season due to 62cm sea level rise about 364,200 ha (10%) more area will be inundated (inundation more than 30cm) for A2 scenario in the year 2080. However, 15cm sea level rise has insignificant impact on inundation in dry season.

Table 4-5. Area (ha) to be inundated due to SLR in Monsoon and Dry Season in various years

Scenarios	Monsoon Season		Dry Season	
	Inundated area, [ha]	Increase in inundation area, [ha]	Inundated area, [ha]	Increase in inundation area, [ha]
Base	1,720,200 [50%]		404,500 (12%)	-
B1, Yr 2080 (SLR 15cm)	1,863,600 [54%]	143,500 [4%]	Insignificant change	-
A2, Yr 2050 (SLR 27cm)	1,972,200 [57%]	252,000 [7%]	559,100 (16%)	154,600 [4%]
A2, Yr 2080 (SLR 62cm)	2,189,200 [63%]	469,000 [13%]	768,600 (22%)	364,200 [10%]
A2, Yr 2080 (SLR 62cm+10% rainfall)	2,271,700 [66%]	551,500 [16%]	Not Applicable	

Source: DEFRA, 2007.

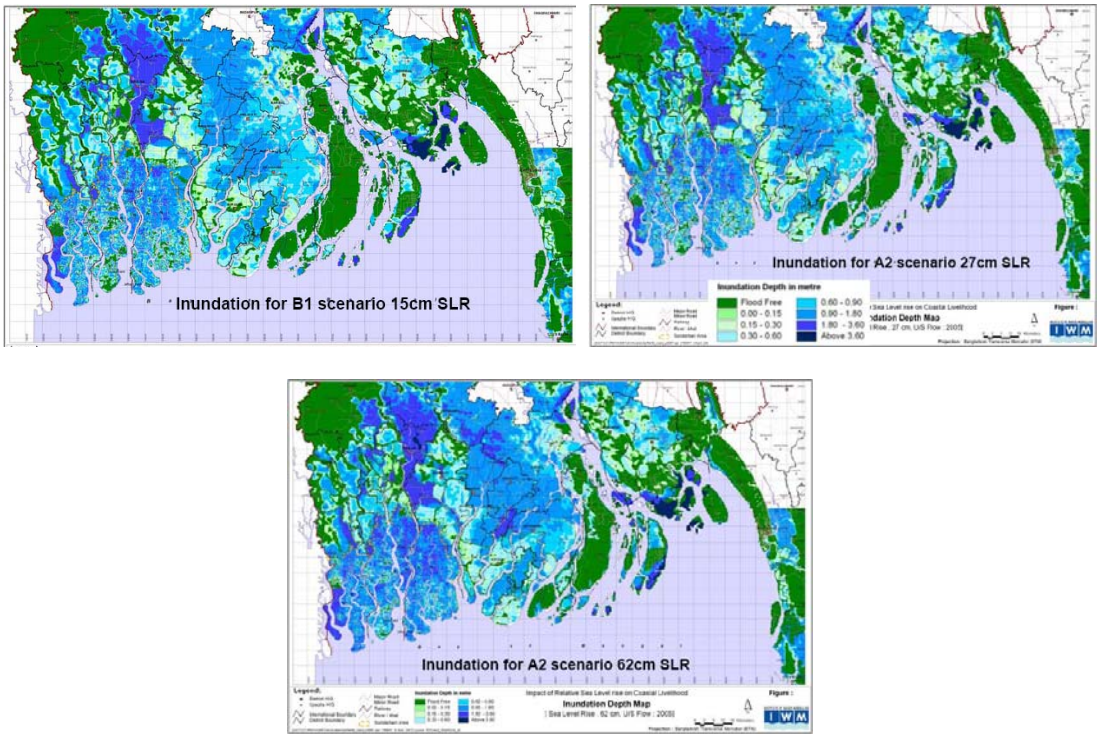


Figure 4-3 (three figures). Projected inundation for SLR 15cm (B1), 27cm (A2) and 62cm (A2). (Source: DEFRA, 2007)

Drainage congestion/water logging

About 25 polders (i.e. circular dykes that are constructed in the coastal areas in the 1960's to protect coastal areas from saline water and to reclaim for rice production) in the southwest region may experience severe drainage congestion due to 62cm sea level rise and 13 polders embankment will be overtopped due to increased water level in the peripheral rivers. Due to the overtopping of the embankment about 120,200 ha of these polders will be deeply inundated (more than 60cm) whereas in base condition inundated area is only 42,200ha. About 32% more area will be deeply inundated due to overtopping of embankment. The LACC-II coastal upazilas are likely to face such drainage congestion and waterlogging in future situation.

Polder/dyke overtopping

Sea level rise and potentially higher storm surge is likely to result in over-topping of saline water behind the embankments of the polders. Modeling results fro IWM (under DEFRA study) shows that for 62cm sea level rise for A2 scenario shows that 13 polders may cause inundation due to overtopping of the embankments for 62 cm sea level rise, as shown in Figure 4-4. Due to the overtopping of the embankment about 120,200 ha of these polders will be deeply inundated (more than 60cm) whereas in base condition inundated area is only 42,200ha. About 32% more area will be deeply inundated due to overtopping of embankment. Some of the LACC-II coastal upazilas fall into these potentially overtopped polders.

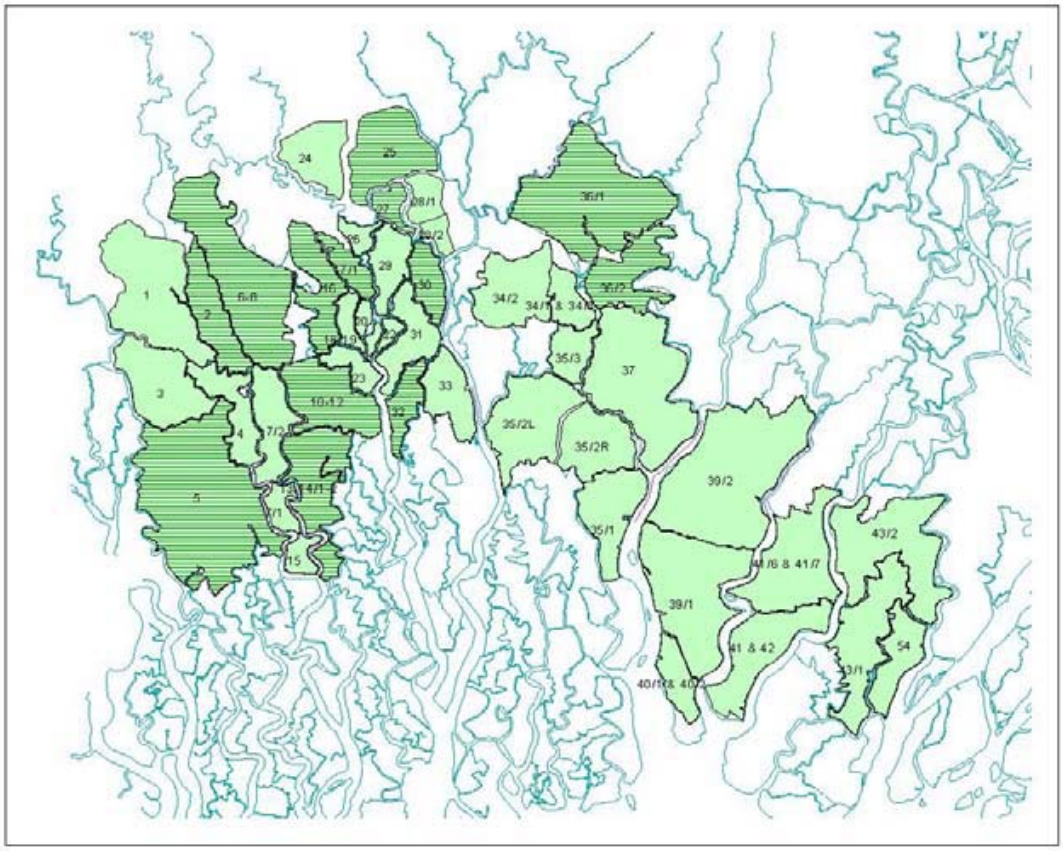


Figure 4-4. Projected polder inundation due to embankment overtopping for A2 scenario 62cm SLR.

4.1.2 Water Salinity

As per the DEFRA (June, 2007) study, salinity is anticipated to intrude more landward specially during dry season due to sea level rise. Consequently brackish water area would increase and it is seen that sea level rise of 27 cm causes 6% increase of brackish water area compared to base condition. About an additional area of 327,700 ha would become high saline water zone (>5 ppt) during dry season due to 60 cm sea level rise. In the monsoon about 6% of sweet water area (276,700 ha) will be lost. Impact of 15cm sea level rise on salinity intrusion under low emission scenario B1 in the year 2080 is insignificant.

Table 4-6. Changes in fresh and brackish water area (ha) in dry and monsoon

Scenario	Dry season			Monsoon season		
	Fresh water area (<1 ppt)	Brackish water area (>1 ppt)	Change (%)	Fresh water area (<1 ppt)	Brackish water area (>1 ppt)	Change (%)
Base	2,562,500	2,152,000		3,779,600	9,403	
A2, 27cm [2050]	2,273,300	2,441,200	289,200[6%]	3,665,400	10,508	114,200[2%]
A2, 62cm [2080]	2,135,700	2,578,800	426,800[9%]	3,502,800	12,111	276,700[6%]

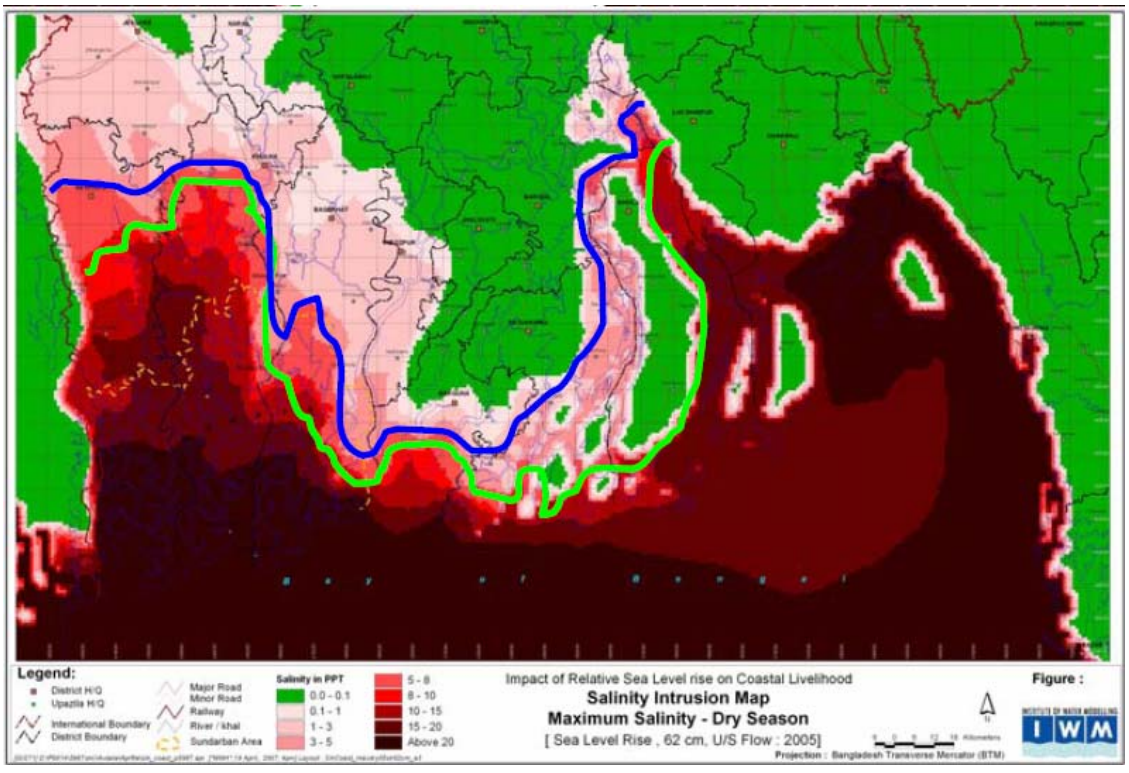


Figure 4-5. Maximum salinity intrusion in dry season for 62cm SLR; figure shows 5ppt saline front movement; green line for base condition (2005) & blue for 62cm SLR. Source: DEFRA (June, 2007).

Figure 4-5 suggests that the LACC-II project upazilas under Khulna districts will be affected by salinity in the dry season quite heavily.

4.1.3 Changes in Storm Surge and Incursion

The IDS ORCHID study in 2007 has made an attempt to estimate future wind velocity and surge height for the Bangladesh coast following the above methods; empirical response functions between temperature and wind speed and wind speed and surge height.

The results show that increases in wind velocity range from 3% to 12% by the 2020s and from 4% to 20% by the 2050s. Storm surge heights increase from 15% to 25% (2020s) and 32% (2050s) due to increases in temperature. Changes in surge intrusion length (x in km), for different coastal zones of Bangladesh are also estimated in Table with the highest temperature changes for the 2020s and 2050s (i.e. worst case).

The LACC-II coastal pilot areas resides in the **Zone 5 (Barguna to Symnagar)** and shows storm surge intrusion length maximum of 43.38km in 2020 and 46.63km in SRES A2 Scenario and 40.01km and 45.20km in SRES B1 Scenario.

Table 4-7. The storm surge intrusion length (x in km), for different coastal zones of Bangladesh for Max. and Min. SRES A2 and B1 for 2020s and 2050s. LACC-II pilot areas are under zone-5.

Coastal Zones	HRA	Intrusion Length X (km)							
		SRES A2 Scenario				SRES B1 Scenario			
		2020s		2050s		2020s		2050s	
		Max	Min	Max	Min	Max	Min	Max	Min
Zone 1 (Tecknaf to Cox's bazar)	3.00	3.47	3.32	3.72	3.45	3.55	3.42	3.61	3.42
Zone 2 (Cox's bazar to Chittagong)	6.50	9.14	8.73	9.86	9.09	9.39	9.00	9.54	9.00
Zone 3 (Chittagong to Noakhali-Bhola)	20.00	30.72	29.31	33.17	30.53	31.55	30.24	32.09	30.23
Zone 4 (Bhola to Barguna)	31.00	38.91	37.19	41.91	38.67	39.94	38.33	40.59	38.31
Zone 5 (Barguna to Symnagar)	39.00	43.38	41.52	46.63	43.13	40.01	38.21	45.20	42.73

Source: IDS (April, 2007).

The study also showed that (following figure) that the existing cyclone High Risk Area (HRA) moves further inland with the distance varying between zones according to their physical characteristics. Increases in the wind velocity and storm surge height result in greater inland intrusion and an increase in the area exposed to cyclone hazard. The HRAs increase to 35% and 40% in the 2020 and 2050, respectively. The LACC-II project coastal pilot upazilas also reside in this and will face the similar risk.

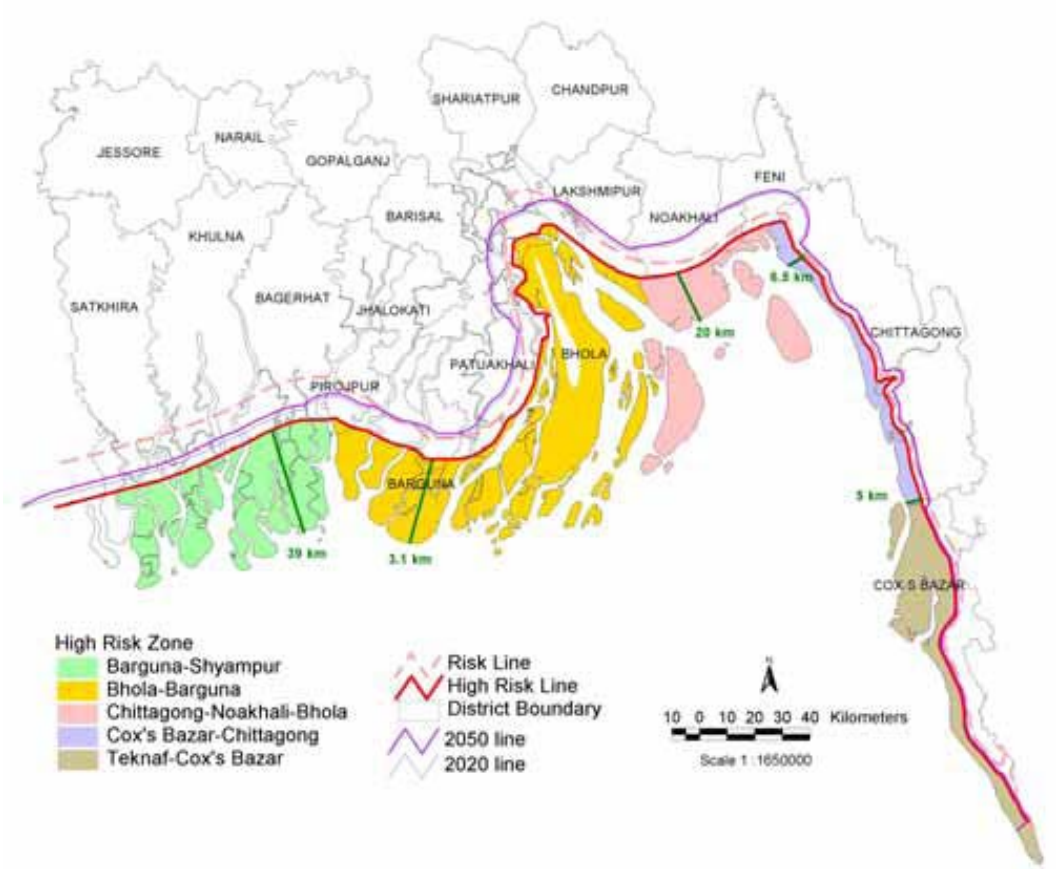


Figure 4-6. Changes in cyclone High Risk Areas for current conditions, the 2020s and the 2050s. Only worst case examples included – highest warming. Source: IDS (April, 2007).

4.2 Uncertainties in prediction and downscaling

As indicated in the beginning of the chapter the scope of this analysis is to come up with generic indications of the future anticipated risks that will impact the country as well as the LACC-II project pilot areas in the coastal zone. In this regard, the core and latest research findings are looked at and presented briefly in this chapter. However, in reviewing findings for the location specific risk information it was found that the PRECIS model results are primarily developed based on the BMD observation areas and their operational regions where they have climatic station data.

The LACC-II project pilot upazilas fall under the Southwest Region (SW) from this grid thereby the results for SW are connoted for the LACC-II pilot project areas. Independent analysis for the LACC-II upazilas is difficult at this point using the existing model run results from models such as PRECIS. At this point, very little, local historical data is available that would allow a comprehensive climate modeling for the LACC-II project upazilas. However, the upazila based analysis in this chapter may give some local specific

indications. It needs to be kept in mind that from the national level climatic model run results one cannot anticipate all the local or location specific risks.

PRECIS and other regional climate models allow to identify indications for the region, but also have many limitations given the complexity of climatic variables and limited number of model parameters. Limitations refer to:

a) location specific limitations;
b) modeling uncertainties related to model assumptions, model parameterisation and application; and
c) limited availability and reliability of data used for modeling

Despite significant uncertainties in the model results presented in this chapter due to above limitations, the results provide some indications about future climate trends and might be useful for policy recommendations. However, they can only provide guidance for the general adaptation strategy development. This has to be complemented by concrete participatory situation assessments at local level using local level observations and making innovative attempt of livelihoods based participatory analysis (see other chapters of this situation assessment report).

For framing livelihood adaptation, both the set of future risk and the continued analysis of the present situation should be used in a mutually inclusive manner. This should be seen as a two way process where "technical downscaling" of climatic risk analysis should improved and the "gradual upscaling" of local participatory risk assessments need to be established through a regular monitoring of climate data and climate risks at the ground.

5: RISKS AND THEIR PERCEPTION

5.1 Community perception of hazards and risks

Community people of the different unions of the study area have their own understanding and perception of risks, based on the respective local hazard and risk history, geo-physical setting, cultural belief system and other factors. In general it was observed that the elderly people know a lot about the changes happening in the weather and climatic condition in the area over the period of few decades.

People's perceptions of climatic risks were collected through group work and discussions as well as through direct interviews with farmers. The general perceptions are summarized below.

- Community people perceived that while previously six seasons could be evidently observed in the area, now only two seasons - summer and winter - are distinct. They also felt that the seasonal cycle could not be anticipated now any longer.

- Many respondents pointed out that irregular weather and climatic conditions create problems for crop production. Farmers are often forced to change their crop production plan due to the uncertainty of the climate and weather. The cropping pattern has been altered due to the changes happening in the weather and climatic conditions.

- Local people also recognized that both water and soil salinity have been increasing in the last ten years, which has affected the crop production. In the month of March and April, they observe more light reflection in the water of rivers or canals, which is a sign of salinity. If they drink water it tastes salty. They say that salinity appears from the month of January, increases up to April and decreases with the onset of rainfall.

- Regarding soil salinity in the Rabi season, especially in the months of March and April, the local people observe white patches in fallow lands, which they attribute to an increase in soil salinity. Sometimes Rabi crops like chili, brinjal, potato and tomato dried and died due to soil salinity.

- The community people are also experiencing that the pressure and height of tide water has been increasing over the last ten years. On the basis of the tide water level, they prepare seedbeds for Boro as well as T-Aus and cultivate Rabi crops in the high lands, which had normally not been affected by rising water levels during high tide. But during the last ten years they had to shift Rabi crops cultivation to much higher lands. Sometimes seedlings and Rabi crops are being damaged due to uncertainties and unpredictability of the higher tide water level.

- In the coastal areas water surrounds the community, but the community people are nevertheless suffering from scarcity of water for both crop cultivation and household purposes. In the Rabi season, due to salinity, water is not suitable for irrigation. Ground water in many areas is also not suitable for irrigation. A major portion of the study area upazilas lands remains fallow during Rabi season due to scarcity of suitable irrigation water.

- Some of the elderly community leaders also pointed out the changes in temperature conditions and mentioned that the duration of cold days has decreased substantially. They also feel that summers have become more severe and that there are changes in the rainfall pattern as rainfall has become very irregular and untimely.

- Farmers also reported that the soil fertility has been decreasing and that pest and disease infestation is increasing, which adversely affects agricultural production. .

- People also noted that in some areas siltation is increasing in the riverbed and that the water carrying capacity of rivers and canals has decreased substantially. The navigability of the rivers is decreasing, also as a result of reduced water flow from the upstream.

- The majority of the local people feel that the overall risks and hazards, climatic as well as non-climatic, have been increasing significantly and almost every year compared to earlier days.

5.2 Current risks

5.2.1. Risk Classification and Ranking

The community people in the study area are suffering from adverse impacts of climatic risks. These risks affect their lives in many ways, including their livelihood. The local risks in the study area upazilas were identified through a PRA exercise using focus group discussion, mapping and calendar as tools. A brainstorming process was initiated and participants were requested to list the major risks in their respective area. After identifying the risks, the participants were asked to classify the risks as climatic and non-climatic. The non-climatic risks were then divided into human-induced, technological and biological risks. Finally, the risks were ranked by the participants, based on their frequency, intensity and severity, i.e. the damage caused to the livelihoods and infrastructure in the area concerned, with 1 representing the highest frequency, intensity and severity (see Table 5.1).

Community people from all the four upazilas participating in the sessions identified a number of risks, which according to them have put their livelihoods at stake. There were some differences among the participants regarding the ranking of the risks, particularly among the different livelihood groups (see the subsequent vulnerability assessment of the different livelihood groups for more details). However, in general, in all the four study area upazilas, increased salinity was ranked as number one risk, causing huge damage to the crops, water and the entire environment of the area. In addition to salinity, the other major risks identified include cyclone and floods, storm surge, droughts, water logging, deforestation and forest degradation, insect and disease infestation and virus infestation in fishes. Besides natural hazards, the livelihoods of the local communities are also adversely affected by various human induced and biological risks. Depending on the intensity/ frequency of hazards and the vulnerability of the respective local community, the severity of the risks and their impacts on livelihood vary from upazila to upazila. Among the four upazilas, in general Dacope is most vulnerable, where almost all types of risks mentioned above are more devastating and affect different livelihood sectors more adversely.

Table-5.1: Local risks and their classification with ranking

Risks							
Climatic	**Rank**	**Non-Climatic**					
		Human-	**Rank**	**Technological**	**Rank**	**Biological**	**Rank**

		induced					
Salinity increase	1	Fire	14	Brick field smoke	8	Insects and diseases infestation in crop	6
Cyclone	4	Deforestation, forest degradation	15	Transport smoke (auto-rickshaw)	14	Virus infestation in fish	9
Storm surge	3	Environment degradation	12	Electricity problem	11		
Drought	10	Communication barrier	13				
Floods	2						
Water logging	7						
River bank erosion	5						

5.2.2. Risk impacts on various sectors

Following the identification, classification and general ranking of main risks during PRA exercise the community people undertook a scoring exercise to depict how the identified major risks impact various economic sectors, making the livelihood activities depending on them vulnerable to the impacts of the risks.

Salinity, cyclones, floods and storm surges were considered the main risks affecting almost all important sectors of the area, including agriculture, fisheries, livestock and forestry.

During discussion with community people, there were some differences while ranking the risk, yet again, salinity was regarded as the single most present and emerging issue for agricultural production and the overall environment of the area. The other main risks adversely affecting the

local livelihood sectors identified are cyclones, floods, storm surges and river bank erosion (see Table-5.2). The exercise helped in developing the hazard and risk maps of the upazilas, which were further refined incorporating secondary data and further discussions with different GOs and NGOs (see Annex V).

Table-5.2; Hazards impact on various sectors

Hazard	**Vulnerable sectors**						
	Agriculture/ Crop Production	Fisheries	Livestock	Forestry	Infrastructure	Education	Health
Salinity	√	√	√	√	√	X	√
Cyclone	√	√	√	√	√	√	√
Storm surge	√	√	√	√	√	√	√
Flood	√	√	√	√	√	√	√
River bank erosion	√	√	√	√	√	x	x
Drought	√	√	√	√	x	x	√
Water Logging	√	√	√	√	√	√	√
Pest Infestation	√	√	√	√	x	x	x
High temperature	√	√	√	√	x	√	√

√ = impact, x = no impact

5.3. Comparison with past risks and their impacts

Community people identified the risks of the past years through the same process as the one used for current risks identification and equally classified them according to the frequency, intensity and the extent of the damage. Local people reviewed the situation since early sixties and found that the occurrence of the extreme climatic events and natural hazards in general has increased. Comparing past and present risks, the community people identified evident changes in the risks types, their frequency and intensity. Emergence of new risks such as water logging, pest infestation and salinity problems were noted, while floods and cyclones have become a recurrent phenomenon by now.

In contrast to peoples perception, different records (district gazetteer, DAE and SRDI documents, and other reports) suggest that the changes in frequency and intensity of risks is a regular phenomenon in the study area and only a few risks like cyclone, increased salinity, up surge etc. are on the increasing trend. Among the major risks, until recently flood has been most frequent

and damaging. As far as its extent of damage is concerned, it varies among the upazilas. However, the agricultural crop sector is worst affected, almost everywhere in the study areas.

Some of the major past disasters, which people still remember are listed in the succeeding text:

1. Cyclones and water surges:

- The elderly people remember the severe cyclone of 1991, which killed more than 125, 000 people and damaged huge amounts of infrastructure and agricultural crops.
- In 1998, a strong cyclone hit the area, specially the Dacope upazila, with severe tidal surge causing serious damage to different livelihood sectors and infrastructure like, roads, embankments, houses and school etc. Ripen rice and forest plants were highly damaged, fish ponds were overflown, and cattle drowned.
- *Cyclone SIDR***.** The memory of Cyclone SIDR of 15th November, 2007 is still fresh in people's mind, which caused extensive damage to all sectors. In the study area, maximum damage was estimated in the Dacope Upazila where it destroyed standing field crops, houses, caused death of many cattle in all of the unions of the study area. In Dacope union, above 80% of the crop was destroyed, 90% of the trees were highly affected and more than 10% of poultry and livestock died due to SIDR. In Laudobe union, 75% of the rice was damaged, 20% of the people become shelter less, and approximately 20 % livestock died. In Bajua union, about 98% of the rice was damaged, 25% of the people became shelter less and 30% of the livestock was killed in some wards.

  In the other two study area upazilas, i.e. Terokhada and Bhandaria, the impact of *SIDR* was also quite damaging. In Terokhada Upazila the cyclone affected 16,687 farm families and partially damaged 8,862 hectares of crop land directly damaging above 1,963 metric tons of crop production.

  In Pirojpur district, both study area upazilas were affected by the cyclone. In Bhandaria, the *SIDR* affected more than 35,000 farm families, damaging crop production of 10,000 M. tons. The Nazirpur upazila the impact was not so damaging and only 1850 hectares of rice crop was damaged by the cyclone.

2. Droughts:

In 1989, 1998 and 2005, drought appeared as a serious climatic hazard for agriculture sector in the study area upazilas. In Laudobe union of Dacope Upazila almost all the ponds and canal dried, the pond fish population was highly reduced, and cattle suffered from various diseases. Aus rice,

late sawn due to drought in 1998, was highly affected by droughts. In Dacope upazila, 70% of the crop was damaged, 90% of the fish ponds dried due to lack of sufficient water and salinity increase in1989.

3. Floods**:**

In1995, 2000, 2004 floods heavily damaged the field crops and fish resources. Many houses were destroyed, and many fish ponds over floated.

4. Hail storms:

In 2005 and 2006, hail storms damaged watermelon, sweet gourd and mango crops, and 75% of the trees lost their leaves. The Rabi crop was also highly affected by hail storm. The main damage was observed in Dacope upazila.

5. Pest and disease attacks:

In Dacope upazila, field crops were highly affected by pest attack, and a huge number of poultry and cattle died from diseases in 2008. Some cattle had also died due to a plague attack in 1991, especially in Dacope upazila.

5.4. Seasonality of the risks

As mentioned, different types of natural risks affect the study area at different times of the year. The severity of most of these risks varies by season. Figure 5.1 below depicts the seasonality of the main hazards in the study area. The content of the table is based on peoples' feed back from different upazilas (which was further refined in consultation with DAE officials).

Figure- 5.1: Seasonality of main risks

Hazards	Bai	Jai	Asa	Shr	Bha	Ars	Kar	Agra	Pau	Mag	Fal	Cha
Salinity												
Tide												
River bank erosion												
Drought												
High temp												
Heavy rainfall												
No/less rainfall												
Cyclone												
Tide surge												

Kalbaisakhi	
Ashina	
Heavy fog	
Tornado	
Flood	
Hailstorm	
Water logging	
Rat attack	
Insect-pest infestation	

(Bai=Baishakh=April-May, Jai=Jaistha=May-June, Ash=Ashar=June-July, Shr=Sravan=July-August, Bha=Bhadra=August-September, Ash=Ashwin=September-October, Kar=Kartik=October-November, Agra=Agrahayan=November-December, Pau=Paush=December-January, Mag=Magh=January-February, Fal=Falgun=February-March, Chai=Chaitra=March-April)

5. 5. Future risks

A possible future risk scenario including its impact on the agricultural sector was drawn by the community people, using a risk identification matrix (Table-5.3). The scenario was based on the peoples' past experiences and perceptions, and current trends of increasing risks due to changing climatic conditions and accelerating intensity and frequency of natural hazards. The people perception is that if the climatic conditions keep on changing at the current rate, the impact of the main natural hazards on agriculture and allied sectors will be even more adverse in the next ten to fifteen years.

Community people estimated that crop agriculture is most at risk and in the near future will be threatened by almost all major risks like salinity, cyclones, floods and storm surges. Other sectors like fisheries will also continue to be affected severely by various risks like cyclone, storm surge etc., which may lead to wash out the fishponds and sanctuaries and to an increase in disease infestation and, resulting in decreased fish production.

Most of the risks and their increased trend were thought to render livestock in fodder crises, disease infestation and more death in coming future. Among other risks, flood and cyclone were considered most critical for the loss of the livestock.

In the study areas of Pirojpur district, nursery seedling and saplings were estimated to be affected by the current risks threatening to damage the whole nursery enterprise in the area.

The participants of the study area of Dacope upazila also thought that the salinity, both in soil and water will, continue to increase in the coming years and will have profound impact on all sub-sectors of agriculture.

Table-5.3: Future risk scenario (based on local community perceptions and linking it with the climate change/ impact data)

Hazard	Vulnerable sector	Climate change impact/risk in coming future
Salinity	Agriculture/crop	Major crop losses per year, lower growth rate of plants, leaf injury and yield losses
	Livestock	Approx. 20% less production
	Fisheries	Loss of domestic fish varieties, approx. 70% yield losses
	Forestry	Plants become infested with different diseases, plants death rate increases, less production of fruits, enormous loss of betel nut, mango, jack fruit and litchi tree
Cyclone	Agriculture/crop	Huge crop damage, especially of Rabi crop
	Livestock	Increased death rate of livestock
	Fisheries	Approx. 50% of fish washed out from water bodies, increased fish death rate
	Forestry	Approx. half of the total tree stock damage
Storm surge	Agriculture/crop	Huge crop losses
	Livestock	Approx. 30% livestock losses
	Fisheries	One third fish loss, increased disease infestation
	Forestry	Approx. 30% of nursery seedling damaged
Flood	Agriculture/crop	Two third loss of T. Aman crop and huge damage to preserved food grain storage
	Livestock	Increased disease infestation, large number of deaths of cattle and poultry
	Fisheries	fish washed out from many fish fields
	Forestry	About 20% damage to nursery seedlings and saplings
Drought	Agriculture/crop	Rice crop damage
	Livestock	Scarcity of animal feed, livestock losses

	Fisheries	Approx. 20 % fish loss, increased disease infestation
	Forestry	Lower productivity of coconut and betel nut, increased fruit dropping, plants damaged due to lack of irrigation
Water logging	Agriculture/crop	Increased fallow land area, sweet potato, water melon, potato, gourd, chili, and tomato crop losses,
	Livestock	Increased disease infestation, approx. 20% less production of live stock
	Fisheries	About 15% fish loss
	Forestry	Approx. 15% seedling damaged
Pest and disease infestation	Agriculture/crop	Approx. 12 to 15 % crop loss, 8 to 10 % crop loss by rats, difficulties in growing quality seed, hampered quality of crops
	Fisheries	Attacked by viral and bacterial diseases, lower productivity
	Livestock	Different diseases, decreased breeding capacity, lower productivity, poor laying capacity of duck and poultry
	Forestry	Lower growth rate, decreased productivity

6: LIVELIHOOD PROFILES AND VULNERABILITY

Different livelihood groups and patterns, including their respective vulnerability, were identified by the participants. They assessed local livelihood options and their seasonal dimensions and changing trends.

6.1 Livelihoods grouping and classification

A livelihoods classification was done through a participatory discussion with the community people and based on national data in order to understand the status of the livelihood groups of the study area (Table-6.1 and Figure 6.1).

The livelihood grouping of the project area upazilas in general shows that

- Farmers represent the major livelihood group in this area, i.e. about 65- 70%
- The day laborer are the second most prominent group in all upazilas (15-20%), except Terokhada, where they form only 8% of the total.
- In Terokhada, businessmen make a major livelihood group, about 14.5%.
- In Terokhada, fishermen are another major livelihood group in comparison to other upazilas.
- In Dacope, some new categories of livelihoods were found, who are dependent on nearby forest resources (the Sunderban forest). These include *bawali* (honey and other minor forest product collectors), wood collectors, transport laborers for tourists, *rhishi* (doing bamboo work) and small traders dealing with minor forest products.
- In all upazilas most people are unable to sustain their livelihood from one single source and thus are involved in multiple activities. A large number of people (mainly with small land holdings and daily laborers) change their livelihood activities frequently, depending on availability of resources.

Table 6.1: Upazila wise livelihood classification of the community in the study area upazilas

Livelihood group	**%**			
	Dacope	Terokhada	Bhandaria	Nazirpur
Farmer	66	63	71	66
Wage laborer	19	8	15	21
Fisher	3	7	4	3
Businessmen	6	14.5	6	5
Service holder	5	4.5	3	4
Others	1	3	1	1
Total	100	100	100	100

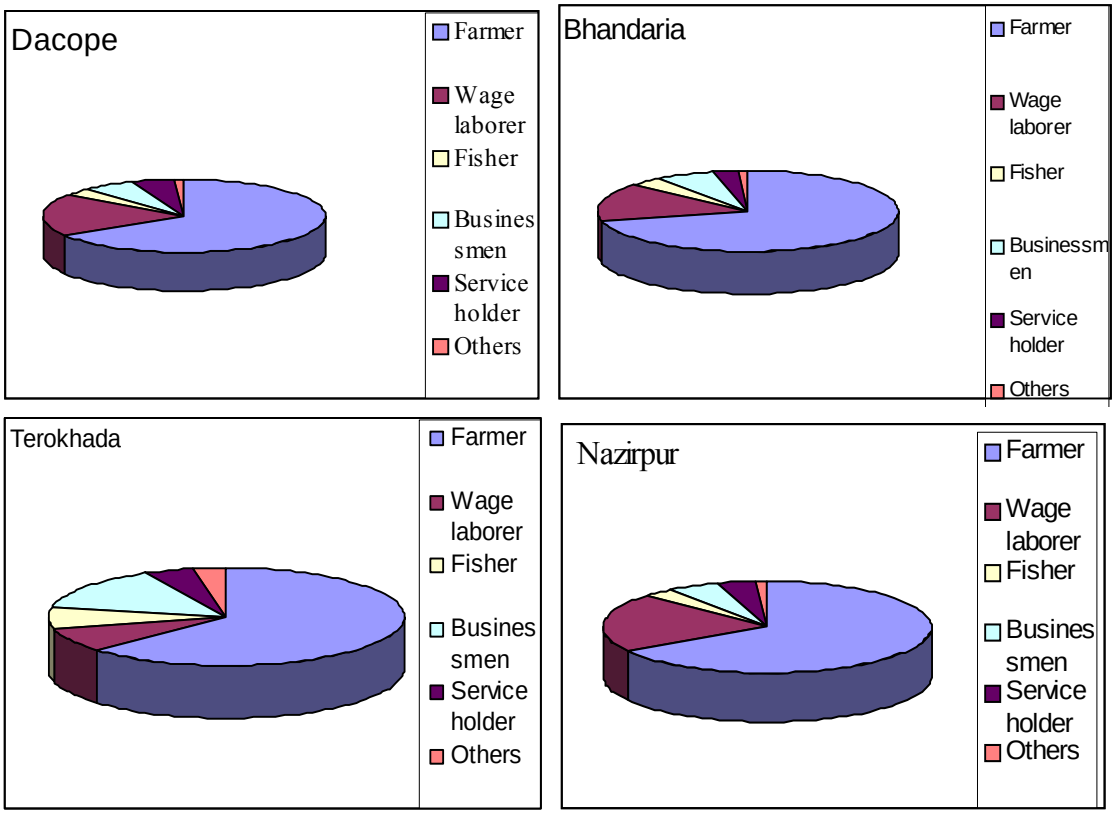


Fig –6.1 Livelihood group profiles in different project upazilas

6.2. Vulnerability of different livelihood groups

As mentioned in the preceding section, the local community in the study area upazilas consists of various livelihood groups. Almost all livelihood groups are affected by different types of natural and man made risks. However, the vulnerability of these livelihood groups to different risks depends on various physical and socio-economic factors:

a. ***Physical assets*** – cultivable land, irrigation facilities, agriculture/ fishing equipment, livestock, housing conditions, orchard/ homestead garden etc.

b. ***Human resources***- literacy, education, knowledge and skills, availability of health facilities, overall health of the family etc.

c. ***Socio-economic conditions*** - Overall social status, access to local decision making groups, cash savings credit and markets, cash valued assets**)**

As the same risks may have different impacts on different sectors and members of society, the local communities have been divided into various livelihood groups, i.e. small/ marginal farmers, large farmers, rural wage laborers, fishers, large business men and petty traders. Special attention was given to the specific vulnerability of women.

a) Small and marginal farmers

Small and marginal farmers form a major livelihood group of the study area upazilas: In Dacope - 49%; in Terokhada - 53 %; in Bhandaria - 68% and in Nazirpur - 72% of the total agricultural community belong to this category.

Small and marginal farmers of the study area are the most vulnerable group to various risks in comparison to other livelihood groups. Among the four project upazilas, the small farmers of Dacope upazila of Khulna are worst affected by adverse impacts of natural as well as human induced risks. Increasing salinity in the area has substantiality reduced productivity of land. Several other physical and natural factors like river erosion, siltation, blockage of discharging canals, water logging, artificially created due to shrimp cultivation, and lack of cultivable land have made the situation more serious. In earlier days the local people used to produce sufficient amounts of rice during T. Aman season and additionally reared cattle and cultivated fish in their own ponds. Due to increasing salinity, river erosion and other risks local people are forced to lease or sell their land to shrimp cultivators and are often becoming landless. Small farmers are also much more vulnerable to natural disasters like cyclone, flood etc., which sometimes destroy

all their livelihood assets, forcing them to become labourers or to migrate to urban areas to earn their living

Introduction of shrimp culture, especially in Dacope upazila, has further worsened the situation of small farmers. Many of the small land holdings of these farmers have been taken on lease by big business men, who started doing shrimp farming on this once agricultural land. This process has not only eliminated a potentially sustainable source of income for the small farmers, but also deteriorated the soil conditions by increasing its salinity. Due to stagnant saline water used for shrimp culture, homestead fruit trees like jackfruit, betel nut and coconut are dying, which results in a loss of income opportunity from the homestead. Lack of alternative employment opportunities for this group of society is a major factor for poverty and increased vulnerability in the rural society of the area. As the land holdings of small farmers are very small, this group has to depend also on other sources for their livelihood.

In addition to natural factors, socio-economic factors as well as social customs and traditions prevalent in the local society, like illiteracy and dowry system, are playing a major role in making small farmers more vulnerable. The lack of proper marketing facilities is another major constraint, which debars local farmers from getting fair prices for their homestead products like vegetables, pond fish and fruits. The high price rise of agricultural inputs, the deterioration of soil quality, lack of health care facilities, arsenic contamination in drinking water etc. are some other factors responsible for increased vulnerability of small farmers. In brief, all the factors mentioned in the preceding text have made the small farmers generally more vulnerable to changing climatic conditions and associated risks.

The degrees of vulnerability (very high, high and medium) of small farmers in the four upazilas of the study area to various risk factors are shown in Table-6.2, which is based on focus group discussion and interaction with different NGOs and GOs officials.

Table-6.2 Upazila wise levels of vulnerability of small farmers

Major risk factors	Nature	Dacope	Terokhada	Bhandaria	Nazirpur
Salinity	Climatic	VH	M	H	VH
Tidal water intrusion	Climatic	VH	M	VH	H
Tidal surge	Climatic	VH	M	VH	H
Drought	Climatic	H	H	H	M
Heavy rainfall	Climatic	H	M	M	M
Water logging	Non-climatic	M	H	M	M
Flood	Climatic	M	M	VH	M
Kalboishakhi	Climatic	M	M	M	M

Depression	Climatic	M	M	M	M
Hail storm	Climatic	M	M	M	M
Thunderstorm	Climatic	H	M	M	M
Cyclone	Climatic	VH	H	VH	VH
River bank erosion	Climatic	VH	M	VH	H
Insect- pest infestation	Non-climatic	VH	VH	M	H
Fog	Climatic	M	M	M	M
High price of agricultural inputs	Non-climatic	M	M	M	M
Unavailability of agricultural inputs	Non-climatic	M	M	M	M
Crop yield reduction	Non-climatic	H	M	M	H
High temperature	Climatic	M	M	M	M
Change in land use pattern (from agriculture to shrimp cultivation)	Non-climatic	VH	M	NA	NA

Legend: VH- Very high; H- High; M- Medium, NA – Not Applicable

b) Large farmers

Large farmers having land more than 3 hectares of land make a small fraction of the community of all the study upazilas. In Dacope- 6.49 %, Terokhada -5.42 %; in Bhandaria- 3 % and in Nazirpur- 2.05 % of the total agriculture community belong to this category.

Large farmers are more capable to cope with the changing climatic conditions and are thus less vulnerable. At current production status, most of the large farmer families can produce enough to meet their year round demand and to sell part of their harvest at high prices at the market. They can easily adopt alternative improved technologies to cope with the changing situation. Most of them are also involved in shrimp culture (especially in Dacope Upazila). The rest is involved in highly productive and profitable crop cultivation activities like watermelon, sweet gourd, okra and T. Aman rice production and in rearing cattle, goat and poultry. Some of them have also partly become involved in other activities, like agricultural product marketing, in profitable way.

The large farmers are financially well equipped and are thus capable of having more production in a single season or having more crops in different seasons. This category of farmers is also capable of increasing inputs (fertilizers, better seeds, irrigation, use of insecticides and better agriculture tools etc.) and thus, achieving higher yields in comparison to poor and marginal

farmers. Despite all these factors, the rich farmers are also facing adverse effects of climate change and become vulnerable when the salinity and drought situation becomes more severe.

c) Rural wage laborers

Rural wage laborers form 8-20 % of the total livelihoods in the study area upazilas. In Dacope 19%, Terokhada 8%, Bhandaria 15 % and Nazirpur 21% of the total livelihood groups belong to this category. The people belonging to this category are either landless or have very small land holdings, which do not give them sufficient income. The majority of this group of people depends on agriculture and allied activities for their livelihood. As agriculture activities do not continue through out the year, most of the laborers are also involved in other jobs like rikshaw pulling, land filling, petty business etc. During lean period or at the time of natural calamities the majority of the daily laborers migrate to urban areas in search of jobs

Due to the changing climatic conditions, agro-based activities are no longer available year round in the upazila. Due to adverse climatic conditions (like droughts, increased salinity etc.), a large portion of agriculture land remains fallow, making rural wage laborers unemployed. Furthermore, as a result of more and more cultivable land being leased out for shrimp culture, labor demand in agriculture has significantly decreased. Decreasing crop diversification, resulting from increased salinity, has further deteriorated the situation. Economic factors like low market prices for agricultural products and low wage rates for both male and female workers are other dominating factors making this section of the society more vulnerable to adverse impact of climate change.

As a result of frequent droughts, the number of livestock is also decreasing. It is observed that two decades ago, most of the families (>80%) used to rear more than ten cattle like cows and goats, but now this percentage has tremendously decreased and only 40% families have more than five cattle. As the rural wage laborers used to get some income form cattle rearing in the past, this negative trend in the cattle rearing has enormously affected their livelihood. Farm mechanization, like use of tractors, has also decreased labor demand in agriculture.

Among non-climatic factors responsible for increased vulnerability of this section of the society the non- availability of year round employment opportunity, lack of cash/savings, poor food storage, facilities, lack of cultivable land, poor healthcare facilities and low wage rate, lack of education, seasonal migration and diseases of domestic livestock/poultry, are the most prominent.

The vulnerability of the rural wage laborers also depends on season. During the Monsoon months, i.e. July and August, the rural laborers become more vulnerable due to non-availability of any farming or other related work.

The degrees of vulnerability (very high, high and medium) of the rural wage laborers in the four upazilas to various risk factors are shown in Table- 6.3.

Table-6.3 Upazila wise vulnerability categories of rural wage laborers

Major vulnerability factors	Nature	Dacope	Terokhada	Bhandaria	Nazirpur
Salinity	Climatic	VH	M	VH	VH
Tidal water intrusion	Climatic	M	M	M	M
Tidal surge	Climatic	H	M	VH	M
Drought	Climatic	VH	M	M	VH
Heavy rainfall	Climatic	H	VH	VH	H
Water logging	Non-climatic	M	H	M	M
Flood	Climatic	M	M	VH	M
Cyclone	Climatic	VH	VH	VH	H
River bank erosion	Climatic	VH	VH	M	VH
Low wage rate	Non-climatic	H	M	VH	VH
Non-availability of year round employment opportunity	Non-climatic	VH	VH	VH	VH
Migration to other area	Non-climatic	H	M	VH	H
Lack of health care	Non-climatic	H	H	VH	H
Lack of cultivable land	Non-climatic	VH	VH	H	VH
Lack of savings	Non-climatic	VH	VH	VH	VH
Social barriers	Non-climatic	VH	H	VH	H
Legend: VH- Very high; H- Severe; M- Moderate					

d) Fishers

Fishery is an important livelihood source in all the study area upazilas. In Terokhada 7%, in Dacope 3%, in Bhandaria 4 % and in Nazirpur 3 % people are earning their livelihood through this sector and many more rely on fisheries as an additional source of income.

Changing climatic conditions and their impacts, mainly increased water salinity, scarcity of fresh water, water pollution, tidal surge, siltation, flood and inundation as well as water pollution are negatively affecting this livelihood sector. The vulnerability of fishers is high in Dacope upazila and medium in the other three upazilas. Increased salinity is the main factor of worry for the

fishery sub-sector. As a result of increased salinity and lack of fresh water in ponds and canals, fresh water fish are disappearing, resulting in income erosion of fishers. Cyclone and tidal bores are also reducing fish resources and species. Siltation and water logging in the rivers, rivulets and ponds are making fishing more difficult task for the fishers. The lack of water during dry season in the fresh water ponds and rivers is also responsible for the decreasing fish quantity in the region.

Due to reduced supply of fishes, fish traders, as well as fish laborers, are facing a loss of income opportunity and are seeking other professions, like river transportation, or migrate to urban areas for other employment. Fishers have also become more vulnerable due to several other non-climatic factors, like overfishing, illegal fishing gears, poor law and order situation (pirates, frauds, political groupings etc.), lack of fishing equipment and training, lack of hatcheries, limited infrastructure (fish markets, storage facilities etc.), difficulties in getting lease for fishing in *khas* (public) water bodies and complex access to the credit facilities (high interest rate, poor access etc.).

The degrees of vulnerability (very high, high and medium) of fishers in the four upazilas to various risk factors are shown in Table- 6.4.

Table-6.4 Upazila wise vulnerability categories of fishers in four upazilas

Major vulnerability factors	Nature	Dacope	Terokhada	Bhandaria	Nazirpur
Salinity	Climatic	VH	M	VH	VH
Tidal water intrusion	Climatic	VH	M	VH	VH
Tidal surge	Climatic	VH	M	VH	VH
Drought	Climatic	VH	H	M	H
Heavy rainfall	Climatic	M	M	VH	M
Water logging	Non-climatic	M	H	H	M
Flood	Climatic	M	M	VH	M
Cyclone	Climatic	H	H	VH	H
Virus infection in fish	Climatic	H	VH	VH	M
Lack of fishing equipment	Non-climatic	H	M	H	H
Faulty fish pond leasing system	Non-climatic	VH	M	VH	H
Overfishing by some groups	Non-climatic	VH	H	VH	H
Lack of proper marketing	Non-climatic	M	M	VH	H

facilities					
Lack of storage facilities	Non-climatic	VH	VH	H	VH
Lack of access to savings/credit systems	Non-Climatic	VH	VH	VH	VH
Social barriers	Non-climatic	VH	H	VH	H
Legend: VH- Very high; H- High; M- Medium					

e) Large businessmen

In the region there are some large businessmen involved in trading of agriculture products such as rice, potato, oil pulse and spices. They are the main beneficiaries of the price hike due to reduced seasonal productivity of agricultural products. However, due to poor storage facilities, they also face problems as a result of long lasting rainy season, high humidity, cyclones and tidal bores. But they usually compensate this loss with high market prices of their goods. Large businessmen having good storage facilities are less affected by seasonality. However, even large retailers are affected by climatic factors: During drought and heavy rain period, the sale and revenue of retailers decreases substantially.

The impact of climatic risk is higher on businessmen involved in agricultural business. The non-agricultural business largely remains unaffected by the climatic risks. Due to deteriorating climatic conditions and their impact on overall agricultural activities and yield, businessmen dealing with agricultural equipment, inputs and products are facing many problems.

f) Petty traders

Most of the petty traders in the region are involved in fish, rice, vegetable, poultry egg, spices and milk products trade at small scale. Women are also found as shop keepers. Some of them are earning their livelihood by selling fruits. A large number of small traders is engaged in seasonal trading. Their business solely depends on agricultural production. The majority of the petty traders have no separately organized shop. Many of them make business from their own houses and sell their goods in local weekly hat-bazaars. In dry season, especially during the drought period, their sales are highly reduced. Their business also depends on big traders, who control the supply of various goods. Thus this section of the society is directly worse affected due to changes in weather/ climatic conditions resulting into loss to crop production.

g) Gender specific vulnerability

Although climatic and non-climatic risks and constraints are affecting both, male and female population of the study area, due to a number of reasons women are facing more severe problems. In Bangladesh, women are generally more vulnerable than men to all kinds of disasters and climate related impacts due to gender inequalities in various social, economic and political institutions. Men tend to control income distribution, property, access to credit, decision-making processes, and sources of food. Women have limited access to and control over natural resources or money, and more importantly are less mobile and have limited access to information. The social customs prevailing in the region like dowry and purdah systems have further increased their vulnerability to various risks. Various impacts due to climate change have further increased the vulnerability and sufferings of female in the region, as shown in the succeeding Table-6.5.

Table- 6.5: Gender Specific Vulnerability factors

Impacts of climate change	**Gender specific vulnerability**	**Description**
Increased soil/ water salinity and other disaster frequency/ intensity	Low employment opportunities and low female wage rate	Due to increased salinity, scarcity of irrigation water, unavailability of cultivable land, increased disasters etc., the employment opportunities for women are decreased in the area; This also results in women getting very poor wage rates (or share of crop in kind).
Soil degradation and scarcity of irrigation water	Increased work load in the fields	Due to various climatic factors the land preparation requires more labor and women (particularly of wage laborers and small farming households) face increasing work loads in preparing lands in assisting their male family members in agriculture.
Increased water salinity & scarcity of fresh water	Increased drinking water carrying burden	Due to scarcity of fresh drinking water, the women face considerable burden in fetching drinking water. The increased salinity has further accelerated the problem.
Arsenic / contaminated water	Health hazards	Due to contamination in water, mainly arsenic, the women are facing many health hazards and suffer from diseases.
Erratic variation of	Health consequences/maladies	Due to erratic temperature behavior the women face more

temperature		health problems and suffer from various diseases.
Increased frequency of floods/ cyclones	Specific problems during floods/ cyclones	Women face many problems during disasters (cyclone, floods, storm surges etc.) in getting proper shelter. The sanitation facility, insecurity, safe child delivery are some of the specific problems women have to face during disasters.
Fodder and forage scarcity for cattle	Difficulties in livestock/poultry feeding	In the region arranging fodder and feed for cattle and fowls is mainly the responsibility of women. Due to deteriorating foraging land women have to make additional efforts in arranging sufficient amount of livestock fodder.
Less employment opportunity for male leads to migration	Social insecurity in absence of male members	Due to lack of employment opportunity male members of households often migrate out; women have to take over the lead of the household and often face social insecurity.
Deforestation due to cyclone, floods etc.	Difficulty in collection of firewood etc	Due to deforestation and destruction of trees during disasters (cyclone, storms, floods etc.) firewood sources decrease and women face difficulties in collecting and gathering these on a regular basis.
Scarcity of fresh water	Sanitation, hygiene and bathing related constrains	Due to scarcity of fresh surface water sources women face difficulties in having sufficient water within the households for sanitation, hygiene and bathing. The problem becomes more serious during disaster time.

6.3 The importance of livestock for livelihood groups and related vulnerability

In the all four study area upazilas, livestock is an important livelihood sector, especially for the landless and marginal farmers. The local people are dependent on livestock to meet their needs for food and energy in the form of milk, eggs, meat and for preparing land for agriculture crops. Many landless and marginal farmers' livelihoods depend solely on livestock. Table 6.6 below clearly shows that livestock is an integral part of rural livelihood in the study area.

Table- 6.6 Livestock population in study area upazilas

Livestock type	Dacope	Terokhada	Bhandaria	Nazirpur
Cattle	53992	34472	25033	21832
Goat	9825	7955	9042	11600
Fowls	173377	237249	333330	457144
Pig	2015	76	NA	NA

The changing climatic conditions are having adverse impact on livestock, too. Scarcity of fodder/ feed, increasing disease patterns causing cattle and fowl death and viral/ bacterial infection during disasters are the major risks the livestock sector is facing due to climate change. The impact of climate change and natural disasters is very obvious in the study area in the form of –

- Scarcity of fodder and pasture land - Due to high temperature, low rainfall and increased salinity the fodder cultivation is decreasing. As a result of salinity increase grass land is becoming barren.
- Increase in disease due to high temperature and other climatic factors-. Some of the common diseases which have increased among the cattle during the last few decades are: foot and mouth disease, black quarter disease, haemorrhagic septicemia, nematodiasis. coccidiosis, cholera etc. The fowl also show symptoms of increase in various diseases like ranikhet, foul fox, gomboro and duck plague. Some figures about the increasing disease trend in livestock, available from Terokhada upazila, are as given in Table -6.7. Similarly, in Dacope and Nazirpur upazilas there are also reports of cattle and poultry casualties due to various diseases. In Dacope about 2% of poultry and 0.5% of cattle have died due to various diseases in the recent past.

Table – 6.7: Portion of disease affected cattle and poultry in Terokhada upazila during the last eight years

Name of disease/ Year	Foot and Mouth Disease for cow	Black Quarter Disease for cow	Anthrax for Cattle	Haemorr-hagic Septicemia for cattle	PPR for Goat	Nemato-diasis for Goat	Ranikhet for Poultry	Foul fox for Poultry	Gamboro for poultry	Duck plague	Coccidiosis
2008	13%	3.6 %	5.5%	2.5%	8%	11%	11%	4%	6.5 %	13%	5.5%
2007	21%	3.8	8%	4.9%	17%	15%	23%	10.8	9.2	18.4	8.2%

		%						%	%	%	
2006	14%	2.4 %	6.5%	3.3%	9.5%	12.2 %	12.5 %	7%	6.2 %	1.5%	2.5%
2005	10.5%	1.2 %	3.5%	-	12.8%	-	7.5%	6%	3%	7.3%	-
2004	19%	3.6 %	6.4%	4.2%	16%	5%	26%	11%	5.5 %	19.5 %	5.06%
2003	8.5%	-	6.5%	-	8.2%	-	13.8 %	5.4%	2.4 %	5.5%	-

- Casualty due to natural disasters- Natural disasters like cyclone and flood result into large casualty of the livestock. After disaster usually the livestock suffer from various viral and other infectious diseases. During SIDR in Dacope Upazila only 150 goats, 75 sheeps, 62 cattle, and more than 1200 chicken and ducks died. In Nazirpur upazila about 3100 cattle, 2500 goats, 125 000 chicken and 2000 ducks have been affected by diseases, mainly after SIDR.
- Impact of increased salinity on cattle and poultry population- The increased salinity is affecting livestock population in project upazilas. Some examples in this regard from Dacope upazila are given in Table-6.8. One critical observation here is an increase in number of fowls and a decrease in cattle population.

Table -6.8: Impact of increased salinity on livestock population and fodder production in Dacope upazila during the last ten years

Name	**Impact of increased salinity**	**Impact on livestock population during the last ten years**
Cattle	Salinity highly affected it.	Population decreased by 20%
Poultry	The local species is not able to sustain salinity.	Rearing of local variety has decreased. Population increased by 25% due to poultry farming
Pig	Salinity does not affect it	Population increased by 10%
Sheep	Salinity does not affect it	Sheep can sustain and grow well in both saline and drought conditions. Population increased by 15%
Goat	Salinity affected it.	However due to inability of local community to rear big cattle like cows due to fodder scarcity, the population of goats increased by 15%.
Fodder production	Salinity affect fodder cultivation and production	80% decrease in fodder production. (During dry season while salinity is higher and severe crisis of fodder, people transfer their cattle in near Upazila for rearing on relatives' land.)

The above figures on the change in livestock population are also supported by the figures available from Bhandaria upazila in Pirojpur district (Table-6.9), where the number of cattle and goats has decreased and fowls increased between 1984 and 2005.

The figures from the different upazilas clearly indicate that whereas cattle population is decreasing in the area, the fowl population is increasing. This fact is very much supported by the local people perceptions. During various group discussion and meetings the local elite persons told that 10-20 years back almost each household used to rear some cattle and on an average the middle class farmer had 4-5 cows. Now people prefer to rear goat, hens or ducks in place of cattle. Possible reasons for this may be the scarcity of fodder (due to salinity increase) and increase in cattle diseases (due to high summer temperature and floods etc.).

Table 6.9: Changes in livestock population between years 1984 and 2005 in district Pirojpur and its Bhandaria upazila

Description	1984		1996		2005	
	Pirojpur	Bhandaria	Pirojpur	Bhandaria	Pirojpur	Bhandaria
Cattle	245908	33226	203538	26368	192564	25033
Goat	78854	12067	50481	6392	59560	9042
Fowls	787020	116493	989695	143838	2222201	333330

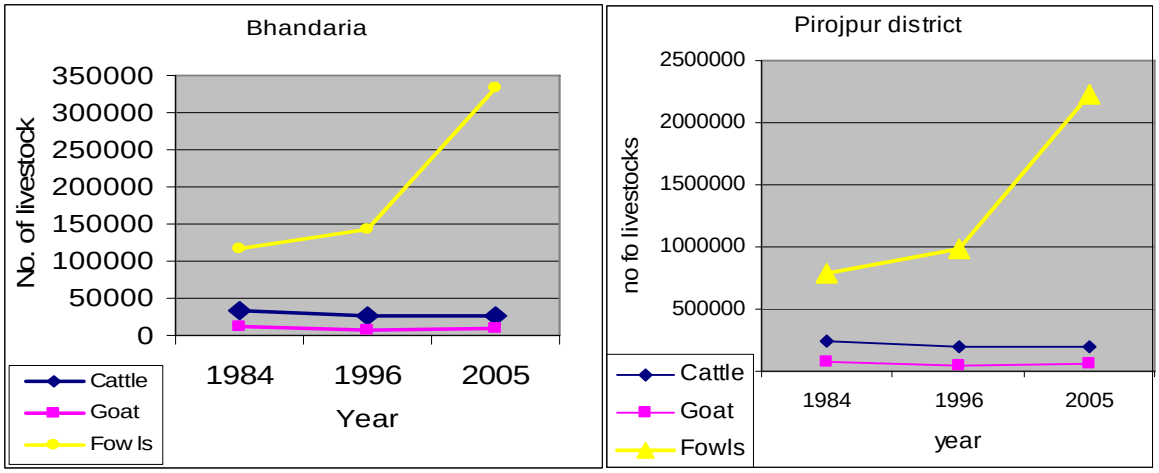


Fig. 6.2.: Graphical presentation of changes in livestock population in Pirojpur district and Bhandaria

6.3 Temporal variations in livelihood vulnerabilities

As listed above, the community people of the study area pursue various strategies and a range of activities to support their livelihoods throughout the year. However, natural and man made

hazards limit their income opportunities differently in different months. Agricultural crop production activities are affected by almost all types of hazards during various months of the year.

The study area is dominated by the T. Aman cultivation in the Kharif-II season, which is damaged by salinity in the month of *Ashar* (June-July) at the tender age of the seedlings. In some parts of all the upazilas, water/storm surge could affect the area and cause damage to the standing *T. Aman* in the following months i.e. July to September. Likewise pest and diseases affect the growth of the rice crop in the months of December and January.

Day laborers were identified as the most vulnerable group due to limited access to income opportunities, especially in the months of July to September. Due to submergence caused by flood, laborers were forced to sit idle without income and food and other times cyclone or water surge made them unable to pursue any activity. During the high salinity period of the year they are equally unable to get any employment in agricultural activities, as the land remains fallow due to high salinity.

7: ADAPTIVE RESPONSES AND COPING STRATEGIES

As people in the study area are vulnerable to various natural and human induced risks, they have been trying to build their own coping strategies and mechanisms to cope with the hazards affecting agricultural performance and other factors adversely affecting their livelihoods. According to local perceptions, in earlier days the people of the region used to obtain high yields of rice and fish in natural high and low tide situation. Now, people observe that the situation is changing very fast and now they are facing more risks, including climatic hazards, in comparison to earlier days. The majority of the local population states that after the Green Revolution, i.e. during the Seventies, the construction of artificial embankments has increased their problems mainly by increasing siltation.

A wide range of community level adaptive responses and coping strategies have been found during field studies. People identified them from their regular practices and of experiences of the past. The main adaptive responses evolved by local community in the study area are discussed below:

7.2. Common Adaptive Responses:

7.2.1. Community Responses:

- Mini pond**:** In medium low land, where watermelon and other cash crops are cultivated, farmers have tried to excavate mini sized ponds for increasing the availability of water for irrigation. In this mini pond, ground water is stored through leaching within several days after excavation. Farmers get better yields by using this water for irrigating watermelon and other crops.

- Canal excavation**:** For increasing fresh water availability, farmers are also trying to re-excavate the local canals. Some international NGOs like World Vision are helping local communities by providing technical and other assistance in carrying out this job. The canal water is used for irrigation and meeting other daily needs of local community.

- Retention of rainwater in canals**:** The practice of retaining water in the canal is common in the study area. In these canals water is retained near the crop fields. The boro crop which is extensively dependent on the irrigation water or the short duration variety of

Aus is often cultivated by local people taking water from these canals (locally called *khal*) and from ponds. The retained water from the canal is often optimally used in the Aus season. However, only a limited amount of farmers, whose land is located near these canals, can benefit from this option.

- Adjusting with Tide water***:*** The agriculture in the coastal area (especially in Dacope and Terokhada upazilas) solely depends on the tide water. There are two events regarding tide (Bengali known as *Joar-Bhata*) in a month. During tide (Locally-*Joba, Bhora kathal*) river/sea water experiences its highest level and during ebb tide (Locally-*Dala, Mora kathal*) the water level reaches the lowest level. Every day (in 24 hrs) farmers experience two times inundation of lands by tide water. Depending on the tide water level, farmers select lands for seedlings raising, transplantation of T. Aus and T. Aman and on lands which are suitable for Rabi crops, different crop varieties like short and long duration, deep water rice, salinity tolerant rice and/or other crops are grown. Community people also raise homestead depending on the tide water level.

- Boro rice cultivation**:** In the study area T. Aman rice is cultivated in a major portion of the cropped land. Due to decreasing yield trend of *T. Aman* rice (Maximum 6.5 T/ha), farmers have started to increase yields by increasing the cropping intensity. At the same time, observing the performance of Boro rice, they have started experimentally cultivating Boro rice such as *BRRI dhan 28* in the homestead area, where fresh water from the pond is available, and they received high yields of 28 *mond* or approx. 10.5 T/ha per *bigha*. Now farmers are excavating their ponds and canals for harvesting rain water for *boro rice* cultivation.

- Increasing cultivation of Local T. Aman**:** Yield performance of improved rice varieties are gradually decreasing due to increasing salinity. In the present situation, local T. Aman rice varieties, like *Nonakachi, Sadamota, Batiaghata balam,* perform better than the improved rice varieties. Farmers have taken initiatives for increasing cultivation of the above mentioned local T. Aman rice variety.

- *Sarjan* Method for Cultivation**:** *Sarjan or Kandhi-ber* is a method for a wide range of crop cultivation in the coastal areas, popular in Bhandaria and Nazirpur upazilas. Due to geo-physical reasons like the nature of the soil and land topography, water logging and

tide water, a large number of land areas remain fallow. On land which remains under water for 6 to 9 months of the year and where farmer cannot cultivate more than one crop, they practice this method to produce crops also in other seasons. In this method farmers dig up soil from the land areas between two adjacent beds and keep it on the elevated bed. The width of the beds usually ranges between 8 and 15 ft. The depth of the drain between two beds is generally of 5 to 6 ft. Farmers cultivate different leafy vegetables on the raised beds and also make bamboo roofs on the drain (in between two beds) and cultivate vinous vegetables on it. When water is available in the drains they also grow different fast growing fish in it. In the long run farmers establish perennial fruit garden using this method. By applying this method, farmers are able to use lands around the year for crop and fish production.

Vegetables cultivated on raised beds include Red amaranth, radish, wol, cabbage, cawliflower, tomato, brinjal, chilli, Indian spinach, kangkong, data and okra.

Vegetables cultivated on bamboo roofs are Bitter gourd, snack gourd, sweet gourd, bean, sponge gourd, pumpkin and gourd. Perennial crops/fruits grown are Banana, betel nut, mango and wood trees.

- Alternative farming**:** In the study area some of the farmers are starting to apply alternative farming systems, which were not practiced earlier. A few farmers have already established jujube gardens with improved varieties like Apple kul, BAU kul etc. The variety is suitable for this area and salinity tolerant.

- Fresh water fish/*Golda* cultivation**:** In the area there are many canals/*khals* connecting the crop fields as well as community places to the river/seas. These canals pass through the crop fields and thus allow the farmers to cultivate rice and fish simultaneously in a single crop field.

- Indigenous fish species culture in pond**:** Due to increasing salinity, many local fresh water fish species are disappearing from the local rivers, canals and even from low land ponds. To compensate this loss, a number of farmers have started trying to cultivate other local, more salinity resilient fresh water fish species, such as *Koi, Shing, Rui, Katla* etc. in their ponds near their homestead, obtaining good performance.

7.2.2. State and NGO supported responses:

In the study area a number of state supported adaptive responses were found, which are mainly driven by government agencies. The government department LGED has taken the initiative to construct drainage canals through projects conducted by water user groups for ensuring irrigation facilities as well as supply of pure drinking water to the people. The department of forestry has established strip plantations to mitigate different risks and hazards. Some NGOs have started activities like vegetable gardening, pond digging etc. However, these practices are not based on scientific consideration of climate change and its future impacts.

7.2.3 Socio-economic adaptive responses:

To cope with the changing climatic conditions and overcome future livelihood risks, some socio-economic responses are also very common in the study area. They include saving money through banking, receiving credit from NGOs, bank, and other financial sources, receiving loan from money lenders (*Mohajon*), migrating, taking up multiple livelihood activities at a time and mortgaging property or land.

7.3. Adaptation Options Identification

The above text showed that the local population in the study area is trying to adapt the changing climatic and other socio- economic conditions**.** There is, however, scope for identifying new options and for upgrading and/or refining the existing ones to meet the local livelihood needs. During PRA sessions and interaction/ discussion with many local elite/experienced persons and various government and non-government organizations officials a number of options have been identified as having the potential to improve livelihoods adaptation and the management of climatic risks in the area. The suggested options coming from different upazilas may be relevant for all project area upazilas. Based on thorough discussions with technical experts the main options have been compiled in the succeeding tables (Table- 7.1 to Table 7.3) season-wise, i. e. for Kharif-I, Kharif-II and Rabi.

Table-7.1. Locally practiced adaptation options during the Kharif –II season (16 July to 15 October)

Sl	**Name of option**	**Climatic Suitability and other additional benefits**

1.	Cultivation of T. Aman- Suitable variety: BR 31,33,40,41,46 (HYV), local-Vozon, Maynamoti, Mota, Naizershile -Life cycle of BR 33:120-125 days, -Life cycle of BR 40, 41:145-150 days	Suitable variety for local weather, short duration, socially accepted, high productivity, lower production costs
2.	Homestead vegetable cultivation-kangkong (gima kolmi), okra, spinach, ridge gourd, snake gourd, bitter gourd, sweet gourd, egg plant, cucumber, ash gourd, teasel gourd, data	Suitable and adapted, nutritious value, land utilization, compost use and environmental friendly situation production, financial benefits, tolerant and thus reduce vulnerability to salinity
3.	Rice fish culture- Suitable fish species: Rui, katla, Mrigel, Minar carp, Telapia, golda, sarputi Rice variety:local-Moynamoti, Mota, Vozon	Azola and Weed control, increase soil fertility, insect control, financial benefit, less food requirement for fish, multiuse of land, fulfill protein demand
4.	Small scale duck rearing- Species : local, Khaki cambel, Gingding	higher resistance to diseases, suitable for local weather, high egg productivity, high demand, waste use as food for fish and manure
5.	Fodder cultivation- Variety : napier, maize, para, ipil ipil	Suitable variety, less water demanding , nutrition supply to livestock, higher beef and milk productivity, economic benefits, optimum land use salinity tolerant crops and thus reduce vulnerability to salinity
6.	Semi scavenging poultry rearing	Familiar and socially accepted, lower disease and death rate, easy management, waste use as fish food and manure

Table-7.2. Locally practiced adaptation options during the Rabi season: (16 October to 15 March)

Sl	**Name of option**	**Climatic Suitability and other additional benefits**
1.	Cultivation of rice- Variety: BRRI dhan 47 (HYV), local-	Suitable variety for local weather, water and soil conditions, socially accepted, lower

	Vozon	production costs, salt tolerant
2.	Seed production of BR-47	Locally adapted, fulfills seed demand, salt tolerant, economic benefit
3.	Zero tillage cultivation of potato, pulse (lentil, kheshari, mungbean) and mustard	Easy cultivation, less production cost, suitable for this area, lower water demand, proper land utilization, environmentally friendly practices are ensured
4.	Winter vegetable cultivation- Suggested crop species: potato, sweet potato, bitter gourd, sweet gourd, cabbage, cauliflower, broccoli, radish, red amaranth, spinach, chili, onion, garlic, turmeric, tomato, carrot	Suitable and locally adapted varieties, nutritious value, land utilization, compost use and environmentally friendly , economic benefit, salinity salinity tolerant crops and thus reduce vulnerability to salinity
5.	Watermelon, sugarcane and wheat cultivation	Suitable and adapted, may be grown in soil with less nutrients, nutritious value, land utilization, financial benefit
6.	Improved stove making	Time and money saving, easy to make, less smoke- environmentally friendly, socially accepted, lower fuel consumption and demand
7.	River and canal re-excavation	Reduced salinity, water availability for irrigation, high demand, reduced water logging
8.	Better management of coconut and betel nut trees	Easy management, high demand, very suitable to local climate, socially accepted and adapted variety
9.	Compost/organic manure preparation	Increased soil fertility and water holding capacity, ensure environment, friendly cultivation practices and reduce salinity, incidence of less pest and disease infestation, best use of waste and cow dung
10.	Preparation of bio pesticide, using herbal plants- i.e. using *neem, nishinda, bishkatal*i tree	Climate and environmentally friendly, lower cost, lower health risk.

Table-7.3. Locally practiced adaptation options during the Kharif –I season: (16 March to 15 July)

Sl	Name of options	Climatic impacts
1.	Cultivation of Aus- Variety:BR- 21,26,27; local- goressar, shatia, soloy	Suitable variety for local weather/soil conditions , socially accepted
2.	Cultivation of vegetable and miscellaneous Crops: til, mungbean, sweet potato, *madraji oal*, turmeric, teasel gourd, zinger, gourd, bitter gourd, okra, snake gourd, ash gourd, spinach	Suitable and adapted to local conditions, nutritious value, land utilization, good surrounding environment, economically beneficial, salinity tolerant crops and thus reduce vulnerability to salinity
3.	Mini pond	Locally adapted, environmentally friendly, use for irrigation and drinking water supply, economically beneficial, multiuse of land, fulfill local demand
4.	Mini nursery with locally suitable plant species	Fulfill local demand for plantation species, source of quality planting material (QPM), environmentally friendly, socially accepted
5.	Plantation of phoenix, palm and teak tree	Suitable and adapted to local conditions, , salt tolerant, socially accepted , climate friendly
6.	Fruit gardening-jujube, mango, guava, lemon	Proper land use, fulfill local demand, decrease salinity, increased soil fertility, economically beneficial, creation of new business opportunities
7.	Cultivation of green manuring crop	Reduce salinity, use of fallow land, increase soil fertility and water holding capacity, increase crop production, climate friendly, easy to cultivate, socially accepted.
8	Prepare manure using water hyacinth	Increased productivity of crops; improved water flow in water bodies due to removal of hyacinth from water bodies,
9.	*Renu(fish spawn)* culture in nursery	Fulfill local demand, improved water

	pond	management, environmentally friendly
10.	Cattle raising	Meets local demand, economically benefit, waste use as fish food and manure, environmental benefits through provision of manure, nutrient to households.
11.	Rain water harvesting (for drinking)	Supplies drinking water, less disease through improved water quality, locally high demand, socially accepted, and also suitable for raising fresh water fish
12.	Fruit tree and medicinal plantation in fallow land and other unused space such as educational institutions- mango, *neem, bohera, horitoki, amloki, arjun, satomul*, alovera	Fulfills nutritional demands, medicinal value, environmental benefits through green coverage

7.4 Local energy supply status and scope for new resources:

Certain adaptation options require a secure energy supply. Hence, the local energy supply status is of great importance. People in the study area were found using various types of energy mainly for cooking, irrigation, transport, and other domestic purposes. Local people burn biomass in a large scale to meet the local energy needs. Dry leaves, fuel wood, crop residue, rice husk residuals etc. are the major types of biomass used by the local community to meet their energy demand Household members collect leaves, fuel wood, and crop residuals from homestead gardens, forests, fallow land, roadside trees, crop fields and so forth. Relatively poorer households collect their necessary biomass from natural sources outside their own premises and which they need not pay for. The better off households on the other hand purchase fuel wood from markets or collect it from their own orchards, crop fields etc. It was observed that a local method of processing and burning cow dung as fueling material is a widespread practice in the study area.

Electricity is mainly used in commercial places such as markets and some households. Scarcity of electricity is a major problem in the area.

Fossil fuels such as diesel, kerosene, petrol etc. are used in irrigation pumps, transport, for commercial purposes and by few richer households mainly for lighting, cooking, motor bike running and heating purposes. A locally modified form of a motor engine driven rickshaw van

(locally called *votvoti*) is a major diesel consumer in the local transport sector. It was found that these engine operated rickshaw vans contribute significantly to air pollution. The use of renewable energy sources such as solar energy was found quite limited, mainly due to high cost involved in their installation. Recently some NGOs have tried to introduce solar energy small house hold plants in the area in a few villages under the "Eco-Village Project".

Table 7.4. Local energy resources, uses and risks/ constraints

Energy resource	Main use	Constraints and risks
Solid biomass- firewood, cattle dung, dry leaves, farm residues etc.	• Cooking in household, restaurants/ tea stalls etc. • Brick kilns and other small industries	• Scarcity of fuel wood trees in the region due to changing soil conditions- mainly salinity. • The main source of firewood in the study area is forests. This puts additional pressure on already degraded forests in the area. • The use of cow dung debars the agriculture fields from the rich nutrients. • The use of wood in brick kilns implies a significant hazard not only for the forest but also for the air quality.
Fossil fuel- diesel, petrol, kerosene, coal etc.	• Irrigation pumps, power tillers, transport vehicles, industries, generators for lighting.	• The price is very high and not in reach of poor rural households. • The supply system is not good. The local retailers supplying the fuels usually adulterate it to get more benefit. • The use of poor quality fuel increases the air pollution and thus the hazard for health. • The transport motor vehicles are very old and use a lot of fuel and create more pollution.
Electricity-	Lighting, irrigation, industries etc.	The electricity supply situation in the study area is very poor, especially in the rural areas, where few (10%) villages have electricity supply. The power supply in the area is also very irregular; therefore, the people depend on diesel generators for

		irrigation and other purposes.
Alternative energy sources- solar and wind energy.	Solar PVC for lighting and TV etc. Solar energy for drying crops Wind energy for crop processing	The cost of solar panels is very high and thus only affordable for very rich people. Some NGOs are providing solar panels for a subsidized rate, but their use is still very limited. There is no provision of making use of wind energy- except in processing the rice or wheat crops.
Bio gas-	For cooking and lighting	The biogas plants may be a good alternative source of energy, but there are many constraints like- • reduced cow dung availability due to decreasing cattle population, • the costs are very high and beyond reach of poor people. • sometimes gas leakage from the plant create problem.

In brief, the energy situation in the study area is poor and needs immediate attention. The analysis of primary as well as secondary data indicates that there is scope to introduce innovative alternative energy sources i.e. biogas plants, solar energy plants and the use of tidal and wind energy in the area. There is also scope to reduce the amount of biomass burning through the introduction of energy efficiency measures, such as improved cooking stoves. The forestry sector may also play a significant role in reducing negative environmental and socio-economic effects of biomass burning, e.g. through the planting of short duration tree species under social and agro-forestry projects.

8. INSTITUTIONAL ASSESSMENT

Several governmental (national and sub national), international and non-governmental organizations, community clubs as well as informal local self help groups/ agencies are engaged in developmental and other social activities in the study areas. Many of them work on social awareness, community based income generating activities etc. Some are also working on disaster preparedness and on increasing community awareness of disaster and climatic risks. Many of them are directly or indirectly involved in climate change adaptation and mitigation activities. Extensive upazila and local level workshops along with meetings and discussions helped in identifying and reviewing the mandates, services provided, capacities, the gaps etc. of the institutional system for disaster and climate change risk management at local level.

The findings about the institutional assessments in the study area are outlined under the following subheadings in the succeeding text.

1. National and Upazila level government agencies
2. National and International NGOs
3. Local level NGOs/ institutions
4. Informal institutions
5. Local level disaster management institutions

8.1 National and Upazila Level Government Agencies and their activities:

The national and upazila level government departments are contributing to disaster and climate risk management through various activities, listed in the Table-8.1.

Table- 8.1: National and Upazila level government departments, their mandates and activities:

Agencies	Mandates	Activities
Department of Agricultural Extension (DAE)	Agricultural Extension and Development.	Agricultural advice and extension, SIDR Agriculture Rehabilitation programs, suggestions for salinity management, HYV rice cultivation; IPM/ICM, training and awareness programs; tree plantation, etc.
Department of	Fisheries	Netting in the pond/gher bank, pond bank

Fisheries	Extension and Development.	raising & compaction, salinity resistant fish species introduction, encouraging fresh water fish cultivation, pond fish culture, fish fry discharge in govt. open water body; advice for fish safety and diseases. Small pond/retention pond excavation technical knowledge; training and awareness programs.
Department of Livestock	Livestock, poultry birds Extension and Development.	Encouraging farmers for suitable fodder species production, small scale poultry & duct rearing ; use multivitamin for animals; vaccination programs etc.
Bangladesh Rural Development Board (BRDB)	Rural development.	Micro credit, rehabilitation of poor, loan for farmers & women
Bangladesh Water Development Board (BWDB)	Water resources development	Salinity & Flood control, Dam & sluice gate setup, river erosion and drainage control related activities.
Local Government and Engineering Department (LGED)	Local government and engineering development	Employment opportunities for disaster victims in road maintenance and tree plantation programs; Improve irrigation through canal excavation; tree plantation etc.
Directorate of Relief and Rehabilitation (DRR)	Food and disaster management	Food for Work (FFW) program; Provide relief during and after disaster, rehabilitation of disaster victims.
Department of Public Health Engineering (DPHE)	Public health Services.	Health care services, sanitary latrines and safe drinking water supply, Arsenic testing & other health related suggestion.
Department of Youth Development (DYD)	Youth development and training Services.	Loan for poultry, agriculture, training and public awareness programs.
Department of Forest	Forestry Development.	Tree plantation in the road side and other open spaces, social forestry/agro- forestry,

		Embankment to protect soil and plantation.
Department of Women Affairs	Women & children services	Legal assistance for women & children

8.2 National and International NGOs:

Major national and international NGOs engaged in disaster risk management and climate change adaptation activities in the region are *World Vision, Caritas, Head Bangladesh, Prodipan, Rupantar, BRAC, Proshika, CARE* and others. For capacity building in disaster preparedness and climate change adaptation, these NGOs provide trainings to different professionals like teachers, NGO staff, elected representatives, community leaders, *imams* and volunteers. They usually also conduct a number of awareness raising programs, like meetings, hanging signboards and billboards at public places, performing street drama, addressing public gatherings. Some NGOs, e.g. Prodipan and ADO Bangladesh, are involved in different disaster and climate risk mitigation activities, like roadside plantation, making small embankments and check dams, constructing disaster proof houses etc. During post disaster periods, large NGOs like World Vision, Caritas, Pupantar, Prodipan, and Head Bangladesh play a significant role by providing agriculture inputs like seeds, fertilizers and technical support for agricultural rehabilitation. Some of the NGOs like World Vision, CARE, *Prodipan* and *Sushilon* play also a vital role in climate change adaptation process.

"Reducing Vulnerability to Climate Change in South West Bangladesh (RVCC) project", implemented by CARE, was one of the most prominent climate change programs in the area. Its main objective was to increase the capacity of communities to adapt to the adverse effects of climate change. The CIDA funded project was implemented at four levels: household level, community level, institutional level and national level. At the household level, the project helped improving the capacity of vulnerable households to adapt to climate change impacts by making them aware of new livelihood strategies, using a group-based approach. At the community level, local partner organizations were trained to work with Union Parishads/councils and community leaders to increase their awareness of climate change impacts and to develop and implement community-level adaptation strategies. At the institutional level, the capacity of six local organizations was built up in three areas i.e.: collection and dissemination of information related to climate change; advocacy on salinity and its impact on potable water; and awareness campaigns on climate change issues. Tools developed included pictures, illustrating the causes

and effects of climate change and possible adaptation strategies, traditional folk songs, drama shows, posters and a series of radio programs, focusing on proven adaptation strategies. The project developed an 8-session module on climate change (including a flipcharts, easy-to-read books and a teacher's handbook). At the national level, the project succeeded in advocating with national-level stakeholders to increase awareness of local climate change implications and local people's needs, focusing on the lack of potable water due to salinity. The project made a valuable contribution to the improvement of the capacity of vulnerable households to innovate their livelihood strategies, and thereby reduce their vulnerability to climate change. In addition it also helped in improving the capacity to develop and implement community level adaptation strategies. Some of the household activities, e.g. floating gardens, community water supply, and water filter system, have been cooperative and involved community decisions.

World Vision's climate change adaptation activities in the region include canal and pond excavation and re-excavation for rain water harvesting for increasing availability of sweet water in dry season and for fish cultivation. For increasing fodder production, World Vision is demonstrating the cultivation of *Napier, Para and German grass*. For increasing agricultural productivity in the dry season, a watermelon extension program has also been taken up by several NGOs in Dacope and Bhandaria upazilas.

8.3 Local level NGOs

In the study area upazilas formal local NGOs play a vital role in awareness raising in the field of disaster risk management (DRM) and climate change adaptation (CCA) in collaboration with national and international NGO's and with the help of the local government. NGOs are also involved in local Union Disaster Management Committee activities. These NGOs work during all three stages of disaster risk management i.e.-pre-disaster, during disaster and post disaster rehabilitation stages. In the pre-disaster stage, local organizations are active in mobilizing communities for taking appropriate preparedness measures and also help in capacity building through meetings, awareness campaign and training the people. During the disaster stage, these NGOs work for relief and rescue operation in close collaboration of local governments and administration. Some local NGOs provide voluntary services in post disaster situations for rehabilitation of the affected community. In addition to disaster management, a number of local NGOs are involved in different activities related to climate change adaptation. The activities of the various local level NGO's relating to DRM and CCA are listed below (Table- 8.2)

Table 8.2.- Major local level NGOs active in the region and their contribution to disaster risk management and climate change adaptation:

NGO/institutions/Cooperative Society	**Major activities for Disaster Risk Management**
Local BRAC	Post disaster relief distribution-financial support, food, cloth, medicine, agriculture input. Awareness generation about DRM and CCA
Dak Die Jai	Relief distribution
PDBF	Provide support to administration in relief distribution and awareness generation
Union agriculture committee	Awareness creation among farmers on disaster risk management, provide relief in the form of agriculture inputs
Palli water supply and sanitation committee	Awareness creation, water conservation, sanitation
Union police committee	Provide support in maintaining law and order during disaster situation.
Market committee	Awareness creation among business community on Disaster Risk management
ASA	Micro credit- for rehabilitation
Grameen Bank	Micro credit- for rehabilitation
Proshika	Micro credit- for rehabilitation
Eskender Welfare	Micro finance and relief distribution
Joy Arto Samajik Protisthan	Micro credit- for rehabilitation
Sheikhmatia Motsha Samobay Samity	Fish culture
Suprosh	Micro credit- for rehabilitation
Unnayan	Micro credit- for rehabilitation
RIK	Micro credit- for rehabilitation
Hoglabunia Bazaar Committee	Market development
Kodek	Micro credit- for rehabilitation
Motshajibi Samity	Fish culture
Gano Unnayan	Relief distribution , awareness creation and social activities

8.4 Activities of informal institutions

In addition to formal NGOs and agencies, there are number of informal institutions in the region actively engaged in many social welfare and cultural activities. These organizations, if provided proper guidance, support and training, may play a significant role in disaster and climate risk management in the future. Based on KII with Union Parishad Chairman, following informal (i.e. not registered) institutions enlisted are active in almost all four upazilas (Table 8.3.)

Table 8.3: Informal institutions and main activities

Informal institutions	**Activities**
Rajlokkhi Foundation	Social activities like distribution of food, cloth, finance and medical support to vulnerable peoples during disaster
Ekata Tarun Sangha	Social activities, cultural and sports
Tiger Friends Jubo Sangha	Social activities, cultural and sports
Mukul Sporting Club	Social activities, cultural and sports
Fruit Business Samity	Social activities
Tempoo Autoriksha Malik Samity	Social activities, guiding people to reach shelter centre
Muktijoddha Sangshad	Social activities
Sapla Sangha	Social activities
Sarna Samaj Unnayan Sangha	Social activities, relief distribution
Baniari club	Social activities, cultural and sports
Union Farmers Association	Agricultural activities
Krishok Shramik Sangha	Ensure labour wage
Baticram Sangha	Health service, book distribution to poor students, awareness programme on disaster risk management
Mouchak Sangha	Shelter and primary treatment
Amra Kjon Sangha	Social activities
Sonar Bangla Jubo Sangha	Shelter, rescue and social activities
Progati Sangha	Shelter and social activities

8.5 Local level disaster management institutions

The national disaster management institutional structure for comprehensive disaster management acknowledges the significance of the institutional presence down to the local, i.e the union, level. In the proposed structure, the line agencies work at Upazila level under the supervision of UNO (the upazila administrative head) and at union level through the coordination of the Union Parishad Chairman (which is an elected person). The composition of the union level disaster management committees is shown in Table 8.4.

Table- 8.4: Formal structure of union level disaster management committee:

Chairman of Union Parishad	Chairman
All Members of the Union Parishad	Members
Teacher representative	Member
Officials/ staffs of the respective departments	Members
Team Leader of the CPP in cyclone prone unions	Member
Representative of Bangladesh Red Crescent Society	Member
NGO/CBO representative	Member
Women representatives (at least 2)	Members
Secretary of the Union Parishad	Member – Secretary

Though this local level structure of union disaster management committees officially exists in the study areas, it is not very effective and popular. At many places it was found that many people are not aware about this institutional structure and its functioning. Local people, especially of vulnerable livelihood groups, disclosed that they have very poor access to disaster management discussions even at union level. These observations and finding suggest that the local vulnerable group members have very limited information about the role, mandates and functioning of these disaster management committees at the ground level. It is also a common observation in all upazilas that these committees, though quite active during and after disaster periods, are not doing much for preparedness and disaster mitigation. In addition, the committee members have very limited knowledge about the issues related to climate change and need capacity building.

8.6 Extent and Use of Information Sources:

As far as the institutional system for disaster and climate change related information flow, awareness and dissemination in the study area is concerned, it emerged from the fieldwork that some information regarding weather, agriculture and disasters are disseminated by government assisted national and regional news media such as Bangladesh Betar (Radio) and Bangladesh Television (BTV) . The national and regional newspapers have reasonable access up to upazila level. As DAE has presence up to block level, its extension staff, mainly the SAAOs, help in disseminating the information in respective blocks and at farmer level to some extent. Local market places, religious places, educational institutions, upazila and union parishads are the common places from where information spreads to the community and household level. However, farmers and other livelihood group members hardly find this information in time and in most of the cases this information is neither very user friendly nor location specific and thus not much used by the target groups. The dissemination of the information to vulnerable groups like women is very rare. The existing information flow and its utility based on PRA sessions feed back, discussion with different other stakeholders is outlined in Table- 8.5. It reveals that the information flow about weather, agriculture and disaster warning is weak at village level. The weaker section of the society and women usually do not get reliable and complete information and thus are at greatest risk.

Table 8.5.- Local level information flow and its utility-

SOURCES	**UTILITY STATUS AT VARIOUS LEVELS**		
	Upazila level	Village level	Vulnerable groups (including rural women)
Radio	**W, A, D**	**W, A, D**	**W, A, D**
National and regional TV	**W, A, D**	**W, A, D**	----------
News paper	**W, D**	**W, D**	----------
Local DMC	**D**	**D**	----------
Mobile SMS/ message	**D**	**D**	----------
Local market and	**W, D**	**W, D**	**W, D**

common places li7ke local Hat			
DAE	**A**	**A**	----------
Other GO- NGO institutions	**W, D**	**W, D**	**W, D**

Legend-

W- Weather related information i.e. rainfall, wind, temperature, humidity etc.

A- Agriculture related information i.e. crops, pest, pesticides, market rate, fertilizer etc.

D- Disaster related warning for flood, cyclone, heavy rainfall, storm surge etc.

(Dark green -Very useful, and timely information, Light green- useful and timely information flow and dissemination, Dark blue- Weak flow and dissemination of information, Light blue- Very weak and only partial information flow)

8.7. Coordination mechanisms and institutional linkages

The activities of the government agencies in the study upazila are largely dependent on their respective district offices, where the major financial and planning decisions are made for development and coordination. In the study upazilas, the upazila level line agencies remained largely responsible to their agency or departmental superiors at district level. For example, most of operations of the Department of Fisheries in the study area were found to be controlled and decided at district level. At operational tier the upazila level administration is found more responsible for execution of activities. This is the level where more coordination is needed both vertically and horizontally. In most of the cases this coordination is mainly dependent on liaison among officials. The relationship within upazila administration departments in general seems quite satisfactory.

As discussed in the preceding section, a number of NGOs and other local agencies are working in the region for disaster risk management and other related aspects. However, a proper coordination mechanism among them is still lacking. Some of the NGOs, especially international and national organizations, rarely meet in the Upazila Coordination Committees, chaired by the Upazila Nirbahi Officers (UNO). In few cases these NGOs (both national and international) maintain good liaison with different government departments, like the agriculture and livestock department. Some of the NGOs, like World Vision, provide coordination platforms to local community based

organizations and also assist and support them financially in carrying out various disaster risk management related activities.

At union level the coordination among the government agencies is found to be comparatively weak. Most of the line departments are found to have good networks up to the upazila level, while below the upazila level, except DAE, all departments evidently have a shortage of staff, which hampers their functioning. In comparison to other local administration departments, DAE functioning is found quite satisfactory at block level, where the Sub Assistant Agriculture Officers (SAAOs) work in close collaboration with the community.

The vertical linkage of the NGOs operating in the study area also seems not to be very effective. Except few national NGOs, such as ASA, PROSIKA, BRAC, GRAMEEN BANK, most of the other NGOs lack wider networks at the community level. The coordination within the NGOs and coordination between NGOs and government departments in case of disaster and climatic risk management in the area is in general absent. At upazila level coordination meetings are called in the study upazilas, but the practical execution of work rarely reflects any coordinated action against the climate risk management at ground level.

8.8 Analysis and Suggestions

The analysis of the secondary and primary information about the institutional system for disaster risk management and climate change adaptation clearly shows that there is urgent need to build capacity of local NGOs and other formal and informal institutions and develop an effective coordination mechanism. There is good scope to work on the following issues-

- Capacity building of NGOs (National and local NGOs), GOs, Local DMCs and other informal agencies/ groups.
- Sector specific disaster management planning and its implementation
- Developing strong coordination among the agencies through regular experience and sharing meetings and workshops

Capacity Building**:** There are a number of agencies (both GOs and NGOs) working in the area in different developmental and social sectors. However, they are not much concerned about the CCA and associated issues. There is need to capacitate these organizations in such a way so that disaster preparedness/ prevention and CCA are mainstreamed, i.e. considered integral parts of all developmental activities.. This can be achieved through regular training programmes and

awareness generation activities at various levels. CDMP along with its partner organizations needs to play a lead role in this regard. The Upazila and Union DMC already established by CDMP need to be further capacitated so that they can play their role more effectively.

Disaster Management Planning and its implementation**:** The National Disaster Management Act and Policy (both in draft form) advocate developing sector specific DM plans and their implementation by all GOs and public/ private sectors. There is need to develop and implement such plans at local and regional levels, too. Along with disaster preparedness and prevention such plans should also incorporate CCA issues.

Strengthen coordination mechanisms at regional and local levels: To effectively deal with DRM and CCA issues in the area it is urgently needed that the intra and inter GOs and NGOs coordination system is revitalized and strengthened. As explained in the preceding text, the coordination at upazila level is the sole responsibility of the coordination committee headed by UNO, but due to overburden of work, the coordination is least prioritized and coordination committee meetings are not taken very seriously in general. The coordination among different government departments at upazila level is satisfactory, yet the linkage and coordination of the government departments with NGOs is not always effective. Proper coordination among different NGOs working in same area is also lacking in many cases, resulting in overlapping of activities.

Consultations with different upazila and other GOs and NGOs officials revealed that the upazila level coordination committee has to be made more effective. The coordination committee meetings have to be held more regularly, and follow up action is very much needed. A focal point at upazila level should be established who would be solely responsible for looking after and reviewing the works of different agencies working in the upazila at various levels. Different government departments at upazila level also need to have a focal point to look after, review and guide the work of different NGOs working in that specific sector. At union level, the union disaster management committees are to be further strengthened through capacity building, involving trainings of their members. The DAE, having a good network up to grass root level through its SAAOs, may play an effective role in coordination efforts and thus should consider an active involvement of the SAAOs in different coordination committees.

9. CONCLUSIONS:

The coastal region of Bangladesh due to its geo-physical position and socio- economical context is prone to several types of natural hazards. The recurring hazards like increased salinity, cyclones, storm surges, floods, water logging etc. are leaving lives and livelihood of the coastal community in peril and have severe impact on every sector, agriculture being the worst. The climate change is expected to increase the severity and frequency of these hazards posing a direct threat to agriculture and allied sectors. The present study was carried out with an objective to appraise the livelihood vulnerability of the project area community, which has been exacerbated by the current problems and future risks posed by climate change and identifies the local adaptive and coping responses to the changing climatic conditions. The study was carried out in four upzilas namely Dacope, Terokhada of Khulna district and Nazirpur and Bhandaria of Pirozpur district.

The study area mainly consists of three major physiographic features i.e. Gangetic floodplains, tidal floodplains and partly marshy land and consists of non-calcareous to dark gray and non-saline to seasonally saline with a loamy clayey texture soil types. In general the soils are deficient in organic matter and nutrients, like Potassium, Phosphorous and Nitrogen and have medium to high Sulphur content. The salinity in the soil varies from low to very high and shows increasing trend, both in terms of salt content and area affected. The mean annual temperature in around 25*C and varies between 16 and 35*C. Highest temperatures are observed in the months of April and May (39*C) and lowest in the months of January (7*C). Water salinity is also a major problem in the region varying with season, maximum during months of March to May and decrease with onset of Monsoon. The mean annual total rainfall of the study area varies between 1400 and 1500mm, whereas dry season rainfall is only 18 to 22% of the mean annual rainfall. The relative humidity remains high throughout the year, around 72% and sunshine hours range between 6.5 and 7 hours. The area is subject to tidal bore, and occasionally large areas become flooded with saline water.

The analysis of the past data of the region show signs of change in climatic parameters like decreasing trend for the Monsoon rain during earlier months of the season and increasing trend during the later months; increase in the maximum temperature and decrease in the minimum temperature; and overall decreasing trend in sunshine duration and evaporation. The results of different climate modelling systems have been analysed to get an idea about the future climatic risks in the study area. The PRECIS model outputs indicated that the monsoon rainfall will increase in all years and from 2051 to onwards its surplus amount is large. It will remain almost

same in 2030 and 2050. Importantly, large amount of rainfall is projected in August for all years except its deficit in 2030. Maximum temperature have been projected to increase during monsoon period and to decrease in other periods.

Different studies indicate continuous sea level rise and resulting inundation which is likely to pose a severe inundation threat in the region. For high emission scenario the SLR prediction is 62 cm, which may result into more than half of the land area of the study districts inundated by 2080. Sea level rise and potentially higher storm surge is likely to result in over-topping of saline water behind the embankments of the polders. About 32% more area will be deeply inundated due to overtopping of embankment. Some of the LACC-II coastal upazilas fall into these potentially overtopped polders. SLR is also supposed to increase water salinity. In the case of 62 cm SLR, about 6% sweet water area during Monsoon and 9% area during dry season would be lost. The IDS ORCHID study shows that increase in wind velocity may range from 3% to 12% by the 2020s and from 4% to 20% by the 2050s. Storm surge heights may increase from 15% to 25% (2020s) and 32% (2050s) due to increases in temperature. The LACC-II coastal pilot areas may show storm surge intrusion up to 46.63km in worst Scenario.

As a result of adverse impacts of climatic risks and its increase in near future the lives of local community are adversely affected in many ways, including their livelihood. In the four study area upazilas, increased salinity is ranked as number one risk, causing huge damage to the crops, water and the entire environment of the area. In addition to salinity, the other major risks posing direct threat to livelihoods are cyclones and floods, storm surge, droughts, water logging, deforestation and forest degradation, insect and disease infestation and virus infestation in fishes. The vulnerability of different livelihood groups depends on various physical and socio- economic factors, deciding the coping capacity of the individual group to resist the disaster impacts. Among the various livelihood groups, the rural wage labourers are at the highest risks, followed by small / marginal farmers and fishers. Women due to number of socio- cultural and other physical reasons are generally more vulnerable to climatic and non climatic risks.

The situation study showed that the local population, vulnerable to various natural and human induced risks is already trying to adapt the changing climatic and other socio- economic conditions. There is however, need for further updating and/ or refining of existing practices. Several adaptation options have been identified which have the potential to improve the livelihoods adaptation capacities and the management of climatic risks in the area. Based on

thorough discussions with the technical experts the main options recommended season wise along with climatic suitability and additional benefits are enlisted in the tables 9.1 to 9.3.

Table 9.1: Recommended Adaptation options for the Kharif II season

Sl	Name of option	Climatic Suitability and other additional benefits
1	Cultivation of T. Aman- Suitable variety: BR 31,33,40,41,46 (HYV), local-Vozon, Maynamoti, Mota, Naizershile. Life cycle of BR 33:120-125 days; Life cycle of BR 40, 41:145-150 days	Suitable variety for local weather, short duration, socially accepted, high productivity, lower production costs
2.	Homestead vegetable cultivation: kangkong (gima kolmi), okra, spinach, ridge gourd, snake gourd, bitter gourd, sweet gourd, egg plant, cucumber, ash gourd, teasel gourd, data	Suitable and adapted, nutritious value, land utilization, compost use and environmental friendly situation production, financial benefits, salt tolerant and thus reduce vulnerability to salinity
3.	Rice fish culture- Suitable fish species: Rui, katla, Mrigel, Minar carp, Telapia, golda, sarputi; Rice variety: local-Moynamoti, Mota, Vozon	Azola and Weed control, increase soil fertility, insect control, financial benefit, less food requirement for fish, multiuse of land, fulfil protein demand
4.	Small scale duck rearing- Species : local, Khaki cambel, Gingding;	higher resistance to diseases, suitable for local weather, high egg productivity, high demand, waste use as food for fish and manure
5.	Fodder cultivation- Variety : napier, maize, para, ipil ipil	Suitable variety, less water demanding , nutrition supply to livestock, higher beef and milk productivity, economic benefits, optimum land use, salinity tolerant crops and thus reduce vulnerability to salinity
6.	Semi scavenging poultry rearing	Familiar and socially accepted, lower disease and death rate, easy management, waste use as fish food and manure

Table-9.2.: Recommended adaptation options for the Rabi season:

Sl	Name of option Climatic	Suitability and other additional benefits
1.	Cultivation of rice- Variety: BRRI dhan 47 (HYV), locally - suitable variety for local weather, water and soil conditions, socially accepted, local- Vozon	Suitable variety for local weather, water and soil conditions, socially accepted, lower production cost, salt tolerant
2.	Seed production of BR-47	Locally adapted, fulfils seed demand, salt tolerant, economic benefit
3.	Zero tillage cultivation of potato, pulse (lentil, kheshari, mung bean) and mustard	Easy cultivation, less production cost, suitable for this area, lower water demand, proper land utilization, environmentally friendly practices are ensured
4.	Winter vegetable cultivation: Suggested	Suitable and locally adapted varieties,

	crop species- potato, sweet potato, bitter gourd, sweet gourd, cabbage, cauliflower, broccoli, radish, red amaranth, spinach, chilli, onion, garlic, turmeric, tomato, carrot	nutritious value, land utilization, compost use and environmentally friendly , economic benefit, salt tolerant crops and thus reduce vulnerability to salinity
5.	Watermelon, sugarcane and wheat cultivation	Suitable and adapted, may be grown in soil with less nutrients, nutritious value, land utilization, financial benefit
6.	Improved stove making	Time and money saving, easy to make, less smoke- environmentally friendly, socially accepted, lower fuel consumption
7.	River and canal re-excavation	Reduced salinity, water availability for irrigation, high demand, reduced water logging
8.	Better management of coconut and betel nut trees	Easy management, high demand, very suitable to local climate, socially accepted and adapted variety
9.	Compost/organic manure preparation	Increased soil fertility and water holding capacity, environment friendly cultivation practices and reduce salinity, incidence of less pest and disease infestation, best use of waste and cow dung
10.	Preparation of bio pesticide, using herbal plants- i.e. using neem, nishinda, bishkatali tree	Climate and environmentally friendly, lower cost, lower health risk.

Table—9.3 Recommended adaptation options for the Kharif –I season

Sl	Name of options	Climatic impacts
1.	Cultivation of Aus-Variety:BR-21,26,27; local- goressar, shatia, soloy	Suitable variety for local weather/soil conditions, socially accepted
2.	Cultivation of vegetable and miscellaneous crops: til, mungbean, sweet potato, madraji oal, turmeric, teasel gourd, zinger, gourd, bitter gourd, okra, snake gourd, ash gourd, spinach	Suitable and adapted to local conditions, nutritious value, land utilization, good surrounding environment, economically beneficial, salt tolerant crops and thus reduce vulnerability to salinity
3.	Mini pond	Locally adapted, environmentally friendly, use for irrigation and drinking water supply, economically beneficial, multiuse of land, fulfil local demand
4.	Mini nursery with locally suitable plant species	Fulfil local demand for plantation species, source of quality planting material (QPM), environmentally friendly, socially accepted
5.	Plantation of phoenix, palm and teak tree	Suitable and adapted to local conditions, , salt tolerant, socially accepted , climate friendly
6.	Fruit gardening-jujube, mango, guava, lemon	Proper land use, fulfil local demand, decrease salinity, increased soil fertility, economically beneficial, creation of new business

		opportunities
7.	Cultivation of green manuring crop	Reduce salinity, use of fallow land, increase soil fertility and water holding capacity, increase crop production, climate friendly, easy to cultivate, socially accepted.
8	Prepare manure using water hyacinth	Increased productivity of crops; improved water flow in water bodies due to removal of hyacinth from water bodies.
9.	Renu(fish spawn) culture in nursery pond	Fulfils local demand, improved water management, environmentally friendly
10.	Cattle raising	Meets local demand, economically benefit, waste use as fish food and manure, environmental benefits through provision of manure, nutrient to households.
11.	Rain water harvesting (for drinking)	Supplies drinking water, less disease through improved water quality, locally high demand, socially accepted, and also suitable for raising fresh water fish.
12.	Fruit tree and medicinal plantation in fallow land and other unused space such as educational institutions; mango, neem, bohera, horitoki, amloki, arjun, satomul, alovera	Fulfils nutritional demands, medicinal value, environmental benefits through green coverage

The institutional assessment indentified several active governmental and non- governmental organisations, community clubs, informal local self help groups, which however are mainly engaged in developmental and social activities. Some of them are also working for disaster preparedness and on increasing community awareness of disaster and climatic risks. The analysis of the secondary and primary information about the institutional system for disaster risk management and climate change adaptation clearly shows that there is urgent need to enhance the capacities of local NGOs and other formal and informal institutions and develop an effective coordination mechanism for DRR and CCA. There is good scope to work on - capacity building of NGOs, GOs, Local DMCs and other informal agencies/ groups; sector specific disaster management planning and its implementation; and developing strong coordination among the agencies through regular experience sharing meetings and workshops. The institutional system developed and practiced in the LACC project areas for identifying, validating, field testing and recommending suitable adaptation options, through establishing technical working groups at different levels, may be quite effective and useful in reducing the vulnerability to climatic risks of different livelihood groups in the area.

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11. Annexures:

I. Framework of Activities and Process,

II. Soil and land type maps of four study area upazilas along with soil and land characteristics brief.

III. LACC demonstration sites of soil sample analysis and soil sample analysis results form four upazilas.

IV. Long term climatic data from two stations neighboring to project districts

V. Hazard risk maps of four upazilas- based on past experiences and other secondary information