CREL Knowledge and Impact Series – Report 8

Participatory Climate Vulnerability Assessment and Local Planning

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Climate-Resilient Ecosystems and Livelihoods (CREL)
in association with Bangladesh Centre for Advanced Studies(BCAS)
AID-388-A-12-00007
Dhaka
July 2018

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Cover photos: Group work of stakeholder workshop on PCVA findings sharing at CMC office in Rasulpur, Tangail, PCVA group work at Dacope-Koyra site in Khulna and Himchari site in Cox's Bazar) (Photos: regional and site teams)

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This publication is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents of this document do not necessarily reflect the views of the USAID or the United States Government.

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Abbreviations

AGCM	Atmospheric General Circulation Model
ANR	Assisted Natural Regeneration
BCAS	Bangladesh Centre for Advanced Studies
BMD	Bangladesh Meteorological Department
CMC	Co-Management Committee
CMO	Co-Management Organization
CREL	Climate Resilient Ecosystems and Livelihoods
CNRS	Center for Natural Resource Studies
CBO	Community Based Organization
CBA	Community Based Adaptation
CODEC	Community Development Centre
DoE	Department of Environment
DoF	Department of Fisheries
DRR	Disaster Risk Reduction
ECA	Ecologically Critical Area
FD	Forest Department
FGD	Focus Group Discussion
IPCC	Intergovernmental Panel on Climate Change
MoEF	Ministry of Environment and Fisheries
MoFL	Ministry of Fisheries and Livestock
MoL	Ministry of Land
NRM	Natural Resource Management\
NACOM	Nature Conservation Movement
NGO	Non-Government Organization
PA	Protected Area
PCVA	Participatory Climate Vulnerability Assessment
PF	Peoples Forum
TRMM	Tropical Rainfall Measuring Mission
UP	Union Parishad
USAID	United States Agency for International Development
VCF	Village Conservation Forum

Executive Summary

Climate change is now a reality for the world and this is true for Bangladesh, which is one of the worst affected countries in the world by climate change. Ecosystems, biodiversity, wildlife and natural resources are becoming endangered day by day in Bangladesh due to climate change and man-made activities. The main objective of the CREL Project is to make ecosystems, natural resources and livelihoods climate-resilient and to empower local people. Participatory Climate Vulnerability Assessment (PCVA) follows a participatory, reflection and action approach to engage and empower vulnerable people to identify their climate hazards, risks, and vulnerability to current and future climate hazards. It follows both bottom up and top-down approaches for comprehensive understanding of climate change trends, impacts, risks and vulnerability in the regional/ecological, and local social and institutional contexts. In this process, local people, project staff and climate scientists worked collectively to understand climate change risks and vulnerability, as well as to identify appropriate adaptation and mitigation options in the local context. Secondary data on climate change (past trends and future projections at regional and local contexts) has been triangulated with primary data, views, perspectives, experiential knowledge and insight from local people.

Bangladesh Centre for Advanced Studies facilitated the PCVA process by conducting Training of Trainers for regional implementing partners of CREL project, guiding village conservation forums and Co-management Committees to undertake transact walks and stakeholder workshops, this led to village level adaptation plans. The PCVA process helped local actors identify their own problems and feasible actions that could improve natural resources management, livelihoods, disaster risk reduction, adaptation and mitigation in biodiverse sites. The outputs were used in developing PA management plans and CMO long-term plans.

Long term temperature and rainfall trends were calculated based on Bangladesh Meteorological Department data and the Atmospheric General Circulation Model, and projections to 2030 and 2050 were made for each region where CREL worked, and the main relevant ecosystems in those regions. This analysis predicts continuing rising temperatures in almost all regions and ecosystems, apart from declining winter temperatures in the Chittagong hill ecosystem. In most region-ecosystem combinations only small changes in annual rainfall are predicted, but the seasonal distribution of rainfall will change – with the pre-monsoon becoming much wetter in most sites in the east of Bangladesh, and much drier in the southwest region. Moreover the coast of Cox's Bazar region (already the wettest CREL working area) would become about 50% wetter by 2050. The coast of Bangladesh is affected by tropical cyclones and associated storm surge. The tracks of cyclones, trends of cyclone frequency and its intensity in terms of wind speed were analyzed, but no clear trends in frequency were detected or predicted.

In total 257 PCVAs were undertaken, and these led to 824 village adaptation plans. These were consolidated into adaptation and disaster risk reduction plans for forest beats and Union Parishads, and have been summarized by region for this report. The PCVAs within each region found broadly similar locally perceived trends and future expectations with respect to climatic stresses and hazards, which were considered for the periods 1980-2000, 2001-2010, and 2011-2030. These trends and expectations tended to be in broad alignment with those derived from scientific evidence, where available. The general pattern was of reported low hazards before 2000, more severe or more frequent hazards during 2001-2010 (such as more landslides, higher temperatures, increasing surface and groundwater salinity, and universally pessimistic virew3s of the future to 2030. PCVA participants ranked the level of vulnerability of different sectors and social groups (farmers, fishers, wage earners, women, etc.) of the local economy. There was broad agreement across regions that agriculture is the most vulnerable sector to climate change because multiple climate hazards and trends (from drought, heat, and declining water tables to cyclones and floods) adversely affect agriculture and most farmers have small or marginal landholdings including homestead gardening. Vulnerability ranking of other sectors differed considerably between regions – for example in Cox's Bazar, Chittagong and the

northeast regions nature, forest and wildlife was ranked the sector second most vulnerable to climate change, while health, water and sanitation ranked second in the southwest and third in Cox's Bazar. Within sectors: summer crops were considered the most climate stressed within agriculture; challenges to get safe drinking water were widely reported; drought and salinity intrusion were the main factors adversely affecting forest; drought also reduces surface water and fisheries; salinity, heat and drought cause poultry and livestock losses; floods were the main source of infrastructure damage.

PCVA participants already are aware of and/or practice a range of individual adaptation and coping strategies, but many of these depend on external information and support, and government programs were reported to be short-term rather than long-term. Moreover, there were fewer group or collective adaptations reported. The village adaptation plans average about four actions per village among a wide range of potential measures. Commonly villages plan to change their crop varieties to ones adapted to current trends (drought, cold, salinity, etc., depending on the location) and mainly in the northeast to request support for installing deep tubewells. In the southwest the dominant adaptation actions are for farmers to use virus free shrimp fry when stocking their fish farms and to cultivate salt tolerant fishes, and for more people to adopt crab fattening. Also in the southwest a majority of villages plan to promote keeping poultry that is better adapted to the saline environment, and to keep space for livestock in their cyclone shelters. Out of a range of water and health related actions a majority across regions involve improving access to fresh /safe drinking water, whether from more tubewells or from storing or treating water. Improving local roads and their durability in heavy rains is common to many village plans. Mitigation also features - only around Modhupur NP (central region) were improved cooking stoves a widespread priority for most villages, but expanding social forestry is a widespread priority highlighted by a third of all villages.

Already several CMCs have been able to mobilize resources and agencies, particularly Union Parishads, to help in implementing elements of these local village based adaptation plans. There are many competing demands on limited resources, but PCVAs have helped to articulate and present in a systematic way priority actions to improve resilience of the most vulnerable.

Acknowledgements

Participatory Climate Vulnerability Assessment (PCVA) was conducted in Chittagong, Cox's Bazar, Khulna, Sylhet and Central regions of CREL. Local and regional PCVA reports were prepared, and this report is a synthesis of all these reports. The four authors from Bangladesh Centre for Advanced Studies (BCAS) are thankful to Mr. Shams Uddin, Manager, Landscape Planning, Ecosystems and Biodiversity for help in conducting training of trainers in PCVA and stakeholder workshops in different CREL regions. During the project period, the Regional Coordinators, Site Officers and staff of the CREL partner organizations helped a lot in conducting the PCVAs and preparing PA level PCVA reports in association with BCAS experts.

During the drafting and revision of this report, editing and technical assistance was given by Dr. Paul Thompson, Senior Co-Management Advisor, Mr. Abu Mostofa Kamal Uddin, Deputy Chief of Party, Dr. Abu Syed, GIS Specialist, Mr. Md. Shams Uddin, Manager, Landscape Planning, Ecosystems and Biodiversity, Mr. Utpal Dutta, Senior Community Mobilization Specialist, Mr. Ruhul Mohaiman Chowdhury, Technical Program Coordinator, Sunbeam Rahman, GIS Analyst, Mr. Shariful Islam, Ecosystem and Inventory Specialist and Mrs. Umme Salma, GIS and Remote sensing Specialist. Their helpful efforts are acknowledged with sincere thanks.

Lastly, sincere thanks go to Dr. John A. Dorr, Chief of Party, CREL, for agreeing to preparation of this consolidated PCVA report and for the overall PCVA initiative.

Dr. Atiq Rahman
Executive Director
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CHAPTER 1 INTRODUCTION

1.1 Background and Objectives

Climate change is a reality and one of the great threats to humanity today. It presents additional obstacles to ending poverty and achieving Sustainable Development Goals (SDGS) and social justice. Bangladesh is one of the most vulnerable countries to global climate change impact. Rising temperature, increasing erratic rainfall, and more frequent and severe floods, cyclones and droughts all have significant negative impacts on ecosystems, society and economy and bad consequences for the lives and livelihoods of poor people. The forests, wetlands and biodiversity in the protected areas (PAs) in Bangladesh are already experiencing negative impacts of climate change. In order to ensure sustainable development, climate resilient natural resource management (NRM) and climate change adaptation, it is essential not just to understand who are the most vulnerable to the effects of climate change and why, but to help these communities plan practical actions to improve their adaptation and resilience to current and future climate stresses. CREL aims to build resilience in both ecosystems and human systems. The resilience pathways must be explored in the context of broader socio-economic geo-physical conditions where climate disasters interface with ecosystems, human systems and livelihoods of the community. The complex relationships are demonstrated in Fig. 1.1. Participatory assessment was needed to understand risks and vulnerability, and to plan adaptation options to build resilience.

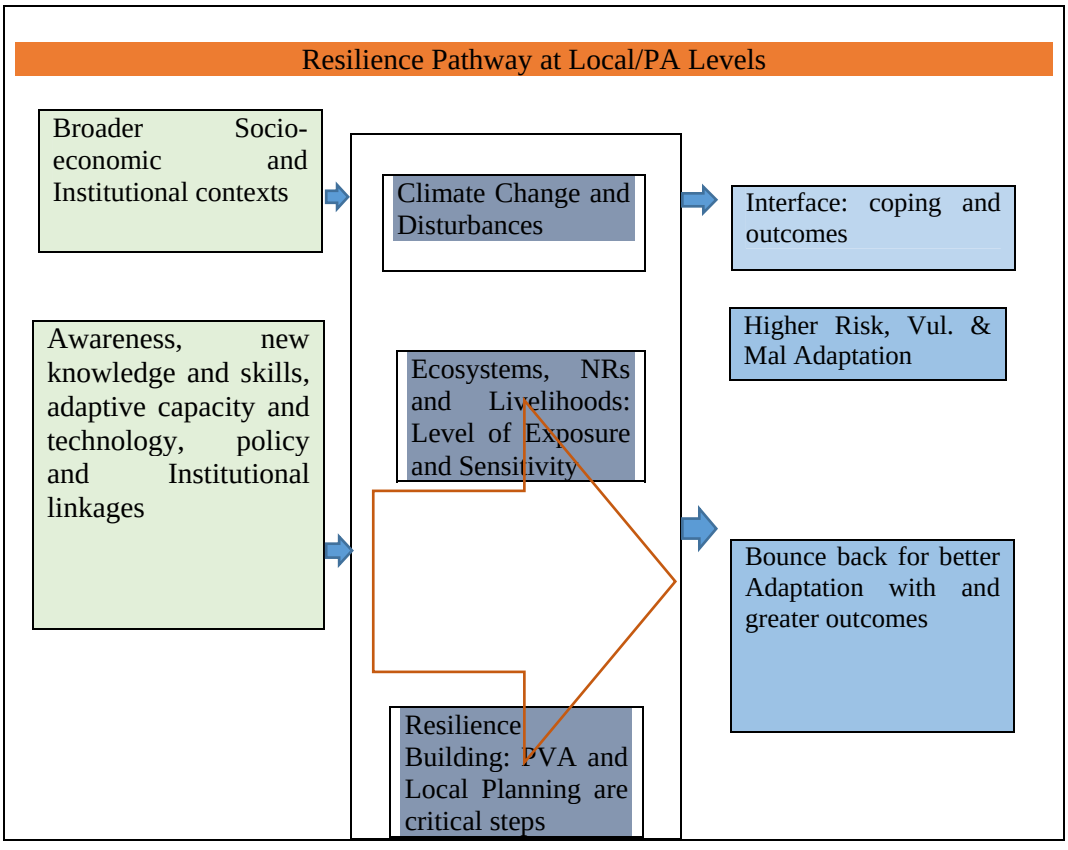


Fig. 1.1: CREL Resilience Framework

Participatory Climate Vulnerability Assessment (PCVA) helps us to understand the impacts and multiple risks of climate change on the ecosystems of forest, wetlands and Ecologically Critical Areas (ECA) and the lives and livelihoods of the people living in the landscape of these areas. By integrating local knowledge with scientific knowledge and climate data, the PCVA process helps

build people's understanding about climate risks and vulnerability, and develop adaptation strategies at local, ecosystem and site levels. It provides a framework for dialogue within communities as well as among communities, government, NGOs and other stakeholders for planning and implementation of adaptation, mitigation, Disaster Risk Reduction (DRR) and climate resilient NRM and livelihoods plans.

PCVA is a systematic process of assessment that involves all members of a community, including vulnerable groups and key stakeholders, for comprehensive understanding and examination of the local context, perspectives of different socio-economic groups, their risks and vulnerability to climate change, current coping, and adaptation needs of the people in general and vulnerable groups in particular (including members of co-management bodies such as Village Conservation Forum (VCF), People's Forum (PF), and Co-Management Committee (CMC). The PCVA gathers and analyzes people's perceptions and experiences in relation to socio-economic, environmental, and climate change stresses (temperature rise, change in rainfall and seasonal patterns); and natural disasters like flood, cyclones and drought. PCVA is mainly a qualitative and collective way of understanding and analyzing risks and vulnerability at spatial and geophysical, temporal, social, institutional and development contexts considering multiple dimensions of climate change.

The objectives of PCVA were to identify the key climatic hazards, the associated risk exposure and vulnerability of the poor, women and marginal communities in villages in and close to the co-managed sites, in relation to NRM such as forestry, forest biodiversity conservation, agriculture, food security, water management, drinking water and health. It further identified the current and future coping, adaptation and mitigation needs and priorities of local community including VCF and CMC. The specific objectives were:

- To determine the extent of climate change related risks and vulnerability of forest and wetland dependent communities;
- To identify present coping and adaptation strategies of the communities to deal with the changing climate;
- To explore local adaptation for both community and ecosystem, along with mitigation and livelihoods strategies to address climate change variability and related disasters;
- Develop adaptation, mitigation and NRM plans at village level; and
- Review the site/PA/CMC management plans and help the villages and CMOs to integrate appropriate adaptation and mitigation measures in sustainable NRM plans.

Bangladesh Centre for Advanced Studies (BCAS), a technical partner of CREL Project facilitated the PCVA process by conducting Training of Trainers (ToT) for regional implementing partners[1] of CREL, guiding local organizations (VCFs, CMCs, etc.) and implementing partners in PCVA field work, facilitating stakeholder workshops on PCVA findings dissemination and village level adaptation plans, and preparing PCVA reports based on the findings at forest beat and union levels. The PCVA process facilitated the project beneficiaries, local actors and other stakeholders to identify their own problems and doable actions in relation to improvement of NRM, livelihoods, DRR, adaptation and mitigation in forests, wetlands and their influence zones. It also helped to revise and improve the management plans, attract local resources and local knowledge in planning and implementation, built local capacity and enhanced institutional strength to support CMO initiatives for adaptation, mitigation of climate change and sustainable NRM.

1.2 Approach, Methods and Steps of PCVA

The PCVA followed a participatory approach to engage and empower people, particularly vulnerable communities and actors, to identify climate hazards, risks, and vulnerability in the current and future climate change context. It involved both bottom-up and top-down approaches for comprehensive

[1] CREL has three regional implementing Partners: a) CODEC in Chittagong and Khulna, b) NACOM in Cox' Bazar, and c) CNRS in North-East, Khulna and Central (Modhupur) regions

understanding of climate change trends, impacts, risks and vulnerability in the regional/ecological, local, social and institutional contexts. Community people, project staff and climate scientists worked collectively in the PCVA process. Secondary data on climate change (past trends and future projections at regional and local context) were triangulated with primary data, views, perspectives, experiential knowledge and insight of the vulnerable community to develop adaptation, mitigation, NRM and livelihoods strategies implemented by the community, CMC, local government bodies and local actors.

The PCVA process was used to understand the features, interest and stakes of different resource user groups, socio-economic groups, engage them effectively and explore the group dynamics in assessment and planning process. The process valued people's knowledge and handed over the sticks (tools and methods) to people (i.e. VCF/CMCs/PF members) while the PCVA team provided necessary guidance and facilitated the process to achieve desired outcomes: identification and prioritization of climate change hazards, risks and vulnerability in the local context, review of management plan, development of local adaptation, DRR and mitigation plan for integration into management plan.

PCVA field work at Dudpukuria in Chittagong

Sharing PCVA findings at Sholakuri union, Madhupur National Park, Tangail

The PCVA exercise is set out in detail in Fig. 1.2 and involved the following tools:

a) Spatial tools: transect walk, resource and hazard mapping;
b) Temporal tools: trend analysis, time line and seasonality; and
c) Other qualitative tools: Focus Group Discussions (FGDs) for hazard identification and prioritization, vulnerability matrix and analysis, livelihood risk analysis, exploring coping patterns, adaptation and mitigation, NRM strategies/options, institutional linkage analysis; and local stakeholder workshops for adaptation and mitigation plans development.

PCVA field work was conducted mainly in Forest PAs but also in ECAs (Fig. 1.3), in total 257 Village Conservation Forums were covered in the main PCVAs. Ultimately the findings were compiled for forest PAs at forest beat and Union Parishad levels in all five regions during 2013-2015, and these also supported village adaptation plan preparation which CREL supported villages in and around forest PAs and wetlands/ECAs. The villages are typically 10-30 km away from the respective

Upazila (sub-district) and district headquarter and connected by earthen, brick soling or concrete roads. However the villages of Khulna region are also connected by river routes with the administrative centers. Half of the villages have electricity supply and the rest of the villages largely depend on solar energy system for lights and other household activities.

BCAS conducted PCVA training in all regions and conducted field work in respective unions and forest beats with the help of site office staff and representatives of CMCs and VCFs. After compilation of field data CREL site offices organized validation stakeholder workshops in presence of representatives of CMCs, VCFs, NGOs, Upazila agriculture and fisheries officers, Forest Department, Department of Environment. After these validation workshops the field team prepared a consolidated PCVA report with adaptation plans for each forest beat or union (merging components from several PCVAs and the responses from other VCFs not covered by PCVAs but located within that union or beat).

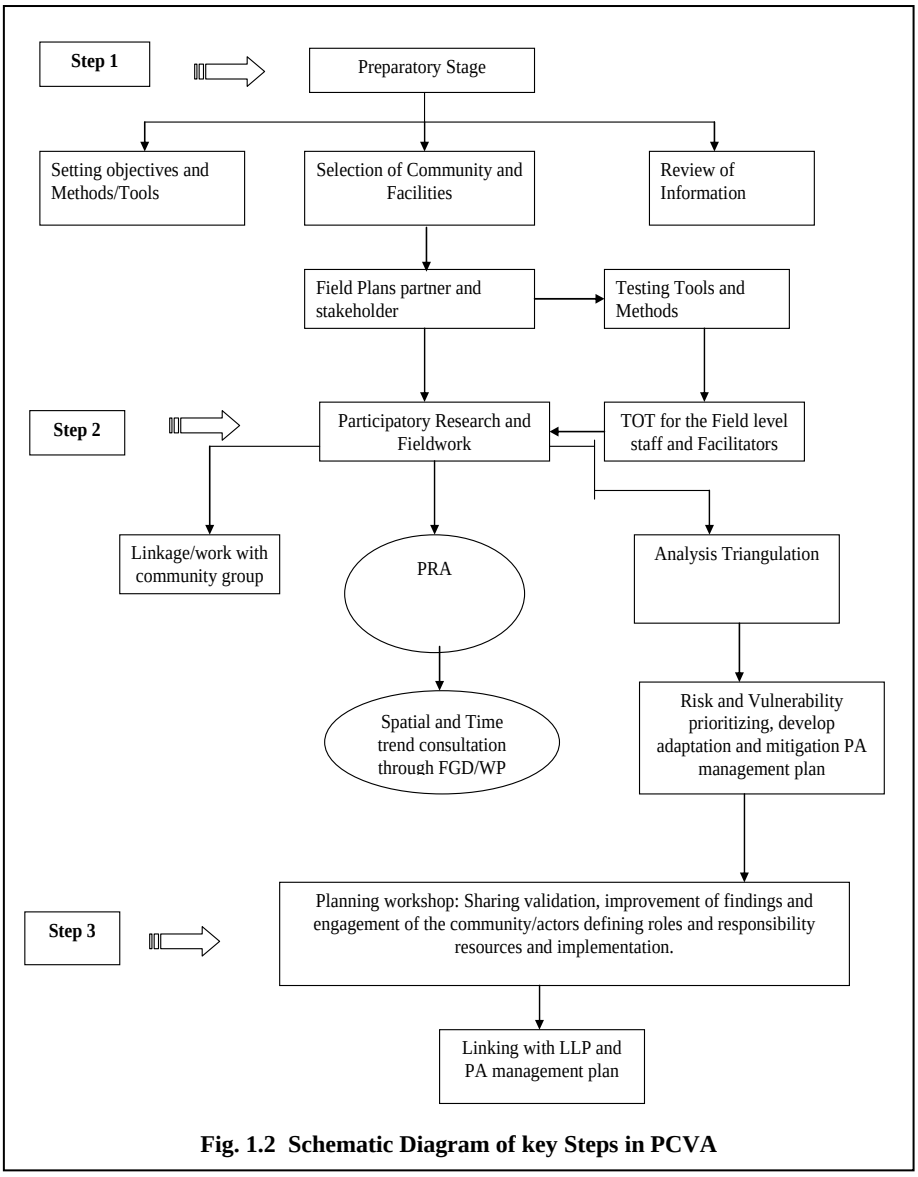


Fig. 1.2 Schematic Diagram of key Steps in PCVA

The key features of the PCVA reports are: summary of past climate change, climatic variation (rise in temperature, change in the trend in rainfall, drought, etc.), disaster risk assessment due to climate change, impacts of risks on natural resources (forest, wildlife, and biodiversity), impacts of climate risks on livelihoods and the socio-economic condition of the vulnerable. The team recognized how the vulnerable community and the ecosystems adapt with climate change risks at present and identified potential future sustainable adaptation, mitigation and disaster risk reduction actions. At the final stage each village prepared their own adaptation plan based on the PCVA findings during their monthly VCF meetings.

Fig. 1.3 CREL sites

1.3 Outline of this Report

This synthesized PCVA report is divided into six chapters. The second chapter explains the context of the CREL regions. Chapter three summarizes the climate trends reported for the CREL regions based on scientific evidence and local experience. Chapter four reflects on climate change impacts, risk and vulnerability by key sectors and social groups. Chapter five focuses on current local coping and adaptation practices, adaptation and mitigation needs, and related roles and responsibilities for implementing local plans. Chapter six ends with concluding remarks and recommendations.

CHAPTER 2: GEOPHYSICAL AND SOCIO-ECONOMIC CONTEXT

2.1 Geophysical Contexts

The geophysical contexts and types and exposure to climate-related disasters differ across the five regions covered by CREL.

The south-west region sites comprise coastal ecosystems, primarily in the Sundarbans, which is one of the largest mangrove forests in the world. In this region, also known as Khulna region, villages adjacent to forest are separated from the Reserved Forest by rivers and are highly prone to cyclones and other natural disasters. The soil type is mostly sandy loam with presence of silt. Surface water salinity, particularly in the dry season, has been increasing in recent years, and has become a major threat to the lives and nature of these villages.

In the central region, the Madhupur tract is a piedmont terrace with many villages in and adjacent to remnant deciduous Sal forest. The landscape in the Sal forest is characterized by two levels of land – slightly raised "Chala" land where Sal trees remain, and slightly lower plain lands "Baid" that are mostly cultivated. Commercial cultivation of banana, pineapple, ginger, turmeric and papaya in Chala lands have shrunken the area of natural forest. In this area there is a cultural diversity of Garo ethnic communities and Bangalis. Soil type is clay, which is known as Madhupur clay. A number of natural channels and streams (locally know as Chana) drain the Madhupur Sal forest.

In the southeast region (Chittagong and Cox's Bazar regions) tropical semi-evergreen and evergreen forest dominated the hills, although much has been cleared or degraded. This hill forest still plays an important role in the life and nature of local people. Numerous small streams flowing from the hills play a lifeline for agriculture and the daily lives of the local community. Flash floods, landslide and storms are some of the main natural hazards that have a very negative impact on livelihoods. The landscapes and associated villages around some of these hill forests extend to the narrow coastal plain bordering the Bay of Bengal, putting some households also at risk from cyclones. In addition one site in this region, Nijhum Dweep NP, is located on a coastal island and comprises mangrove plantations, low islands and intertidal mudflats, all highly influenced by tides and storm surges.

The northeast (Sylhet) region sites are divided between two major ecosystems: hill semi-evergreen forest similar to those of the southeast but here often bordered by tea estates as well as some cultivated land, and large floodplain depressions and wetland systems known as haors which once held extensive seasonally deeply flooded swamp forest, but are now extensively cultivated with rice in the dry season before going under deep water in the monsoon. Numerous streams (Chara) drain the hill forests and flow into the haors. There is high dependency of local communities on the small remaining forests for collecting fuel wood and house construction materials, and on fish and other aquatic resources (plants, mollusks, etc) in the haors. One of the sites - Ratargul – is notable for being the last sizeable area of mature swamp forest.

2.2 Socio-Economic Conditions

2.2.1 Demography

More than 10% of the total population of Bangladesh (around 19 million people) are forest dependent. These forest dependent people primarily include people who live inside the forest; and people who live near forest or in the landscape of the forest and regularly use forest resources for their living and income generation (Rahman and Ahmed, 2016). The qualitative PCVA findings (from Focus Group Discussions and key informant interviews) confirm that the people living in and around the forests are directly and indirectly dependent on forest resources. In the Sundarban in Khulna region dependence

on forest is much higher than in other regions. The factors behind dependency include lack of other occupations, high vulnerability to natural disasters which push people into poverty and force people to take forest resources as a last resort.

According to the census report and PCVA field work findings, the family size in most of the villages in Chittagong and Cox's Bazar is greater than five persons, but in Sylhet, Central and Khulna region the family size is less than five persons.

The literacy rate in the villages covered by PCVAs is behind the national literacy rate (61%). This is largely due to poor communication system, poverty and natural disasters affecting the villages around relatively remove biologically significant areas. Although the situation is improving following government-NGO initiatives, more initiatives would be needed to catch up.

2.2.2 Livelihoods

Just as elsewhere in Bangladesh, people living in the villages covered by PCVAs can be categorized into a series of economic classes. A majority of people are poor in these localities and they run their families on daily income such as wage earning. Agriculture is the second largest profession in these communities. Occupations vary from region to region. In the coastal villages of Khulna, Chittagong and Cox's Bazar fishing and shrimp fry collection are the key occupations. In addition, betel leaf and vegetable cultivation are also important occupations in Cox's Bazar and Chittagong region. In the Northeast and Central region, commercial cultivation of banana, papaya, ginger, and pineapple are important and the forest dependent local communities work in these sectors as wage earners. Most households are engaged in more than one occupation at the same time to survive. Dependency on natural resources for livelihoods is common to the local communities in all forest PAs. Some people are engaged in government and non-government services. Some women of Garo ethnic communities from Madhupur Sal forest (Central region) work in beauty parlors and garments factories in Dhaka and nearby cities. In addition, some people are engaged in construction, plumbing, and rickshaw pulling.

The houses in the landscape villages mostly have mud, bamboo and straw walls. The health situation is not satisfactory in these communities. Poor health care facilities such as community clinic, doctors and poor transportation system are a big challenge to the villagers. Most women are conscious about their health in the villages where health workers visit regularly. Health risk is reported to be higher where people do not follow family planning seriously due to social taboo and/or because of poor access to family planning facilities. Only half of the families use sanitary latrines, the rest of the people cannot use hygienic sanitation due to financial constraints. People suffer from under- and mal-nutrition, and report that consumption of vegetables, meat, egg, milk is irregular due to low incomes. Many people collect drinking water from far places during summer.

CHAPTER 3 CLIMATE TRENDS AND HAZARDS

3.1 Summary of Trends Revealed from Bangladesh Weather Records

Available Bangladesh Meteorological Department data on temperature and rainfall up to and including 2012 was obtained and analyzed for stations assessed as being representative of clusters of CREL sites. Full details of the results are given in Annex 1 and are briefly summarized here. Trends in recent decades were estimated. Forecasts were made of the changes in temperature and rainfall by 2030 and 2050 compared with historic reference periods, these forecasts were made based on 30 years' historical macro-climate data of the specific regions from Bangladesh Meteorological Department (BMD) . The recent trends and forecast changes were shared with the PCVA participants during the field work and validation of PCVA findings. The participants shared their experiences and expectations in these processes, and based on the combined information exchange, the participants completed their vulnerability assessments.

Average annual and seasonal average temperatures of the past do not differ greatly between the different regions and sites/environments within regions (Table 3.1), although the Cox's Bazar coast and center-east Sundarbans are on average the hottest sites, and of course winters are colder in the sites in the northeast and Modhupur (central). Predicted temperature changes to 2050 are almost all modest increases. The notable exception is a predicted 20% fall in winter minimum temperature in the Chittagong hill region (Dudpukuria-Dhopachara WS) which could have implications for agriculture and possibly forest plants. Among temperature rises higher winter minimum temperatures are predicted in the central region (Modhupur NP), also in the center-east parts of the Sundarbans where pre-monsoon man temperature is already the hottest out of CREL sites this temperature is predicted to increase by almost 10%. Note that this last predicted change is of greater importance than some others for community planning as the historic period is more recent – for regions marked in Tables 3.1 and 3.2 only 36% of the predicted change has on average already taken place in 2018, whereas for regions marked a 57% of the change has on average already occurred.

Table 3.1 Average historic and predicted future temperatures in CREL working areas

	Chittagong region			Cox's Bazar		Northeast and central			Southwest		
	Low-land a	Hill a	Coast b	Forest sites a	ECAs/ coast b	Sylhet a	Sriman-gal a	Modhu-pur c	Western Sund c	Center & east d	Tengra-giri c
Historic temperature (^{o}C)											
Annual	25.5	25.3	25.5	25.6	30.2	24.4	24.4	25.3	26.3	31.0	26.1
Pre-monsoon	27.2	27.2	27.2	27.4	31.8	25.5	26.4	26.6	28.9	33.9	28.3
Monsoon	27.7	27.5	28.1	27.3	30.3	27.4	27.7	28.5	29.7	32.0	28.6
Winter (T_{min})	15.1	16.2	13.5	16.3	16.3	13.3	13.2	13.4	13.8	15.8	15.2
Temperature change in 2050 compared with historic (^{o}C)											
Annual	1.31	1.20	-0.08	1.28	0.81	0.92	1.04	-0.52	-0.31	0.59	0.46
Pre-monsoon	0.78	-0.39	0.97	1.25	1.12	2.34	0.43	-0.95	-0.39	3.17	0.94
Monsoon	1.43	-1.05	0.19	1.02	0.07	1.23	-0.63	0.53	-0.07	1.54	-0.22
Winter (T_{min})	1.02	-3.35	-0.70	1.50	-0.72	1.42	1.09	2.23	0.70	0.28	-0.55
Percentage change to 2050 from historic											
Annual	5.1	4.7	-0.3	5.0	2.7	3.8	4.3	-2.1	-1.2	1.9	1.8
Pre-monsoon	2.9	-1.4	3.5	4.6	3.5	9.2	1.6	-3.6	-1.4	9.4	3.3
Monsoon	5.2	-3.8	0.7	3.7	0.2	4.5	-2.3	1.9	-0.2	4.8	-0.8
Winter (T_{min})	6.7	-20.7	-5.1	9.2	-4.4	10.6	8.3	16.6	5.1	1.8	-3.6

Note - Historic period used:
a 1960-1991
b 1981-2000
c 1981-2010
d 1991-2010

Rainfall throughout Bangladesh is strongly seasonal being concentrated in the monsoon, but the pre-monsoon rain is important for crops. Past average annual rainfall across sites ranges from just over 1700 mm to over 4000 mm (Table 3.2). Predicted changes by 2050 show great variation among sites and regions. All the southwest region sites are predicted to loose pre-monsoon rainfall, and in the case of Tengragiri the center and east Sundarbans this is predicted to disappear – which will likely impact agriculture and salinity balances. On the other hand pre-monsoon rainfall is predicted to increase substantially in many of the other sites particularly in the south-east regions (Chittagong and Cox's Bazar) where 50-80% more pre-monsoon rain could help agriculture.

Table 3.2 Average historic and predicted future rainfall patterns in CREL working areas

	Chittagong region			Cox's Bazar		Northeast and central			Southwest		
	Low-land a	Hill a	Coast b	Forest sites a	ECAs/ coast b	Sylhet a	Sriman-gal a	Modhu-pur a	Western Sund c	Center & east d	Tengra-giri c
Historic rainfall (mm)											
Annual	2811	2485	3214	3556	4231	4130	2396	2172	1755	1919	2794
Pre-monsoon	398	446	581	377	366	1003	713	476	286	279	392
Monsoon	2139	1782	2274	2815	3491	2812	1435	1479	1238	1374	2020
Rainfall change 2050 compared with historic average (mm)											
Annual	541	213	71	355	2351	-49	-110	241	-89	261	-218
Pre-monsoon	329	238	-163	317	328	307	120	104	-76	-257	-477
Monsoon	73	-73	452	80	1615	-311	-200	69	80	590	337
Percentage change to 2050 from historic											
Annual	19.3	8.6	2.2	10.0	55.6	-1.2	-4.6	11.1	-5.1	13.6	-7.8
Pre-monsoon	82.6	53.4	-28.0	84.2	89.5	30.7	16.8	22.0	-26.7	-91.9	-121.7
Monsoon	3.4	-4.1	19.9	2.8	46.3	-11.1	-14.0	4.6	6.4	42.9	16.7

Note - Historic period used:
a 1960-1991
b 1981-2000
c 1981-2010
d 1991-2010
The data analysis results have not bene corrected for logical impossibilities – while negative rainfall (as predicted by 2050 for Tengragiri in the pre-monsoon) is clearly impossible, the analysis suggests this period would become completely dry.

In addition to temperature and rainfall data analysis, reviews were undertaken of selected climatic hazards. Cyclones and tropical storms are a frequent hazard in the Bay of Bengal and coastal areas. No clear trend in the frequency of cyclonic storms could be detected, while maximum wind speed recorded had a slightly increasing trend. (Annex 1). Flash floods are a specific hazard to many of the CREL working areas in hill areas in the northeast and southeast, but no analysis for patterns of intense rainfall events could be made.

3.2 Community Perceptions of Climate Change Trends and Disaster Patterns

The participants in each PCVA prioritized hazards based on their impacts, analyzed the historical and present trends of these hazards, and make future projection based on their experiences.

In Cox's Bazar region flash flood (Pahari Dhal), water logging, landslides, decreasing ground water level, drought, cyclones, heavy rainfall, heat waves, strong tide and salinity were all identified as important climate hazards (Table 3.3).

Table 3.3 Summary of PCVA trend analysis of climatic hazards in Cox's Bazar region

Hazards	Pattern during 1980-2000	Experience during last 10 years (2001-2010)	Future expectation (2011-2030)
Flood/hilly flash flood	Less before and the damage was also less.	Increased due to continuous heavy rainfall and heavy rain in a short duration.	Hilly flash flood is likely to increase.
Water logging	It was less.	Increased due to heavy rain, hilly flash flood and filling up the bed of chhara.	Water logging is likely to increase.
Landslides/ hill slides	It was less.	Landslides increased due to deforestation and heavy rain in short time.	Landslide is likely to increase.
Decreasing underground water level	It was normal.	Now underground water level becomes low during the summer months.	Underground water level will decrease more.
Drought	Not experienced	Dry soil surface during the summer months.	Drought condition is likely to increase more.
Cyclones	Less.	The frequency of signals (government warnings) has increased. Frequency of cyclones has increased. Their intensity is more and the damage caused by them is also more.	Frequency and intensity of cyclones are likely to increase more.
Heavy rainfall	Rainfall was normal.	More short duration heavy rainfall and erratic falls occur, causing disasters.	Heavy rainfall and erratic falls are likely to increase.
Heat waves	normal	More - higher temperature is felt due to deforestation in the hills.	Temperature is likely to increase.
Strong tide and salinity	Sea level was less so salinity of soil and water was less.	Salinity has increased in the water of tube-well due to advance of the sea towards land i.e. increase in sea level.	Salinity of soil and water is likely to increase.

In Chittagong region drought, heavy rainfall, erratic rainfall, and hilly floods were the main climatic hazards identified, with nor'westers (violent pre-monsoon storms), cyclone, and flood secondary hazards. Future expectations are for all hazards to worsen (Table 3.4).

Table 1 Summary of PCVA trend analysis of climatic hazards in Chittagong region

Hazards	Pattern during 1980-2000	Experience during last 10 years (2001-2010)	Future expectation (2011-2030)
Increase in temperature/ drought	Intensity of heat waves and drought was less i.e. normal	Temperature has increased and the intensity of drought is more. Especially drought occurs for a long time in summer along with intense heat waves.	Temperature and drought are likely to increase
Nor'westers	There were more before.	Still occurred.	Likely to increase in frequency and intensity
Hailstorms	Less than now.	More occur in some places.	Likely to occur more in future.
Heavy rain and timing of rain	Normal rainfall used to occur in time and was not harmful.	Major change in rainfall pattern: heavy rainfall occurs untimely, when is not necessary and becomes harmful.	Rainfall pattern will continue to change and will be more harmful.
Flash floods/ landslides	Hilly floods and landslides were less	Increased due to untimely and erratic heavy rainfall.	Likely to increase more.
Cyclones	Occurred by less often.	The frequency of signals and cyclones has increased. Their intensity is more and the damage caused by them is also more.	Frequency and intensity are likely to increase more.
Heat waves	Normal	More often. Higher temperature is felt due to deforestation in the hills.	Temperature is likely to increase in future due to climate change.
Strong tide and salinity	Sea level was less before, so salinity of soil and water was less before.	Salinity has increased in the water of tube-well due to advance of the sea towards land i.e. increase in sea level.	Salinity of soil and water is likely to increase
Water logging	It was less before.	Increased.	Likely to increase more

In the north-east region primarily drought, but also nor'wester, cold wave, erratic rainfall, heavy rainfall, decreasing ground water level, landslide and hail storms are the key climate hazards reported.

Unfortunately in the PCVAs in this region the participants did not share their future expectations (Table 3.5).

Table 3.5 Summary of PCVA trend analysis of climatic hazards in northeast region

Hazards	Experience 10- 20 years before	Present conditions
Drought	Intensity was less and duration was short	Drought condition prevails during the summer months and duration is longer than before.
Nor'westers	Normal before and the damage caused by them was moderate	Frequency and intensity not reported, but participants said they are likely to increase in future.
Cold waves	Normal.	More compared to previous period.
Heavy and erratic rainfall	Rainfall was normal in rainy season and erratic falls did not occur in the season.	Heavy and erratic rainfall are likely to increase (current status not reported).
Temperature rise	Temperature was normal and heat was tolerable	Heat waves occur more often compared to previous period. Higher temperature is felt due to deforestation in the hills.
Hail storm	Very few and low impacts	Increased much more in present time.
Landslides/flash Flood	Landslides were fewer in the area	Landslides increased.

In the central region drought, temperature rise and erratic rainfall are the most common and important hazards for all unions surveyed. Ground water level decline, combined with drought and temperature rise pose big risks on agriculture and vegetable production (Table 3.6). PCVA participant expectations are that all climatic hazards will get worse. Note that some of the climatic hazard trends were attributed to direct degradation of the forest ecosystem (loss of large trees), implying that local ecosystem restoration and protection would be regarded as directly reducing exposure to hazards.

Table 3.6 Summary of PCVA trend analysis of climatic hazards in Central region

Hazards	Pattern during 1980-2000	Experience during last 10 years (2001-2010)	Future expectation (2011-2030)
Drought	The extent was less. Rainfall was timely and agricultural production was good...	The extent of drought has increased.	The extent of drought will increased
Erratic rainfall	The trend of rainfall was normal.	Short duration heavy rainfall and erratic falls occur more, causing disasters.	Heavy rainfall and erratic rainfall are likely to increase in future.
Temperature rise	Temperature level was normal and there was no visible drought.	Increase of temperature is observed and it is largely due to the loss of big trees in the forest and in the locality.	Temperature rise is likely to increase more in future.
Ground water depletion	Level was normal	Ground water level has declined.	Ground water level is likely to decline.
Nor' wester/ hail storm	Frequency was normal.	Now cause more casualties and damage	More nor'wester and hailstorm with big casualties and damage
Cold wave	Normal level	Sometimes very abnormal situation	The trend is likely to continue resulting in more diseases

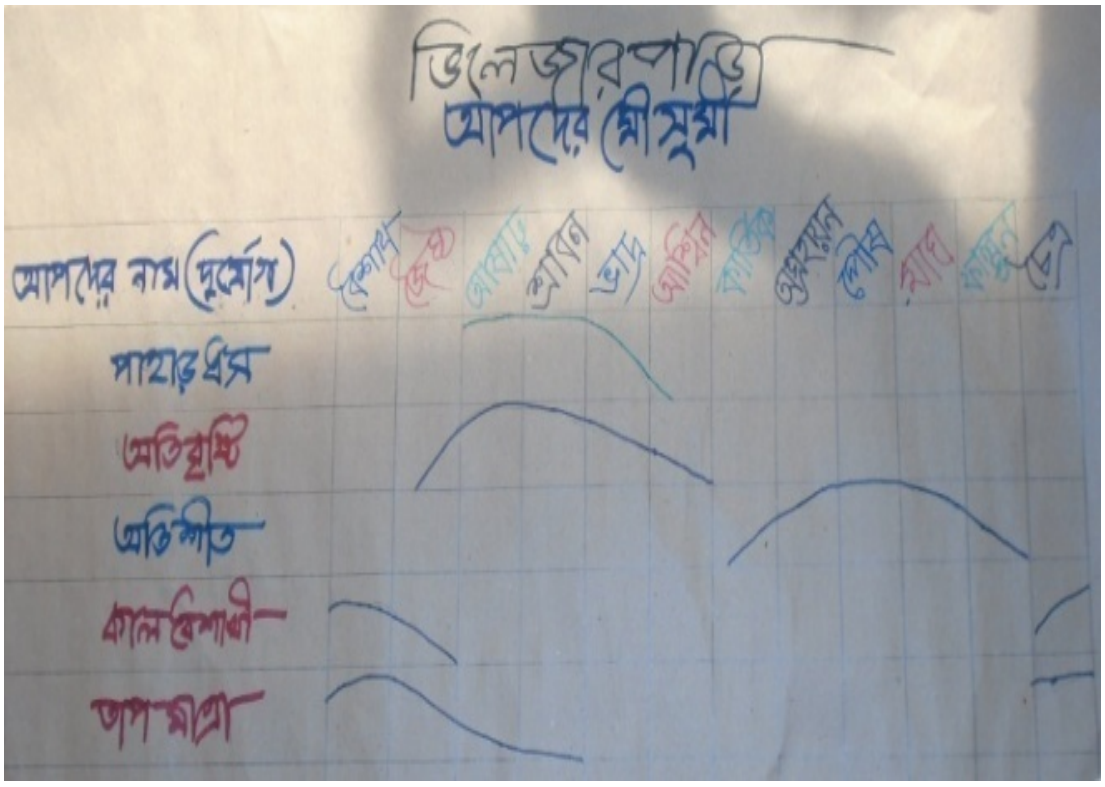
In Khulna (southwest) region, cyclones including storm surge, river bank erosion and salinity increase in water and soil were reported to be very common and the most important hazards for all sites. High or strong tides are another important hazard for the villages. Trends for all of these hazards are adverse (Table 3.7) and expected to worsen.

Table 3.7 Summary of PCVA trend analysis of climatic hazards in Khulna region

Hazards	Pattern during 1980-2000	Experience during last 10 years (2001-2010)	Future expectation (2011-2030)
River bank erosion	Less extensive	Increased extent. It has devoured some parts of VCFs.	The extent will increase. Actions to protect banks should be taken now to save the VCFs from river erosion.
Cyclone and water surge	Cyclones were fewer and would happen after every 2 or 3 years.	The frequency of signals has increased. Every year there are 3 to 4 cyclone signals. Cyclones Sidr in 2007 and Aila in 2009 were accompanied with water surge and caused severe damage to the locality.	Frequency and intensity of cyclones are likely to increase more in future.
High/ strong	It was normal before.	The loss of navigability of rivers and sea level rise	High and strong tides are

Hazards	Pattern during 1980-2000	Experience during last 10 years (2001-2010)	Future expectation (2011-2030)
tide		have accelerated the high or strong tide.	likely to increase in future.
Salinity in water and soil	The extent was less. A little increase in salinity occurred during March to April of every year.	A sharp increase in salinity is noticed from February to June every year posing threats to agriculture, fisheries, health, water, livestock, biodiversity, forest and wildlife.	Salinity of soil and water is likely to increase so much that agriculture could not be practiced here.
Extreme drought	Temperature level was normal and there was no visible drought.	Increase of temperature is observed and drought condition prevails during the summer months.	Drought condition is likely to increase more in future.
Heavy rainfall	The trend of rainfall was normal.	At present short duration heavy rainfall and erratic falls occur more often, causing disasters.	Heavy rainfall and erratic rainfall are likely to increase in future.
Waterlogging	Water logging was less	Strong/ high tide, loss of navigability of rivers and heavy rainfall have resulted in waterlogging with severe impacts on the lives and livelihood of the local community	Water logging is likely to increase in future
Temperature rise/ increase	Temperature rise was less	Now temperature rise has increased due to loss of tress	Temperature rise is likely to increase in future

Overall local people have observed decadal changes in the above mentioned hazards in their localities, these were also found to be consistent with trends found through analysis of meteorological records (Annex 1). Among the disasters, drought, ground water depletion and less rainfall are largely interrelated in upland forest PAs. At the same time, they observed an inter-relation between cyclone, water surge and increase of salinity in the coastal region. The local people have linked these disasters to deforestation and loss of greenery in the locality. The local communities apprehend that if these trends continue, then the trend of these disasters is likely to increase in future. However, different diseases and pest attacks were also mentioned by the communities as hazards for agriculture. Storms including hail storms, waterlogging, cold waves and fog have also become important hazards for the villagers of most regions. Forest vegetation and the number of wild animals are declining, and the PCVA participants observed that social forestry has been implemented mostly with exotic species which they consider to be a hazard.



Example of a hazard calendar drawn by community people in Hazarikhil WS, Chittagong.

CHAPTER4 CLIMATE CHANGE IMPACTS, RISKS AND VULNERABILITY BY KEY SECTORS

4.1 Definitions

Local people and natural resource bases become more vulnerable when they cannot cope or adapt to risks or those climate hazard risks increase. As per IPCC the definitions of vulnerability and risk are given:

> **Risk:** The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. In this report, the term risk is often used to refer to the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure. {WGII, III} (IPCC, 2014)

> **Vulnerability:** The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. {WGII} (IPCC, 2014).

4.2 Vulnerable sectors

4.2.1 Regional rankings

In the PCVA findings, which are summarized in detail in Annex 2, the most vulnerable sectors have been identified in the context of the impact of major climatic factors. In the PCVA process, the villagers identified different hazards they face and prioritized those hazards and their impacts on different sectors through casting votes.

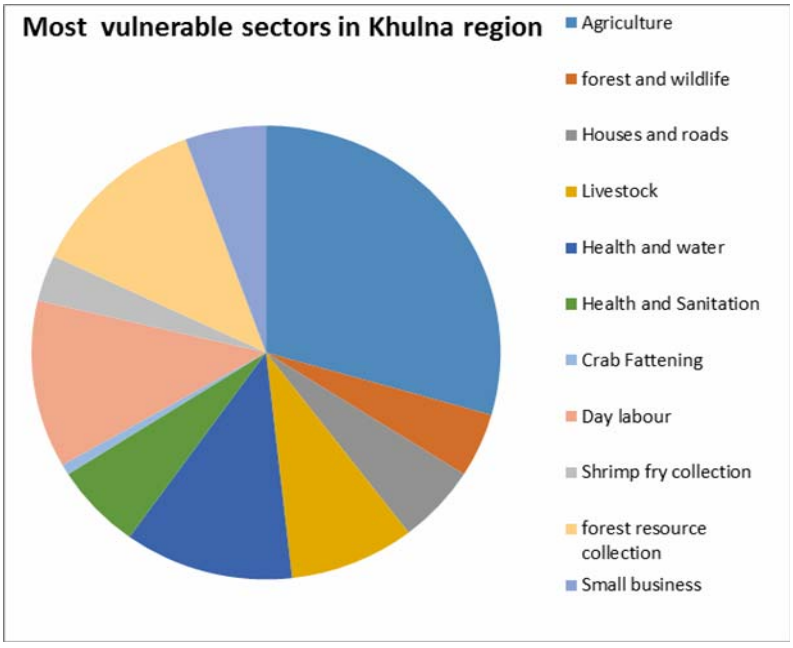


Fig. 4.1 Most vulnerable sectors of Khulna region

In Khulna region agriculture is the most affected sector (Fig. 4.1). This sector is affected by salinity temperature rises, drought, less rainfall and waterlogging. Standing crops are badly impacted by cyclones, while homestead gardening is affected by drought, temperature rise and salinity. Health, water and sanitation is the second most impacted sector by cyclone, water surge, salinity, water logging and drought. Day labor or wage earning is the third most affected sector by cyclone, river erosion, temperature rise and severe cold.

Among the affected sectors fisheries and day labor work are the two main affected sectors in Southkhali, Rayenda, Borobogi and Sonakata unions. Health, water and sanitation is the most affected sector for the unions where Dacope-Koyra CMC is located. The local people of the following unions - Southkhali, Gabura, Burigoalini, Koikhali and Chila - have identified resource collection from forest as one of the major affected sectors. Fish cultivation which is affected by salinity, cyclone and river erosion is another vulnerable sector in four unions (Koikhali, Burigoalin, Munshiganj and Gabura) in Munshiganj.

In the Central region the most vulnerable sectors impacted by different hazards are agriculture, water and health, livestock, forest and wildlife, and day labor (Table 4.2). Agriculture is affected by all hazards but is badly impacted by drought, ground water depletion, temperature rise, nor'westers and cold waves. Drought, temperature rise, and ground water depletion have also negative impacts on water and health, livestock, day labor and all other sectors. Wage earning is the second most impacted sector. Day laborers face hardship to run their family during all these hazards, especially during nor'wester, temperature rise and cold wave. High vulnerability of day laborers is a function of living day-to-day with no security of income during climatic hazards. Those engaged in fishing and forest resource collection are badly impacted by excessive rainfall and water logging. Fishery resources are declining due to drought, temperature rise, and fishing with improved nets and pumping out of water from the water bodies. Excessive rainfall and nor'westers pose a threat to cottage industries. Trees cannot grow at their normal pace and wild animals were reported to suffer from acute crisis of drinking water due to drought, temperature rise and ground water depletion. Sometimes forest fires also take place during summer. Wild animals come out from the forest in search of fodder and water. Livestock suffers an acute crisis of fodder during drought.

Table 4.2 Vulnerable sectors of central region by forest beat

Vulnerable sectors	Ghoga and Daogaon	Sholakuri	Aronkhola
Agriculture	1st	1st	1st
Day labor/wage earning	5th	3rd	2nd
Small Business	7th	7th	6th
Water and health	4th	2nd	
Forest and wildlife	3rd	5th	
Livestock	2nd	4th	
Fertility loss in the soil	9th		
Fishery	8th	6th	3rd
Social forestry	6th		
Forest resource collection			4th
Cottage Industries			5th

Daogaon and Ghoga unions are the most vulnerable in terms of number of affected sectors (nine sectors) followed by Sholakuri (seven sectors) and Aronkhola (six sectors). However the main affected sectors are almost the same for all four unions. Social forestry and fertility loss in the soil are the two main different impacts in Daogaon and Sholakuri from the other two unions.

The disaster and sectoral vulnerability matrix for Cox's Bazar reveals that agriculture is the most impacted sector. It was ranked the most vulnerable sector in 13 out of 14 PAs in the region (Table 4.3). This sector is affected by multiple climate hazards including temperature rise and increasing drought, heat stress, heavy rain and flash flood, cyclone and tidal surge. These hazards not only destroy standing crops and reduce harvests, but drought and erratic rainfall also affect planting, growth and flowering of paddy and other crops. Natural resources, forest, biodiversity and wildlife were identified as the second most impacted sector in the region in most beats, except that participants in Shamlapur beat ranked it as the most vulnerable sector.

Temperature rise, heat stress, erratic and heavy rainfall as well as climate extremes like cyclone, tidal surge and flash flood affect the natural resource base, their productivity and wildlife. The third most impacted sector in Cox's Bazar is drinking water sanitation and health. Women and children were considered to be the most affected group due to climate induced health risk. In a few cases this sector was ranked the most vulnerable. Drought and heat affect the health of the poor. Drought and low rain affect drinking water sources, while sanitation facilities of the poor are badly affected by flash flood, cyclones and tidal surges.

Table 4.3: Vulnerable sectors (ranks for overall three most vulnerable) by forest beat in Cox's Bazar region

Vulnerable sector	Dulahazra	Fasiakhali	Himchhari	Chainda	Jhilonja	Kalatali	Link road	Hnilla	Mid-Hnilla	Mochani	Razarchara	Shilkhali	Teknaf	Shamlapur
Agriculture and homestead garden	1	1	1	1	1	1	1	1	1+	1	1	1	1	2
Nature, forest and wildlife	2	2	2	2	2	3	5	2	2	2	2	2	2	1
Health and water	3	3	3	3	3	2	3	1+	1	1+	1+	3	1+	4

In Chittagong region landslides, high tide, salinity, water logging, drought, cold waves and heat stress are the major climate hazards. Increase in temperature, heavy rainfall, erratic rainfall, hilly floods, landslides, cyclones, and drought are common hazards in all the beats but their ranking varied between beats. For example, in Dudhpukuria and Dhopachhari beats, nor'westers occur during the pre-monsoon season. In general agriculture and homestead gardens, and nature, forest and wildlife were considered the most vulnerable sectors. Other sectors such as livestock, health and water, day labor and social forestry were also reported to be affected by hazards and climate change in Chittagong region. Agriculture and homestead gardening is the top most vulnerable sector due to climate induced hazards in Chittagong region. (Annex-3)

In the north-east region drought, heavy rainfall, erratic rainfall, temperature rise and cold wave are the main hazards. The region is also affected by landslides, water logging, hail storm and heat stress. During the PCVA activities, the villagers of different beats identified different hazards, prioritized them, and their impacts on different sectors were prioritized through casting votes. Drought, heat waves, heavy rainfall and landslides are common in all the beats but their ranking varied (Table 4.4). Agriculture and homestead gardening and nature, forest and wildlife are the two most vulnerable sectors. Other sectors such as livestock, health and water, day labor and social forestry were also reported to be affected by the different hazards and climate change in the region.

Table 4.4: Vulnerable sectors (ranks for six most vulnerable) by forest beat in Sylhet region

Vulnerable sector	Kadimnagar	Lawachara	Chawtoli	Ratargul	Rashidpur	Rema	Chanbari	Kalenga	Deorgach	Paikpara	Sahjahanpur	Mirzapur
Agriculture and homestead garden	1	1	1	2	1	1	1	1	1	2	3	2
Day labour	2	2	2	2	2	3	5	2	2	2	2	2
Service	6	4	5	4	5	7	4	5	5	5	5	6
Small business	5	5	4	5	4	5	6	3	3	3	3	4
Cattle rearing	3	3	3	3	3	2	3	4	4	4	4	3
Fish cultivation	4	6	6	6	6		5	6	6	6	6	5

4.2.2 Sectoral hazards

In all regions, agriculture is the most vulnerable sector and is affected by multiple hazards. In Khulna and other coastal areas of Chittagong and Cox's Bazar, salinity is the major factor posing negative impact on agriculture. Temperature rise, drought, cyclone, ground water depletion and flash flood are major hazards that have big negative impacts on agriculture in Chittagong, Sylhet and Central regions (Table 4.5). All these climate factors affect field

Box-1
Villagers recommended alternative occupations to reduce dependency on forest, and requested help for alternative incomes.

crops as well as homestead vegetables by decreasing growth and damaging yields. The vulnerability of farmers is high - if production of crops becomes less, it poses a big impact on profit as costs are still incurred.

Table 4.5 Agriculture and homestead gardening impacts of climate stresses by region

Khulna	Chittagong	Cox's Bazar	Sylhet and Central region
Salinity, cyclone, tidal surge and water logging badly affect crop planting and productivity. Vegetable growing in the crop field and homesteads is also hampered by salinity, water-logging and erratic rainfall	Crops are damaged by flash flood. Summer crops (vegetables and paddy) are damaged by drought and heat stress	Erratic and heavy rain, flash flood and water logging affect agriculture practices and production. Paddy and vegetables (cucumber, chilly, pumpkin, watermelon, banana etc.) are affected by heat stress, drought and fog in winter.	Irrigation problems due to draw down of underground water and drying up surface water in the summer. Early flood and flash flood damage paddy and vegetables. Vegetable and summer crops are affected by drought and heat stress. Fog and cold wave also affect crops.

Fishery resources are getting depleted due to drought, temperature rise and fishing by improved nets and pumping out of water from water bodies in the northeast and central regions (Table 4.6). Fish catch and shrimp fry collection in Khulna and other coastal regions are affected by cyclone, water surge and salinity. Sea level rise and high tide increase soil and water salinity in the coastal areas of Chittagong, Khulna and Cox's Bazar regions. Strong tides damage embankments and saline water enters into the agricultural land and floods fish farms. Fish farmers can suffer big losses but are less vulnerable than fisher communities that depend for their income on each day's catch. Some fishers during PCVA reported that they work in fishing trawlers and earn about Tk. 250-300 daily. When there are cyclones, storm surges, or heavy rainfall, fishing in the sea has to stop and the fishers cannot work. During this time they have no other wage earning sources. Also in the coastal region, small fish traders earn Tk. 300-500 per daily by buying and selling fish.

Table 4.6 Aquaculture and open fisheries impacts of climate stresses by region

Khulna	Chittagong	Cox's Bazar	Sylhet and Central region
Aquaculture including shrimp farming affected by cyclone, salinity and high tide.	Salinity, cyclone, high tide. Loss of habitat due to drought, flash flood, excessive rainfall, salinity and cyclone.	Salinity, Cyclone, high tide. Loss of habitat due to drought, flash flood, excessive rainfall, salinity and cyclone.	Loss of habitat due to drought, flash flood, excessive rainfall is one reason for depletion of fishery resources.

Climate hazards have big impacts on water, health and sanitation of the local communities especially affecting women and children (Table 4.7). Drinking water sources, latrine and sanitation systems collapse during cyclone storm surges in the coastal region and during flash floods, nor'westers, hilly floods and landslides in the northeast, Chittagong and Cox's Bazar region. Temperature rise, ground water and salinity increase pose irreparable loss of quality and quantity to drinking water sources.

Box-2

Drinking water and daily useable water crisis due to temperature rise, drought, salinity and ground water depletion are a big problem for local communities and especially for women and children. Collection of water and fuelwood becomes difficult for women.

Table 4.7 Water, health and sanitation impacts of climate stresses by region

Khulna	Chittagong	Cox's Bazar	Sylhet and Central region
Salinity increases pose a threat to drinking water sources and health, especially for child and maternal health.	Underground water depletion, flash flood/hilly flood pose threats to drinking water sources and health especially for child and maternal health.	Salinity increase and underground water depletion destroy water sources, and weaken health service systems.	Sanitation facility in gets damaged by drought, heat stress. Depletion of ground water level

Cyclones and salinity have negative impacts on the forest resources and biodiversity in Khulna, and other coastal areas in Chittagong and Cox's Bazar (Table 4.8). Temperature rise, drought and ground water depletion are key climate hazards with negative impacts on forest resources and biodiversity of hill and Sal forest respectively in the northeast and central regions. According to the participants forest resources lose productivity and biodiversity declines due to these climate factors.

Table 4.8Forest and biodiversity impacts of climate stresses by region

Khulna	Chittagong	Cox's Bazar	Sylhet and Central region
Forestry resources are damaged by slow growth and top dying diseases due to temperature rise and salinity intrusion	Temperature rise, drought, erratic rainfall and nor'westers damage forest biodiversity	Trees and forest biodiversity are damaged by drought, heat waves, underground water depletion, cyclone and heavy rainfall.	Forest resources and habitat of wildlife are destroyed by erratic rainfall, drought, groundwater depletion.

Roads and communication in all regions are damaged and collapse due to flash floods and general floods in all regions (Table 4.9). Cyclones and tidal surges affect the roads and communications in southwest and southeast region.

Table 4.9 Communication and infrastructure impacts of climate stresses by region

Khulna	Chittagong	Cox's Bazar	Sylhet and Central region
Roads and infrastructure are destroyed in cyclone, storm surge, river erosion and salinity.	Roads and communication are severely impacted by, nor'wester and hilly flood/flash flood.	Communication infrastructure are damaged by flash flood/flood, landslide and water logging. Poor people and wage earners face occupational crisis during this period.	Roads and communication are damaged by flash flood/flood, heavy rain. Poor people and especially day laborers suffer severely since they cannot go out for work.

Livestock and poultry are an important affected sector. These are good income sources for the local community, especially for poor women, but are risky. Storms, temperature rise, salinity increase, and flash flood are some important hazards that badly affect livestock and poultry in all regions (Table 4.10).

Table 4.10 Livestock and poultry impacts of climate stresses by region

Khulna	Chittagong	Cox's Bazar	Sylhet and Central region
Livestock and poultry are severely affected by cyclone and salinity. Women bear loss in this sector as chickens die and cattle are sold at low price during climate disasters.	Livestock and poultry are severely affected by temperature rise, cold waves and drought. The number of poultry and livestock goes down during this period.	Livestock and poultry are severely affected by temperature rise, heat waves, cyclone and drought. The number of poultry and livestock goes down during this period.	Livestock and poultry are severely affected by heat waves, drought, and severe cold. Women bear loss in this sector as chickens die and cattle are sold at low price during climate disasters.

The characteristics of the five most vulnerable social groups identified in the PCVAs are summarized in Table 4.11.

4.3 Livelihood Assets, Options and Interface with Climate Change

The people in the landscape villages of forest Protected Areas (PAs) are blessed with forest, agricultural lands and natural streams. The contribution of these natural resources to the lives of the villagers is immense. Forest plays a natural shield against nor'westers/thunderstorms, cyclones, water surges, hilly/flash flood and temperature rise. Local people collect fuel wood, timber, dry leaves and medicinal plants for everyday life. However, a sharp decline in forestry resources was also reported in the PCVAs due to the negative impact of drought, temperature rise, cold wave and other climatic hazards.

In Khulna region, dependency on forest and rivers has increased in recent years especially after two big cyclones Sidr (2007) and Aila (2009). Agricultural production and practices have declined due to salinity intrusion in soil and land and common people have resorted to natural resources for a living –fishery resources of rivers in particular. However, a sharp decline in fishery resources was also reported, and attributed to loss of navigability of rivers and using different fishing gears for fishing in the rivers. Local people are largely dependent on forest for fuel wood, timber for house construction and logs for fishing gears.

Fuelwood collection from Madhupur Sal forest

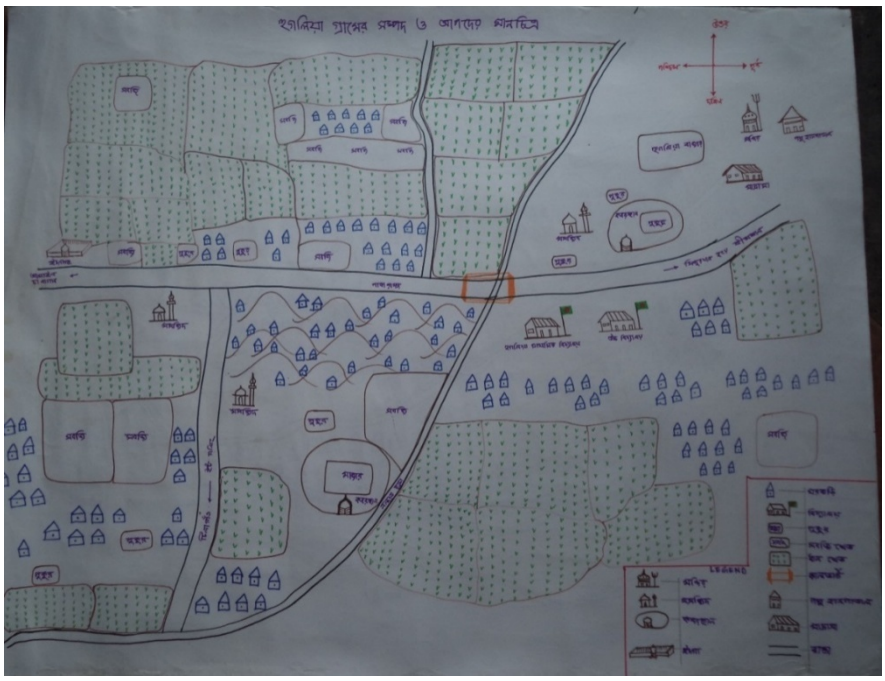
Table 4.11 Level of vulnerability of social groups

Vulnerable Groups	Level of Vulnerability
Farmers	Farmers are the most vulnerable group in all regions. Farmers comprise the main occupational group and are affected by the major climatic hazards (cyclone and salinity intrusion in coastal regions; drought, flash flood, temperature rise in North-East, central and hill areas of Chittagong and Cox's Bazar regions)
Fishers	Fisher community comprises a large population especially in coastal region as well as in other parts of the country. Fishery sector is usually affected by cyclone, water surge, and salinity in coastal region and by flash flood, heavy rainfall, cold wave, temperature rise in North-East, Central region and hilly areas of Chittagong and Coastal region. Small fish farm owners and daily wage earners in this sector suffer from occupational crisis during the climate disasters.
Forest dependent people	The poor people living the landscape of forest PAs are largely dependent on forest resources and suffer from occupational crisis during storms, cold wave, hill slides and other climate disaster. They cannot collect forest resources and suffer from economic hardship
Women, children and elderly people	Among the affected community people this section is badly affected by all types of climate hazards. Women have to pass a long time to collect drinking water in coastal areas which decreases their time available for family needs. During disasters children, women and elderly people suffer health hazards.
Wage earners	Laborers typically earn Tk. 300-400 a day in different sectors and they can work for 20-25 days in a month. Work is mostly seasonal and they cannot manage the same number of days work with same wage rate for the whole year. During rainy season, cold waves, cyclones and other disasters, they become jobless. Houses, business establishments and roads get damaged by nor'wester, cyclone, storms, waterlogging and excessive rainfall. During these hazards day laborers and small businessmen face hardship. Their houses get collapsed. They repair it and get engaged in alternative occupation during disaster.

In the central region (Madhupur Sal forest) people in and around forest villages collect fuel wood, timber, dry leaves and medicinal plants from the Sal forest for their everyday necessity. However, a sharp decline in forestry resources was reported due to the negative impact of drought, temperature rise and cold wave.

In Chittagong and Cox's Bazar regions, the dependency of local people on natural resources is almost the same. They collect fuel wood, broomcorn (chhon), grasses, bamboo and cane, wood for building houses, medicinal plants and honey from the forest. They also collect fodder for livestock from the forest. They are most dependent on the forest for fuel wood. Some people of villages nearer to the sea depend on fishing. They also collect sea shells, snails and make various types of handicrafts, house decorating materials, toys and ornaments. They select forest as the alternative source of income when they go through a crisis due to natural disasters or extreme climatic events including cyclone, hill-slides, droughts, temperature rise, cold wave and heat wave.

In the Northeast region (Sylhet), the villagers are mostly dependent on the forest for fuel wood. They also collect wood for building houses/ shelter, straw for brooms and bamboo. The community people of Ratargul forest largely depend on wetland plants *Bet*, and *Murt*a. They make mats for sale from Murta *Schumannianthus dichotomus*. Tea gardens are an important natural resource base bordering Khadimnagar PA. People depend on tea gardens as tea workers for their livelihoods. Other PAs of Sylhet region have common features in terms of dependency on natural resources like collecting wood, bamboo, grasses for livelihoods. They also collect fruits and medicinal plants from the forest. To reduce dependency on forest, alternative occupations are necessary as opined by the villagers. Moreover natural disasters including flash flood, nor'wester, temperature rise and drought have big impacts on the livelihoods of common people as well as on natural resources.



Resource and hazard map of Huglia village at Kaleng forest beat under Rema-Kalenga Wildlife Sanctuary, Habiganj

4.4 Current Coping by Communities and Need for Adaptations

Box-3

The PCVA has identified a number of long term adaptation, mitigation and resilience building options for the communities and government departments. These should be implemented with multiple actors for climate risk reduction, livelihood promotion and sustainable natural resource management in the forest landscapes and wetlands.

Participatory research with the resource users and stakeholders in the five regions identified coping, adaptation and mitigation options and measures. It was found that community people are coping with climate hazards, but in most cases they lack adaptive capacity. Government departments including the Forest Department, Department of Agricultural Extension (DAE), Department of Public Health and Engineering (DPHE) and Department of Fisheries are promoting a few planned adaptations, which are mainly ecosystem based responses with communities and actors. However, these are planned for short-term and immediate benefit. Long-term adaptation and mitigation measures (Table 4.12) need to be integrated into natural resources management and community resilience building.

Adaptation needs and practices identified in PCVA process and implemented by the CMOs have improved the resilience of social groups based on increased knowledge about climate change impacts, vulnerability, better coping and planning adaptation. The social groups have exchanged their experiential knowledge with scientific knowledge and are now better informed about the necessary technology and information. For example, in PCVA finding validation workshops the participants held experience sharing discussions with sectoral specialists improving information about appropriate agriculture, fisheries, water and sanitation, and forestry. Tree plantation, road construction, canal excavation, mangrove plantation and nursery development are some good examples of planned adaptation with proper information, knowledge, innovation and engagement of concerned

stakeholders (CBOs/CMOs, sector specialists and union parishads) in effective adaptation and resilient building initiatives. Full details are given in Annex 2.

Table 4.12 Key coping and adaptation needs suggested in PCVAs

Sector	Adaptation
Agriculture	➢ **Awareness, Knowledge, Information and Training** • Integrated Pest Management and training for farmers • Demonstration plot on drought resilient rice (BRRI-56, BRRI-57, BR-28 and HL-8) and vegetable cultivation and disseminating information regarding this cultivation among the farmers. • Crop diversification and organic crop cultivation. • Proper implementation of shrimp policy to protect agriculture from saline water intrusion • Floating garden and hanging gardening in plastic pots
Fishery	• Fish sanctuary to protect fishery resources from drought and temperature rise. • Excavation of natural water bodies like canals.
Aquaculture	• Cultivation of heat, salinity and cold tolerant and early variety fishes (Tilapia)
Water, sanitation and health	• Installation of deep tube well for drinking water during summer and dry season • Preserving drinking water sources with better construction at safe and high places. • Community clinic for better health facilities • Excavation of ponds and canals to preserve water for drinking and domestic use. • Use of sanitary latrine • Use of Improved Cooking Stoves to reduce smoke and heat during cooking in summer
Infrastructure and communication	• Plantation of storm tolerant tress around houses and homesteads • Road construction and reconstruction with improved technology and materials to save it from excessive rainfall and flash floods • Construction of strong houses to reduce impact of nor'wester and cyclone • Excavation of canals for better drainage during excessive rainfall
Livestock and poultry	• Rearing of chicken and duck that are adaptive to temperature, cold wave and heat stress • Diseases tolerant livestock and poultry rearing. • Construction of strong and improved shade for poultry and livestock • Safe and separate space in cyclone shelter for livestock • Diseases and drought tolerant poultry and livestock rearing (for example goat and sheep)
Wildlife and biodiversity	• Plantation of storm tolerant trees around homestead and public places • Taking part in social forestry program • Fresh water pond preservation in the forest for wildlife • Plantation (road side and institutional) with local, drought and salinity tolerant species. • Mangrove nursery and conservation • Assisted natural regeneration in the PAs • Alternative occupation for forest dependent people to reduce pressure on forest resources.

Sector-wise adaptation needs and practices have also been suggested for prioritized adaptation that may contribute to resilience building and disaster risk reduction of the local communities. Collective initiatives with climate information and knowledge would be required. The adaptation options that have been undertaken increased existing and alternative livelihoods practices. Community people are now aware of hazard protection measures. Information regarding early varieties of fish and paddy cultivation will increase the resilience of people and reduce the extent of disaster risk from temperature rise, drought and ground water depletion.

CHAPTER 5 LOCAL PLANS FOR ADAPTATION, CLIMATE RESILIENT NRM AND LIVELIHOODS

Adaptation needs and priorities of vulnerable community and key actors have been identified from five regions. Adaptation needs are categorized in four groups: a) Awareness, knowledge and information, b) Local adaptation/mitigation actions, c) Adaptation and mitigation technologies and innovation, and d) Institutional support and integration.

The sectoral adaptations in the key impacted areas such as, agriculture, fisheries, livestock and poultry, forest and wetland, water, sanitation and health, infrastructure, small trade and business were identified. Gender differentiated adaptation needs and priorities of women and girls across the regions are also identified and presented in the following sections.

5.1 Sectoral Adaptation and Mitigation

5.1.1 Agriculture and food systems

Agricultural activities and productivity are being affected by climate variability and extremes in all the five regions. Farmers are coping and taking limited adaptation measures in the face of impacts on land and soil fertility, irrigation and pest management. For examples in Khulna region, agriculture is being impacted by growing salinity, cyclones and tidal surge and water logging in the crop fields. Adaptations in the action plans include: raising beds of vegetables and crop fields; integrated fish culture with crop on the bunds; salt water and flood tolerant crop varieties; improving embankment and tidal regulation; canal excavation for preserving fresh water for irrigation.

In the central region (Madhupur), farmers have suggested drought tolerant varieties of crops and vegetables; mulching to retain soil moisture; re-excavation of canals and ponds in the fields to preserve water to facilitate irrigation during dry season to address increasing drought; and cultivation of short duration and early varieties of crops.

Temperature rise, drought and erratic rainfall are affecting agriculture in Chittagong region. Coping and adaptation measures suggested by the local communities include: repeat cultivation; cultivation of paddy on the banks of canals; introduction of drought and heat stress tolerant varieties of crops (Papaya F1, TIA, BINA-7, BR-28 and long beans). They also re-excavate canals for water conservation and install deep tube wells for irrigation. They proposed cultivation of early varieties of cucumber and chilly to protect them from heat, heavy rain and flash floods.

In Cox's Bazar region, agriculture is badly affected by heavy rain, flash flood, water logging, cyclone and salinity. Local communities have identified better management of stream (Chhara) and drainage systems to reduce water logging and flash flood; and propose to introduce flood tolerant varieties of crops. The farmers also experience drought and heat stress and they are improving water conservation for irrigation and drought management; and want to install deep tubewells for irrigation.

In the Northeast region, farmers are encountering drought, heavy rain induced flash flood, draw down of ground water, pest attack, fog and cold waves. They have suggested to adopt early varieties of paddy and vegetables, and using mulching to protect soil and crops from heat stress and drought. Other proposed measures include cultivation of crops and vegetables which take less water, and installation of deep tube-wells for irrigation. They are also promoting fruit orchards of orange, lemon

and pineapple. They protect seedlings from cold and fog with plastic cover. The participants shared many common local adaptation measures considering frequency and intensity of climate stress. They also use local knowledge and inputs in adaptation and risk management.

5.1.2 Water, health and sanitation

In all the five regions the water, sanitation and health sector is affected by climatic hazards and extreme events. This sector is most vulnerable in southwest and coastal region due to cyclone, salinity increase, water surge, river erosion, waterlogging, temperature rise, erratic rainfall and drought.

In Khulna region, the key adaption strategies at community level include harvesting rain water at community and individual level, collecting water from Pond Sand Filter (PSF), and getting advice from local paramedics (and in some cases visiting the Upazila Health Complex) to get cured from water born and other diseases. People take adaptive measures at their own initiatives and also with the support of Government and NGOs, including: protecting community water sources by raising the banks of ponds, installation of Pond Sand Filter (PSF) and tube well at high places, installation of water treatment plant, and improving the services of community clinics. Awareness building is another important initiative which the communities are continuing to improve their adaptive and resilience capacity.

In the Central region, drought, heat wave, erratic rainfall and cold wave are accelerating the water scarcity situation and causing health hazards. Ground water level goes down during summer due to drought. People collect water from far away and preserve it in earthen pots. They also take advice from Upazila hospital and local doctors to address heat, water and cold borne diseases. Local people suggested adaptive measures which include: re-excavation of ponds and Charra (stream), improving services of Community Health Clinics and use of Improved Cooking Stoves (ICS).

In Chittagong region, temperature rise, nor'wester, erratic rainfall and drought are some key climate hazards that have a big impact on water, health and sanitation. Harvesting and use of rain water during rainy season and collecting and use of stream water during summer are some popular coping strategies in the face of water crisis due to drought, erratic rainfall and temperature rise. To get cured from water borne diseases (diarrhea, dysentery, typhoid and skin diseases), people visit community clinics. They suggested some adaptive measures which include: re-excavation of ponds and streams (Chhara), improving service of community health clinics, and increasing awareness.

In Cox's Bazar region cyclone, salinity, waterlogging, drought, declining ground water and heavy rainfall are causing spread of diseases, water crisis and health hazards. Local people use stream water and collect water from far away to mitigate water crisis during summer. They also harvest rain water and this is becoming popular. They also consult with quack doctors when facing sickness. Some adaptive measures that people have prioritized include: increasing awareness; government, non-government and community level initiative; and taking shelter in safe places during cyclone. They also implement plantation programs to reduce heat stress and storms.

In Sylhet region water, health and sanitation sector is badly impacted by flash flood, nor'wester, waterlogging, drought, severe cold, and heat waves. At community level, people cope for example by staying at home more during nor'wester and other natural calamities, and getting treatment during sickness. Adaptive measures include increasing awareness and improving health facilities.

5.1.3 Fishery

The fishery sector includes both open water sources (capture fisheries) and cultured fishery (aquaculture), and is impacted by different hazards in the five regions, however the PCVAs were dominated by (better off) fish farmers in several regions and only in a few such as Cox's Bazar fairly reflect the views of (usually poorer and more vulnerable) capture fishers.

In Khulna region, the fishery sector is impacted by salinity increase, cyclone and storm surge, river erosion, drought and temperature rise and excessive rainfall. During cyclone, storm surge, and river erosion fish farms are washed away, increase of salinity accelerates spread of white spot diseases in the shrimp farms and loss of native species. Fish farm owners suggested some measures which include, setting fish farms back from the river, repairing embankments along river, using lime and fertilizer in fish farm, and alternative occupations. They also identify adaptation needs which include: virus free shrimp and fish fry, fencing with net around fish farms, increasing the height of pond banks, cultivation of salinity tolerant quick growing variety fish (e.g. Tilapia), distribution of refract meter to check salinity level in the water, demonstration farm on salinity tolerant fish cultivation.

In the central region, drought, erratic rainfall, waterlogging and cold wave are the major hazards for fishery sector. Loss of habitat, species and spread of diseases due to drought threaten fishery resources. Fish production is also affected by waterlogging and cold wave. Fish farms are washed away during rainy season. Farmers are taking some coping measures such as: cultivation of quick growing varieties of fish, using lime and fertilizer in fish farms to stop spread of diseases, making fence with net on the bank of the fish firms. Fish farmers recommended cultivation of heat tolerant and early variety fishes (Tilapia). Fishers recommended more resilient ecosystems through: re-excavation of natural water bodies (Beel and Charra) to restore habitat for fish, establishing and protection of fish sanctuaries, and alternative occupations for fishers.

In Chittagong region, fishery resources in the coastal area (Nijhum Dwip and main coastline near Chunati WS) are severely impacted by cyclone, storm surge, and excessive rainfall. In the hilly areas flood, excessive rainfall, drought, temperature rise, ground water depletion and waterlogging impact on the fishery sector. Fish catch is drastically reduced during cyclones and storm surges since the fishers cannot go to sea. Fish production is also reduced due to drought, temperature rise and ground water depletion. During excessive rain fish farms are flooded. People take some coping strategies which include: making fence with net on the bank of the pond, they also reduce the fish cultivation area and catch fish from their ponds immediately during disasters to recover the loss. The fishers face occupational crisis, sometimes they get alternative work, or collect fuel wood from forest, or do wage labor work in the city. The fisher farmers suggested transferring knowledge of early variety fish cultivation, and raising banks of ponds and fish farms for adaptation.

In Cox's Bazar region, fishers faces occupational crisis during excessive rainfall, cyclone, water surge, temperature rise and drought. During cyclone and storm surge, the fishers usually do not go to sea, and also during temperature rise and heat wave they stay at home. All these hazards make the fisher community vulnerable by pushing them into deteriorating food insecurity. The fishing community's adaptation measures include: getting day laboring work in the town, collecting firewood from forest for sale, take loan, sale of labor in advance, and taking up alternative occupation. They suggest some adaptation measures which include improved early warning system on natural disasters, capacity development training, and developing alternative incomes.

In the Northeast region flash flood, drought and temperature rise are the major hazards for fishery resources. Fishes of open water sources (haor) and fish farms dispersed in flash flood. Fish farmers cultivate fast growing varieties of fish and raise heights of their pond banks to protect fish from floods. They also put fence made of net around their fish farms. During the summer the water level declines and aquaculture is reduced. Adaptation options include more fast growing fish cultivation.

5.1.4 Livestock and poultry

Livestock and poultry is one the key supplementary ways for vulnerable people to increase incomes. But this sector is becoming vulnerable to the increasing intensity of climate hazards and extreme events. People are taking some coping and adaptive measures based on their experience and with the help of different development partners.

In Khulna region, salinity increase, cyclone and storm surge, temperature rise and drought are major climate hazards to livestock and poultry. Loss of grazing lands and spread of diseases are the important outcomes due to climate hazards. Existing adaptation strategies within the community include: rearing of livestock and poultry in a very small scale, and use of tree branches to feed cattle during cyclone and rainy season. The adaptive measures proposed include: rearing poultry and livestock in a planned way, rearing poultry and livestock that are adapted to the locality (such as lamb), and training on poultry and livestock.

In central region, livestock and poultry are affected by erratic rainfall, heat wave and cold wave. Cattle are covered with warm cloth and lights are put in the poultry sheds during cold wave. People suggested: vaccination program for poultry, getting training from livestock officials and NGOs on poultry and livestock rearing, and rearing poultry and livestock that are adapted to the locality.

In Chittagong region, temperature rise, heavy rainfall, nor'wester and cold wave are the major climate hazards for poultry and livestock. Existing adaptations include: livestock and poultry are put in a safe place during disasters, and local veterinary doctors are consulted to get treatment for livestock and poultry during disasters. The major adaptation options proposed include: constructing cow and poultry sheds in safe and dry place, and preserve feed for emergency period.

In Cox's Bazar region, droughts, declining ground water level, and heat waves are the major climate hazards to poultry and livestock. As per the coping and adaptation strategy, community people use extract of medicinal plants (Achila trees) and Bel leaves (*Agle marmelos*) to cure livestock of dehydration during heat waves, and showering with salt water for chickens to treat them against pox diseases during summer. Cattle are kept in a safe place during disaster and fed with dry straw and tree leaves. Some adaptation options that the community people are taking include: construction of safe and strong shed for poultry and livestock, keeping disease tolerant poultry (such as naked-necked chicken), and planting trees around the cow and poultry shed to reduce the impact of storm and heat.

In Sylhet region, livestock and poultry are severely affected by heat waves, drought and severe cold. As per the coping and adaptation strategies, cattle and poultry sheds will be kept dry and clean to reduce the impact of climate hazards, communication with the Upazila livestock officer will increase, and farmers will give dry feed (e.g. straw) during disasters. These could be up-scaled as adaptation measures

5.1.5 Infrastructure and communications

Infrastructure and communications in all five regions get damaged by climate hazards with a big impact on the local community especially the poor who have to move around for daily work.

In Khulna region, infrastructure and communications are badly impacted by cyclone and storm surge, high and strong tide, river erosion, salinity and excessive rainfall. The local community takes shelter in cyclone shelters during cyclone. During post disaster situation, many of them live in makeshift houses and repair roads on their own initiative and also by the support of the Government and NGOs. Some adaptation measures which can be up-scaled within the community include homestead, roadside

and institutional plantation, increasing heights of the base (plinth) of the houses, and construction of women, child and elderly people friendly cyclone shelters.

In the central region, water logging, excessive rainfall and nor'westers are the major climate hazards to infrastructure and communications. To cope with these natural calamities, people: reconstruct houses and roads after disaster, and reduce movement during excessive rainfall and nor'wester. The major proposed adaptation measures include plantation, training on disaster management, and excavation of canals for better drainage during excessive rainfall.

Infrastructure, communication and public movement get severely affected by temperature rise, erratic rainfall, nor'wester, cyclone and cold wave in Chittagong region. People use their traditional knowledge to cope, for example by constructing houses with mud and clay to keep cooler, and planting native trees around the houses to protect from nor'westers and storms. During excessive rainfall and cyclones, people take shelter in safe places, their movement declines and most of them stay at home during disasters. Construction of makeshift houses and temporary roads are some other coping options. Adaptation practices proposed include: construction of strong houses, constructing roads with strong materials, and planting native trees around houses and along the roads.

In Cox's Bazar region, cyclone and heavy rainfall are the major climate hazards to infrastructure and communications. The adaptation strategies that local people have suggested include: less movement, reducing heights of the houses, protection wall to protect the roads from landslide, and houses tied with rope and covered with plastic sheet during excessive rainfall. For adaptation, local people are participating in nature conservation activities like plantation, awareness about consequences of forest destruction and hill cutting, and biodiversity conservation.

In Sylhet region, excessive rainfall, flash flood, nor'wester, and hilly flood are the major climate hazards which have very severe impacts on infrastructure and communications. During flash flood, hilly flood and excessive rainfall, houses and roads are damaged and people reduce movement and in many cases use boat for communication. The key adaptation measures suggested include awareness among the local community and planting trees.

5.1.6 Forest and biodiversity

In Khulna region, cyclone and storm surge, salinity increase, high tide and flood, temperature rise and drought are some major climate hazards which lead to top dying and slow growth of mangrove trees, also wild animals get sick by drinking saline water. Drinking water from few ponds inside the forest is major coping strategy of wild animals during cyclone and the dry season. The adaptation options include river bank plantation, road side plantation, planting salinity tolerant trees, and use of Improved Cooking Stoves (ICS).

In the central region, drought, erratic rainfall, heat wave and cold wave lead to slow growth of trees and scarcity of fodder and fresh water for wild animals. During summer, when water crisis becomes acute wild animals drink water from a few ponds inside the forest. Adaptation options that are in place include planting native trees inside the forest, awareness about conservation of biodiversity, and re-excavation of streams.

In Chittagong region, temperature rise, droughts, cold wave, erratic rainfall, and nor'wester are causing destruction of forest resources and biodiversity, and water crisis. The Forest Department and community people water planted trees. The major adaptation measures include planting more trees, and preserving and re-excavating water reservoirs.

In Cox's Bazar region, drought, heat wave, declining of ground water level, cyclone and heavy rainfall are the major climate hazards to forest and biodiversity. Tree resources and habitat of wild

animals and birds are destroyed during disasters. Irrigation from streams is one of the major coping strategies. Adaptation options include tree planting by communities and the Forest Department, and stream re-excavation.

In Sylhet region, drought, heat wave, decline of ground water level and erratic rainfall are some major climate hazards to forest and biodiversity. Using streams to irrigate trees is a major coping strategy. Local community and Forest Department suggested more tree planting and assisted natural regeneration as ecosystem based adaptation measures.

5.2 Adaptation Suggested by Social Groups

The VCF members of all regions have identified their adaptation options which in some cases are similar and in some cases are location specific (See Table 5.1).

Farmers: Growing drought and heat resilient crops (paddy and vegetables), with the help agriculture extension officers and NGOs is the most widespread action villages have adopted, particularly in Chittagong region. Almost as widespread (VCFs of North East, Chittagong and Cox's Bazar regions) is growing early varieties of crops to save crops from flash floods. Growing salinity tolerant crops was included in their plans by a majority of Cox's Bazar villages, but notably not by villages in the southwest region. Some measures are readily adopted by individual farmers, such as organic farming, but others will require collective action organized by the village/VCF such as re-excavation of canals to preserve fresh water/ rain water planned by 18% of all villages. Installation of deep tube-well is another common plan component especially in the northeast region, but is a less sought-after option for the south-west region due to presence of saline ground water in the ground level, and will require investments by large farmers or the government.

Fish farmers: Adaptations were mainly planned in the southwest where much of the land has already been converted from crops to fish farms due to salinity. Here the VCFs plan to promote salinity tolerant fish cultivation, obtaining virus free shrimp fry, and crab fattening.

Capture fishers: Most of the actions planned are in the southwest region, but even here only a minority of VCFs have included fishery adaptations. These include: establishing fish sanctuaries, re-excavation of canals, a ban on poison fishing, and a ban on catching small fish (presumed to mean juvenile fish).

Poultry and livestock adaptations arise mainly from day laborers and women who face a lack of work and income during disasters occupations. Poultry and livestock were mainly included in adaptation plans in the southwest with an emphasis on locally adapted varieties (given the high salinity here) and making safe spaces for livestock in existing cyclone shelters.

Health and sanitation adaptations also arise mainly to address priorities of women and children. The main adaptation options are to continue existing good practices by increasing the number of shallow tubewells for drinking water and to promote installation of sanitary latrines. Surprisingly only 5% of villages in the southwest included maintenance or installation of Pond Sand Filters in their plans. Quite a high percentage of villages plan to establish community clinics to improve medical treatment including of water borne and cold induced diseases. Improved Cooking Stoves (ICS) were included in a majority of central region village plans but in few other plans, indicating either low acceptability or interest in other regions, or catching up in the central region. A related quite widespread priority was to improve local roads so that they are not damaged in heavy rain. While a number of coastal villages will lobby to have cyclone shelters built.

Conservation and forest dependent communities: Since the VCFs have been formed for forest conservation and a majority of their members make use of forest resources, it is no surprise that the

single most widespread adaptation action is to expand social forestry included by a third of all villages in their plans and by 85% of northeast region villages. Other conservation related adaptation options were only included by a few villages, such as freshwater ponds for wild animals inside the forest and marine turtle nurseries.

Table 5.1 Main priorities agreed in PCVAs for community based adaptation

Adaptation	Number of villages adopting actions in their plan						Percentage of villages adopting actions in their plans					
	North East	Chitta-gong	Cox's Bazar	South West	Central region	All	North East	Chitta-gong	Cox's Bazar	South West	Central region	All
N (no PCVAs) ->	158	200	194	183	89	824						
Agriculture (13)												
Adopt/promote drought and temperature resilient crops and varieties	35	135	27	11	22	230	22.2	67.5	13.9	6.0	24.7	27.9
Adopt/promote saline tolerant crops and varieties		40	102			142	0.0	20.0	52.6	0.0	0.0	17.2
Promote cultivation of early varieties of crops	41	69	73	20	10	213	25.9	34.5	37.6	10.9	11.2	25.8
Promote organic farming	30	60	12	62		164	19.0	30.0	6.2	33.9	0.0	19.9
Promote use of mulching to improve drought resilience	21		9	12	7	49	13.3	0.0	4.6	6.6	7.9	5.9
Promote cultivation in bags, sacs and plastic pots				12		12	0.0	0.0	0.0	6.6	0.0	1.5
Promote cold resilient crops					71	71	0.0				79.8	8.6
Re-excavate canals (drainage, preserve water)	34	9	40	52	15	150	21.5	4.5	20.6	28.4	16.9	18.2
River re-excavation	3					3	1.9	0.0	0.0	0.0	0.0	0.4
Install deep tube wells	107	43	63	5	5	223	67.7	21.5	32.5	2.7	5.6	27.1
Dam construction in canal (preserve water for irrigation)		3	2			5	0.0	1.5	1.0	0.0	0.0	0.6
Water pump machine		3				3	0.0	1.5	0.0	0.0	0.0	0.4
Water reservoir			12			12	0.0	0.0	6.2	0.0	0.0	1.5
Aquaculture (4)												
Promote salinity tolerant fishes				90		90	0.0	0.0	0.0	49.2	0.0	10.9
Promote early variety fishes	2	23				25	1.3	11.5	0.0	0.0	0.0	3.0
Virus free shrimp fry cultivation				120		120	0.0	0.0	0.0	65.6	0.0	14.6
Crab fattening				90		90	0.0	0.0	0.0	49.2	0.0	10.9
Capture Fisheries (4)												
Adopt/establish fish sanctuaries		1		21		22	0.0	0.5	0.0	11.5	0.0	2.7
Re-excavate natural water bodies	3			17		20	1.9	0.0	0.0	9.3	0.0	2.4
Ban poison fishing in the canals of Sundarban				29		29	0.0	0.0	0.0	15.8	0.0	3.5
Ban catching small fish			3	12		15	0.0	0.0	1.5	6.6	0.0	1.8
Poultry and livestock (6)												
Promote poultry varieties adapted to the locality	8		14	113		135	5.1	0.0	7.2	61.7	0.0	16.4
Promote disease tolerant livestock and poultry		11	27	10	30	78	0.0	5.5	13.9	5.5	33.7	9.5
Adopt improved (stronger) sheds for poultry and livestock		5				5	0.0	2.5	0.0	0.0	0.0	0.6
Provide safe space in cyclone shelter for livestock			2	107		109	0.0	0.0	1.0	58.5	0.0	13.2
Strengthen vaccination of poultry	19			25		44	12.0	0.0	0.0	13.7	0.0	5.3
Veterinary hospital		7	1			8	0.0	3.5	0.5	0.0	0.0	1.0
Heath and other needs (11)												

Adaptation	Number of villages adopting actions in their plan						Percentage of villages adopting actions in their plans					
	North East	Chitta-gong	Cox's Bazar	South West	Central region	All	North East	Chitta-gong	Cox's Bazar	South West	Central region	All
Create community clinic for better health facilities.	56	13	21	31	9	130	35.4	6.5	10.8	16.9	10.1	15.8
Build drinking water tanks in safe flood free places.	22		5	50		77	13.9	0.0	2.6	27.3	0.0	9.3
Re-excavate ponds and canals to store drinking water.	4	22	9	55		90	2.5	11.0	4.6	30.1	0.0	10.9
Shallow Tubewell	40	29	50	16	23	158	25.3	14.5	25.8	8.7	25.8	19.2
Water treatment plant				15		15	0.0	0.0	0.0	8.2	0.0	1.8
Pond Sand Filter (PSF)				10		10	0.0	0.0	0.0	5.5	0.0	1.2
Well/Kup	10					10	6.3	0.0	0.0	0.0	0.0	1.2
Auto pump installation	4					4	2.5	0.0	0.0	0.0	0.0	0.5
Community initiative for water distribution by motor			3			3	0.0	0.0	1.5	0.0	0.0	0.4
Promote use of sanitary latrines	47	42	22	38	6	155	29.7	21.0	11.3	20.8	6.7	18.8
Promote use of Improved Cooking Stoves		23			70	93	0.0	11.5	0.0	0.0	78.7	11.3
Hazard resilience (2)												
Make roads so they are not damaged by heavy rains	40	21	33	61	9	164	25.3	10.5	17.0	33.3	10.1	19.9
Cyclone shelter	1	11	24	37		73	0.6	5.5	12.4	20.2	0.0	8.9
Conservation (6)												
Expand/promote social forestry program	134	21	32	77	22	286	84.8	10.5	16.5	42.1	24.7	34.7
Make freshwater ponds in forest for wildlife	4			52	1	57	2.5	0.0	0.0	28.4	1.1	6.9
Setting earthen pots in the trees for birds	18					18	11.4	0.0	0.0	0.0	0.0	2.2
Operate mangrove nursery and plant mangroves				63		63	0.0	0.0	0.0	34.4	0.0	7.6
Sand dune plantation			3			3	0.0	0.0	1.5	0.0	0.0	0.4
Turtle conservation action			4			4	0.0	0.0	2.1	0.0	0.0	0.5
Mean no types action per PCVA							**4.3**	**3.0**	**3.1**	**7.2**	**3.4**	**4.2**

Note: green shade indicates regions where an action was adopted in over 50% of village adaptation plans, and adaptation titles included in a quarter or more of all village plans.

5.3 Roles and Responsibilities for Implementing Local Adaptation Plans

The implementation of adaptation plans was expected to be performed by a wide range of institutions. The extension offices of Upazila level as well as private sectors and government funding sources are approached by the local communities in various capacities to implement their adaptation plans. As of November 2017, 22 Union Parishads had included major adaptation options in their Annual Development Program (ADP). A total of 15 Co-Management Committees (CMCs) from ten Protected Areas prepared a proposal for Bangladesh Climate Change Trust Fund (BCCTF) and submitted it through Forest Department. This proposal is based on the findings of the relevant PCVAs and local adaptation plans. In Chittagong region the CMCs have also tapped resources from the private sector to implement their adaptation plans. However, at the village level many of the adaptation plan elements are feasible for local people to directly take up either as individuals or as collective action by a VCF or coordinated by a CMO, or by requesting local government or NGOs to take up local priority actions.

The approach for implementation of the adaptation plans developed through the PCVA process should be a bottom-to-top approach by communicating the needs and priorities of the communities to the higher levels. For this local government (Union Parishads and the Upazila administration) could keep part of their budget in the Annual Development Plan (ADP) to address needs arising from climate change impacts.

While addressing local needs and hazards has long been a responsibility of local government, climate change has complicated this with the need to consider not only historical climate variability but also future climate change. Yet there is currently a general lack of either legislative directive or community best practice for how to incorporate climate risk and its uncertainties into local decision-making. This process, which necessitates learning, investment of resources, and policy development, must occur while local government fulfils the range of existing responsibilities. As such, climate adaptation is currently competing for space on the policy agenda as well as in the budgets of local governments.

CHAPTER 6 CONCLUSIONS

As a first step towards landscape level adaptation planning, CREL conducted Participatory Climate Vulnerability Assessment (PCVA) in project villages covering both forest and wetlands ecosystems in five CREL regions. The PCVA process captured recent and expected climate change impacts on people and ecosystems (forest, wetlands and biodiversity) of over 800 villages and developed village level adaptation and disaster risk reduction, which were consolidated into wider plans covering the villages associated with a forest "beat" in forest PAs and elsewhere for Union Parishads. This involved the active participation of the VCF, CMC members and other relevant actors. Each PCVA determined the local climate trends (variability and extremes of last 20-30 years), and the impacts of climate hazards and stresses on lives and livelihoods of the forest and wetland dependent communities, the level of vulnerability of different impacted "sectors" and social groups (farmers, fishers, wage earners, women, etc.). These participatory assessments also identified the current coping strategies and adaptation needs of the communities and social groups. This report has summarized the key findings from all the five regions. It has not only identified risks and vulnerabilities, but also documented the immediate and long term adaptation needs and priorities identified by the communities. Many of the adaptation options have been included in PA and wetland management plans, and associated ten year plans developed by the CMCs in PAs and Resource Management Organizations in Hail Haor.

Adaptations and mitigation measures were suggested in small-scale agriculture, aquaculture, fisheries and wetland, forest and biodiversity, water and sanitation, and small infrastructure in and around the PAs and wetlands. Many of the adaptation and mitigation options could be implemented by the communities, village groups, CMOs, FD, DoF and other local government bodies including Upazila administration and Union Parishads. Implementation of local adaptation plans will build resilience in the community and ecosystems as well as reduce their vulnerability to climate change.

The climate change impacts on livelihoods and natural resources in the context of respective unions and forest beats have been compiled in this synthesized PCVA report. There are some common hazards for all unions notably drought and nor'wester storms, at the same time some location and region specific hazards have also been identified by the PCVAs, and have been discussed in this report. The PCVA process helps the local people to have a better understanding about climate disasters in their locality based on their experiential knowledge as well as from scientific knowledge on long term trends of climate change, shared by the PCVA teams. The process also brought together people of different occupations to identify hazards, impacts, current coping actions, and adaptation options.

Selected adaptation options (both immediate and long term) from adaptation plans have been incorporated into Annual Development Plans (ADP) of Union Parishads. Adaptation plans now need to be implemented, and CMOs and concerned authorities associated with the PCVA process should play a proactive role to carry this initiative forward.

The PCVA approach offers tested tools for vulnerability assessment, hazard identification, and adaptation planning. The tools and methods for PCVA and local adaptation planning were found to be effective and resulted in local adaptation plans owned by the VCFs and CMOs. The process and plans give them capacity and strength to communicate with relevant government departments and actors to seek funds for implementation of their local plans, for example from Forest Department and government climate adaptation funds. Eleven CMOs have already submitted proposals to the Forest Department for funding based on their local adaptation plans. Implementing local adaptation strategies and actions will ultimately build financial capacity, resilient ecosystems and CMO sustainability.

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ANNEX 1

PAST TRENDS AND FUTURE PROJECTIONS IN CLIMATE CHANGE

The analysis and tables included in this annex (and that formed the basis for sharing predictions with communities during PCVAs) are based on secondary data collected from Bangladesh Meteorological Department (BMD) and on outputs from AGCM downscaling data on rainfall and temperature supplied by M.M. Rahman and then analyzed by BCAS (S. Karmakar).

1 Past Trends and Future Projections for Chittagong Region

Within Chittagong region CREL worked on co-management of seven biologically significant sites: Kaptai National Park (NP)(dropped in 2015); Hazarikhil Wildlife Sanctuary (WS); Baroiyadhala NP; Dudpukuri- Dhopachori WS; Chunati WS; Halda River Basin (dropped in 2016), and Nijhum Dwip NP. Kaptai NP, Dudpukuria-Dhopachori WS and Chunati WS each have two co-management committees. The geo-physical contexts of these sites are varied including: lowland forest ecosystem, hilly ecosystem and coastal mangrove ecosystem. Weather records from Chittagong were assumed to represent the plains/lowlands (Chunati, Halda), records from Rangamati were assumed to represent the hill forests (Kaptai, Hazarikhil, Baroiyadhala, Dudpukuri- Dhopachori), and records from Sitakunda (although distant, the nearest weather station) were assumed to represent the coastal ecosystem (Nijhum Dweep).

1.1 Chittagong/plain temperatures

The annual mean temperature in plain ecosystem of Chittagong region varied from year to year during 1961-2012, but has been increasing at the rate of +0.176°C/10 years (decade) (Table 1). Average seasonal temperature is increasing at +0.105°C/10 years in the pre-monsoon and +0.197°C/10 years in the monsoon season. The winter minimum temperature has increased at +0.20°C/10 years. Hence monsoon and winter seasons are warming relatively rapidly (about 1°C per 50 years. However, the long term trends are uncertain as the decadal trends in annual mean temperature varied significantly from one decade to another. If the present trend of temperature rise continues, in 2050 the average annual temperature in the plain ecosystem of Chittagong region is likely to be 26.82°C, the pre-monsoon temperature will be 27.96°C, monsoon temperature 29.12°C, and the winter minimum temperature is likely to be 16.09 °C. Compared with mean temperature during 1961-1990, annual mean temperature is likely to rise by +1.31°C in 2050, and the monsoon will be even hotter (+1.433°C in 2050). The winter minimum temperature in this ecosystem is likely to be +1.015°C. The documented increase in temperature in this ecosystem is in line with the trend mentioned by the community people.

Table 1: Trend in annual and seasonal mean temperature (°C/year) and projection of annual and seasonal mean temperature (°C) in Chittagong region

Sites	Annual/ Seasonal	Decadal trends (°C/year)					Overall trends (°C/year)	Mean temperature (°C)	Mean temperature (°C)	Projected changes in temperature (°C) with respect to mean during 1961-1990*	
		1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	1961-2012*	1961*	1961-1990*	2030	2050
Plain Ecosystem: Jaldi and Chunati	Annual	+0.0027	+0.0203	+0.0561	+0.0406	-0.0462	+0.0176	25.32	25.51	+0.96	+1.31
	Pre-monsoon	-0.0369	+0.0246	+0.0579	-0.0273	-0.0129	+0.0105	28.03	27.18	+0.574	+0.784
	Monsoon	+0.0097	+0.0225	+0.0512	+0.0114	-0.0129	+0.0197	27.35	27.69	+1.039	+1.433
	Winter (T_{min})	+0.0230	+0.0020	+0.133	+0.0660	+0.114	+0.0200	15.29	15.07	+0.615	+1.015
Hilly Ecosystem : Dudhpukuria-Dhopachhari WS, Hazarikhil WS, Baroiyadhala NP	Annual	+0.073	+0.068	-0.065	+0.033	+0.029	-0.000	24.6	25.34	1.20	1.20
	Pre-monsoon	+0.060	+0.056	-0.054	-0.014	+0.109	+0.001	27.27	27.18	-0.41	-0.39
	Monsoon	+0.045	+0.061	-0.028	-0.003	+0.015	+0.010	27.18	27.52	-1.246	-1.046
	Winter (T_{min})	+0.139	+0.046	-0.173	+0.036	-0.033	-0.067	15.28	16.20	-2.01	-3.35
Coastal Ecosystem: Nijhum Dwip (* projections are against 1981-2010)	Annual	-	-	+0.047	-0.005	+0.029	+ 0.0058	25.36	25.5	-0.196	-0.08
	Pre-monsoon	-	-	+0.076	-0.06	+0.107	+0.0252	26.2	27.23	+0.461	+0.965
	Monsoon	-	-	+0.049	-0.022	+0.023	+0.0086	28.13	28.05	+0.018	+0.19
	Winter (T_{min})	-	-	-0.002	-0.056	-0.027	-0.0240	13.49	13.53	-0.215	-0.695

1.2 Rangamati (hill) temperature

The temperature of Rangamati represents the temperature of Hilly Ecosystem. In the Hilly Ecosystem of Chittagong region, there are inter-decadal and inter-annual variations of annual and seasonal mean temperature. The annual mean temperature has almost increasing and decreasing trend during 1961-2012 in this system. As a result, the annual mean temperature is likely to be 26.53°C both in 2030 and 2050, an increase by 1.2°C as compared to the mean annual temperature during 1961-1990, part of which has already occurred. The pre-monsoon and monsoon mean temperatures have a slight increasing trend in this ecosystem at the rates of +0.01 and +0.10°C/10years respectively. In both these seasons, the mean temperature is likely to decrease with respect to the mean temperature during 1961-1990. The winter mean minimum temperature has a decreasing trend at -0.067°C/year during 1961-2012 and is likely to be 15.28°C and 16.20°C in 2030 and 2050 respectively. These temperatures are well below the mean minimum temperature during 1961-1990 by -2.01°C and -3.35°C respectively in 2030 and 2050. The results indicate that the winter minimum temperature is likely to be less than the winter minimum temperature of 1961-1990. This may have negative impact on the cropping patterns of this hilly ecosystem. The decreasing trend in winter minimum temperature will enhance cold wave in this ecosystem and have impact on the livelihoods and food security of the community people.

1.3 Coastal temperatures

The temperature at Sitakunda represents the temperature in the Coastal Ecosystem of Chittagong region, having the data for shorter period (1977-2012). In the Coastal Ecosystem of Chittagong region, there are inter-decadal and inter-annual variations of annual and seasonal mean temperature. Table 1 shows that the annual, pre-monsoon and monsoon temperatures have increasing trends at +0.058, +0.252 and 0.086°C/10 years respectively during the period 1981-2012. Compared with the mean temperature during 1981-2010, the annual temperature is likely to decrease by -0.08°C in 2050; the pre-monsoon and monsoon temperatures are likely to increase by +0.965°C and +0.19°C respectively in 2050 as compared to the mean temperature during 1981-2010. The winter minimum temperature in this coastal ecosystem has decreasing trend at a rate of -0.024 °C/year during 1981-2012. This decreasing trend will give result in the decrease in winter minimum temperature by -0.215°C and -0.695°C in 2030 and 2050 respectively as compared to the mean winter minimum temperature during 1981-2010. This decreasing trend in winter minimum temperature will enhance cold wave in this ecosystem and have impact on the agriculture and livelihoods of the community people.

1.4 Chittagong rainfall

The rainfall of Chittagong represents the rainfall of Plain Ecosystem. Annual total rainfall has been increasing in the Plain Ecosystem of Chittagong region at the rate +7.419 mm during the period 1961-2012, this rain amounts to almost 2.92 inch per decade (per 10 years). But the trend is positive and for more rain is likely in the pre-monsoon season with increasing rate of +4.4 mm/year. The rainfall in the monsoon season is found to have increasing trend at +1.3 mm/year during the period 1961-2012. The annual and seasonal rainfall has inter-annual variation. The trend of more seasonal rain may increase the risk of landslides, storms and flash floods particularly in the pre-monsoon and monsoon seasons, posing a threat to livelihoods and natural resources in the Plain Ecosystem of Chittagong region. One example is the heavy rainfall and landslide in Chittagong on 11 June 2007, when 425 mm rainfall occurred in 24 hours. The decadal rates of annual rainfall vary from one decade to another; during the 5 decades of the study period, the decadal trends are maximum positive during the decade 1991 to 2000. With the present trends in annual and seasonal rainfall, it has been projected that the annual total rainfall will increase and is likely to be 3353 mm in 2050, when total rainfall in monsoon will average 2213 mm, and pre-monsoon rainfall will likely to have average 727 mm. The Atmospheric General Circulation Model (AGCM) forecasts 893.94 mm annual rainfall in 2030, which is well below the projected value of 3352.7 mm. Compared with the mean annual rainfall during 1961-1990, annual rainfall is likely to increase by 392.62mm in 2030 and by 541.32 mm in 2050, pre-monsoon rainfall is likely to increase by 240 and 329 mm in 2030 and 2050 respectively. The monsoon rainfall is likely to increase by 48 and 73 mm respectively by 2030 and 2050 as compared to the average rainfall during 1961-1990. The increase in annual rainfall in 2050 is 19.25% of the mean total rainfall during 1961-1990, whereas the increase pre-monsoon rainfall is 82.58% of the mean total rainfall during 1961-1990. It indicates that the pre-monsoon rainfall may affect the biodiversity in the Plain Ecosystem of Chittagong region in future.

1.5 Rangamati (hill) rainfall)

The rainfall of Rangamati represents the rainfall of Hilly Ecosystem of Chittagong region. In the Hilly Ecosystem of Chittagong region, the annual and seasonal total rainfalls have inter-decadal and inter-annual variation, and their decadal trends vary from one decade to another. The annual and pre-monsoon rainfalls have increasing trends in this ecosystem at 2.49 mm/year and 3.15 mm/year respectively whereas the monsoon rainfall has decreasing trend at -1.31 mm/year during 1961-2012. If

these rates continue, the annual, pre-monsoon and monsoon rainfall would be 2697 mm, 648 mm and 1709 mm respectively in 2050 (Table 2). In comparison to the mean rainfall during 1961-1990, the annual and pre-monsoon rainfall will be higher by 213 mm and 238 mm in 2050 i.e. 8.57% and 53.39% in 2050 respectively. At the same time, the monsoon rainfall will decrease by 4.09% in 2050. The increase in pre-monsoon rainfall may increase hilly floods and landslides in this region, causing significant impact on agriculture and livelihoods of the community people.

The rainfall of Sitakunda represents the rainfall of Coastal Ecosystem. In the Coastal Ecosystem, the annual and seasonal rainfalls have inter-decadal and inter-annual variability and the trends vary from one decade to another during the period 1981-2012. The trends of annual, pre-monsoon and monsoon rainfalls are +0.52 mm/year, -3.12 mm/year and +7.620 mm/year. If these trends of annual and seasonal rainfall continue, the annual, pre-monsoon and monsoon rainfall would be 3273 mm, 480 mm, 2574 mm in 2030 and 3285 mm, 418 mm, and 2726 mm in 2050 respectively. In comparison to the mean rainfall during 1981-2010, the annual rainfall will increase by 59 mm and 71 mm in 2030 and 2050 respectively; the pre-monsoon rainfall is likely to decrease by -100 mm and -163 mm in 2030 and 2050 respectively and the monsoon rainfall is likely to increase by 300 mm and 452 mm in 2030 and 2050 respectively. The increase in monsoon rainfall is 18.88% with respect to the mean rainfall during 1981-2010 in the coastal ecosystem of Chittagong region (Table 3). This increase in monsoon rainfall may increase hilly flood in the coastal ecosystem and water logging there, thereby causing serious damage of agricultural crops and impact on the livelihoods of the community people. In the per-monsoon season, the decrease in rainfall may enhance drought condition in this ecosystem.

Table 2: Trends in annual and seasonal rainfall (mm/year) and projection of annual and seasonal rainfall (mm) in Chittagong region

Protected Areas	Annual/ Seasonal	Decadal trends (mm/year)					Overall trends (mm/ yea)	Total Rainfall (mm)	Mean Rainfall (mm)	Projected changes in rainfall (mm) with respect to mean during 1961-1990 (*1981-2010)	
		1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	1961-2012 (*1981-2012)	1961 (*1981)	1961-1990 (*1981-2010)	2030	2050
Plain Ecosystem: Jaldi and Chunati	Annual	-55.5	15.0	-5.5	87.9	53.8	+7.4	3702	2811.4	+392.6	+541.3
	Pre-monsoon season	-3.3	28.8	-11.4	20.4	-11.8	+4.4	184	398.1	+240.4	+328.7
	Monsoon season	-49.9	-13.1	-25.0	67.7	62.8	+1.3	3179	2139.2	+48.4	+73.4
Hilly Ecosystem: Dudhpukuria-Dhopachhari WS, Hazarikhil WS	Annual	-	-	25.0	97.8	-38.2	+2.5	3386	2484.7	+163.0	+212.8
	Pre-monsoon season	-	-	-10.8	33.5	-10.8	+3.1	202	446.2	+175.3	+238.2
	Monsoon season	-	-	-29.3	74.7	-23.9	-1.3	2884	1782.3	-46.6	-72.9
Coastal Ecosystem: Sitakunda Eco Park, Baraiyadhala NP, Nijhum Dwip	Annual	-	-	25.0	97.8	-38.2	+0.6*	2334*	3213.9*	+58.9*	+70.7*
	Pre-monsoon	-	-	-10.8	33.5	-10.8	-3.1*	696*	580.5*	-100.2*	-162.6*
	Monsoon	-	-	-29.3	74.7	-23.9	+7.6*	1600*	2274.0*	+299.6*	+452.0*

Historical trend analysis of hazards/disasters due to climate change in Chittagong region done by the community people is given in Chapter 3.

2 Cox's Bazar Region

Cox's Bazar region comprises eight Protected Areas, namely Himchari National Park; Teknaf Wildlife Sanctuary; Fashiakhali Wildlife Sanctuary (WS); Medhakachapia National Park; Sonadia Island ECA; Saint-Martin Island ECA; Cox's Bazar-Teknaf Peninsula ECA; and Inani Protected Area (PA). The geo-physical context of the Protected Areas of Cox's Bazar is featured with coast of Bay of Bengal, hills and plain lands. The trends in temperature and rainfall have been studied for two Ecosystems. The secondary data of Cox's Bazar observatory of BMD represents data of Plain and Hilly Ecosystem and the data of Teknaf observatory of BMD represents the Coastal Ecosystem.

2.1 Forest temperatures

The mean annual temperature has been increasing at the Plain and Hilly Ecosystem of Cox's Bazar region at the rate of +0.162°C/10 years (decade) during 1961-2012. In pre-monsoon season, average seasonal temperature is increasing at +0.165°C/10 years and in the monsoon season it has an increasing rate of +0.144°C/10 years. The winter minimum temperature is increasing at +0.29°C/10 years during the same period. This rate of increase is statistically significantly at 100%. This indicates that the winter season is warming at a significant rate and is alarming. The decadal trends in annual and seasonal mean temperature vary significantly from one decade to another and are all positive except in the pre-monsoon season. If the present trend of temperature rise continues, the annual average temperature, pre-monsoon temperature, monsoon temperature are likely to be 26.88, 28.66 and 28.33°C respectively in 2050. The winter minimum temperature is likely to be 17.46°C in Cox's Bazar region in 2050. In comparison with the mean annual and seasonal temperatures during the period 1961-1990, the annual mean temperature is likely to rise by +1.2°C in 2050, pre-monsoon will be hotter by +1.25 °C in 2050, monsoon will be less hot by +1.02°C in 2050 and the winter will be hottest by 1.5°C in the Plain and Hilly Ecosystem.

2.2 Coastal temperatures

The annual temperature has been increasing at the Coastal Ecosystem of Cox's Bazar region at the rate of +0.19°C/10 years (decade) during 1977-2012. In pre-monsoon season, average seasonal temperature is increasing at +0.21°C/10 years and in the monsoon season it has an increasing rate of +0.20°C/10 years. The winter minimum temperature is decreasing at -0.12 °C/10 years during the same period. This indicates that the winter season is likely to be cooling in future. The decadal trends in annual and seasonal mean temperature vary significantly from one decade to another. If the present trend of temperature continues, the annual average temperature, pre-monsoon temperature, monsoon temperature are likely to be 31.04, 32.9 and 30.41°C respectively in 2050. The winter minimum temperature is likely to be 15.61°C Coastal Ecosystem of Cox's Bazar region in 2050. In comparison with the mean annual and seasonal temperatures during the period 1981-2010, the annual mean temperature is likely to rise by +0.81°C in 2050, pre-monsoon will be hotter by +1.12°C in 2050, monsoon will be less hot by +0.07°C in 2050 and the winter will be colder by -0.72°C (Table 3). The rise in annual mean temperature, pre-monsoon temperature and monsoon temperature supports the opinion of the community people in this ecosystem.

Table 3: **Trends in annual and seasonal mean temperature (°C/year) and projection of annual and seasonal mean temperature (°C) in Cox's Bazar region**

Protected Areas	Annual/Seasonal	Decadal trends (°C/year)					Overall trends (°C/year)	Mean Temperature (°C)	Mean Temperature (°C)	Projected changes in temperature (°C) with respect to mean during 1961-1990 (*1981-2010)	
		1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	1961-2012 (*1977-2012)	1961 (*1981)	1961-1990 (*1981-2010)	2030	2050
Plain and Ecosystem Hilly: Fasiakhali, Medha-kochhopia, Himchhari, Inani PA	Annual	+0.0227	+0.051	+0.0176	+0.0405	+0.0512	+0.0162	25.32	25.6	+0.95	+1.28
	Pre-monsoon season	+0.0273	+0.063	+0.0121	-0.0194	+0.1071	+0.0165	27.8	27.41	-0.92	+1.25
	Monsoon season	+0.0188	+0.0347	+0.0098	+0.0109	+0.0338	+ 0.0144	27.00	27.31	-0.72	+1.02
	Winter season (T_{min})	+0.022	+0.027	+0.102	+0.093	+0.033	+0. 0.029	21.43	16.29	+0.92	+1.5
Coastal Ecosystem: Teknaf and Shahparir Dwip	Annual	-	-	+0.027	+0.087	+0.007	+0.019*	29.40	30.23*	+0.43*	+0.81*
	Pre-monsoon season	-	-	-0.006	-0.003	-0.027	+0.021*	30.53	31.78*	+0.70*	+1.12*
	Monsoon season	-	-	+0.073	+0.067	+0.038	+0.020*	29.83	30.34*	-0.33*	+0.07*
	Winter season (T_{min})	-	-	-0.025	-0.010	+0.020	-0.012	16.71	16.33*	-0.48*	-0.72*

2.3 Rainfall in Cox's Bazar forest areas

The annual total rainfall increase during the period 1961-2012 is about +4.01 mm/year, this amounts to an increase of almost 15.76 inch per decade. The trend of rainfall in the pre-monsoon season is found to be positive and equals to +4.13 mm/year and the rainfall has less positive trend in the main monsoon the rate of trend is +0.44 mm/year Table 4). There exists inter-annual variation of annual and seasonal rainfall. The trend of more rain may increase the risk of landslides, storms and flash floods particularly in the pre-monsoon season, posing a threat to livelihoods and natural resources in Cox's Bazar region. The decadal rates of annual and seasonal rainfall vary from one decade to another; during the 6 decades of the study period, the decadal trends are increasing in 3 decades but any lower rainfall in the monsoon season in the most recent years may not be representative of the longer-term trend. With the present trends in annual and seasonal rainfall, it projected that the annual total rainfall will increase and is likely to be 3911 mm in 2050, when total rainfall in monsoon will average 2895 mm, and pre-monsoon rainfall will likely to have average 694 mm. AGCM model forecasts 3587 mm annual rainfall in 2030, which underestimated with respect to the projected value of 3831 mm by 244 mm. Compared with the mean annual rainfall during 1961-1990, annual rainfall is likely to increase by 275 mm in 2030 and by 355 mm in 2050, pre-monsoon rainfall is likely to increase by 234 mm in 2030 and by 317 mm in 2050 with a increase in monsoon rainfall by 71 mm and 80 mm in 2030 and 2050 respectively as compared to the average during 1961-1990.

2.4 Rainfall in Cox's Bazar coast

In the coastal ecosystem of Cox's Bazar, the annual rainfall is found to have increasing trends at +45.23 mm/year, and the seasonal rainfall has increasing trends at +6.026 mm/year and 31.31 mm/year respectively in the pre-monsoon and monsoon seasons during the period 1977-2012. These rates of rainfall are very high. If these rates continue, annual rainfall is likely to increase by 2351 mm (55.56%), pre-monsoon rainfall is likely to increase by (89.48%) and the monsoon rainfall is likely to increase by (46.25%) in 2050 with respect to the mean rainfall during 1981-2010. As a result, the Coastal Ecosystem will have profound impact of rainfall change, causing flood and water logging in the area.

The increase in rainfall in this ecosystem is comparable with the opinions of the community people (Chapter 3).

Table 4: Trends in annual and seasonal rainfall (mm/year) and projection of annual and seasonal rainfall (mm) in Cox's Bazar

Protected Areas	Annual/ Seasonal	Decadal trends (mm/year)					Overall trends (mm/year)	Total Rainfall (mm)	Mean Rainfall (mm)	Projected changes in rainfall (mm) with respect to mean during 1961-1990 (*1981-2010)	
		)61-)70	1971-1980	1981-1990	1991-2000	2001-2010	1961-2012 (*1977-2012)	1961 (*1981)	1961-1990 (*1981-2010)	+2030	+2050
Plain and Ecosystem Hilly: Fasiakhali, Medhakochhopia and Himchhari, Inani PA	Annual	-124.52	+38.45	-213.97	+56.15	+102.73	+4.0	4311	3556.5	+274.7	+354.8
	Pre-monsoon season	-11.77	+5.30	+5.9818	+24.22	+0.33	+4.1	327	376.7	+234.3	+317.0
	Monsoon season	+46.26	189.78	+16.012	+68.86	-38.54	+0.4	3617	2815.1	+71.0	+79.7
Coastal Ecosystem: Teknaf and Shahparir Dwip	Annual	-	-	-17.31	+5.25	+20.87	+45.2*	4366*	4231.4*	+1446.5*	+2351.1*
	Pre-monsoon season	-	-	-9.097	+34.58	+2.47	+6.0*	475*	366.4*	+207.4*	+327.9*
	Monsoon season	-	-	-22.18	-22.84	-19.44	+31.3*	3649*	3490.9 *	+988.4*	+1614.6*

3 Khulna Region

In Khulna region four site offices which include Sharnkhola site, Chandpai site, Dacope-Koyra site and Munshiganj site offices are assigned for the resilience building activities of Sundarban and the people living in the landscape. Another site office named Tengragiri site office at Taltali Upazila in Barguna District under Barisal Division is assigned for the protection and resilience building of Tengragiri Wildlife Sanctuary and the natural resource dependent communities on the edge of the forest. The data of Satkhira, Mongla and Khepupara observatories of BMD will represent the data for (i) Shyamnagar, (ii) Sharankhola, Chandpai and Dacope-Koyra and (iii) Tengragiri respectively. Table 5 gives the summary of temperature trends and projection in different ecosystems of Khulna Region.

3.1 Khulna region temperatures

Mean annual temperature at Shyamnagar Ecosystem of Khulna region has slight increasing trend at +0.09°C/10 years during the period 1991-2012. In pre-monsoon season, average seasonal temperature is increasing at 0.10°C/10 years and in the monsoon season it has an increasing rate of +0.24°C/10 years. The winter minimum temperature is increasing at +0.33°C/10 years during 1991-2012. This rate indicates that the winter season is warming at faster than other seasons and is alarming. The decadal trends in annual and seasonal mean temperature are not constant but vary significantly from one decade to another and are positive during the recent decades. The average annual, pre-monsoon, monsoon and winter mean minimum temperatures are likely to be 25.98, 28.55, 29.6 and 14.46°C respectively in 2050. Atmospheric General Circulation Model (AGCM) model has simulated annual mean temperature of 26.53 °C in 2030. This is higher than 25.8°C, projected for 2030 by 0.73°C. The above projected temperatures are compared with the mean temperature during 1981-2010 and found that the pre-monsoon temperature is likely to decrease by -0.394°C and the winter minimum temperature is likely to increase by -0.701°C in 2050. The annual temperature is likely to decrease by -0.307°C whereas the monsoon temperature is likely to decrease by -0.07°C in 2050 in Shyamnagar Ecosystem.

In the Sharankhola-Chandpai-Dacope-Koyra Ecosystem, the annual, pre-monsoon and monsoon average temperatures are found to increase during the period 1991-2012 the rates of +0.37 °C/10years, +0.071°C/10years and +0.31°C/10years respectively whereas the mean minimum temperature is found to decrease at a rate of -0.12°C/10years. Decadal trends vary from one decade to another and are higher in the decade 2000-2010 in case of annual and pre-monsoon mean temperature. If the present rates of temperature continues, the annual, pre-monsoon, monsoon mean temperatures and winter mean minimum temperature are likely to increase by +0.50°C, 3.17°C, 1.54°C and +0.28°C respectively in 2050 as compared with the mean temperature of the period 1991-2010. The increase in pre-monsoon season is very significant and likely cause serious impact on the natural resources like forest and fisheries, and livelihoods of the community people. This may also increase the thunderstorm activities in the ecosystem.

In Tengragiri, the annual, pre-monsoon and monsoon average temperatures have also increasing trends at 0.05°C/10 years, +0.22 C/10 years and +0.15 C/10 years respectively during 1991-2012. The winter mean minimum temperature has a decreasing trend of -0.30 C/10 years during the same period. If these rates of temperature continue, the annual and pre-monsoon temperatures are likely to rise by +0.46°C in 2050 whereas the monsoon temperature and winter minimum temperature are likely to fall by -0.22°C and -0.55°C in 2050 as compared with the mean temperatures during 1981-2010. The decrease in winter minimum may enhance the cold wave activity in Tengragiri and affect the livelihoods of the people there.

Table 5: Trends in annual and seasonal mean (°C/year) temperature and projection of annual and seasonal mean temperature (°C) in Khulna region

Protected Areas	Annual/Seasonal	Decadal trends (°C/year)		Overall trends (°C/ year)	Mean Temperature (°C)	Mean Temperature (°C)	Projected changes in temperature (°C) with respect to mean during1981-2010 (1991-2010*)	
		1991-2000	2001-2010	1991-2012	1991 (1981*)	1981-2010 (1991-2010*)	2030	2050
Shyamnagar	Annual	+0.0101	+0.0442	+0.009	25.9	26.29	-0.49	-0.31
	Pre-monsoon season	-0.0539	+ 0.096	+0.010	29.00	28.94	-0.59	-0.39
	Monsoon season	-0.0095	+0.0758	+0.024	29.43	29.67	-0.55	-0.07
	Winter season (T_{min})	-0.149	+0.079	+0.033	14.27	13.76*	+0.04	+0.70
Sharankhola, Chandpai and Dacope-Koyra	Annual	+0.030	+0.034	+0.037	30.80	31.04*	-0.15*	+0.59*
	Pre-monsoon season	+0.004	+0.045	+0.071	34.03	33.88*	+1.75*	+3.17*
	Monsoon season	+0.031	+0.003	+0.031	31.85	32.00*	+0.92*	+1.54*
	Winter season (Tmin)	-0.006	+0.043	-0.012	16.38	15.76*	+0.52*	+0.28*
Tengragiri	Annual	-0.013	+0.043	+0.005	26.03	26.11	0.344	+0.46
	Pre-monsoon	-0.063	+0.111	+0.022	28.93	28.26	+0.50	+0.94
	Monsoon	-0.005	+0.044	+0.015	28.73	28.63	-0.52	-0.22
	Winter season (T_{min})	-0.030	-0.005	-0.030	15.62*	15.24	+0.05	-0.55

3.2 Khulna Region rainfall

In Shyamnagar of Khulna region, the annual and pre-monsoon rainfall has decreasing trend at -1.807 mm/year and -1.306 mm/year during 1991-2012 whereas monsoon rainfall has increasing trend at +1.583mm/year (Table 6). The decadal trends of annual and seasonal rainfall vary from decade to decade and are decreasing in the recent decades. Inter-annual and decadal variability in rainfall exist in Shyamnagar. If the decreasing trends in annual and pre-monsoon rainfall continue, annual and pre-monsoon rainfalls are likely to decrease by -89.15mm and -76.43mm in 2050 respectively as compared with the mean rainfall during 1981-2010. Continuation of the increasing trend in monsoon season would increase rainfall by 79.75 mm in 2050 as compared with the mean rainfall during 1981-2010.

The decrease in pre-monsoon season would enhance drought and cause shortage of drinking water in Shyamnagar; this would affect the natural resources and livelihoods there.

In the Sharankhola-Chandpai-Dacope-Koyra Ecosystem, the annual and monsoon rainfall has increasing trends at 5.217 mm/year and 11.730 mm/year respectively during 1991-2012, whereas the pre-monsoon rainfall has decreasing trend at -5.168 mm/year. If these trends of rainfall continue, the annual rainfall will increase by 261 mm (13.62%), monsoon rainfall will increase by 590 mm (42.90%) and pre-monsoon rainfall will decrease by 257 mm (91.91%) in 2050 as compared to the rainfall during 1991-2010. The rainfall condition during pre-monsoon season is very alarming and

will enhance severe drought and scarcity of drinking water. As a result, agriculture sector, fisheries sector and the livelihoods are likely to be seriously affected. This future projection also supports the opinions of the community people.

At Tengragiri, the annual and seasonal significant decreasing trends in the recent decades. During the period 1991-2012, the annual and pre-monsoon season rainfalls have decreasing trends at -6.403 mm/year and -10.18 mm/year respectively, whereas the monsoon rainfall has increasing trend of +5.968 mm/year. If these trends of rainfall continue, the annual rainfall will decrease by -218 mm (7.8%), monsoon rainfall will increase by 337 mm (16.69%) and pre-monsoon rainfall will decrease by -477 mm (114.2%) in 2050 as compared to the rainfall during 1981-2010 (Table 6). This result indicates that there will be severe consequences of drought condition in this area.

Table 6: Trends in annual and seasonal rainfall (mm/year) and projection of annual and seasonal rainfall (mm) in Khulna region

Protected Areas	Annual/Seasonal	Decadal trends (mm/year)		Overall trends (mm/year)	Annual and seasonal total rainfall (mm)	Mean total rainfall (mm)	Projected changes in rainfall with respect to mean during 1981-2010 (1991-2010*) (mm)	
		1991-2000	2001-2010	1991-2012	1991	1981-2010 (1991-2010*)	2030	2050
Shyamnagar	Annual	+22.92	-49.07	-1.807	1768	1754.80	-53.01	-89.15
	Pre-monsoon season	+28.36	-11.61	-1.306	145	286.13	-50.31	-76.43
	Monsoon season	-6.672	-25.57	+1.583	1397	1238.40	+48.09	+79.75
Sharankhola, Chandpai and Dacope-Koyra	Annual	+ 59.6	-62.73	+5.217	1955	1918.55*	+156.96*	+261.30*
	Pre-monsoon season	+ 21.14	-20.48	-5.168	199	279.35*	-153.39*	-256.75*
	Monsoon season	-4.016	+ 1.387	+11.73	1435	1374.00*	+354.90*	+589.50*
Tengragiri	Annual	+55.14	-44.47	-6.403	3083	2793.75	-89.84	-217.90
	Pre-monsoon	+19.22	-15.59	-10.18	319	392.37	-273.77	-477.37
	Monsoon	+56.59	-39.52	+5.968	2129	2020.12	+217.92	+337.28

4 Central Region (Madhupur)

In central region Madhupur National Forest is the only Protected Area under CREL project. Madhupur Sal forest is famous for natural and cultural biodiversity. Sal tress is the main species of this forest and Garo ethnic community villages are in and around of Madhupur Sal forest.

4.1 Modhupur temperature

Mean annual temperature at Madhupur varies between years during 1961-2012, but has been decreasing at the rate of -0.10°C/10 years (decade). It is also seen that the annual mean temperature is increasing from 1991 at a rate of +0.04°C/10 years (decade). Average seasonal temperature is decreasing sharply from 1961 to till date at -0.26°C/10 years in the pre-monsoon season, but it has increasing trend from 1991 at a rate of 0.18°C/10 years (decade). During the monsoon season, the seasonal temperature has been found to increase for both the periods 1961-2012 and 1991-2012 at the rates of +0.03 and +0.20°C/10 years respectively. The winter minimum temperature is increasing at 0.12°C/10 years at Madhupur. The decadal trends in annual and seasonal mean temperature is not constant but varies significantly from one decade to another. The present trends in both annual and seasonal mean temperature at Madhupur have been linearly projected for 2030 and 2050. The projected values of annual mean temperature are 24.67°C and 24.75°C in 2030 and 2050 respectively at Madhupur, whereas the projected seasonal mean temperature is higher than 25°C in the two seasons

and are also higher than the projected annual mean temperature. Atmospheric General Circulation Model (AGCM) model has simulated annual mean temperature of 24.95 °C in 2030 at Madhupur. This compares well with annual mean temperature of 24.67°C projected for 2030 and is higher than the projected temperature by 0.28°C. The winter minimum temperature projected up to 2050 is 13.89°C. Compared with mean temperature (25.53°C) during 1961-1990, annual mean temperature is likely to fall by -0.78°C in 2050, pre-monsoon will be cooler by -1.6°C in 2050 and monsoon will be hotter by +0.55°C in 2050.

Table 7 gives the summary of trends in annual and seasonal mean temperature and projection of annual and seasonal mean temperature in Central Region based on the data of 1991-2012 and comparison of the projected temperature with that during 1981-2010. The table indicates that the annual and pre-monsoon temperatures are likely to fall by -0.52°C and -0.95°C in 2050 in comparison with the mean temperature of 1981-2010. The monsoon temperature is likely to increase by 0.53°C and winter minimum temperature is likely to increase by 2.23°C in 2050. The increase in winter minimum temperature is likely to affect the agriculture production in future.

Table 7: Trends in annual and seasonal mean temperature (°C/year) and projection of annual and seasonal mean temperature (°C) in Central Region (Madhupur)

Protected Areas	Annual/Seasonal	Decadal trends (°C/year)		Overall trends (°C/year)	Mean Temperature (°C)	Mean Temperature (°C)	Projected changes in temperature (°C) with respect to mean during1981-2010	
		1991-2000	2001-2010	1991-2012	1991	1981-2010	2030	2050
Madhupur	Annual	+0.028	+0.026	+0.004	24.69	25.27	-0.6	-0.52
	Pre-monsoon season	+0.021	+ 117	+0.018	25.67	26.59	-1.31	-0.95
	Monsoon season	+0.00	+0.012	+0.020	28.20	28.51	+0.13	+0.53
	Winter season (T_{min})	+0.103	+0. 0.062	+0.012	11.96	13.42	+1.31	+2.23

4.2 Rainfall trend in Madhupur

The annual rainfall has an increasing trend at Madhupur at a rate of 3.515 mm/year. The seasonal total rainfall has increasing trend at a rate of 1.660 mm/year in the pre-monsoon season and at a rate of 1.047 mm/year in the monsoon season (Table 8). High rainfall rate in the monsoon season may cause flooding condition over the area. If the increased monsoon rainfall is likely to occur within a short period, it may cause disastrous effects on the ecosystem, biodiversity and livelihoods in the region. The decadal rates of annual rainfall vary from one decade to another. With the present trends in annual and seasonal rainfall, it has been projected that the annual total rainfall will increase and is likely to be 2413 mm in 2050, when total rainfall in monsoon will average 1548 mm, and pre-monsoon rainfall will likely to have an average of 580 mm only in 2050. AGCM model forecasts 972 mm annual rainfall at Madhupur in 2030, which is underestimated with respect to the projected value of 2342 mm by 1370 mm. If this model forecast becomes true, there will be a serious water crisis in Madhupur. Compared with the mean annual rainfall during1961-1990, annual rainfall is likely to increase by 241 mm in 2050; pre-monsoon rainfall is likely to increase by 104 mm with an increase in monsoon rainfall by 4.65% in 2050 as compared to the average during 1961-1990 at Madhupur region. The pre-monsoon rainfall is likely to increase by 21.97% in 2050. This information is very alarming during the pre-monsoon season and is likely to cause water logging in the area. There is no possibility of drought to occur if these trends in rainfall continue and if regular rainfall occurs in Central region (Madhupur). But if erratic rainfall occurs, there will be possibility of drought even if these increasing trends continue.

Table 8: Trends in annual and seasonal rainfall (mm/year) and projection of annual and seasonal rainfall (mm) in Central Region

Protected Areas	Annual/ Seasonal	Decadal trends (mm/year)		Overall trends (mm/year)	Total rainfall (mm)	Mean total rainfall (mm)	Projected changes in rainfall with respect to mean during 1961-1990 (mm)	
		1991-2000	2001-2010	1961-2012	1991	1961-1990	2030	2050
Madhupur	Annual	+21.54	-10.79	+3.515	3312	2172.09	+170.36	+240.66
	Pre-monsoon season	+13.99	-15.24	+1.660	800	475.53	+71.27	+104.47
	Monsoon season	-43.62	+26.74	+1.047	1898	1478.94	+47.77	+68.71

5 Sylhet Region

In Sylhet region there are five forest Protected Areas and two wetlands which include, Satchari National Park; Rema Kalenga Wildlife Sanctuary; Lawachara National Park; Ratargul Special Biodiversity Area; Khadimnagar National Park; Hail Haor and Hakaluki Haor. The geo-physical context of the Protected Areas of Sylhet region is featured with swamp forest; wetland and forest. The climate data of Sylhet and Srimangal observatories of BMD will represent the data of (i) Khadimnagar and Ratargul Ecosystem and (ii) Rema Kalenga, Satchari and Lawachara Ecosystem respectively. The summary of temperature and rainfall trends and their projections are given in Tables 14 and 15 respectively.

5.1 Temperatures in Sylher

Mean annual temperature at Khadimnagar and Ratargul in Sylhet region varies between years during 1961-2012, but has been increasing at the rate of +0.11°C/10 years (decade). Average seasonal temperatures are also increasing from 1961 to 2012 at +0.04°C/10 years in the pre-monsoon season and at +0.15°C/10 years (decade) in the monsoon season. The decadal trends in annual and seasonal temperature vary from decade to decade. If the present trends of annual and seasonal temperature continue, then the annual temperature, pre-monsoon temperature, monsoon temperature and winter minimum temperature at Khadimnagar and Ratargul in Sylhet region are likely to be 25.32, 27.81, 28.64°C and 14.76°C respectively in 2050. Atmospheric General Circulation Model (AGCM) has simulated annual mean temperature of 25.4°C in 2030. This compares well with 25.32°C, projected for 2030. The projected temperatures are compared with the mean temperature during 1961-1990 and found that the pre-monsoon temperature is likely to increase by 2.34°C, the annual temperature is likely to increase by 0.92°C whereas the monsoon temperature is likely to increase by 1.23°C and the winter minimum temperature is likely to by 1.42°C in 2050. The increase in annual and seasonal temperatures is alarming for the ecosystem and biodiversity of the area.

5.2 Temperatures in Srimangal

In the Ecosystem of Rema Kalenga, Satchari and Lawachara of Sylhet region, the annual, monsoon and winter minimum temperatures have increasing trends at +0.018°C, +0.130°C and +0.031°C respectively whereas the pre-monsoon temperature is decreasing at the rate of -0.120°C during the period 1961-2012. If these trends continue, the annual temperature would be 24.87°C and 25.23 °C in 2030 and 2050 respectively; pre-monsoon would be 27.02°C and 26.78°C in 2030 and 2050; monsoon

temperature would be 26.79°C and 27.05 in 2030 and 2050 respectively and the winter minimum temperature would be 13.67°C and 14.29°C respectively 2030 and 2050. In comparison to the mean annual and seasonal temperatures during the period 1961-1990, the annual and pre-monsoon temperatures would rise by 1.04°C and 0.43°C respectively in 2050; monsoon temperature would fall by -0.63 °C and the winter minimum temperature would rise by 1.09°C in 2050. These changes in temperature would have bad impacts of the biodiversity and agriculture of this ecosystem in Sylhet region (Table 9).

Table 9: Decadal and overall trends in annual and seasonal mean temperature (°C/year) and projection of annual and seasonal mean temperature (°C) in Sylhet Region

Protected Areas	Annual/Seasonal	Decadal trends (°C/year)		Overall trends (°C/year)	Mean Temperature (°C/)	Projected changes in temperature (°C/) with respect to mean during 1961-1990 (°C/)	
		1991-2000	2001-2010	1961-2012	1961-1990	2030	2050
Khadimnagar Ratargul	Annual	+0.091	+0.045	+0.011	24.4	+0.69	+0.92
	Pre-monsoon season	+0.076	+0.104	+0.004	25.47	+0.25	+2.34
	Monsoon season	+0.008	+0.006	+0.015	27.41	+0.92	+1.23
	Winter season (T_{min})	+0.101	+0.051	+0.033	13.34	+0.76	+1.42
Remakalenga, Satchari and Lawachara	Annual	+0.01	+0.051	+0.018	24.4	+0.68	+1.04
	Pre-monsoon	+0.0059	+0.1657	-0.120	26.35	+067	+0.43
	Monsoon	-0.0211	+0.0239	+0.130	27.68	-0.89	-0.63
	Winter season (T_{min})	-0.059	-0.003	+0.031	13.20	+0.47	+1.09

5.3 Rainfall trend Sylhet

In Khadimnagar-Ratargul Ecosystem in Sylhet region, the annual total rainfall has been increasing during the period 1961-2012 at a rate of +0.542 mm/year, this rain amounts to almost 2.13 inch per decade (per 10 years). But the trend is positive and for more rain in the pre-monsoon season with +4.567 mm/year having also considerable variation between years, and the rainfall has negative trend in the main monsoon at a rate of -3.665 mm/year. The trend of more rain may increase the risk of landslides, storms and flash floods particularly in the pre-monsoon season, posing a threat to livelihoods and natural resources at Khadimnagar-Ratargul Ecosystem in Sylhet region. The less rainfall in the monsoon season is likely to enhance the drought condition in the region. The decadal rates of annual and seasonal rainfall vary from one decade to another. With the present trends in annual and seasonal rainfall, it has been projected that the annual total rainfall is likely to be 4081 mm in 2050, when total rainfall in monsoon will average 2500 mm, and pre-monsoon rainfall is likely to have average 1310 mm. AGCM forecasts 4082 mm annual rainfall in 2030, which compares well with the projected value of 4070.26 mm. Compared with the mean rainfall during 1961-1990, annual rainfall is likely to decrease by 48.7 mm in 2050, pre-monsoon rainfall is likely to increase by 307.4 mm (30.69%) with a decrease in monsoon rainfall by 11% in 2050 as compared to the average during 1961-1990.

5.4 Rainfall trend - Srimangal

In Rema-Kalenga, Satchari and Lawachara Ecosystem in Sylhet region, the annual and seasonal rainfall varies from decade to decade. But the annual has decreasing trend at -1.329 mm/year, pre-monsoon rainfall has increasing trend at +1.927 mm/year and monsoon rainfall ha decreasing trend at

a higher rate of -2.797 mm/year during the period 1961-2012. If these rates continue, the annual, pre-monsoon and monsoon rainfall would be 2286 mm, 832 mm and 1235 mm respectively in 2050. In comparison with the mean rainfall during 1961-1990, the annual rainfall is likely to decrease by 110 mm, pre-monsoon rainfall is likely to increase by 120 mm and monsoon rainfall is likely to decrease by 200 mm (13.95%) in 2050.

It appears from above discussion that increased rainfall in pre-monsoon season in Sylhet may cause landslides and flash floods, which will have serious impact on agriculture and livelihoods in the region. The decreasing rainfall trend in monsoon season may enhance drought situation, which will have negative impact on agriculture and livelihoods of the community people. These future consequences support the opinions of the community people in the region.

Table 5*:* Decadal and overall trends in annual and seasonal rainfall (mm) and projection of annual and seasonal rainfall in Sylhet region

Protected Areas	**Annual/Seasonal**	**Decadal trends** (mm/year)		**Overall trends** (mm/year)	**Mean rainfall (mm)**	**Projected Changes in Rainfall (mm) with respect to Mean Rainfall during 1961-1990**	
		1991-2000	**2001-2010**	**1961-2012**	**1961-1990**	**2030**	**2050**
Khadimnagar and Ratargul	Annual	-11.04	+52.19	+0.542	4129.80	-59.54	-48.70
	Pre-monsoon season	-6.60	+52.00	+4.567	1002.94	+216.074	+307.41
	Monsoon season	+3.303	+14.818	-3.665	2812.06	-238.01	-311.31
Remakalenga, Satchari and Lawachara	Annual	16.06	-89.06	-1.329	2395.76	-83.63	-110.21
	Pre-monsoon	+10.13	-24.61	+1.927	712.82	+80.99	+119.53
	Monsoon	+12.01	-51.62	-2.797	1435.41	-144.32	-200.26

6 Comparison between regions of past trends

Among the five CREL regions, the annual mean temperature has the maximum increasing trend of+0.037°C/year over Sharankhola, Chandpai and Dacope-Koyra PAs and this rate is statistically significant at 100% level of significance. Due to this significant increasing trend of annual temperature, the ecosystems, natural resources, fisheries and agricultural sectors are likely to be affected in future, if this trend continues. Considering the annual rainfall trend among the PAs, the maximum increasing trend in annual rainfall has been found in the Coastal Ecosystem of Teknaf and Shahparir Dwip; this is evident from Fig. 1 and 2.

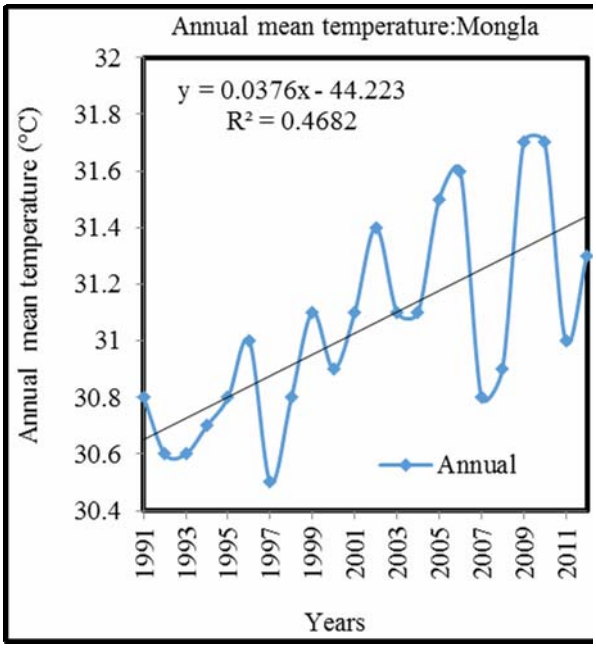

Figure 1: Trend in annual mean temperature at Mongla representing Sharankhola, Chandpai and Dacope-Koyra

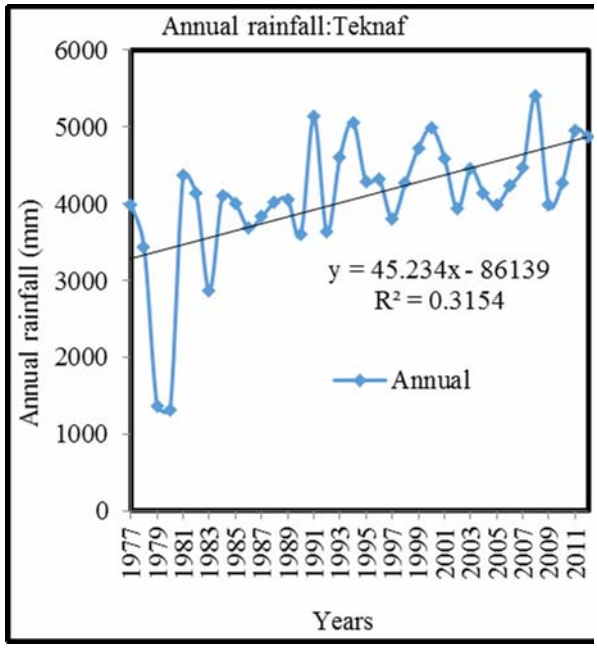

Figure 2: Trend in annual rainfall (mm) at Teknaf

7 Tropical Cyclones and Storm Surge

Bangladesh has a long coast of about 710 km (Ahsan, 2013) and this coast is very much vulnerable to tropical cyclones and associated storm surge. Bangladesh coast is the worst affected coast of the world because of the funneling shape of the coast and its shallow bathymetry. Three CREL regions such as Khulna, Chittagong and Cox's Bazar are attached to this coast. High wind speed and storm surge associated with tropical cyclones badly affect these coastal regions. A number of people is killed and natural resources are damaged by tropical cyclones. The coastal agricultural lands are inundated with saline water intrusion. But now the death toll is reduced due to early tropical cyclone warnings issued well ahead of time by Bangladesh Meteorological Department (BMD) and the better disaster management by the Government of Bangladesh. Still more long term adaptation measures need to be undertaken to make the livelihoods and natural resources of the coastal CREL regions climate-resilient. Some of the tracks of tropical cyclones, which affected the CREL regions, are given in Figs. 3-6.

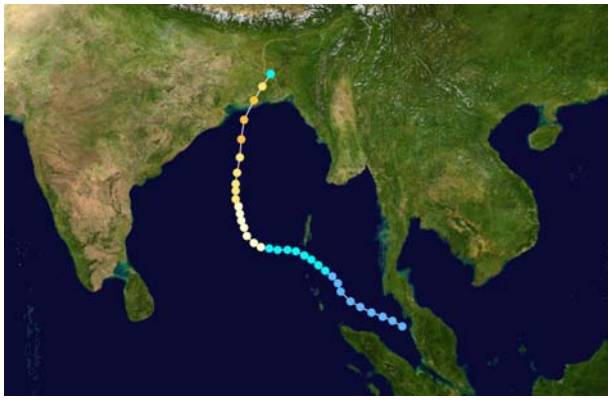

Figure 3: Track of Cyclone of 29 November 1988 (Wikipedia):Crossed Khulna Coast (MWS=161km/h, Surge=14.5 ft; Karmakar, 1998)

Figure 4: Track of Cyclone of 29 April 1991(Wikipedia):Crossed Chittagong Coast (MWS=225km/h, Surge=20-25ft; Karmakar, 1998)

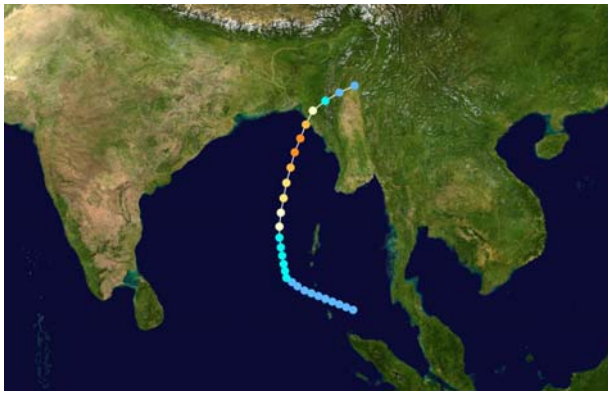

Figure 5: Track of Cyclone of 2 May 1994 (Wikipedia): crossed Cox's Bazar Coast (MWS=200-240 km/h, Surge =12-16 ft; Karmakar, 1998)

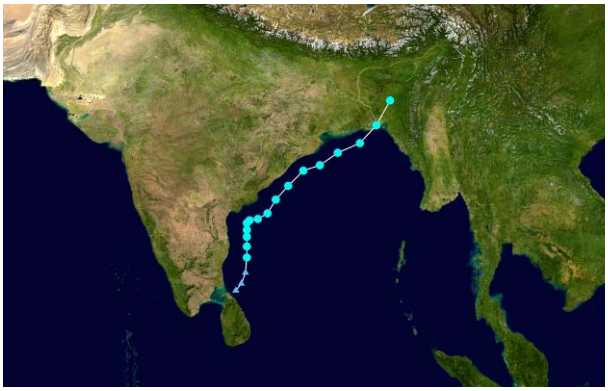

Figure 6 Track of Cyclone Roanu of 22 May 2017: Crossed Chittagong Coast (MWS=110 km/h, Surge=7 ft; Wikipedia)

The frequencies of severe cyclonic storms formed in the Bay of Bengal during 1891-2012 are collected from Bangladesh Meteorological Department (BMD) and the temporal variation is shown in Fig. 7. The figure shows that the frequency of severe cyclonic storms has a slight increasing trend at a rate of 0.003/year. But if the period 1971-2012 is considered, the frequency of severe cyclonic storms has decreasing trend at -0.006/year. From the analysis of cyclonic disturbance (depression + cyclonic storm + severe cyclonic storm), depression and cyclonic storm, it has been seen that their frequencies have decreasing tendency in the Bay of Bengal. The results are similar to the study made by Karmakar (2003). This indicates that the impact of climate change on tropical cyclonic disturbances and cyclones is not yet sure.

The data on wind speeds associated with the tropical cyclones, which formed in the Bay of Bengal during 1960-2017, have been collected from BMD, SMRC (Karmakar, 1998).The trend in wind speeds has a slight increasing trend at a rate of 0.015 km/hr per cyclone (Fig. 8), having the highest maximum of 260 km/hr in case of several cyclones after 1998. It may be mentioned that the rate is not statistically significant.

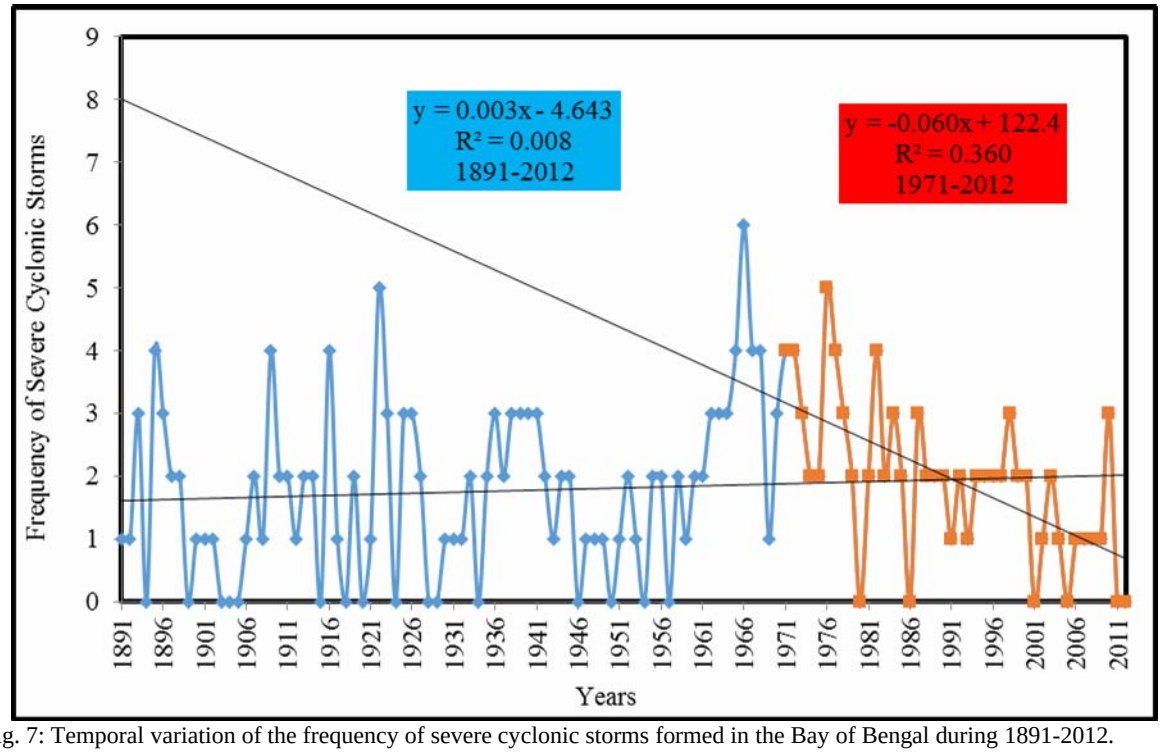

Fig. 7: Temporal variation of the frequency of severe cyclonic storms formed in the Bay of Bengal during 1891-2012.

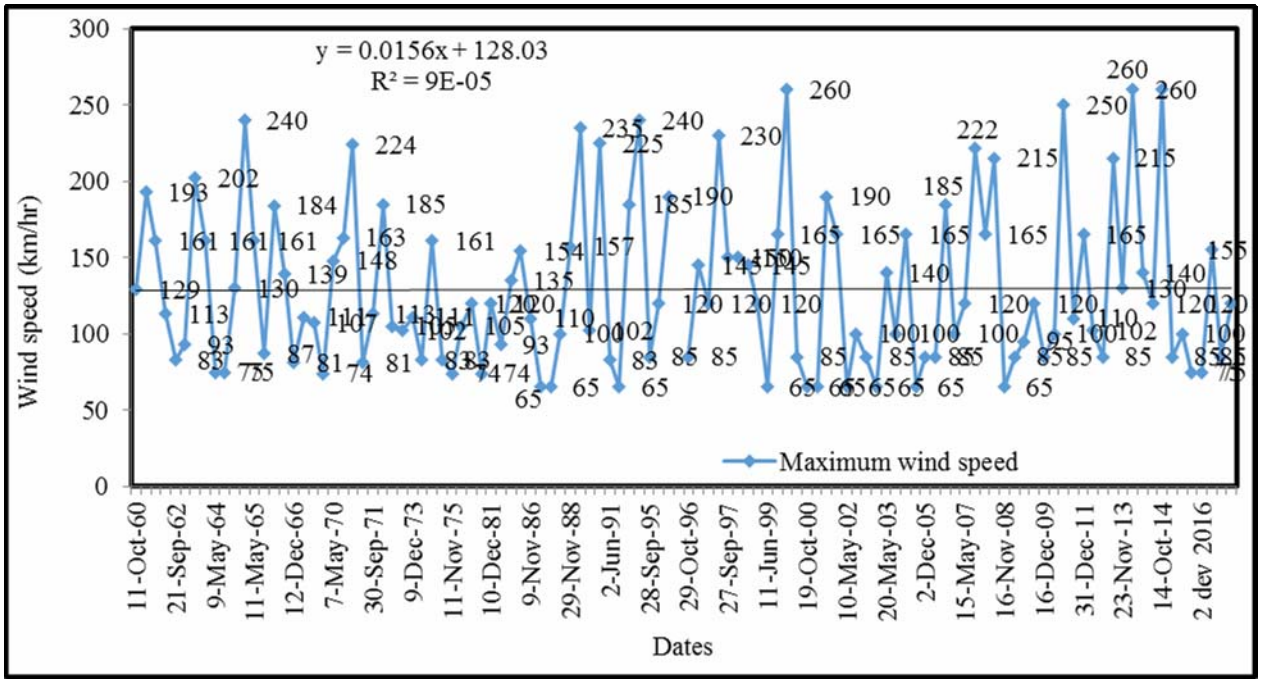

Fig. 8: Trend in wind speeds associated with cyclones formed in the Bay of Bengal during 1960-2017

8 Floods in Northeast and Southeast CREL Regions

Sylhet region is the northeast region of the CREL project. This region is affected by extreme floods, either monsoon flood or flash flood, almost every year. Flash flood occurs in this region due the severe thunderstorm in the pre-monsoon season, when heavy showers occurred over Sylhet region and adjoining Meghalaya of India as can be seen Fig. 9, showing the amount of 24 hours TRMM rainfall. This rainfall caused a severe damage to crops, fisheries, infrastructures and livelihoods of the people of Sunamganj. During monsoon season, severe floods also cause inundation in his region and affects livelihoods of the community people. During these floods, education sector is also badly affected; students cannot go to schools and their study is hampered. Fig. 10 shows flood inundation surrounding a school at Kulaura of Moulavibazar.

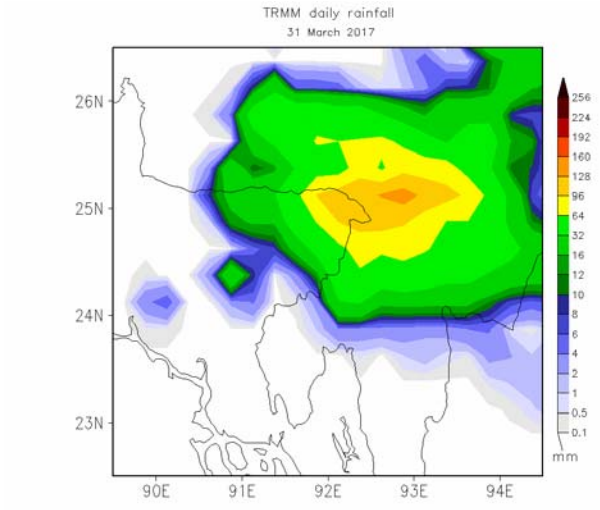

Figure 1: 24 hours accumulated TRMM rainfall over Meghalaya and Sylhet on 31 March 2017 (Source: Karmakar *et al.*, 2017)

Figure 102: The Kairchak Govt. Primary School in KulauraUpazila of Moulvibazar surrounded by flood water (Source: Star file photo, the Daily Star, 02 July 2017)

An extraordinary rainfall event was localized over Chittagong region and recorded 425 mm of rainfall within a span of 24 hrs on 11 June 2007. This huge amount of rainfall caused serious landslides, killing 124 people in Chittagong. The amount of TRMM Satellite rainfall is shown in Fig. 11. In 2004, Sylhet region was also severely affected by monsoon flood with rainfall of 300-400 mm rainfall during 5-12 July (Fig. 12). At the end of July, flood depth in northeastern region was more than 300 cm.

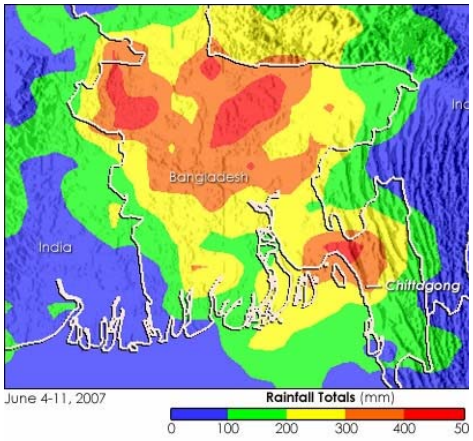

Figure 11: TRMM rainfall in Chittagong during 4-11 July 2007
(Source: ttps://en.wikipedia.org/wiki/2007_Chittagong_mudslides)

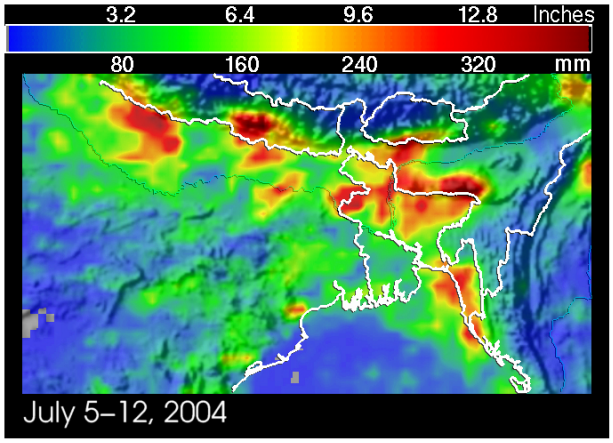

Figure 12: TRMM rainfall in Chittagong during 5-12 July 2004
(Source:https://eoimages.gsfc.nasa.gov/images/imagerecords/4000/4642/India_TRMM2004194_lrg.jpg)

Practically, Bangladesh is affected by flash flood in the northeast region during the pre-monsoon season and moderate to severe monsoon flood in the north and central parts of the county because of its geographical location having the major catchments (92%) in the north of Bangladesh. These catchments sometimes receive continuous moderate to heavy rainfall, which produces heavy onrush of water draining through Bangladesh and causes floods in the country. The trend in affected areas (%) by recent floods is given in Fig. 13, which shows the area of flood affected areas has increasing trend at 0.1753%/year. The figure also shows that floods were devastating and covered higher areas in 1987, 1988 and 1998 of which the flood of 1998 inundated maximum area of 68% of Bangladesh. Floods of 1987, 1988 and 1998 killed 1657, 2379 and 1050 people respectively.

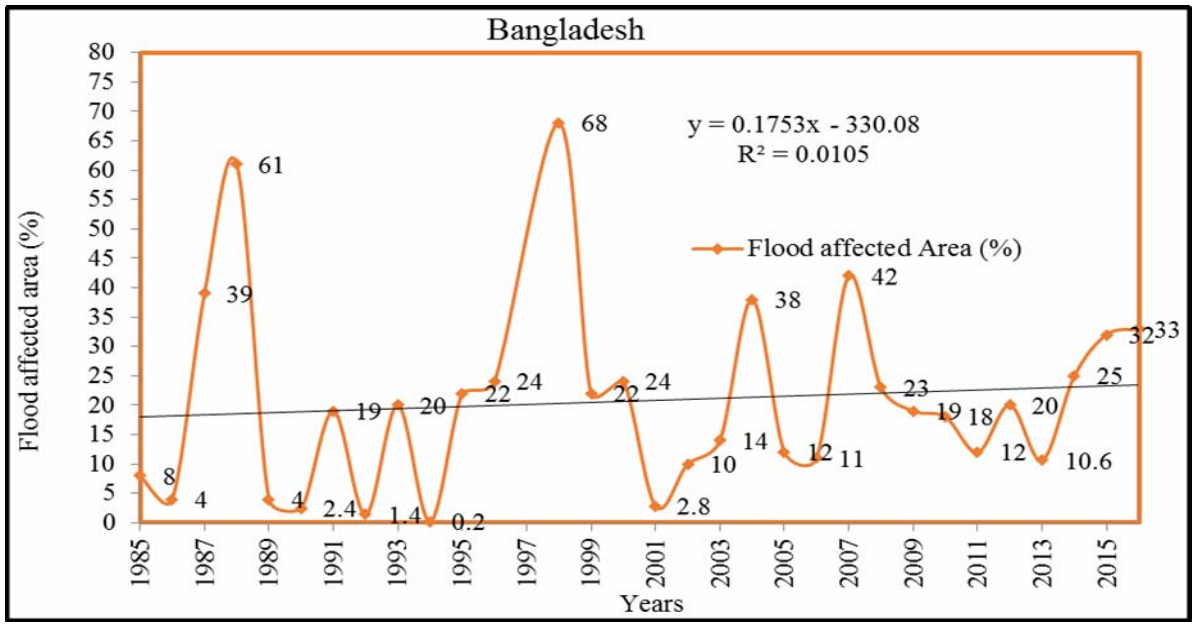

Figure 3: Area affected by floods in Bangladesh during 1985-2016

ANNEX - 2: ADAPTATION PLANS BY REGION

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
Agriculture	Chandpai	Cyclone and water surge, River erosion, salinity increase	• Paddy cultivation get delayed and damaged • Paddy and kitchen garden get damaged • Crop/agricultural land get washed away in river erosion	• Cultivation again • Vegetable cultivation in high place in the homestead • repairing embankment along the river • cultivation of salinity tolerant paddy and vegetable in small scale • Fish cultivation in agricultural land	• Improved and strong embankment along the river • Vegetable cultivation in the high places around the homestead • Road reconstruction • Canal excavation • Distribute salinity tolerant paddy and vegetable seed among farmers and encourage them about climate resilient farming • Promote cultivation of Robi crops (Potato, onion, Chili and garlic) and cyclone tolerant crops (coconut, sunflower, Safeda, Tal, Baukul, Guava) • Demonstration plot of climate resilient cultivation • Lobby and networking with concerned authorities for embankment and sluice gate reconstruction • Information, training and demonstration plot on saline tolerant paddy and vegetable	• Local community • Water Development Board • NGO • CMC
	Dacope-Koyra	• Salinity increase • Cyclone and water surge • Waterlogging •	• Paddy cultivation is hampered by salinity • Homestead gardening is hampered by salinity • Fertility loss in the soil • Vegetable field is flooded by excessive rainfall	• Agricultural lands are turned into shrimp farm • Cultivation of vegetable in plastic pot in a small scale •	• Salinity tolerant paddy(BRI-49, BINA-8, BINA-10, BINA-7, Shakti) & vegetables seed distribution among farmers • Use of organic manure • Digging of fresh water pond • Shallow tube well installation • Demonstration plot of Climate Resilient cultivation • Sluice gate and culvert construction to mitigate waterlogging • Canal re-excavation for preserving fresh water • Crop diversification and organic cultivation • Digging small pond in agricultural land to preserve fresh water • Regular communication with Upazila agricultural officer • Demonstration plot of climate resilient cultivation of paddy and wheat • Zoning of Shrimp and Agricultural land • Proper implementation of shrimp policy to protect agriculture from saline water intrusion • Distribution of Refractometer to identify salinity level in the water • Hanging gardening in plastic pots • Mulching to protect crops and vegetables from drought	• Agriculture extension office • Local community • NGOs • LGED

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
					• Integrated Pest Management (IPM) • Improved irrigation System	
	Munshiganj	• Salinity • Cyclone and water surge • Drought	• Fertility loss in soil • Decline in paddy and vegetable cultivation due to salinity	• Vegetable cultivation in plastic sack • Vegetable cultivation in high places • Boro cultivation with rain water in small scale	• Salinity tolerant paddy (BRI-53, BRI-54, BRI-49, BRI-55, BR-40, BR-42, BRI-47, BRI-61, BINA-8, BINA-10, BINA-7)& vegetables (Pumpkin, chili and) seed distribution among farmers. • Demonstration plot of integrated cultivation of vegetable and fish. • Separate zone for shrimp and agriculture • Regular network with block supervisors • Regular visit of Local Service Providers (LSP) to farmers for giving advice on different aspect of agriculture • Training on vegetable cultivation on the bank of shrimp and fish farm	• Agriculture Extension office • NGOs • Local community • Union Parishad • CMC
	Sarankhola	• Cyclone and water surge • Salinity increase • Excessive rainfall • Drought • High tide • River erosion	• Paddy and field and vegetable/ kitchen garden get flooded • Production declines due to salinity	• Use of organic manure in small scale • Irrigation from fresh water ponds • Cultivation of salinity tolerant paddy and vegetable	• Vegetable cultivation in sacks and plastic pots with salinity free soil and fresh water • Early variety and salinity tolerant paddy (BRRI-55, BRRI-47 and BINA-7) and vegetable (pumpkin, chili and ladies finger) cultivation • Collective initiative to preserve fresh water by digging small ponds in the agricultural lands • Use of organic manure • Canal re-excavation • Hanging garden • Integrated Pest Management (IPM) • Improved irrigation System • Mulching to protect crops and vegetables from drought • Culvert construction	• Agriculture Extension office • NGOs • Local community • Union Parishad • CMC
	Tengragiri	• Less rainfall, drought • Temperature rise • Cyclone • Excessive Rainfall • Salinity increase • Flood • Thunder storm • Cold wave • Water logging	• Fertility of agricultural land decreases • Delay in summer crop cultivation and • Loss in summer production • Loss in Aman production	• Preserve water in canal by constructing dam • Digging canal to collect irrigation water from ponds • Cultivation of early variety of paddy • Cultivation of winter vegetable	• Drought and temperature tolerant paddy and vegetable cultivation • Cultivation of early variety crops and vegetable that need less irrigation (peanut, sunflower etc.) • Improved irrigation system • Deep tubewell installation • Canal excavation • Salinity tolerant paddy seed (BRRI-11, BRRI-47, Swarna Mosuri, BINA-8, BINA-10) distribution among the farmers • Integrated cultivation of paddy	•
Fishery	Chandpai	• River Erosion, • salinity increase, • Cyclone and water surge	• Fishes from ponds and farm are washed	• Fish farming at distance place from the river	• Virus free fish fry release in the fish farm • Information and training about salinity tolerant and early	• Department of Fisheries • Fish fry traders

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
			away in river erosion • White spot diseases spread among shrimp and fish • Native species fish becomes near extinct • Fishers suffer from occupational crisis	• Repairing embankment along river • Using lime and fertilizer in fish farm • Alternative occupation • Fencing with net on the bank of ponds • Raise heights of pond banks	variety fish cultivation (Tilapia) • Planned and strong sluice gates construction • Canal re-excavation for preserving fresh water • Knowledge about white spot diseases and skill about its prevention. • Alternative occupation of fishers	• Local community • Water Development Board
	Dacope-Koyra	• River Erosion, • salinity increase, • Cyclone and water surge, • Drought and temperature rise, • excessive rainfall	• Fishes from ponds and farm are washed away in river erosion • White spot diseases spread among shrimp and fish • Native species fish become near extinct • Fishers suffer from occupational crisis	• Fish farming at distance place from the river • Repairing embankment along river • Using lime and fertilizer in fish farm • Alternative occupation • Fencing with net on the bank of ponds • Raise heights of pond banks	• Ban juvenile fish catching • Virus free fish fry release in the fish farm • Information and training on salinity tolerant and early variety fish cultivation (Tilapia) • Planned and strong sluice gates construction • Canal re-excavation for preserving fresh water • Knowledge about white spot diseases and skill about its prevention. • Alternative occupation for fishers • Construction of sluice gates • Guide wall along the river to protect embankment from river erosion • Provide technical knowledge and training on crab fattening • Demonstration farm on crab and fish • Cultivation of early variety fish	• Department of fisheries • Fish fry traders • Local community • Water Development Board
	Munshiganj	• Cyclone and water surge • Salinity increase • River Erosion • Temperature rise	• Loss of production during summer (March-May) • Occupational crisis of fishers	• Use lime and other medicine as per suggestions of local expert • Pump out water from virus/diseases affected ponds	• Virus free shrimp and fish fry release in fish farm/pond • Fencing with net around the fish farm • Increase the height of the bank of pond • Cultivation of salinity tolerant and early variety fish (Tilapia etc.) • Distribution of refractometer to check salinity level in the water • Alternative occupation for fishers • Demonstration farm on salinity tolerant fish cultivation	• Department of fisheries • Fish fry traders • Local community • Water Development board
	Sarankhola	• Cyclone and water surge • High tide • Salinity increase • Excessive rainfall • Drought	• Depletion of native species from open water sources • Fishery resources	• Fencing with net around fish pond and farm • Increase height of the bank of pond	• Virus free fish fry cultivation in the pond and farm • Training on crab fattening • Increase the height of fish farm • Salinity tolerant fish cultivation • Fish Sanctuary in the locality • Ban juvenile fish catching	• Fishermen • Local community • Department of fisheries • NGO • Union

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
			get affected with virus and diseases • Fishes get washed out during excessive rainfall	• Alternative occupation • Use lime and other medicine as per the advice of local expert	• Ban fish catching with toxic/poison • Increase height of the ponds and fish farms • Guide wall with concrete block along the river to protect fish farms from river erosion • Embankment plantation	Parishad
	Tengragiri	• Cyclone • High tide	• Occupational crisis of fishers	• Engaged in alternative occupation	• Alternative occupation	• Department of fisheries • Local community • Upazila Administration
Water, Health and Sanitation	Chandpai	Salinity increase, Cyclone and water surge, river erosion	• Water borne diseases • Diarrhea, • Suffering of Pregnant women due to saline water	• Consult with local doctors • Visit to Upazila and District health complexes for severe illness	• Embankment reconstruction • Health centers at union and village level by both government and non-government initiatives. • Re-excavation of fresh water pond • Distribution of water tank • Appointment of MBBS doctors at union level health clinics	• Local community • Local Government and Engineering Department (LGED), NGO
	Dacope-Koyra	• Salinity increase • Cyclone and water surge • Temperature rise • Thunder storm	• Water borne diseases due to salinity • Sanitation system breaks down during cyclone • Local people get sick during temperature rise	• Get advice and treatment from local doctors • Harvest rainwater in plastic and earthen pot • Collect fresh water from ponds of far places	• Pond Sand Filter (PSF) and water harvester installation • Distribution of water tank • Appointment of MBBS doctors in health centers at union level. • Installation of shallow and deep Tubewell • Community clinic • Water treatment plant • Distribution of Sanitary latrine construction materials among villagers • Health awareness	• Local community • NGO • LGED • Union Parishad
	Munshiganj	• Salinity increase • Cyclone and water surge • Temperature rise and drought	• Water borne diseases due to salinity • Sanitation system breaks down during cyclone • Local people get sick during temperature rise	• Get advice and treatment from local doctors • Harvest rainwater in plastic and earthen pot • Collect fresh water from ponds of far places	• Pond Sand Filter (PSF) and Rain water harvesting plant installation • Distribution of water tank • Appointment of MBBS doctors in health centers at union level. • Installation of shallow and deep Tubewell • Community clinic • Water treatment plant • Distribution of Sanitary latrine construction materials among the villagers • Health awareness	• Local community • NGO • LGED • Union Parishad
	Sarankhola	• Salinity increase • Cyclone and water surge • Waterlogging and excessive rainfall • High tide • River erosion	• Scarcity of drinking water due to salinity •	• Preserve rain in plastic and earthen pot • Collect water from pond of far places • Common get injured during Cyclone • Damage of sanitation system	• Preserve of fresh water pond • Deep Tubewell installation • Distribution water tank for harvesting rain water • Pond Sand Filter (PSF) construction • Water treatment plant • Health clinic and construction • Awareness about better sanitation system (washing hand with soap before taking food)	• Local community • NGO • LGED • Union Parishad

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
					• Construction of Cyclone shelter • Construction of sanitary latrine • Health awareness among common people	
	Tengragiri	• Waterlogging • Depletion of ground water level	• Scarcity of drinking water • Spread of water borne diseases • Women have to waste long time to collect water from far places	• Use less amount of water compared to the demand • Consult with local doctors for physical sickness	• Community Clinic • Deep Tubewell • Health awareness especially regarding child and mother • Pond digging for fresh water	• Local community • Union Parishad • LGED • NGO
Infrastructure and communication	Chandpai	Cyclone and water surge, high and strong tide, river erosion	• House and roads get collapsed and flooded • Transportation system get disrupted	• Take shelter at Cyclone shelter • Living in makeshift house on the embankment • Reconstruction of house and roads	• Raise the height of basement of houses • Construction of strong houses • Plantation of storm tolerant tress around houses • Training on Disaster management • Construction of School-cum cyclone shelter • Road reconstruction • House construction with salinity tolerant ingredients	• Local community, Union Parishad, Water development Board, LGED
	Dacope-Koyra	• River Erosion • Cyclone and water surge	• Houses get damaged • Communication systems get broken down	• Taking shelter in Cyclone shelter • Living in makeshift houses on embankment	• Guide wall to protect river erosion • Resettlement and alternative occupation for the victims of river erosion. • Sluice gate, culvert and bridge construction for better drainage. • Road reconstruction • Cyclone shelter construction	• Water Development Board • Local community • NGO • Union Parishad
	Munshiganj	• Cyclone and water surge • Water logging • Salinity	• Houses and business establishments get damaged • Communication systems get broken down	• Taking shelter in Cyclone shelter • Living in makeshift houses on embankment	• Guide wall to protect river erosion • Resettlement and alternative occupation for the victims of river erosion. • Sluice gate, culvert and bridge construction for better drainage, communication and to • Road reconstruction • Cyclone shelter construction	• Water Development Board • Local community • NGO • Union Parishad
	Sarankhola	• Cyclone and water surge • Salinity increase • River erosion • High/strong tide	• Infrastructure are damaged • Communication systems are disrupted	• Infrastructures and communication systems are repaired	• House construction with salinity tolerant ingredients. • Guide wall with concrete blocks to protect embankment from river erosion • Homestead plantation • Increase height of the basement of houses	• Water Development Board • Local community • NGO • Union Parishad
	Tengragiri	• Cyclone • Flood • Excessive rainfall	• Infrastructure, roads get damaged and flooded	• Keeps the houses standing with logs and ropes	• Road reconstruction • Construct strong houses • Plantation of storm tolerant trees around homestead • Construction of shelter homes for victims of river erosion	• Water Development Board • Local community • NGO

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
						• Union Parishad
Livestock	Chandpai	• Salinity increase • Cyclone and water surge	• Cattle and poultry get infected with water borne diseases • Loss of grazing land	• Rearing of livestock and poultry in a very small scale	• Specific space in Cyclone shelter for livestock • Rearing poultry and livestock in planned way • Rearing of chicken and duck that are adaptive to the locality • Training on poultry and livestock rearing	• Department of Livestock services • Local community • CMC • NGOs
	Dacope-Koyra	• Salinity increase • Cyclone and water surge • Temperature rise and drought	• Cattle and poultry get infected with water borne diseases • Loss of grazing land • Cow shades and poultry farm get broken down during cyclone	• Rearing of livestock and poultry in a very small scale • Using tree branches to feed goat and sheep • Rearing cows and poultry in high places	• Rearing poultry and livestock in planned way • Rearing of chicken and duck that are adaptive to the locality • Training on poultry and livestock rearing • Diseases, drought tolerant poultry and livestock rearing (for example Sheep) • Ensure safe place for livestock and poultry in the cyclone shelter • Excavation canal to preserve fresh water	• Department of Livestock services • Local community • CMC • NGOs
	Munshiganj	• Salinity increase • Cyclone and water surge • Temperature rise and drought	• Cattle and poultry get infected with water borne diseases • Loss of grazing land • Cow shades and poultry farm get broken down during cyclone	• Rearing of livestock and poultry in a very small scale • Using tree branches to feed goat and sheep • Rearing cows and poultry in high places	• Rearing poultry and livestock in planned way • Rearing of chicken and duck that are adaptive to the locality • Training on poultry and livestock rearing • Diseases, drought tolerant poultry and livestock rearing (for example lamb) • Ensure safe place for livestock and poultry in the cyclone shelter • Excavation canal to preserve fresh water	• Department of Livestock services • Local community • CMC • NGOs
	Sarankhola	• Salinity increase • Drought • River Erosion	• Loss of grazing land • Affected with water borne diseases • Cow shade and poultry farms are washed away during Cyclone	• Using tree branches and straw to fee livestock during rainy season and drought • Consult with local veterinarians	• Rearing livestock that are suitable for the region (Goat, sheep) • Keeping livestock under the trees and cow shade during drought • Regular communication with the office of Upazila Livestock Officer	• Department of Livestock services • Local Community • NGO • Union Parishad
	Tengragiri	• Drought • Cyclone • Excessive rainfall • Temperature rise • Flood	• Livestock and poultry get infected with disease	• Locally treatment with experiential knowledge	• Rearing diseases tolerant Chicken, duck and livestock • Rearing improved variety of livestock • Improved shade with south facing and increased basement for livestock	• Local community • The office of Upazila livestock officer • CMC • Union Parishad
Forest and Biodiversity	Chandpai	• Cyclone and water surge, salinity increase	• Top dying of mangrove species	• Wild animals drinks water from a few	• Increases vegetation in Sundarban • Plantation of salinity tolerant	• Forest Department • CMC

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
			• Slow growth of mangrove species • Wild animals get sick by drinking saline water	numbers of fresh water pond inside the forest	trees in homestead • Increase number of fresh water ponds in the forest • Roads and Embankment plantation • Restriction on forest resource collection right after the disaster	• Local Community • Union Parishad
	Dacope-Koyra	• Salinity increase • Cyclone and water surge • High tide and flood • Temperature rise and drought	• Wild animals get sick by drinking saline water • Top dying of mangrove species	• Forest Department takes initiative of new plantation • Wild animals drink fresh water from a few number of ponds inside the forest	• River bank plantation • Digging Fresh water pond inside the forest • Road side plantation • Alternative occupation for forest dependent communities • Institutional plantation • Improved Cooking Systems (ICS) • Awareness among local community	• Forest Department • Local community • Water Development Board • NGO
	Munshiganj	• Salinity increase • Cyclone and water surge • Temperature rise and drought	• Wild animals get sick by drinking saline water • Top dying of mangrove species •	• Forest Department takes initiative of new plantation • Wild animals drink fresh water from a few number of ponds inside the forest	• River bank plantation • Digging Fresh water pond inside the forest • Road side plantation • Alternative occupation for forest dependent communities • Institutional plantation • Improved Cooking Systems (ICS) • Awareness among local community	• Forest Department • Local community • Water Development Board • NGO
	Sarankhola	• Cyclone and water surge • Salinity increase • Drought	• Trees are uprooted and broken down • Slow growth trees in the forest and in locality •	• New plantation in the degraded land •	• River bank plantation • Restriction resource collection from forest after cyclone and other disaster • Fresh water ponds for wild lives inside the forest • Plantation of salinity tolerant species in the locality • Increase vegetation in the forest	• Forest Department • Local community • CMC • NGOs
	Tengragiri	• Drought • Less Rainfall • Heat wave • Ground water depletion • Cyclone • Excessive rainfall	• Common people get sick • Trees are broken down • Habitat of wild birds are damaged • Houses get collapsed	• Irrigation from pond and canal	• Social forestry (Institutional and road side plantation) • Mangrove plantation with Nypa fruticans (Golpata) •	• Forest Department • Local community • CMC • NGOs
Day labor and small business	Chandpai	• Cyclone, • High tide, • River erosion	• Decrease scope of work • Physical sickness • Decline in sale • Business	• Alternative occupation (i.e Rickshaw pulling in town and day labor work) • Run families with loans	• Training on alternative occupation • Savings on daily income • Plantation of storm tolerant trees around homestead • Taking part in social forestry program	• Local community • NGO • CMC • Department of Youth Development • Department of
	Dacope-Koyra	• Cyclone • High tide, • River erosion • Temperature rise				
	Munshiganj	• Cyclone				

a) Khulna Region Community and Ecosystem Based Adaptation (CBA & EBA)						
Sector	**Site**	**Hazards**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
		• High tide, • River erosion • Temperature rise	infrastructure gets damaged	and savings • Restart business with loan and savings.		cooperatives • District offices of Bangladesh Small and cottage Industries Corporation (BSCIC)
	Sarankhola	• Cyclone • High tide, • River erosion • Temperature rise				
	Tengragri	• Drought • Less rainfall • Excessive rainfall • Heat wave				

Central Region (Madhupur National Park)

Central Region Community and Ecosystem Based Adaptation (CBA& EBA)						
Sector	**site**	**Hazards (ranked as severity)**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
Agriculture	Aronkhola	• Drought • Ground water Depletion • Heat Wave • Less Rainfall • Waterlogging • Cold wave	• Paddy land becomes fallow due to lack of irrigation • Delay in paddy cultivation • Decline in production • Spread of insects during drought • Agricultural production is flooded in excessive rainfall • Decline in production	• Setting water pump in 10 to 15 feet below from the earth surface during drought for irrigation (depth of ground water level) • Irrigation from pond and canal during drought at small scale • Preserving water by constructing dam over the canal • Water spray on the crops before the sun set	• Re-excavation of canal for preserving water to facilitate irrigation during drought and ground water depletion • Installation of deep tubewell for irrigation during summer • Integrated Pest Management and training for farmers • Demonstration plot on drought resilient crops and vegetable cultivation (BRRI-56, BRRI-57, BR-28 and HL-8) and disseminating information regarding this cultivation among the farmers. • Mulching to keep moisture in crop field during summer • Re-excavation of Canal and chona in Haoda beel and within the forest • Cultivation of early variety crops and vegetable • Promote cultivation of Robi crops (Potato, onion, Chili and garlic) • Demonstration plot of climate resilient cultivation • Training on modern technology in agriculture	• Local community • NGO • CMC • LGED • UP
	Sholakuri	• Drought • Ground water Depletion • Heat Wave • Less Rainfall • Waterlogging • Cold wave	• Paddy land becomes fallow due to lack of irrigation • Delay in paddy cultivation • Decline in production • Spread of insects during	• Setting water pump in 10 to 15 feet below from the earth surface during drought for irrigation • Irrigation from pond and canal	• Re-excavation of canal for preserving water to facilitate irrigation during drought and ground water depletion • Installation of deep tubewell for irrigation during summer • Integrated Pest Management training for farmers. • Demonstration plot on drought resilient crops and vegetable cultivation (BRRI-56, BRRI-57, BR-28 and HL-8) and disseminating information	• Agriculture extension office • Local community • NGOs • LGED • UP

Central Region Community and Ecosystem Based Adaptation (CBA& EBA)						
Sector	**site**	**Hazards (ranked as severity)**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
			drought • Agricultural production is flooded in excessive rainfall • Decline in production	during drought at small scale • Preserving water by constructing dam over the canal • Water spray on the crops before the sun set	regarding this cultivation among the farmers. • Mulching to keep moisture in crop field during summer • Re-excavation of Doair Khal and chona in and around the forest to preserve fresh water for irrigation. • Cultivation of early variety crops and vegetable • Promote cultivation of Robi crops (Potato, onion, Chili and garlic) • Demonstration plot of climate resilient cultivation • Training on modern technology in agriculture	
	Ghoga-Daogaon	•Drought •Ground water Depletion •Heat Wave •Less Rainfall •Waterlogging •Cold wave	• Paddy land becomes fallow due to lack of irrigation • Delay in paddy cultivation • Decline in production • Spread of insects during drought • Agricultural production is flooded in excessive rainfall • Decline in production	• Setting water pump in 10 to 15 feet below from the earth surface during drought for irrigation • Irrigation from pond and canal during drought at small scale • Preserving water by constructing dam over the canal • Water spray on the crops before the sun set	• Re-excavation of canal for preserving water to facilitate irrigation during drought and ground water depletion • Installation of deep tubewell for irrigation during summer • Integrated Pest Management training for farmers. • Demonstration plot on drought resilient crops and vegetable cultivation (BRRI-56, BRRI-57, BR-28 and HL-8) and disseminating information regarding this cultivation among the farmers. • Re-excavation of Kadam Alir Khal canal, Jaloikhal canal, Dhonura Beel and Banar river to preserve fresh water for irrigation. • Cultivation of early variety crops and vegetable • Promote cultivation of Robi crops (Potato, onion, Chili and garlic) • Demonstration plot of climate resilient cultivation • Training on modern technology in agriculture	• Agriculture extension office • Local community • NGOs • LGED • UP
Fishery	Aronkhola	• Drought, • Erratic Rainfall, • Waterlogging • Cold wave	• Loss of habitat and species variety loss due to drought • Spread of diseases due to drought • Loss in fishery production due to waterloggin g, cold wave	• Cultivation of early variety fishes at small scale • Using lime and fertilizer in fish farm • Alternative occupation • Fencing with net on the bank of ponds	• Excavation of natural water bodies (Chana and beel to protect fishery resources from drought and • Cultivation of heat tolerant and early variety fishes(Tilapia) • Fish sanctuary to protect fishery resources from drought, temperature rise and waterlogging. • Digging ditches near pond to preserve water for use in the fishery pond during summer. • Alternative occupation of fishers	• Department of fisheries • Fish fry traders • Local community • UP

Central Region Community and Ecosystem Based Adaptation (CBA& EBA)						
Sector	**site**	**Hazards (ranked as severity)**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
			• Fishers suffer from occupational crisis	• Raise heights of pond banks		
Water and Health	Aronkhola, Sholakuri and Goghaand Daogaonuni o	• Drought, • Heat Wave • Erratic rainfall • Cold wave	• Ground water level declines and shallow tubewell doesn't work properly during drought, heat wave • Women and children get infected with cold borne diseases.	• Collect water from far places and preserve water in earthen pot. • Visit to Upazila and District health complexes for severe illness	• Installation of deep tubewell for drinking water during summer. • Community clinic for better health facilities for community specially during summer and cold wave. • Digging well at community level for getting drinking water round the year specially during drought • Excavation of ponds and canals to preserve drinking water. • Use of Improved Cooking Stoves to get cure from smoke and heat during cooking in summer • Use of sanitary latrine	• Local community • Local Government and Engineering Department (LGED), NGO
Infrastructure and communication	Aronkhola, Sholakuri and Ghoga and Daogaon	• Waterlogging • Excessive rainfall • Nor'wester	• House and roads get collapsed and flooded n excessive rainfall and nor'wester • Transportati on system gets disrupted in excessive rainfall and nor'wester	• Reconstruct ion of house and roads • Less movement during excessive rainfall and nor'wester	• Road construction and reconstruction with improved technology and materials to save it from excessive rainfall and • Construction of strong houses to reduce impact of nor'wester. • Plantation of storm tolerant tress around houses • Training on Disaster management • Excavation of canals for better drainage during excessive rainfall	• Local community, • Union Parishad, • LGED
Livestock	Aronkhola, Sholakuri and Ghoga and Daogaon	• Erratic rainfall • Heat Wave • Cold Wave	• Fodder crisis for livestock during drought and erratic rainfall • Cattles are infected with diseases during winter and heat wave.	• Keeping livestock and poultry in safe place during heat wave and cold wave. • Cattles are kept warm with warm clothes and lights during winter	• Diseases tolerant livestock and poultry rearing. • Construction of strong and improved shade for poultry and livestock • Rearing of chicken and duck that are adaptive to the locality • Training on poultry and livestock rearing • Vaccination program for poultry	• Department of Livestock services • Local community • CMC • NGOs • UP
Forest and Biodiver sity	Aronkhola, Sholakuri and Ghoga and Daogaon	• Drought • Erratic rainfall • Heat wave • Cold wave	• Growth of trees become slow due to drought and erratic rainfall • Wild animals suffer from fodder and	• Wild animals drinks water from a few numbers of fresh water pond inside the forest • Wild animals go outside of	• Excavation of Streams and ponds inside forest for ensuring drinking water for wild animals during drought • Roadside plantation to reduce risk of heat wave, drought and storm. • Gap filling with native species inside forest. • Restriction on wild animals	• Forest Department • CMC • Local Community • Union Parishad

Central Region Community and Ecosystem Based Adaptation (CBA& EBA)						
Sector	**site**	**Hazards (ranked as severity)**	**Impact**	**Current coping**	**Adaptation**	**Implementing authorities**
			drinking water during drought, erratic rainfall and cold wave • Fire incident during drought.	forest in search of fodder	hunting • Protection of Reserve forest. • Awareness about preservation biodiversity and forestry resources. • Distribution of saplings among community members	
Day labour and small business	Aronkhola Sholkuri Ghoga and Daogaon	• Drought • Waterlogging, • Excessive Rainfall, • Nor'wester • Cod wave	• Houses and business establishments get collapsed during nor'wester • Communication and transport system get disrupted during disaster • Get infected with diseases during waterlogging, cold wave and excessive rainfall	• Repair houses after nor'wester and excessive rainfall • Less movement during drought, excessive rainfall and nor'wester • Get engaged with alternative occupation.	• Training on alternative occupation • Savings on daily income • Plantation of storm tolerant trees around homestead • Taking part in social forestry program	• Local community • NGO • CMC • Department of Youth Development • Department of cooperatives • District offices of Bangladesh Small and cottage Industries Corporation (BSCIC)

Cox's Bazar Region

Cox's Bazar Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazard**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
Agriculture	Cyclones	Damages paddy fields	Again cultivation of paddy	Cyclone resistant paddy/early variety paddy cultivation	Agriculture Department, Union Parishad, CREL and CMC
	Heavy rainfall / water logging/ flood	Inundates crop lands	Again cultivation of paddy	*Excavation / Re-excavation of Chhara in the villages where necessary *Cultivation of Flood resilient and early variety crops *Agricultural Exhibition Farm of saline and flood tolerant paddy and early variety vegetables in different villages of the region	Agriculture Department, Union Parishad, CREL and CMC
	Heat waves / drought	Crops are burnt	Lessening the cultivation of vegetables	Establishment of tube well in the villages where necessary	Agriculture Department, Union Parishad, CREL and CMC
	Decreasing the level of underground water	Reduction of winter and summer crop production	The villagers use the water from shallow/deep tube wells for the production of winter and summer crops due to decreasing the level of underground water	*Establishment of tube well in the villages where necessary *Building of water reservoirs	Agriculture Department, Union Parishad, CREL and CMC
	Salinity	Decreasing of soil fertility	To save the crops from the bad impact of salinity, the villagers cultivate some saline resilient paddy BRRI-47 and BRRI-48 paddy are cultivated	Saline resilient paddy(BRRI-47, BRRI -48)	VCF/CMC, seed production organization, Agricultural Extension
Water	Decreasing the level of underground water	Water crisis prevail, children and women are to fetch water from remote places	Collection of water from remote places. Use the water of Chhara and use less water in the daily life.	*Establishment of tube well in the villages where necessary	Union Parishad, VCF, CMC, Department of Public Health, NGO
	Water logging/Heavy rainfall/Flood/ Cyclones	Source of water is polluted	Collection of water from remote places. Use of rain water in the daily life.	➢ Establishment of tube well in the villages where necessary and preservation of rain water	Department of Public Health, NGO
	Salinity	Water becomes undrinkable	Collecting water from safe source of water	Increasing health awareness Harvesting and Preserving rain water Establishing tube well on an elevated land	Department of Public Health, NGO
Health	Water logging and flood	Water borne diseases, cold and cough, fever, pneumonia	Get health treatment /health service from Local and regional community Clinic, Chemist, Village doctors. In case of acute/complex disease, people go to Upazila Health Complex	Increasing awareness, increasing health service both with initiatives of government and private organization, improving the local and regional Community Clinic. Improvement of Community Clinic and health services	Union Parishad, CMC and Forest Department
	Cyclones	People are killed and injured by storm surge, by fallen trees due to high wind speed	Get health services/ treatment from local Chemist, Village doctors, local clinic and Upazila Hospitals	Taking shelter in Cyclone Shelters or in safe places	Bangladesh Meteorological Department (BMD), Department of Disaster Management (DDM), Forest Department, Union

Cox's Bazar Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazard**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
					Parishad
	Cold waves	Attacked by diseases due to cold	Get health services/ treatment from local Chemist, Village doctors, local clinic and Upazila Hospitals	Increasing awareness Improvement of Community Clinic and health services	Bangladesh Meteorological Department (BMD), Department of Disaster Management (DDM), Forest Department, Union Parishad
	Heat waves and drought	Dehydration, Diarrhea, fever and other diseases	Get health services/ treatment from local Chemist, Village doctors, local clinic and Upazila Hospitals	Plantation of drought resilient tees Increase health awareness Improvement of Community Clinic and health services	Bangladesh Meteorological Department (BMD), Department of Disaster Management (DDM), Forest Department, Union Parishad
Houses	Cyclones and Heavy rainfall	House tops are blown away, Storm surge washes away valuable resources	Makes drains for protection from hilly flood, Houses are tied with strong ropes during cyclones and the people makes the low-height houses at the top of hills.	People build strong houses and plant cyclone protected trees around the houses. ▪ Use of Bandhu Chula.	Bangladesh Meteorological Department (BMD), Department of Disaster Management (DDM)
Homestead social forestry and natural forest	Drought/ Heat waves/ Decrease in underground water level	Trees are damaged, bird's nests are damaged	Irrigation of water from Chhara	Social forestation (Institutional and forestation along the road sides, in front of mosques)	CREL, VCF, CMC
	Cyclones			Social forestation (Institutional and forestation along the road sides, in front of mosques, Primary Schools and High Schools, in protected area) Drought resilient forestation (such as Dumur, Amlaki, Haritaki (Terminalia chebula), Mango, Olive.	Bangladesh Meteorological Department (BMD), Department of Disaster Management (DDM), Union Parishad
	Heavy rainfall			Raising the height of Dams, cleaning of Chhara, building of Culvert over canal	DPHE and LGED
Roads	Heavy rainfall	Roads are submerged/ inundated	Draining of water by making drains along the sides of roads, lessening the communication over the roads.	Making of protection wall by filling the roads with mud/soil. Building sandy roads along the mosques and primary schools.	DPHE
Livestock and poultry	Drought/ decreasing the level of underground water/ Heat waves	Foot-and-Mouth Disease (FMD) commonly known as 'Khurarog' and loose Diarrhea and pox in poultry (ducks and chickens	Feeding the juice of leaves of some medicinal plants (Achhila tree) and the leaves of bel (*Aeglemar melos*) for curing diarrhea. Take advice of veterinary doctor for Khurarog. During summer when the ducks and chickens are attacked by pox, they are cured by washing the ducks and chickens with salt water During the food crisis, dry feed is given to cattle	Building of houses for livestock in a safe and dry place. Disease resilient poultry (such as naked-necked chicken)	VCF, CMC
	Cyclones	Houses are damaged	Building temporary houses /shelters on an elevated land /road	•Need arrangement to keep livestock and poultry in cyclone shelters.	

Cox's Bazar Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazard**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
				• Plantation of cyclone-resilient trees surrounding the houses of livestock	
Day labor /wages	Drought, Heat waves	Less opportunity of work, Physical sickness	Sell labor in advance and run the family by taking loan	Engage themselves in alternative profession	CMC, Department of Cooperatives, Department of Youth Development
	Cyclones	Sell labor in advance and run the family by taking loan	Sell labor in advance and run the family by taking loan	Engage themselves in alternative profession	CMC, Department of Cooperatives, Department of Youth Development
Small business	Cyclones, Floods, Heavy rainfall	crease in sale, shops are damaged	Run the family by taking loan/spend savings	Building strong structures for small business/ shops, Capacity of alternative income	Department of Youth Development, CMC, GO/NGO

Chittagong Region

Chittagong Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazard**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
Agriculture	Temperature rise	Less production, loss of paddy and vegetables, increase in diseases	Repeat cultivation of paddy, use of insecticides, get the advice of Agriculture Officer	➢ Cultivation of heat resistant paddy/ vegetables: (Papiya F-1, TIA), Lady's finger (Gree Finger F-1, Silvia F-1, BARI-2), long beans (Barbati, Upsi BARY-1), paddy (Bina-7, BR-28, BR-42, BR-46). ➢ Use of Perching System for controlling insects	Union Parishad (UP), Agriculture Department, NGO
	Drought	• Less production, loss of paddy and vegetables	• Villagers cultivate paddy on the banks of Shilak canal at Dudhpukuria during drought. • Early harvesting of crops. • Use irrigation.	*Establishment of deep tube well *Excavation/Re-excavation of Chhara/Canal in the villages where necessary *Agro-forestry in the hills surrounding the villages	Union Parishad (UP), Agriculture Department, NGO
	Erratic rainfall	Cannot cultivate during the right time, less production of paddy and vegetables	Delayed cultivation of crops, quick harvesting of crops.	Cultivation of early variety of vegetables (Cucumber, khira, chilly)	Union Parishad (UP), Agriculture Department, NGO
	Gusty winds/ Kalbaishakhi	Destroy crops	Re-cultivation of crops. Delayed cultivation of crops	Cultivation of early variety of vegetables (Cucumber, khira, chilly)	Union Parishad (UP), Agriculture Department, NGO
	Intensity and duration of winter	less production of paddy and vegetables	Cultivation of winter crops and vegetables	Cultivation of cold resistant native variety of potato (Diamond, Cardinum, Genola), maize (984. Specific-11, Brownia-60, NK-40)	Union Parishad (UP), Agriculture Department, NGO
Water	Temperature rise	Want of pure water. Decrease of water in Chhara	*Use of rain water for drinking and daily use in the month of Ashar-Shraban. *Use the water of Chhara during excessive heating of the summer (months of Chaitra-Baishakh). *Use less water in the daily life. *Collection of water	*Establishment of tube well in the villages where necessary *Re-excavation of ponds	Union Parishad (UP), Government, NGO

Chittagong Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazard**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
			from Chhara of remote places.		
	Drought	Want of pure water. Decrease of water in Chhara, Wild animals face water crisis.	Use of rain water for drinking and daily use in the month of Ashar-Shraban. Collection of water from Chhara of remote places, if the Chhara dries out.	*Establishment of deep tube well *Re-excavation of ponds *Re-excavation of Chhara	Union Parishad (UP), Government, NGO
	Heavy rainfall	Source of water is polluted	Use of rain water in the daily life and drinking.	*Establishment of tube well on an elevated and secured place. *Making the banks of Ponds and Ghona high before the starting of rainy season.	Union Parishad(UP), Government, NGO
	Gusty winds / Kalbaishakhi	Source of water is polluted	*Collecting pure water from remote places. *Drink water after boiling.	*Establishment of deep tube well *Dissemination of information of disasters.	Union Parishad (UP), Government, NGO
	Untimely/erratic rainfall	Source of water is polluted	During the untimely rainfall in the months of Aswin-Kartik, water is preserved by digging hole in the earth.	*Establishment of tube well *Digging of ponds for preserving water *Re-excavarion of Chhar	Union Parishad (UP), Government, NGO
Health	Increase in temperature, gusty winds/ Kalbashakhi, intensity and duration of winter	Diarrhea, dysentery, Typhoid, skin disease	*Get health treatment /health service from Local and Regional Community Clinic, Upazila Health Complex and Govt. Medical College	Establishment of Community Clinic in every village	Union Parishad (UP), Government, NGO
Houses	Temperature rise	Corrugated roofing sheets become very hot	*Making houses with mud/clay and use bamboo chatai under the roof of the house to protect from heat. *Plantation of different fruit trees like mango, jackfruit in the yard of house	Distribution of fruit trees and forest trees from Government organization and NGO at free of cost or nominal cost	Union Parishad (UP), Government, CREL, NGO
	Untimely/ erratic rainfall	Damages houses	People take shelters in buildings and nearest Primary schools and also Buddist Temples	*Building protection wall along the sides of Shilak Canal in Dudhpukuria /Canal to protect from erosion and planting trees with branches. * Distribution of fruit trees and forest trees from Government organization and NGO at free of cost or nominal cost *Building strong houses, High-raised and semi-pucca houses	Union Parishad (UP), Government, CREL, NGO
	Gusty winds/ Kalbaishakhi	Damages houses	People take shelters in buildings and nearest Primary schools and also Buddist Temples	*Making houses strong in the villages *Building strong houses, High-raised and semi-pucca houses	Union Parishad (UP), Government, CREL, NGO
Communication	Increase in temperature	Communication facilities are stopped due to increase in temperature	Stay in houses	Aforestation along the road sides with Raintree, Mehagani and Shisu trees.	Forest Department, Union Parishad (UP), Government, CREL, NGO
	Erratic rainfall	Communication facilities are	People make temporary	*Building bridges, and re-excavation of Canal.	Forest Department, Union Parishad

Chittagong Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazard**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
	/Untimely rainfall	stopped due to increase in temperature	wooden/bamboo bridge for communication over Shilak canal at Dudhpukuria Stay in houses and go out less	*Making roads strong and pucca.	(UP), Government, CREL, NGO
	Winter intensity and duration	Communication is disrupted	Stay in houses and go out less during severe cold	Afforestation along the road sides with Raintree, Mehagani and Shisu trees.	Forest Department, Union Parishad (UP), Government, CREL, NGO
	Gusty winds /Kalbaishakhi	Roads are broken and communication is disrupted and cut off	Quick repairing of roads for communication and take secured shelters	Making roads strong and pucca	Forest Department, Union Parishad (UP), Government, CREL, NGO
Livestock and poultry	Increase in temperature/ Heavy rainfall / Kalbaishakhi /Cold waves	Livestock and poultry are affected different diseases, face food crisis	*They are taken under shade *Given treatment locally.	*Building of houses for livestock in a safe and dry place. *Preservation of cow feeds Arrange	Livestock Department, Union Parishad (UP), Government, NGO
Forest and natural Resources	Increase in temperature and drought	Trees in the forest die, Animals and birds face crisis of drinking water	Arrange irrigation from Chhara but it is not sufficient	*Afforestation of the sides of roads *Increase Agro-forestry *construction of water reservoir *Re-excavation of Chhara	Forest Department, Local People, CMC
	Cold waves, Erratic rainfall, Sudden rain, Kalbaishakhi	Trees are broken and livestock and pets are affected by diseases.	Removal of broken trees and plantation of new trees.	Establishment of houses, storm resistant trees along the sides of roads, plantation of trees with more branches	Forest Department, Local People, CMC
	Commercial cultivation, Establishment of houses in plain land, grazing of livestock, Fire and attack from elephant	Due to deforestation the living places/nests of birds wild animals and livestock are destroyed	Local people with the help of Forest Department try to identify the illegal occupied people, extinguishes bush fire and returns the wild animals	*Increase in awareness and the activities Forest Guards. *Prepare gardens of banana and guava over a vast bare land	Forest Department, Local People, CMC

North-East Region (Sylhet Region)

North-east Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazards**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
Agriculture	Drought	Ground water level decline, Irrigation hampered in paddy field, Damages crops	Build embankment and storage of water into the Chhara and irrigate water in dry season.	Select early variety of paddy seeds. Use mulching technique to protect seeds from drought. Cultivation of plants and vegetable which needs low amount of irrigation. Installation of Deep tube well Construct of water tank for rain water harvest Re use of domestic purpose uses water into agriculture.	Upazil/Union Parishad, Local government/ Community people.
Vegetable Cultivation	Erratic rainfall /Severe cold/ Drought/ Hail Storm/	Crops damage due to severe drought, Ground water level decline, unable	Installation of deep tube well, Build embankment and storage of water	Use mulching method for reduce drought. Cultivate fruits trees, cultivate less water dependent crops, Installation of deep tube well.	Upazila/Union Parishad Agriculture Department, local community.

North-east Region Community and Ecosystem Based Adaptation (CBA& EBA)					
Sector	**Hazards**	**Impacts**	**Coping strategy**	**Adaptation**	**Implementing Authorities**
	Heavy rainfall/ Flash flood	to irrigate water into vegetable garden due to water crisis, Again heavy rainfall Inundates crop lands	into the Chhara for irrigation, Climate resilient vegetable farming		
Livestock and poultry	Heat waves / drought/ Severe Cold/Cold wave.	Different diseases attack animals like loose Diarrhea and pox in poultry (ducks and chickens	Heat waves / drought/ Severe Cold/Cold wave.	Keep dry and clean of the shed of cattle. Keep communication with livestock department at union level for medicine and treatment. During the food crisis, dry feed is given to cattle	Local community/ Union Parisad and VCF
Health and Water	Drought, Severe Cold, Heat Waves, Cold Waves, Nor'wester, Water logging	Water borne diseases, cold and cough, fever, pneumonia	Get health treatment/health service from Local and regional community Clinic, Chemist, Village doctors. In case of acute/complex disease, people go to Upazila Health Complex	Increasing awareness, increasing health service both with initiatives of government and private organization, improving the local and regional Community Clinic. Improvement of Community Clinic and health services	Union Parisad /Local community and public health engineering department.
Homestead social forestry and natural forest	Drought/ Heat waves/ Decrease in underground water level/ Erratic rainfall	Trees are damaged, bird's nests are damaged	Irrigation of water from Chhara	• Social forestation (Institutional and forestation along the road sides, in front of mosques)	CREL, Forest dept. VCF, CMC
Day labor/wages	Nor wester, Drought, Heat waves, Heavy rainfall	Less opportunity of work, Physical sickness	Sell labor in advance and run the family by taking loan	Engage themselves in alternative profession	CMC, Department of Cooperatives, Department of Youth Development
	Cyclones	Sell labor in advance and run the family by taking loan	Sell labor in advance and run the family by taking loan	Engage themselves in alternative profession	CMC, Department of Cooperatives, Department of Youth Development
Small business	Cyclones, Floods, Heavy rainfall	Decrease in sale, shops are damaged	Run the family by taking loan/spend savings	Building strong structures for small business/ shops, Capacity of alternative income	Department of Youth Development, CMC, GO/NGO

ANNEX 3: IMPACTS OF DIFFERENT HAZARDS ON DIFFERENT SECTORS OF LIVELIHOODS IN CHITTAGONG REGION

Beat	Vulnerable sectors and ranks												
	Agriculture/ Paddy /homestead garden	Communication	Houses and roads	Livestock	Health and water	Forestry/ Social forestry/Wildlife	Day labor	Handicraft and tourism	Collection of forest resources	Small business	Service (Govt.)	Vegetables/Fishing	Fruits cultivation
Dudhpukuria beat	1st			3rd	2nd	4th	5th	6th		5th			
Dhopachhari beat	1st	6th		4th	3rd		8th		5th	9th		2nd /	7th
Kamalachhari beat	1st			3rd	4th	2nd	5th			5th			
Sangu beat	1st	7th	4th	3rd	2nd		5th			6th			
Sukhabilas beat	1st			2nd	4th	3rd	5th			5th			
Chunati Sanctuary beat	2nd			5th	3rd	4th	1st			1st			
Harbung beat	1st			5th	3rd	4th	2nd			2nd			
Aziznagar beat	1st				3rd	2nd	4th			4th			
Chambal beat	1st		2nd	6th	4th	5th	3rd			3rd			
Jaldi beat	1st		2nd	6th	3rd	5th	4th			4th			
Napora beat	1st		2nd	6th	5th	4th	3rd			3rd			
Puichhari beat	1st		2nd	6th	5th	4th	3rd			3rd			
Shilkup Eco-Park beat	1st	8th	5th	7th	3rd	2nd	4th	6th		4th			
Fatikchhari beat	1st			5th	3rd	4th	2nd		2nd				
Hazarikhil beat	3rd			5th	1st	2nd	4th			4th			
Baraiyadhala beat	1st	9th		6th	3rd	2nd	5th	8th	7th	4th	0		
Baratakia beat	1st			3rd	2nd	2nd				4th			
Gobania beat	1st			5th	3rd	2nd	4th						
Char Osman beat	1st		8th	3rd	2nd	4th	7th			6th		/5th	
Sitakunda Eco Park	1st			4th	5th	6th	2nd	8th	7th	3rd	9th		

ANNEX 4

EXAMPLE OF VILLAGE LEVEL PCVA FINDINGS FROM TEKNAF WILDLIFE SANCTUARY

Around 40 local people with the technical support of CREL (NACOM) site staff conducted a PCVA in two out of five VCFs linked with Mathavanga forest beat of Teknaf Wildlife Sanctuary in Cox's Bazar District from 18 February to 5 March, 2014. These villages are around 14 km north of Teknaf Upazila headquarters and 71 km south of Cox's Bazar district headquarters. Participatory tools used in the field work included: Spatial (transect walk, resource and hazard map, hazard prioritization), Temporal (climate trend analysis, livelihood and hazard calendar) and Qualitative (vulnerability matrix, focus group discussion, adaptation map, key informant interview).

At first the community members identified the resource bases and the presence of hazards in their villages through a transect walk and drawing a resource and hazard map. Then they prioritized hazards by casting votes, and prepared a trend analysis matrix/table based on their experience. The prioritized hazards were: temperature rise and heat wave, cyclone, ground water depletion, excessive rainfall, drought, hill slides, salinity, and flood/hilly flood. They also prepared hazard and livelihood calendars following the Bangla year to identify the links between hazards and livelihoods. After identifying the hazards and affected livelihood sectors, the participants developed a vulnerability matrix. In the matrix the community members identified the most affected sectors (livelihoods, natural resources, and other aspects that are associated with their lives and livelihoods) by putting scores against the identified hazards. The most affected sectors identified in the vulnerability matrix were: nature, forest and biodiversity including social forestry; agriculture; water and health; livestock; and wage labor.

In the third stage the participants identified the coping strategies for the affected sectors and formulated their adaption plan and prepared an adaption map through Focus Group Discussions, this was also supported by the facilitators undertaking Key Informant Interviews. The PCVA findings were validated a year later in a stakeholder workshop on 15 February 2015 at the Union Parishad complex, involving 44 participants including representatives from the VCF, CMC, People's Forum, Forest Department and Union Parishad. Adaptation plans at beat level and village level were finalized based on the PCVA findings. Subsequently, one of these two VCFs - Barodayle VCF - prepared its own village level adaptation plan in a VCF meeting attended by around 50 VCF members.

Key findings: hazards of Barodayle Village

Sector	Hazards	Impact
Nature, Forest and Biodiversity	Drought, Ground water depletion,	Lose of tree resources and biodiversity
	Hill slide, Hilly flood/excessive rainfall and Cyclone	Lose of tree resources and habitat of wildlife
Agriculture	Salinity	Lose of production, delayed cultivation
	Cyclone	Damage of production
	Drought/ Temperature rise/ Ground Water depletion	Irrigation crisis/ Damage of production
	Excessive rainfall/Hill slide	Crop and vegetable fields get flooded
Water and health	Temperature rise/heat wave, Ground water depletion	Skin diseases, dehydration, water borne diseases
	Salinity	Water borne diseases, Skin diseases
Livestock and poultry	Temperature rise/heat wave	Livestock and poultry get sick
	Cyclone	Livestock and poultry get injured and killed
Wage earning/labor	Excessive rainfall	Occupation crisis, food scarcity, physical illness, damage of houses, assets and crops
	Cyclone	Occupation crisis, food scarcity, physical illness, damage of houses and assets
Infrastructure and communication	Cyclone, Excessive rainfall	Roads and houses get damaged; communication system gets disrupted

The villagers of Barodayle prepared their own adaptation plan as follows:

Sector	Hazard	Adaptation Options	Implementing institutions
Nature Forest, Homestead forest and Biodiversity	Hilly Flood/ Excessive rainfall/ flood and Cyclone	• Plantation of local tree species in 50 hectares of denuded hill • Improved cooking stove distribution • Community awareness for forest and biodiversity protection • Roadside plantation: 1 km (from LGED road to the sea beach) • Roadside plantation:1 km (from the residence of Kashem to foothill and from LGED road to foothill) • Plant of storm and salinity resilient trees along the beach: 10 hectares (from Marishbonia High School to Barodayle Govt. Primary School)	Forest Department, Local community, Union Parishad
Agriculture	Cyclone/ Hilly flood	• Training and information on early variety crops cultivation for 250 farmers • Rakkhikhali Stream Re-excavation: 1 km (from the foothill to LGED road) • Dhakchara Stream Re-excavation:1.50 Km (from foothill to sea beach) • Nilarchara Stream Re-excavation: 2.5 km (from foothill to marine drive) • Embankment construction: 3 km (from Marishbonia to Barodayle govt. primary school)	Upazila agriculture office, Local community, GO & NGOs
	Temperature rise/ Drought/ Ground water depletion	• Information and training regarding drought resilient crops and vegetable cultivation for 350 farmers • Training on organic cultivation and Integrated Pest Management for 200 households • Install 6 deep tubewells: 1 at Beat Office, 1 near the residence of Abdur Rahim, 1 near the residence of Sabbir Ahmed, 1 near the residence of Hasina Akhter, 1 near the residence of Abdullah-Al-Mamun, and 1 near the residence of Md. Nuru	
Water and health	Temperature rise/ Drought/ Ground water depletion	• Deep tube well installation (Deep tube well for agriculture will be helpful for drinking water supply) • Public and private health service and awareness increase • Health complex construction: near the market	Local community, Local Government and Engineering Department (LGED), Union Parishad
	Cyclone/ Hilly flood/flood	• Protection wall with sand bag surrounding houses near hills • Take shelter in Barodayle Government Primary School-cum Cyclone shelter during cyclone	
Livestock and Poultry	Temperature rise/ Drought/ Ground water depletion	• Make cow and poultry shed under trees and in safe place • Rear disease resilient ducks and chickens • Keep livestock and poultry in cyclone shelters during cyclone	Local community, Upazila Livestock office, NGO
Small Business and Wage labor	Hilly flood/ Excessive rainfall/ flood, Cyclone	• Training for alternative occupation	Regional office of Bangladesh Small and Cottage Industries Corporation (BSCIC), NGO
Infrastructure and communication	Cyclone, Excessive rainfall	• Homestead plantation with storm resilient trees • Road construction:1.5 km (from the residence of Abdur Rahim to LGED road)	Local Community, Union Parishad and Local Government and Engineering Department (LGED)