School of Media, Culture and Creative Arts

Department of Social Sciences and International Studies

Community Perceptions and Adaptation to Climate Change in Coastal Bangladesh

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This thesis is presented for the Degree of

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Dedicated

to

My parents

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: …………………………………………………..

Date: ………1 January 2015………………………………………….

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Abstract

This study examines the ways in which the inhabitants of two coastal communities of southwestern Bangladesh perceive and encounter weather /climate related hazards in their everyday lives. The study villages border the Sundarbans Reserved Forest – the world's largest single unit of mangroves, which is exposed to various climate related hazards such as cyclones, storm surges, sea level rise, salinity intrusion and erosion. It explores local people's understanding of changing weather patterns and related impacts on their local environments and livelihoods and the measures they undertake to adapt to such impacts. The study also examines within resilience and transformation frameworks the effectiveness and sustainability of such community level adaptation measures in response to the impacts and uncertainties associated with current and future climate and non-climate related stressors. The study analyses the impacts of various past development interventions, such as coastal polders, upstream river water diversions, shrimp farming, conversions and privatization of canals and rivers on local environment and livelihoods and their implications for weather/climate induced vulnerabilities.

A mix of qualitative (focused group discussions, key informants interview, trend analyses, case studies) and quantitative (household census, questionnaire survey, knowledge attitude and practice survey) approaches was employed to gather data from various occupational groups, local government representatives, NGO staff and primary schools teachers. A Livelihood Vulnerability Index tool was employed to analyse the climate vulnerability of the study communities. Land use and GIS mapping was done to measure village changes in resource systems over time. Field surveys were aided by two part-time research assistants and field study findings were supplemented by desk-based reviews of relevant literatures.

Field findings revealed the study area was impacted by various exogenous and endogenous past development interventions that had increased the risks and magnitude of weather/ climate change impacts on local social-ecological systems. Local people observed warmer and longer summers with erratic rainfall and shorter and warmer winters, frequent rough sea conditions. They understood these changes to be both historically grounded and relatively new and linked to both weather-

related and non-weather-related processes in the local environment. Thus, corrupt practices and poor maintenance of embankments intensified the impact of cyclonic activity while over-fishing, poor management of fish sanctuaries in the Sundarban, and official failure to implement fish conservation acts combined with prolonged pre/early monsoon drought in affecting fish migration, low recruitment and lower yields. The two villages, while geographically close to each other, showed differences in their perceptions and concerns about climate related stressors. Social vulnerabilities were shaped by geographical location, socio-economic conditions, local resource systems, land uses, livelihood options, and access to resources and institutional governance, which interacted with biophysical hazards to bring about variations in local people's capacity to respond to such hazards.

Community adaptation initiatives to weather stressors were mostly short term and resilience-based rather than medium to longer term transitional or transformative forms. Some initiatives (water management and rice, wetland and mangrove restorations) were based on ecosystems approaches to adaptation with potential to benefit communities in a changing climate. A lack of awareness, capacity and focus on weather/climate change, institutional weakness, poor governance and a lack of local readiness to adapt were barriers to translating local adaptive capacity into actual adaptation. The study suggests that a combination of community-based adaptation (CBA) and a focus on ecosystems based approaches (EbA) that go beyond a traditional resilience framework may help local communities to deal sustainably with weather and non-weather stressors in the longer term. This requires a more proactive role by government agencies, NGOs and local government with the active participation of local communities to make transformational change in the face of climate change impacts.

Glossary of Terms and Acronym

Abohawa	: Weather (In Bengali)
ADB	: Asian Development Bank
Akash bonnaya	: Localised flooding due to intense heavy rains over consecutive few days
Amabotir joe	: Heavy rains in early *ashar* (during 2-10th of *ashar* that enrich soil moisture suitable for tilling)
Amon rice	: Rain-fed monsoon rice (July-August to November)
AR	: Adaptation Readiness
Aus rice	: Summer Rice, partially irrigated (usually April to July)
Bada	: Local name of Sundarbans mangrove forest
Bada'r kaj	: Works for collecting various products from Sundarbans
Bagdi	: A local social group subsists on resources of Sundarbans
BBS	: Bangladesh bureau of Statistics
BCCSAP	: Bangladesh Climate Change Strategy and Action Plans
BCCRF	: Bangladesh Climate Change Resilience Fund
BCCTF	: Bangladesh Climate Change Trust Fund
BDT	: Bangladesh Taka (US 1 = 79 BDT: 2013 rate)
Beel	: Bowl shaped depression mostly retains water year round
Bheri badh	: Embankment also called "badh" or "bheri"
BoB	: Bay of Bengal
Boro rice	: Irrigated winter rice (January to April), locally called "*goromer dhan*"
Bowali	: People who collect forest products from Sundarbans
BPH	: Brown Plant Hopper
BRAC	: Bangladesh Rural Advancement Committee (NGO)
BRRI	: Bangladesh Rice Research Institute
BWDB	: Bangladesh Water Development Board
CBA	: Community based adaptation to climate change
CBOs	: Community Based Organizations
CC	: Climate Change
CCC	: Climate Change Cell

CEGIS	: Center for Environmental and Geographic Information Services
CNRS	: Center for Natural Resources Studies (a Bangladeshi national NGO)
Community	: A neighbourhood, cluster of households within a village
CPR	: Common Pool Resources
CZPO	: Coastal Zone Policy
Dadon	: Traditional loan system usually in practice in remote areas
Dadonder	: People who provide *dadon* to people, also called *mohajon*
DAE	: Department of Agriculture Extension
Decimal	: 100 decimals is equal to 1 acre or 44m2
Dewa	: Rains also called *brishty* in Bengali
DMB	: Disaster management Bureau
DoE	: Department of Environment
DoF	: Department of Fisheries
DPHE	: Directorate of Public Health Engineering
DRR	: Disaster Risk Reduction
EbA	: Ecosystems based adaptation to climate change
ECA	: Ecologically Critical Area
EIA	: Environmental Impact Assessment
EPA	: Environmental Protection Agency, US
EP-WAPDA	: East Pakistan Water and Power Development Authority
EWM	: Early Warning Message on disaster
FD	: Forest Department
FGD	: Focused Group Discussion
GBM	: Brahmaputra-Jamuna and the Meghna River systems
Gher	: Shallow ponds (modified rice paddies) for shrimp farming
GHG	: Green House Gas
Ghurni jhar	: Cyclone
GIS	: Geographic Information System
GK project	: Ganges-Kobadak Irrigation Project
GoB	: Government of Bangladesh
Gon mukh	: High tides during full moon and new moon when fishers use to get higher catch

Gura mach	: A variety of low cost small fish species
Household	: A family unit stays together, uses common resources for living
Homestead	: Yard or compound of a household
HYV	: High Yielding Varieties
IISD	: International Institute for Sustainable Development
IPCC	: Intergovernmental Panel on Climate Change
IUCN	: International Union for Conservation of Nature
IWM	: Institute of Water Modeling
Jaisthay vonnya	: Heavy rains by end of a Bengali month *jaisthay* (May-June) which wash out soil salinity and make lands suitable farming
Jhor-badal	: Storms that accompany rains; cyclonic storms
Jalabayu paribartan	: Climate change
Joloscchas	: Storm surge (also cyclonic storms)
KAP	: Knowledge, Attitude and Practice
Kasthe	: Heavy rainfall for consecutive few days
Khal	: Canal whether natural or man made
Khora	: Drought, particularly during pre-monsoon and monsoon
KII	: Key Informants Interview
LDC	: Least Developed Country
LGD	: Lower Ganges Delta
Lomba khora	: Prolonged drought
LVI	: Livelihood Vulnerability Index
MEA	: Millennium Ecosystem Assessment
MFF	: Mangrove for Future – a regional project of IUCN
MoEF	: Ministry of Environment and Forests
Mohajons	: Wholesale Fish traders and provide loan to poor fishers
MoL	: Ministry of Land
Mowali	: People who collect honey from the Sundarbans
NAPA	: National Adaptation Programme of Action
NGOs	: Non-governmental Organizations
Nona daka	: Usually refers to high soil salinity in croplands
Noyan jhuli	: Roadside borrow pit
ODI	: Overseas Development Initiative, UK

Okal bonnaya	: Untimely flooding (either early or late in the season)
PDO-ICZMP	: Project Development Office for Integrated Coastal Zone Management Plan
PSF	: Pond sand filter - a device to filter pond water for drinking
Rooling	: Rough sea conditions (Rolling in English)
SAR	: Second Assessment Report of IPCC
Shada mach	: Bony fish species cultivate with shrimps (white fishes)
Shrimp PL	: Post larvae of shrimps stock in *ghers* for grow out
SLA	: Sustainable Livelihood Approach
SLR	: Sea Level Rise
SRF	: Sundarbans Reserved Forest – World's largest single unit of mangrove forest
TRM	: Tidal river management
UDCC	: Upazila Development Coordination Committee
UDMC	: Union Disaster Management Committee
UFO	: Upazila Fisheries Officer
UKCIP	: United Kingdom Climate Impacts Programme
UNCBD	: United National Convention on Biological Diversity
UNDRO	: United Nations Disaster Relief Organization
UNDP	: United Nations Development Programme
UNDP-GEF	: Global Environmental Facility of UNDP
UNFCCC	: United Nations Framework Convention on Climate Change
UNICEF	: United Nations International Fund for Children
UNISDR	: United Nations International Strategy for Disaster Reduction
UNO	: Upazila Nirbahi Officer (Chief Executive of Uapzila)
Upazila	: An administrative unit under a district or a sub-district
UP (Union Parishad)	: Lowest administrative unit under local government
UP Chairmen	: Administrative Head of UP, elected locally
UP member	: Administrative Head of a ward under a UP
VGD	: Vulnerable Group Development – a safety net package
VGF	: Vulnerable Group Feeding – a safety net package
Village	: A community comprised of several clusters of households

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Chapter 1:
Introduction

This study examines the ways in which the inhabitants of two coastal villages located in the southwest of Bangladesh perceive and encounter weather and weather-related hazards, threats and shocks in their everyday lives. It has three main research objectives. The first concerns what coastal peoples see as the most important weather /climate related hazards they face. This involves an examination of the extent to which coastal peoples differentiate changes in local environmental conditions as a result of "weather/climate dependent" stressors or of other non-human and natural stressors .The second examines how local understandings and experiences translate into adaptive strategies. The third question focuses on the relationship between local people and the public agencies with which they deal. In particular, it examines how local people evaluate the functions of mainstreaming public agencies towards supporting community level adaptation to impacts of changing weather/climate factors. The remainder of this chapter provides a general introduction to the thesis and outlines the content of the thesis chapters.

Climate change, vulnerability and adaptation in Bangladesh

The subject of climate change has taken on major global significance in recent years as it becomes clearer from the climate science that the planet is getting warmer with potentially devastating implications for all life forms. However, not all countries are likely to be affected in the same way and some are considered to be more vulnerable to climate change impacts. Bangladesh is one of those countries. There is much evidence to show that Bangladesh is likely to be severely impacted by climate change and the country is preparing itself for such an eventuality through the development of adaptation policies and practices. In Bangladesh itself, it is the coastal zone that is regarded as particularly vulnerable (MoEF, 2005; MoEF, 2009; Stern, 2006).

I started my research in these remote coastal communities during a time of repeated weather induced disasters that shook the country. Between 2007 and 2009

Bangladesh experienced two floods, four cyclones (super cyclone “*Sidr*” in November 2007, two cyclones “*Bijli*” and “*Nargis*” in April 2008 and, cyclone “Aila” in May 2009) and prolonged pre and early-monsoon drought in 2009. Such a high variability of climate within such a short span of time is a new experience for Bangladeshis but these climate/ weather-induced events had a disproportionate and negative impact upon the production and extraction sectors in the coastal zone compared to mainland areas of the country. However, disasters due to climate variability and extremes are not new in Bangladesh (such as floods, cyclones, and drought). What is new are recent increases in the frequency, intensity and uncertainties of such climate induced events and processes under changing global climate systems.

Bangladesh’s location and related socio-economic features expose it to climate-induced hazards (Ali, 1999; MoEF, 2005; Stern, 2006). First, its location at the mouth of the funnel of the Bay of Bengal (BoB) exposes it to one of the world’s major tropical cyclone formation zones. Second, the country lies on one of the largest deltas in the world and at the end of one of the world’s largest drainage basins. The combined catchment of three major river systems in the region (Ganges, Brahmaputra and Meghna Rivers) is greater than the size of Bangladesh, and 92% of it remains outside the country, making it prone to river flooding and bank erosion every year. Third, the entire northeastern and southeastern parts of Bangladesh lie at the foothills of the Meghalyan and Tipra hills range of India which is one of the highest rainfall zones of the world, which makes the country susceptible to flashfloods and consequent damages to lives and assets (MoEF, 2009). Fourth, the 710km coastline, with elevations of below 10m of MSL along the coastal plains, exposes the country to permanent inundation from sea level rise (SLR), coastal flooding, salinity intrusion and erosion (CZPO, 2005). Fifth, these major river systems contribute to the high fertility and productivity of Bangladesh and interference with river flows can have major consequences for the lower riparian ecologies and livelihoods. Sixth, the high population density (around 1,000/sq.km) in a small country of 144,550 sq km makes it one of the most land hungry countries of the world with per capita agricultural land availability of 0.05 ha (Qusem, 2011). Seventh, Bangladesh is still a rural and agrarian based country with a majority of the population dependent on climate sensitive production (agriculture and aquaculture) and extraction sectors (fishing and other natural resources from coastal zones, hill slopes and forest resources), making it highly exposed to the shocks of weather induced threats. Finally, poverty, low awareness of climate change issues, lack of technology and poor governance impede the efforts of building adaptive capacity to absorb external shocks from climate change and climate variability. However, the severity of impacts of climate change varies over different geographical landscapes due to distinct geomorphological and socio-economic features which determine the level of exposure and sensitivity of a system to climate perturbations and extremes (Cutter et al., 2008; Adger, 2006).

Among the various vulnerable locations, coastal areas of Bangladesh are more exposed to climate induced threats due to higher sensitivity associated with geophysical and socio-economic factors (IPCC, 1995:34; IPCC, 2007:317; MoEF, 2005). The Bangladesh National Adaptation Programme of Action (NAPA) (MoEF, 2005) stated that the coastal environment (ecosystems) and livelihoods are exposed to multiple climate induced hazards such as rising temperature, erratic rainfall, early and monsoon droughts, cyclones and storm surges, tidal and rain-based flooding, and salinity intrusion. In addition, sea level rise (SLR) is expected to further aggravate the current extent and magnitude of risks. Some estimates suggest a sea level rise of 30cm and 50cm in the Bay of Bengal in 2030 and 2050 respectively (Kumar et al., 2002; CEGIS, 2006) which would create irreversible impacts on coastal environments and livelihoods, including displacement of six to eight million people due to permanent inundation of land by 2050 (IPCC, 2007: 330; MoEF, 2009:14) and increased salinisation (Allison et al., 2003). However, the degree of climate induced impacts would not be common to all coastal communities but vary by location and by the levels of vulnerability of occupational and other groups in different locations. Communities dependent on resource extraction (fishing, honey collection, crab collection) for a livelihood are considered to be more directly vulnerable to climate-related hazards than others (MoEF 2005, 2009). In the face of current and future hazards associated with climate variability and change, adaptation planning for the coastal zone based on a full examination of the vulnerability, resilience and adaptive capacity of coastal populations has become more urgent in official discourse (Adger and Vincent, 2004). Of particular importance is the need to give greater official recognition of the impact of climate change on the structure and function of ecosystems and biodiversity and the potential for growing resource conflicts among coastal users (Barnett and Adger, 2007).

The global recognition of Bangladesh as a front-line state in the response to climate change has led to increased emphasis on climate in development planning. While globally the focus has been on mitigation initiatives, at the national level adaptation is considered the prime option for the least developed countries such as Bangladesh. Bangladesh has a long history of accommodating to climate-induced and other non-climate hazards. One of the central issues in developing a climate-resilient approach to development is the extent to which traditional adaptation measures can be used or modified to deal with a new generation of threats and the changes required in developing planning to meet the twin objectives of improved living standards and a sustainable climate change adaptation strategy. However, pathways to adaptation to moderate climate change induced hazards are constrained due to lack of available methods and information on proper estimates of site-specific climate induced impacts and climate vulnerability (IPCC, 2007:72). One of the objectives of this research is to examine the typology of climate induced stressors currently affecting the coastal communities in the study villages, their levels and types of vulnerability, their responses to such stressors, and the effectiveness of such responses to tackle future uncertainties.

Uncertainties in managing climate change induced threats

Developing a climate change strategy is constrained by uncertainties associated with future climate change, as specific impacts by each climate factor undergoing change are still not clearly known (Dessai and Holmes, 2007). For example, if average winter temperature rises by 2^0 Celsius and remains so for a longer time scale, the specific impacts of such change in temperature on social-ecological systems over different locations of the country are not well known and thus planning adaptation actions to tackle this uncertainty due to temperature rise is problematic. It is difficult to design adaptation strategies and actions without a clear picture of the impacts of climate variability and change on the social-ecological systems of a given geographical location such as the coast. The coastal zone is not unique in its geomorphological and socioeconomic features and thus exposure to external stimuli such as effects of climate change and extremes vary spatially and socio-ecologically.

For example, the 710km long coastal zone of Bangladesh is divided into two vertical sub-zones: a lower area facing the Bay of Bengal and referred to as the exposed coast, and an upper part or interior coast (PDO-ICZMP, 2004). Each has its distinctive characteristics - the exposed coast is more vulnerable to climate induced hazards than the interior coast. Therefore it is expected that the impacts of SLR, cyclones and salinity would vary between the two sub-zones. In addition, the coastal zone is subdivided horizontally into three sub-zones (eastern, central and western) and each has distinctive features in terms of morphology, hydrology, salinity and land use patterns (Pramanik, 1983; Islam, 2001; Islam, 2004). Beyond these broad official zonal divisions, there is wide variability within each zone in land elevation, hydrology, land use, livelihoods, disaster proneness and exposure to coastal hazards. For example, the southeastern edge of the Sundarbans Reserved Forest (SRF) is less saline prone than the southwestern part (Islam, 2011:80). As such land use, livelihoods and the extent of vulnerability to weather stressors are different in different zones of the SRF. Even within a small spatial boundary within a sub-zone, there is much variation between villages in terms of their land elevation and use patterns, livelihoods, exposure to disaster and vulnerability to coastal hazards. As such within each such coastal sub-zone, low lying tidal plains and small islands are more exposed to and would be disproportionately impacted by climate related hazards such as cyclones, SLR and salinity intrusion.

Besides the spatial variability in the coastal zone in terms of differentiated social, economic, ecological conditions and resources endowments, the assessment of climate change induced threats and vulnerability and planning for effective adaptation is further complicated by a lack of general awareness of climate change issues among local peoples. Local people, including government officials and NGOs, have limited understanding of the causes and consequences of climate change on local social ecological systems, including the means (adaptation) by which to moderate such climate-induced adversities (Reynolds et al., 2010). This issue is taken up in Chapter 5 and is followed in Chapter 6 by a detailed examination of local people's observations and interpretations of the impacts of changing climate on their local environment and livelihoods.

The complexities of scale and location related to weather/ climate change impacts have led some observers to raise the question of where the starting point for adaptation should be. This study argues that one important starting point is the local level through a detailed analysis of the specific changes in weather and weather-related events and processes and their impacts on local social-ecological systems. In developing adaptation strategies to deal with predicted or projected impacts, one approach is referred to as “first generation” vulnerability assessment which focuses on evaluation of climate impacts on communities and aims for determining “potential” adaptation framed as “from impacts to adaptation” (Fussel and Klein, 2006). Fussel and Klein (2006) also refer to a second approach that starts from the vulnerability point of view, which they refer to as “second generation” vulnerability assessment. By this is meant that emphasis is placed on understanding how vulnerable the communities are in a given area to the effects of current changes in weather and their potential vulnerability to future changes, including those associated with climate change. This approach has been referred to as” from vulnerability to feasible adaptation”. The core difference between the two approaches is that the first generation approach focuses on responses to biophysical hazards, which inhere in the nature of the climate threat. The second generation approach shifts the focus to the underlying societal causes of vulnerability, which shape the adaptive capacity of a given community to deal effectively with natural and human-induced hazards. An important element of second generation approach is the consideration of various relevant non-climate factors (demographic, social, economic, technological and biophysical drivers) that in turn shape the sensitivity of a system of concern to climate change induced hazards. Such capacity is differentially and unequally distributed in all communities. Thus, the most vulnerable are those with the lowest socially determined capacity (adaptive capacity) to respond to hazards. Kelly and Adger (2000) refer to this as the “wounded soldier” approach. The capacity to adapt to the effects of changing weather factors is also unevenly distributed within and across nations, regions and even at local levels within small geographical areas (Smit and Wandel, 2006; IPCC, 2007). Thus adaptation planning based on generic adaptive capacity may result in unsustainable or maladaptive outcomes. A focus on place-based climate vulnerability assessment can help to resolve this uncertainty.

This research considers the ‘impacts to adaptation’ pathway, with its focus on reacting to impacts, has costs associated with learning to adapt from losses and investing in strategies that may be unnecessary due to failed projections. In contrast, the livelihood vulnerability based pathway is more iterative and builds on local experience and capacity of concerned communities.

The uncertainties associated with site specific variations in the extent of climate/weather induced risks are compounded by significant local environmental changes. These result from multiple past and ongoing development interventions (both exogenous and endogenous in origin). For instance, as an exogenous case, upstream withdrawal of Ganges river water by India through the Farakka barrage adversely impacted on the social-ecological systems of the entire lower Ganges delta in the southwestern part of Bangladesh where the study villages are located. By contrast, local changes in land use such as the shift from rice farming to shrimp farming (endogenous) increased localized salinity that affected the biophysical and social environment. As such, identifying, differentiating and incorporating the impacts of past development interventions are necessary components of the weather/ climate vulnerability assessment, and they provide key inputs in the development of adaptation strategies and plans at the local level.

Pre-existing vulnerability and climate induced impacts

While the impacts of anthropogenic climate change and climate variability are considered to have begun to affect environmental resources and livelihoods (MoEF, 2005; Huq and Ayers, 2008; MoEF, 2009), these are not of the greatest concern to rural peoples in Bangladesh (Raihan et al., 2010). Rural livelihoods are, in reality, shaped and governed by a multiplicity of interacting social, economic, cultural, political and environmental factors in which 'climate' is one of the contributing factors (Raihan et al., 2010; IPCC, 2007). Thus changes in local environments and livelihoods are often due to a combination of climate and non-climate factors. Non-climate drivers such as land use change, land degradation, pollution, water diversions, population growth, and changes in policy have direct and indirect influences on climate change impacts (IPCC, 2007: 84). As such, it is important to analyse the context in which the concerned communities live, act and make their livelihoods and plan for the future. These factors are often cross-scale in nature and are influenced and guided by national development policies and strategies. Their effects are deemed important in assessing climate change impacts and developing adaptation strategies and actions. For example, current *khas* land management policy failed to ensure protection and the pro-poor management of state owned land in the country.

Bangladesh being a least developed country, its economic growth and poverty reduction efforts are constrained by a multiplicity of factors related to lack of advanced technologies, weak capacity to plan and implement development activities, lack of funds, overpopulation, recurrent natural disasters and poor governance (Ali, 1999; Stern, 2006). Weak perspective planning and poor consideration of environmental issues, non- compliance with Environmental Impact Assessments (EIA) in physical development projects (such as flood control investments, road development) and conversions of natural ecosystems and drainage channels impair development outcomes (Shamsuddin &Talukder, 2012). For example, investment in flood control projects has largely benefited the large land owners at the expense of open capture fisheries and wetland biodiversity, upon which many poor people depend for their livelihoods (Minkin et al., 1997). Poor fishers' livelihoods based on fishing in open waters have become more vulnerable independent of climate change impacts (Thompson and Sultana, 1996). Many such development schemes have proved to be maladaptive and created adverse impacts on environment, biodiversity, soil fertility and community livelihoods (Mirza and Ericksen, 1996; Alexander et al., 1998; Halls et al., 1998). Most of these large scale development schemes are exogenous in origin and not rooted in local conditions or the agency of local peoples. These development schemes are considered largely climate neutral in planning but their impacts have exacerbated the adversities associated with changing climate. This has shouldered communities with a "double burden" due to their "double exposure" (Olmos, 2001) to climate and non-climate stressors, which in turn further increases their vulnerability to hazards and shocks.

Besides the impacts of large scale exogenous development schemes, various endogenous localized actions that facilitate conversion of ecosystems and their changing management regimes also create problems and affect local social functions and livelihoods, which in turn increase the vulnerability of poor communities. For example, the illegal grabbing, conversion and restricted access to *khas* land (state-owned wetland and cultivable land) and changes in localized land use has caused adverse impacts on the livelihoods of poor communities. My research area and project villages are located within 10km of the periphery of the SRF (Sundarbans Reserved Forest) and as such within the Ecologically Critical Area (ECA) declared by the Government of Bangladesh (GoB, 1999) in recognition of the largely negative impact of human actions on the forest and urgent need to undertake development schemes.

The IPCC fourth assessment (synthesis) report recognizes difficulties in assessing specific effects of climate change due to past interventions and other non-climate drivers. It comments:

> Effects of climate changes on human and some natural systems are difficult to detect due to adaptation and non-climatic drivers (IPCC, 2007:72).

However, the aspect of pre-existing vulnerability of local people owing to past and ongoing development schemes is seldom considered in recent climate change adaptation projects in Bangladesh. The UNDP assisted community-based adaptation project on the Bangladesh coast and conducted a climate vulnerability assessment in its four project sites. However, they put limited emphasis on pre-existing vulnerabilities caused by past development schemes (such as shrimp farming, land grabbing, coastal polders), which means they disregarded the wider underlying causes of societal vulnerability, which may have implications for the effectiveness of climate vulnerability and adaptation schemes (Nandy et al., 2013).

This research examines the impacts of such exogenous and endogenous development schemes on local social ecological systems. This second generation approach to vulnerability assessment seeks to show that pre-existing impacts have already made people vulnerable to stressors and shocks and have had an effect on identifying the precise impacts of recent changes in weather patterns (possibly linked to climate change) on local ecosystems and livelihoods (Chapter 4). Under conditions of scientific uncertainty about the specific impacts of climate change and climate variability across spatial and social landscapes of the country, the Government of Bangladesh (GoB), NGOs and bilateral donors have collectively under taken various measures to deal with the issue.

Responses to weather induced threats in Bangladesh and research gaps

The development of effective local level adaptation strategies to tackle weather induced impacts is constrained by the scientific uncertainties regarding the specific local impacts of changing weather patterns. There is much literature on the likely impacts of climate change but most is generic and applicable to the broader sub-regional, regional or global scales. Climate change modeling has contributed to our understanding of climate change trends and impacts at a broader scale but has been less successful in providing the detailed knowledge required to assist local communities in planning adaptation strategies for the long-term. To provide that understanding, the Global Facility for Disaster Reduction and Recovery (GFDRR, 2011) recommended that it is essential to conduct detailed vulnerability assessments at the local level to develop appropriate adaptation programmes to tackle climate change impacts. Despite the inadequacy of current micro level climate modeling, local people themselves have noticed erratic patterns in local weather and their concomitant impacts on their livelihoods. They have attempted to use their own local knowledge to deal with these changes but given the unpredictability of climate patterns and high variability, there is concern that such knowledge is insufficient and possibly maladaptive, leading to increased vulnerability. Government has become increasingly aware of the need to assist local communities, especially through the mainstreaming of adaptation into local development planning.

Bangladesh has been identified as highly vulnerable to climate change and increasing international and national attention is being paid to developing policies and programmes to deal with it (MoEF, 2005; Stern, 2006). The first official document on priority and urgent adaptation measures for Bangladesh was the NAPA prepared and submitted to the UNFCCC in 2005 (MoEF, 2005). The Bangladesh NAPA aimed at developing “priority” adaptation interventions through a participatory process from the grass roots to sub-national and national level public consultations. NAPA was to be the document of the “people” of Bangladesh comprising of communities priority adaptation schemes rather than those of the Government. While reviewing the NAPA adaptation schemes I contacted colleagues at the newly formed Climate Change Cell (CCC) within the Department of Environment (MoE) about how the priorities were arrived at and whose priorities were to be served. They informed me that the document was based upon extensive consultation with grass roots communities and that recommended actions were later discussed at district and national levels and finalised as a priority adaptation package for place-based communities living on the frontline of climate change impacts. However, the consultation outcomes were found biased in favour of experts' or facilitators' opinions and preferences (Raihan et al., 2010; Ayers, 2010).

The first priority project of NAPA was the "mangrove afforestation in the coastal zone to provide protection of the communities from cyclones and storm surges". While such an initiative is important in terms of the protection of ecosystem health and biodiversity, land formation, community livelihoods, income generation, and mitigation (through carbon sequestration), it raises some important issues. The first issue concerns the balancing of short term community needs with longer term adaptation-mitigation strategies. Thus, mangroves take 20-25 years to attain maturity and reach a height able to give protection against cyclones. However, poor communities which subsist from hand to mouth on very low daily incomes do not necessarily see the benefit of such an initiative to meet their urgent livelihood needs. Second, NAPA provided a list of priority adaptation actions through an expert-driven consultative process without conducting vulnerability analyses of the local communities exposed to climate change impacts. Third, it ignored the social aspects of climate change impacts and focused largely on the biophysical aspects of climate change such the impacts on water, agriculture and fisheries. In the central coastal zone, 46-68% of households are landless with no land of their own for crop farming or fish culture and they survive on fishing and seasonal engagement in various on and off farm wage laboring activities. The NAPA priority schemes in aquaculture and agricultural adaptation focused largely on those with cultivable land and although it may provide marginal or spill over benefits for the landless poor, it contributed much less to enhancing their adaptive capacity to face climate related challenges as the majority of the vulnerable population comprises landless poor and most of them do not have ponds or cropland for aquaculture or agriculture of their own. They can only get marginal benefits as wage laborers from NAPA suggested agriculture and aquaculture adaptation schemes. NAPA, though a globally recognized participatory process of identifying community driven priority adaptation interventions of the least developed countries (LDCs), it has missed the opportunity to reflect local voices and needs. To this end, Jessica Ayers commented on the Bangladesh NAPA in the following terms:

> …Bangladesh NAPA paid inadequate attention to creating opportunities for vulnerable communities to contest the dominant framing of climate risk, or contribute meaningfully in the identification of the underlying factors that drive vulnerability on the ground (Ayers, 2010:238).

The approach taken in this study focuses on developing adaptation strategies based on an assessment of the social or livelihood vulnerabilities of local communities to climate change shocks. While it is important to understand the exposure and sensitivity of place based communities to climate-induced hazards, it is essential that the communities improve their adaptive capacity to respond. This approach is missing in the NAPA's prioritized list of adaptation interventions.

Besides NAPA, The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) first prepared in 2008 and finalized in 2009 by the Ministry of Environment and Forest (MoEF) is the only document endorsed by the Government of Bangladesh being used to fund adaptation-mitigation projects in Bangladesh (MoEF, 2009). The BCCSAP is a ten year long plan (2009-2018) comprises 44 programmes under six pillar on both mitigation and adaptation options. However, it is an expert-led document based on the views of policy elites (Raihan et al., 2010:64) and as such community voices are not reflected in the design of the strategy nor are based on vulnerabilities of local communities facing climate change threats. The strategy also lacks guidelines as to how the adaptation-mitigation projects will be planned, designed and implemented. Raihan et al., (2010:64) reviewed the BCCSAP and commented:

> ...the BCCSAP makes no reference to policy and gives no directions to formulate a national climate change policy within its action plan. It is said that the implementation of proposed programmes will be backed by sectoral policies, but issues related to climate change are almost absent in those policies.

The Climate Change Cell (CCC) of the Department of Environment commissioned several field studies to generate knowledge on climate change impacts, vulnerabilities and adaptation. One such study on "climate change, gender and vulnerable groups" (CCC, 2009.a) provided a description of the biophysical hazards of some disaster prone areas of the country but lacked analysis of climate vulnerability of the local communities (their exposure, sensitivity and adaptive capacity). The study also lacked comparative accounts of vulnerability among the sites studied which could have contributed to the designing of site specific adaptation strategies based on their varying degrees and types of vulnerability. IPCC Third Assessment Report also stressed that there are considerable knowledge gaps in the nature and extent of exposure, sensitivity and adaptive capacity of physical, natural and social systems to climate change stimuli across geographical scales, which constrains designing effective adaptation and mitigation options. It recommended more empirical research in these areas of climate vulnerability across scales (IPCC, 2001:72).

In Bangladesh, adaptation planning is largely constrained by the compounded effects of both climate and non-climate related stressors and effects that collectively increase the vulnerability of local communities. No comprehensive climate vulnerability assessment (level of exposure and sensitivity to diverse climate induced hazards and adaptive capacity) has been done as yet to unpack the ground reality of climate and non-climate related problems.

In the light of the above considerations, this research assesses at the micro level the livelihood vulnerability of communities to climate change impacts in the coastal zone. It has two main objectives. The first is to provide inputs for designing grassroots adaptation strategies and actions through deepening the understanding of differentiated levels of vulnerabilities, across diverse occupational groups of place-based communities. The second is to contribute to methodological aspects of climate vulnerability assessment by providing an authentic picture of community vulnerability to climate change stressors and extremes. This will provide a basis for further refinement and replication at different and wider scales and thus contribute to enhanced knowledge and capacity in the area of climate vulnerability assessment.

Community adaptation actions and wider adaptation landscapes

People living in vulnerable coastal settings of Bangladesh have adapted to hazards for centuries based on their local knowledge, perceptions and skills that have arisen out of their day to day interactions with local environmental and other social-institutional conditions (Parvin et al., 2008). It is thus important that adaptation planning should be designed with the active participation of coastal communities who are intimately connected to the ecosystems that underpin their livelihoods. Based on local experience, communities in different climate sensitive areas of Bangladesh have already started adapting to changing climate through the adoption of a wide array of local technologies and approaches in the areas of agriculture, aquaculture, water, housing and the like with or without outside support (Rahman and Islam, 2013). However, most of these adaptation actions are undertaken at household rather than community or ecosystems levels, which have reduced the scope for collective action and community learning opportunities.

In an attempt to mobilise wider community resources to deal with climate change, several approaches have been suggested. One of which is the Community-Based Adaptation (CBA) approach, which is being practiced globally to moderate climate change impacts at the grassroots level (Huq and Reid, 2007). CBA is based on the principle that local communities have adequate knowledge, skills, capacity and social networks to plan and design locally appropriate adaptation actions based on their real life experience in dealing with climatic perturbations and their impact on livelihoods and local environments (Dodman and Mitlin, 2013). CBA is defined as:

> …a community-led process, based on communities' priorities, needs, knowledge and capacities, which should empower people to plan for and cope with the impacts of climate change (Reid et al., 2009: 13).

Two such projects are now being implemented in the coastal zone of Bangladesh with UNDP-GEF funding. Central to the success of CBA is that local communities take the lead rather than relying on expert-driven short-cut pathways.

The other approach being much discussed in the global adaptation discourse is that of Ecosystems-based Adaptation (EbA) discussed in more detail later in the study.. This approach harnesses the capacity of nature (ecosystems such as wetlands, forests) to buffer communities against the adverse impacts of climate change through providing various ecosystem services, which include provisioning, regulatory, supporting and cultural services (MEA, 2005). EbA is said to benefit local communities by recognizing the inter-connectivity between ecological, social-cultural, economic and institutional structures (Midgley et al., 2012). It is based on the premise that ecosystems such as wetlands, forests, coastal zone, mangroves, coral reefs and hill slopes will be impacted heavily by climate change induced stressors, resulting in the degradation of ecosystem functions and their ability to provide goods and services to the human population. UNFCCC, in recognition of effectiveness of EbA in adaptation to climate change across scale, has stated:

> The role of ecosystems in adaptation is relevant to, and can be applied at, many levels, such as the regional, national, sub-national and local levels, and in all regions. Ecosystem-based approaches to adaptation are found to be most appropriately integrated into broader adaptation and development strategies, complementing, rather than being an alternative to, other approaches (UNFCCC, 2011:4).

This research draws on both the EbA and CBA approaches in examining community level adaptation actions (see Chapter 8).

It is argued however that such approaches are insufficient for the implementation of effective adaptation actions without reference to what has been called ‘readiness for adaptation’ (Ford and King, 2013). This refers to ensuring that enabling social and institutional environments and supportive policy regimes are in place to guide and facilitate implementation of adaptation interventions at local level. It means that unless the required enabling factors such as local community willingness to adapt and relevant institutional capacity to plan, design, implement and monitor adaptation actions under a climate resilient policy framework with responsive governance are ready and supportive of taking adaptation measures, a system that has adequate adaptive capacity may fail to effectively adapt to weather /climate induced perturbations and extremes. This is the subject of Chapter 9.

Research aims

In the light of the previous discussion, this study examines the ways in which local people perceive and encounter weather and weather-related hazards, threats and shocks in their day to day lives. This focus will be of relevance in assessing the responsiveness of mainstream development agencies community efforts through improved climate risk reduction strategies (“local adaptation readiness”).

My research takes a vulnerability approach and focuses on community perceptions, vulnerabilities and adaptive readiness at the local level. By local level, I mean place-based village communities located on the exposed coast of the southwest and other stakeholders who facilitate community development processes at village level. As such, my research focuses on three interrelated aspects. These are (i) village occupational groups who experience different kinds of vulnerabilities linked to both climate and non-climate factors and processes; (ii) community responses to coastal hazards, which vary according to occupational patterns, land use changes and access to local resource systems and their differentiated exposure, sensitivity and adaptive capacity; and (iii) the extent of adaptation readiness at local level to tackle the adverse impacts of climate.

The study has two practical or policy-related implications. First, it makes available data on community understandings and observations of changing patterns of climate in relation to their livelihoods options and practices and their vulnerabilities to a new generation of threats. Second, the data can serve to support strategies at community level to adjust to changing climate and its impacts. Such strategies can draw on people's local knowledge of living with natural and human-induced hazards over generations and the methods they have used to respond to such hazards.

With this backdrop, this research seeks to contribute to the understanding of these issues by focusing on the perceptions and strategies of local communities in their efforts to adapt to climate-related natural and human-induced hazards in the Bangladesh's coastal zone.

Theoretical Considerations

At the core of the research is community understanding and vulnerabilities to the impacts of climate change and climate variability in the coastal zone of Bangladesh and their strategies to adapt to moderate such impacts. In what follows I draw on the empirical, theoretical and policy-related literature on vulnerability and adaptation to climate change as a framework for an examination of selected local community understanding of climate and weather issues.

Climate, Climate change, Weather: From IPCC to Village Communities

To understand local people's understanding of climate, it is useful to discuss four concepts from the general literature around which climate change impacts are discussed. These concepts are: climate, climate change, climate variability and weather (IPCC, 2012).

According to the IPCC (2012:557), climate is defined as:

> The average weather or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranges from months to thousands or millions of years.

The standard period for averaging these variables is 30 years, as defined by the World Meteorological Organization (IPCC, 2012). The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. From the definition, one can understand that long term (say 20 to 30 years) average of various climate related attributes (temperature, precipitation, wind, etc.) of a given geographical place denotes "climate" for the area of concern, which could be a country, a region or the entire globe.

Climate change is defined as:

> A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2012:557).

Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Climate change is said to occur when the average climate properties including variability in a given area change and remain so for longer periods (20-30 years).

Climate variability refers to

> …variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events (IPCC, 2012:557).

Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). Climate variability is manifested as changes in frequency of weather events like cyclones, droughts, precipitation beyond the normal regular weather events.

Weather is defined as follows:

> Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season (EPA, 2013:W1).

EPA defined climate in a narrow sense as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time (30 years). EPA also differentiated between “climate” as what one expects (e.g. cold winters) and 'weather' as what one gets (e.g. a blizzard).

These abstract concepts circulate among climate experts and policy makers but have little resonance at the level of the local communities in this study. Although local people confront, experience and respond to these climate and weather related factors in their day to day livelihood activities, they do not use such concepts, at least not in the way they are used by experts. Their own weather vocabularies are much more tied to their actual experiences of weather and weather-related events and processes. Although a few community members have received training or orientation from local NGOs on “climate change”, for the most part they have just “heard” such phrases as ‘climate change’ (*jalabayu paribartan* in Bengali) but are unaware of what they mean. One such training participant from one study village (Fultala) said in an interview: “I heard in the training, somewhere in the world ice is melting and for which our coastal land will permanently go under sea water in future”. He was unable to say why ice is melting when or where it is likely to impact on coastal Bangladesh.

Discussions of climate and climate change are rarely heard in the local communities studied except through NGOs and the occasional visits of government officials in the area. However, if one shifts the conversation to local weather, villagers are much more forthcoming about what they understand by it and how it affects their lives. Generally, by the word weather they understand sunlight (*rowd*), temperature (*taap*), clouds (*megh*), rains (*bristy*) and wind (*batash*). The days with rains and storms they refer to as "bad weather" (*kharap abohawya*) and sunny days with clear sky, no storm or strong wind they call "good weather" (*bhalo abohawya*). The idea and meaning of weather is embedded in the community vocabulary around local understanding of factors such as rainfall, drought, cold, seasons, tides, which have been integral parts of their lives and livelihoods over generations. In addition, understandings of weather vary, *inter alia*, by occupational groups, age, political status and gender even in the same village.

To facilitate my field work, I used local terms related to recent rainfall patterns, drought conditions, salinity levels and the like in comparison to the past to get their views on recent changes of these weather factors and how these changes influenced their livelihood assets and activities (see Chapters 5 and 6).

Understanding Vulnerability to Climate/Weather Stressors

Vulnerability is an old concept related to hazard risk perceptions. In the past, it was often linked to biophysical hazards and used in engineering fields to assess the likelihood of infrastructures collapsing or malfunctioning when exposed to the impact of hazards like earthquakes (Hewitt, 1997; Twigg, 2007). Later the concept was brought into a variety of development disciplines and linked to disaster risk, food security, hunger, poverty and the like. According to Cannon (2008), the term has become a "slippery" one used in a wide array of fields. Although schools of thought define vulnerability differently, there is general agreement that it refers to "susceptibility of a system to being harmed" or having a "potential for loss" when exposed to hazards or stressors (UNDRO, 1980; Cutter, 1996; Cutter et al., 2003; UNISDR, 2004). Vulnerability is generally considered a negative feature of society or community but Gallopin (2006) argues that it can have positive outcomes in so far as it generates transformative change. An example from Southwest Bangladesh is where waterlogging induced people to take up integrated hydroponics (floating agriculture) and aquaculture that facilitated the productive use of land and water year round (Irfanullah et al., 2011).

Earlier analyses of vulnerability centered on biophysical hazards and resultant loss to human systems assuming that humans were passive receivers of disaster and suffered losses when exposed to a hazard (UNDRO, 1980). More recently scholars from a range of disciplines such as development policy research, environmental change, food security, epidemiology, disaster risk and climate change have defined vulnerability in different ways relevant to their disciplinary interests and approaches (Adger, 2006; Smit & Wandel, 2006; Deressa et al., 2009). As such, vulnerability lacks a single universally acceptable definition (Deressa et al., 2009). For example, scholars of natural hazards and epidemiological research define vulnerability as the "degree to which a system is susceptible to being harmed by exposure to a perturbation or stress, in conjunction with its ability to cope, recover or fundamentally adapt" (Kasperson et al., 2001). The UNISDR (2004) defines vulnerability as the ''conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards''. Here vulnerability is rooted in a society's internal structures, including local socioeconomic and environmental conditions that determine risk when exposed to a hazard event. In other words, vulnerability refers to the capacity of the system to confront the hazard and is defined as "the characteristics of a person or group and their situation (skills, education, access to information, social networks, etc.) that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisner et al., 2004).Vulnerability, in most cases is viewed as conditional to the intensity and frequency of a hazard event and the potential for loss when exposed (UNISDR, 2004; Wisner, 2002). Wisner (2002) underlines that difficulties in recovering from the negative impacts of a hazard are also part of vulnerability and thus include coping capacity in vulnerability assessment. Thus, vulnerability not only incorporates the weakness of a system's exposure to a specific hazard but also its capacity to cope with the stressor.

Cutter (1996) emphasizes three distinct components of vulnerability. These are i) risk of exposure to hazardous conditions, ii) the capacity to respond (coping or adaptive capacity), and iii) the attributes of places where the hazard originated such as the vulnerability of people living in a flashflood zone (place of hazard). Cutter (1996:533) proposes a "hazards of place" model that includes a geographical domain as vulnerability is the likelihood that an individual or group will be exposed to and adversely affected by a hazard within a specific geographic domain (hazards of place).

Cutter et al. (2003) suggested vulnerability research and assessments should focus on three strands: "exposure" as an essential factor that makes people vulnerable to hazards; "social and institutional" conditions as a component of vulnerability; and the "places" or "origins" of hazards integrated with the exposure and societal responses. Cutter et al. (2009:2) define vulnerability as:

> …the susceptibility of a given population, system, or place to harm from exposure to the hazard and directly affects the ability to prepare for, respond to, and recover from hazards and disasters.

In addition to susceptibility and coping capacity, vulnerability includes adaptive capacity, exposure and the interaction with perturbations and stresses (Turner et al., 2003). The concept has been continuously broadened to encompass various elements that contribute to the vulnerability of a system such as susceptibility, exposure, coping capacity and adaptive capacity. It also depends on underlying physical, social, economic, environmental and institutional settings that shape vulnerability (Birkmann, 2006) (Figure 1.1).

In the context of sustainable development, vulnerability refers to a "condition" and a "determinant" of poverty and marginalization (Malone, 2009). It is expressed as the ability or capacity of people to avoid and cope with or recover from the harmful impacts of factors that disrupt their livelihoods. These factors are often beyond their immediate control such as hazard extremes, changes of government policy, and the longer term decline or changes in availability of resources. With regard to climate change, vulnerability relates to rapid onset of sudden shocks (frequent cyclones), and slow onset events (like temperature rise, sea level rise) which result in the disruption of livelihoods through crop failure, low productivity, water scarcity and so forth (IISD, 2003). Adger (2003) defines social vulnerability as the exposure of groups of people or individuals to perturbation caused by changes in the bio-physical environment, including climate variability and change. Clark et al. (1998:59) define vulnerability to hazards as:

> …'people's differential incapacity to deal with hazards, based on the position of the groups and individuals within both the physical and social worlds'.

From the social vulnerability point of view, community groups are disproportionately affected by climate and non-climate related hazards (Wu et al., 2002), largely due to the socio-political and institutional processes that hinder or facilitate a community's capacity to access resources that enable people to cope with impacts of hazards (Blaikie et al., 1994).

As a result of climate change concerns, vulnerability has been given a greater profile in the global development discourse (Wisner et al., 2004), particularly in relation to the least development countries considered most vulnerable to the effects of anthropogenic climate change and climate variability. However, some commentators (O'Brien et al., 2008) have cautioned that definitions, conceptualizations and interpretations of vulnerability differ not only among the diverse disciplines but also between and among disaster risk and climate change scholars. In addition, the use of "vulnerability" in various IPCC reports shows transformation of the concept over time. The IPCC in its Second Assessment Report (SAR) defines vulnerability as:

> …the extent to which climate change may damage or harm a system, it depends not only on a system's sensitivity but also on its ability to adapt to new climate conditions" (IPCC, 1995:872).

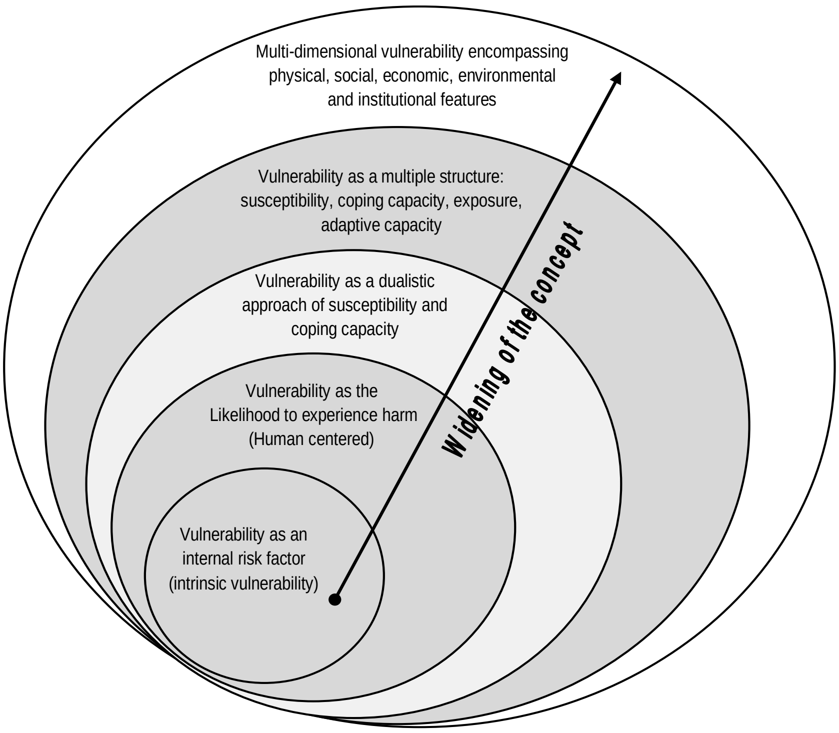


Figure 1.1: Key spheres of the concept of vulnerability (adapted from Birkmann, 2005)

This definition omits climate variability as a stressor. The Third Assessment Report (TAR) of IPCC widened the concept and defined vulnerability as

> …the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001:388).

The fourth assessment report of IPCC (2007) repeats TAR's view of vulnerability and the special report of IPCC (2012) states that "…vulnerability is a result of diverse historical, social, economic, political, cultural, institutional, natural resources, and environmental conditions and processes" (IPCC, 2012:32).

Adger (2006) argues that a person or society can be vulnerable not only due to their exposure to environmental change but also due to social change. He emphasizes the importance of resilience building and concludes that "…resilient ecosystems and resilient human societies can better adapt to both physical and socio-political stresses" (Adger, 2006: 278).

The discussion so far points to three important factors in understanding vulnerability. These are exposure to the hazards (whether external or internal stimuli), sensitivity (likelihood of harm) and adaptive capacity (capacity to withstand, cope, recover and transform when exposed to any hazardous condition) (Figure 1.2). In fact, exposure and sensitivity together determine the potential impacts of climate change on a system, while adaptive capacity is a measure of the extent to which a system can respond to such impacts to moderate harm or exploit benefits of changed conditions (Rosenzweig et al., 2011). These key concepts are discussed in greater detail below.

Exposure

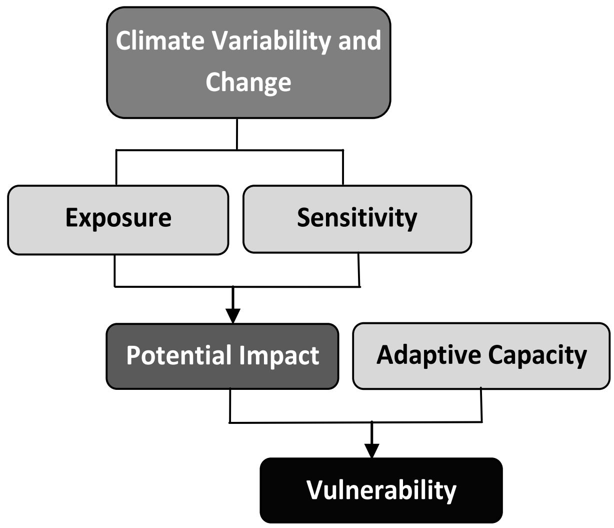
Exposure is considered as one of the core components of vulnerability in climate research (IPCC, 2001; Adger, 2006). Generally, exposure refers to the degree, duration and extent in which a system remains in contact with or is subject to hazards (Adger, 2006; Kasperson et al., 2005). That is, exposure refers to the background climate conditions and stimuli against which a system operates and any changes in those conditions (IPCC, 2001).

The IPCC special report (2012) elaborates the concept, focusing on context. It refers to exposure as:

> "…the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage" (IPCC, 2012:32).

According to these views, exposure is a vital component of vulnerability and should be included in climate vulnerability assessments (IPCC, 2012; Hahn et al., 2009). In addition to exposure, another important factor determining

Figure 1.2: Climate vulnerability and its components (modified from Allen Consulting (2005)



the vulnerability of a system to climate variability is its "sensitivity" to such climate and other perturbations when exposed.

Sensitivity

The IPCC Second Assessment report (IPCC, 1995:5) defines sensitivity as

> … the degree to which a system will respond to a change in climatic conditions (e.g., the extent of change in ecosystem composition, structure, and functioning, including primary productivity, resulting from a given change in temperature or precipitation).

The IPCC Fourth Assessment Report is more explicit, defining sensitivity as:

> … [the] degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC, 2007:881).

The IPCC fifth assessment report endorsed this definition of sensitivity but added …"or species" after the word system (IPCC, 2014). Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes (IPCC, 2001). The effects of these stimuli may be direct as when, for example, there is a change in crop yield in response to a change in the mean, range or variability of temperature, or indirect such as when an increase in coastal flooding results in growing salinization of soil, thus affecting crop yields (IPCC, 2001). Sensitivity of a system to climate induced perturbations is reflected as its "responsiveness" to the extent it is harmed or benefitted in relation to the degree of changes in the severity of that perturbation. For example, a variety of rice may be damaged if it remains inundated by flood water for more than five consecutive days while a flood tolerant variety can survive even if it remains submerged for ten consecutive days. The vulnerability of exposed systems thus varies according to the sensitivity of rice varieties to the spatio-temporal perturbations such as the number of days in which the rice is flooded

The figure 1.2 shows that exposure and sensitivity to climate stimuli together create a potential condition for a system to become vulnerable. However, vulnerability is also shaped by the capacity of the system itself to respond to exposure and sensitivity. This is captured by the term "adaptive capacity", which is the ability of a system to moderate harm.

Adaptive capacity

Adaptive capacity is defined as "…the properties of a system to adjust its characteristics or behavior, in order to expand its coping range under existing climate variability or future climate conditions" (Brooks 2003:8; Brooks and Adger 2004). According to the IPCC fourth assessment report, adaptive capacity is:

> the “ability (or potential) of a system to adjust successfully to climate change (including climate variability and extremes) to: (i) moderate potential damages; (ii) to take advantage of opportunities; and/or (iii) to cope with the consequences”(IPCC, 2007:869).

Thus adaptive capacity is considered a desirable property or positive attribute of a system to reduce vulnerability (Engle, 2011).

Operationally, adaptive capacity is the ability to design and implement effective adaptation strategies or react to evolving hazards and stresses so as to reduce the likelihood of the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards. Socioeconomic factors such as institutions, governance, and resource management are important elements in adaptive capacity. Some are generic (education, income, access to resources) and some are specific to climate induced hazards (local knowledge, technology). In summary, the more adaptive capacity a system possesses, the greater the chances of it being adaptive (or less vulnerable) to impacts of weather/climate stressors and thus is less vulnerable.

Another widely used concept in vulnerability and adaptation framework is the “copying capacity” which is often used as a synonym for “adaptive capacity”. Coping capacity is defined as:

> …ability of people, organizations, and systems, using available skills, resources, and opportunities, to address, manage, and overcome adverse conditions (IPCC, 2012:558).

The strengthening of coping capacities usually helps build resilience to withstand the effects of natural and human-induced hazards (UNISDR, 2004). Levina & Tirpak (2006:13) however, argue that “coping capacity” and “adaptive capacity” could mean the same thing if both concepts refer to the natural ability of a system to adjust to hazards, which implies that adaptation measures will further increase this ability. They go on to argue that adaptive capacity of a system differs from coping capacity, where adaptive capacity implies the extent to which the system is capable of adapting. Turner et al. (2003) distinguish “coping capacity” from “adaptive capacity” and regarded both as components of resilience of a system, while Smit and Wandel (2006) consider “coping capacity” to mean a shorter-term capacity just to survive and designate “adaptive capacity” for long term or more sustainable adjustments to perturbations. In this context, Levina and Tirpak (2006:13) clarified that, "coping capacity" of a system can be increased with adaptation measures while "adaptive capacity" (which is broader in scope) already includes "copying capacity", plus possible adaptation measures, and cannot be increased beyond a certain point when the system becomes vulnerable (Levina & Tirpak, 2006:13).

In climate vulnerability assessment another important concept is the "coping range", which is defined as:

> …the variation in climate stimuli that a system can absorb without producing significant impacts (IPCC, 2001:370).

In other words, the capacity of a system to accommodate deviations from "normal" climatic conditions describes the "coping range", which can vary among systems and regions. Beyond the coping range or critical threshold, the tolerance of the system is exceeded and it runs in to a vulnerable state (Fellmann, 2012).

Conceptually, adaptive capacity represents the potential of a system to adapt rather than actual adaptation (Brooks, 2003) which implies that through adaptation the coping range of a system can be expanded (or adjusted) further to adjust to a certain level in order to moderate climate induced threats. However, the coping range of a system has limits which may vary due to contextual features. Beyond a certain coping range a system becomes vulnerable even after adaptation measures have been implemented because adaptation has also its limits set by the adaptive capacity (Fellmann, 2012) of the system (Figure 1.3).

Within the vulnerability discourse, “resilience” is another concept that refers to the ability of a system to recover from the effect of shocks and stressors that cause harm (UKCIP, 2003). IPCC defines resilience as:

> The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change (IPCC, 2007:880).

According to the IPCC definition, resilience is closely related to “coping range’, as it emphasises the amount of change a system can tolerate. Klein et al. (2004) proposed that adaptive capacity be considered:

> …an umbrella concept that includes the ability to prepare and plan for hazards, as well as to implement technical measures before, during and after a hard event… and the resilience be treated as one property that influences adaptive capacity.

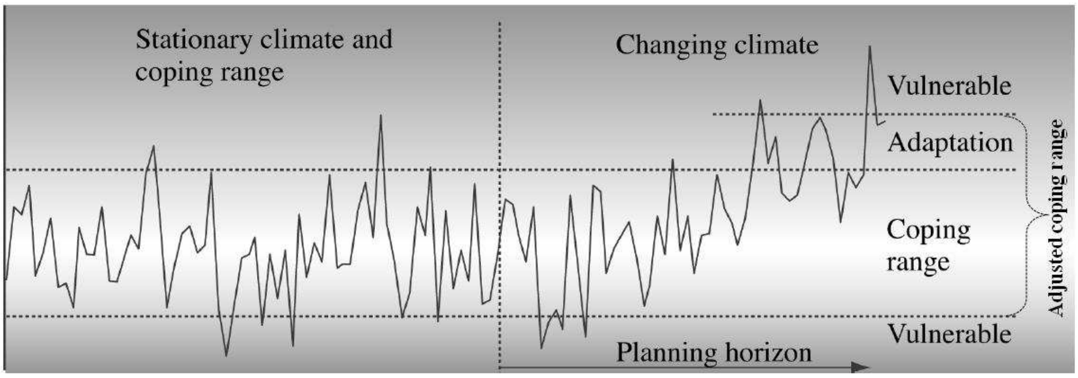


Figure 1.3: Relationships between climate change, coping range, vulnerability thresholds and adaptation (adapted from Fellmann, 2012).

In comparison to adaptation, resilience differs in meaning and scope as resilience involved a return to a state of equilibrium after a disturbance while adaptation (adaptive capacity) goes further to include making adjustments and realizing the benefits of disturbance. Thus, the latter is more robust and takes a longer term perspective and is of greater relevance to slow operating weather/climate induced threats.

Assessment of Vulnerability to climate change

In recent literature, there is greater emphasis on socio-economic factors, especially institutions, governance and management, as central in building the adaptive capacity of a system (Smith and Pilifosova, 2001; Brooks and Adger, 2004; Adger et al., 2007). Practically, the adaptive capacity of a system is subject to human actions that influence the biophysical and the socio-political elements of a system (IPCC, 2012). The emphasis on socio-economic factors plays a major role in distinguishing two broad approaches to vulnerability, that refer to outcome and contextual vulnerability. These approaches give different emphasis to natural and social components in assessing vulnerability.

One way of analyzing vulnerability is based on what is referred to as the ‘end point ‘consideration or ‘outcome vulnerability’ (Kelly & Adger, 2000; Fellmann, 2012; O’Brien at al., 2007). This approach seeks to assess and quantify the net impacts on a system after adaptation measures have been implemented. It focuses on the biophysical aspect of vulnerability and adaptive capacity and emphasizes technological solutions for adaptation and mitigation (new seeds varieties, improved technologies). The second approach is known ‘contextual vulnerability’. It considers vulnerability as the present inability of a system to cope with the changing climate (Figure 1.4). This inability is explained by social, economic, political and institutional conditions rather than biophysical aspects, although these latter play a role in the complex interplay between ‘nature’ and ‘society’. It can be said that the contextual vulnerability approach argues that it is the current vulnerability of the system in question to climate stimuli that determines the adaptive capacity of a system while the end point or outcome vulnerability approach focuses on how the adaptive capacity of a system determines its vulnerability. Socio-economic indicators of adaptive capacity include generic ones such as education, income and health while some are specific to particular climate-induced perturbations and also based on hazards of place such as coastal salinity and the presence of flashflood zones where institutional responses, local knowledge and technologies contribute to enhanced adaptive capacity (Adger et al., 2007).

One practical way to develop effective strategies to moderate weather induced hazards is to undertake actions to reduce current level of exposure and sensitivity of a system to weather stressors as well as to increase the adaptive capacity so that the system of concern can better adjust to the changed/ changing environment by enhancing its coping range. The present research uses the contextual vulnerability approach to assess the vulnerability of the two place-based communities to weather induced threats.

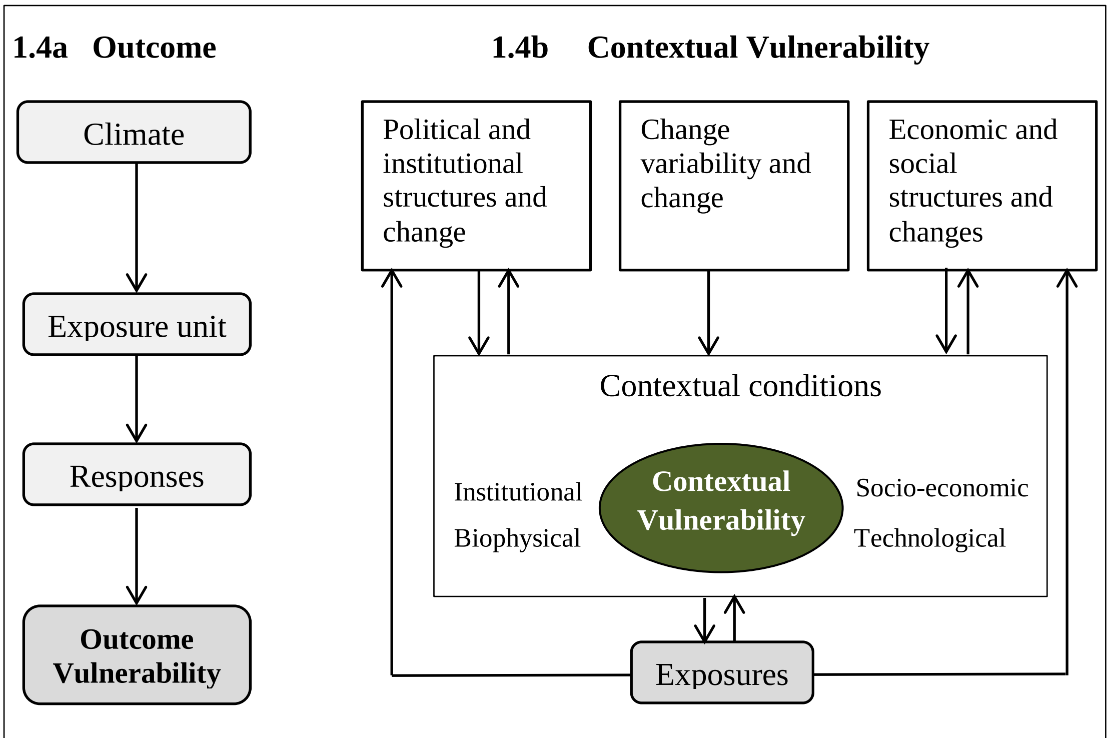


Figure 1.4: Two interpretations of vulnerability to climate change: (1.4a) outcome vulnerability, (1.4b) contextual vulnerability (Adapted from O'Brien et al., 2007)

Turning to how one makes assessments of climate vulnerability, there are number of frameworks and approaches found in disaster risk and vulnerability studies (Bohle, 2001; Patt et al., 2009). The main approaches include the double structure of vulnerability, sustainable livelihood approach, and pressure and release model. Double structure vulnerability approach encompasses an external (exposure to risk and hazards) and an internal component(capacity to anticipate, cope with, resist and recover from the effects of hazard stresses). The interaction of these components shapes the vulnerability of a given system (Bohle, 2001). This approach suggests that assessment of mere exposure to external hazards is not enough to determine vulnerability. Rather, the assessment needs to be conducted simultaneously to characterize relevant external and internal factors that collectively determine the vulnerability of a given system. Indicators of double structure vulnerability, therefore, include biophysical hazards (exposure) as well as the internal capacity of a system, which includes social, economic, political and institutional structures and processes that influence vulnerability. By contrast, the sustainable livelihood approach (SLA) focuses on sustainability and livelihoods issues. Key elements of SLA comprise five livelihood assets or capitals (. human, social, financial, natural and physical capital) including access to and control over such capitals by the marginalized groups to achieve livelihoods outcomes (Chambers and Conway, 1992). Here the vulnerability context is viewed as shocks, trends and seasonality and the influence of changing policy and institutional processes for the sustained livelihood strategies and outcomes (Chambers and Conway, 1992). However, access and control over productive capitals is subject to the capacity of the marginalized groups to maintain social relations and their empowered positionality in the local power structure. Hence the approach also covers the external (shocks, trends, seasonality, institutional policy and processes) and internal factors (capacity to maintain social relations and create niche in local power structure) and provides the potential to apply relevant indicators and processes in climate vulnerability assessment. Another approach is the Pressure and Release model (PAR) which focuses on disaster as the intersection of two forces, namely, processes that create vulnerability of a system and the natural hazard events that have potential to create disaster (Wisner et al., 2004). The PAR approach stresses that the vulnerability and development of potential disaster is the outcome of a process of increasing pressure and the opportunities to relieve the pressure. As such vulnerability of a system is generated under three progressive phenomena. These are root causes (social, economic, demographic political systems including power structures) that determine access to and sustainability of resource systems. These create dynamic pressures that comprise all processes and activities (skills, markets, resource degradations, soil and water productivity, rapid urbanization, land use changes etc.) that transform root causes into unsafe conditions such as people living in dangerous locations, unprotected structures and facilities, low income levels, irregular access to and availability of livelihood assets, lack of early disaster preparedness and warning systems, etc. Assessment of vulnerability of a system thus requires consideration all these conditions to be assessed in a given social-ecological setting.

The double structure and SLA approaches were found to be useful as these are based on and consider contextual vulnerability framework. Giving due consideration to contextual vulnerability, the Livelihood Vulnerability Index (LVI) model was developed by researchers at the University of Wisconsin, USA for assessing climate vulnerability. It was first used in an African context (Hahn et al., 2009) and draws on various relevant indicators under seven major components which make up the three contributory factors in vulnerability research of exposure, sensitivity and adaptive capacity (Hahn et al., 2009).

Livelihood Vulnerability Index (LVI)

Recognizing the multiplicity of factors that collectively constitute the climate vulnerability of local communities, the LVI approach provides a composite index to express climate vulnerability of a system in a given setting. The LVI uses the UNDP's human development index method that defines the quality of life of a nation based on multiple indicators expressed as a composite index. This method also draws inputs and adopted indicators from the sustainable livelihood approach (SLA), which has been shown to be useful in assessing the ability of households to withstand natural and human-induced shocks such as floods, cyclones, change of policy and institutional processes. While the SLA framework originally addressed aspects of sensitivity and adaptive capacity of households to environmental changes, it has been developed further to take account of a new generation of threats associated with climate variability and change (IPCC, 2007). The LVI approach also incorporates the external (exposure to hazards and socio-political vulnerabilities) and internal aspects (coping capacity of a system to anticipate, resist and recover from hazards) of vulnerability and related indicators as proposed by Bohle (2001) in his double structure vulnerability analysis.

The LVI approach integrates the exposure component of vulnerability based on site specific empirical data on climate induced hazards and stressors that have differential spatial and temporal effects on the livelihoods of different community groups. It uses multiple indicators related to climate induced hazards to assess the exposure component, various social and economic indicators to assess the extent of the adaptive capacity of local communities, and several indicators related to water, food and health to assess the sensitivity of the communities to climate hazards (Figure 1.5). Like SLA, a major advantage of the method is that it uses primary data collected through household survey and relies less on secondary data which often do not reflect the ground reality of specific sites at a given time. Data analysis has two stages. The first expresses the LVI as a composite index comprising of seven major components that constitute the climate vulnerability. Second, the data from the seven major components are aggregated into three vulnerability contributory factors such as exposure, sensitivity and adaptive capacity. The LVI is the subject of chapter 7.

Understanding adaptation to climate change

The discussion now turns to the concept of adaptation itself. It has become a central feature of contemporary development discourses and is regarded as a major option for developing countries to tackle impacts of climate change and climate variability (Huq et al., 2003; IPCC, 2007). Although adaptation has its roots in ecology in describing ecosystems' natural processes of adjusting to external stressors and maintaining normal functions (Berkes et al., 2003), it is now being increasingly applied to the interface between human and ecological systems and how human systems can accommodate the adverse impacts of anthropogenic climate change and climate variability.

Adaptation is defined and understood in various ways. The IPCC Second Assessment Report defines adaptation as:

> …the degrees to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in conditions (IPCC, 1995:5).

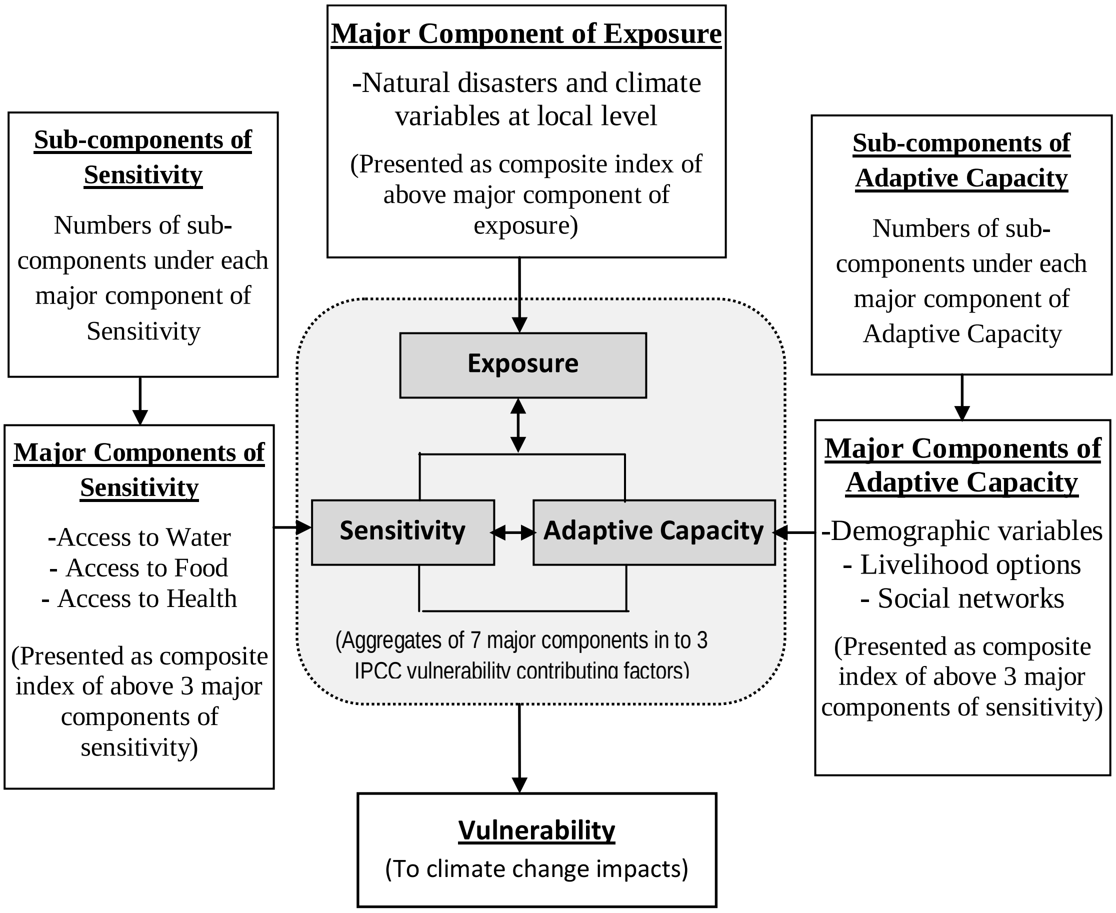


Figure 1.5: Schematic presentation of LVI approach of climate vulnerability assessment (based on the LVI approach of Hahn et al., 2009)

Smit et al. (1999:200) define adaptation as

> …adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts.

Brooks (2003: 8) defines it as

> …adjustments in a system's behaviour and characteristics that enhances its ability to cope with external stresses.

The UK Climate Impact Programme (UKCIP, 2003:111) refers to adaptation as

> …the process or outcome of a process that leads to a reduction in harm or risk of harm,or realization of benefits associated with climate variability and climate change.

This definition speaks of both "process" and "outcome" and explicitly mentions beneficial outcomes in addition to reductions in risk of harm. Smit and Wandel (2006:282) in consideration of human aspects, define adaptation as

> …a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity.

The definition focuses on “actions” aimed at reducing vulnerability which can be measured as outcomes (Maguire and Cartwright, 2008). IPCC Third Assessment Report (2001:365) provides a broader definition of adaptation as:

> …adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

This term refers to changes in processes, practices or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. Despite variations between these various definitions, all focus on a key aspect that through adaptation (whether a process or action or outcome) a system makes adjustment to and/or takes advantage of climate change induced perturbations. For the purpose of this research, I will be guided by the IPCC’s definition in examining adaptation actions or schemes at community and other organizational levels.

Assessment of local adaptation actions

There are a number of types of adaptation categorized according to their timing and spontaneity. For example, an adaptation action can be anticipatory or reactive (time of adaptation) as well as autonomous or planned (its degree of spontaneity) (Smit et al., 2000). The IPCC (2007:869) defines autonomous (or spontaneous adaptation) adaptation as:

> …adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.

In contrast, planned adaptation is defined as:

> …adaptation that is the result of a deliberate policy decision based on an awareness that conditions have changed or are about to change and

> that action is required to return to, maintain, or achieve a desired state.

Anticipatory or proactive adaptation is adaptation that is carried out or organized prior to any impacts of climate change being observed. An example would be the raising of pond dykes in anticipation of possible flooding. Reactive adaptation, on the other hand, takes place after the occurrence of a hazard as when people raise their homes on plinths after a flood. However, whether an adaptation is reactive or proactive depends greatly upon context and time. Reacting to an event can also be seen as a sort of planning for future events of the same sort. This research looks at the various kinds of adaptation practices in the two study villages in terms of these two adaptation continua.

In addition to a focus on specific adaptation strategies at the village level, the study's approach has been influenced by scholars and practitioners in the areas of collective action and ecological sustainability. In particular, two approaches stand out. These are community-based adaptation (CBA) and ecosystems-based adaptation (EbA). The concept of CBA originated from research on community-based development defined as development that includes local beneficiaries in its design and management (Ghazala and Rao, 2004:1). Ayers and Forsyth (2009:26) define community-based adaptation (CBA) as:

> Strategies …generated through participatory process, involving local stakeholders and development and disaster-reduction practitioners, rather than being restricted to impacts-based scientific inputs alone. As such, expertise in vulnerability reduction must come from local community-based case studies and indigenous knowledge of locally appropriate solutions to climate variability and extremes.

In theory, CBA or any community based development initiative focus on poorer and more vulnerable sections of the community with a view to engaging them as active agents in the process of adaptation and development, (Kates, 2000). Obstacles to such engagement include national and local political structure, expert-dominated policy and overarching and non-transparent institutional issues (Dodman and Mitlin, 2013). Dodman and Mitlin (2013:1) go on to argue that:

> CBA needs to recognise the considered experience of participatory development to date, particularly in relation to local involvement in project planning and implementation, as well as acknowledging the specific challenges raised by climate change. Without attention to risks and uncertainty, political structures and institutions, the necessarily multi-level nature of adaptation policy and programming, and the links between mitigation and adaptation politics and practice, outcomes of CBA interventions are unlikely to support pro-poor development.

The second approach gives greater attention to ecological sustainability as a central element of adaptation planning. This approach is often referred to as ecosystem based adaptation (EbA) which seeks to incorporate ecological concerns into planning as it is argued that ecosystems such as wetland, forests, coastal zone, and mangroves will be severely impacted by climate change resulting in a loss of ecosystem goods and services for local communities (CBD, 2009; Chapin et al., 2004). The core idea of EbA is to ensure the capacity of ecosystems to generate essential services for climate change adaptation and requires ecosystems to be managed as components of a larger adaptation landscape of which human activities are a part (Devisscher, 2010). It can be defined as:

> …management of ecosystems within interlinked social-ecological systems to enhance ecological processes and services that are essential for resilience to multiple pressures, including climate change (CBD 2009; Chapin et al., 2004; Piran et al., 2009).

EbA builds on increasing evidence that natural resources play an important and cost-effective role in adaptation (Colls et al., 2009; World Bank, 2009;). An optimal EbA strategy is based on maintaining ecological functions at the landscape scale in combination with multi-functional land uses and multi-scalar benefits for multi-occupational groups, including the extreme poor. It involves management of land use (rice, other crops, vegetables, strip and riparian vegetation) inter-tidal systems and functions (mangroves, biodiversity), wetland (fish ponds, shrimp *ghers*, sweet and saline waters, fish, crabs, mollusks, and shrimp Post Larvae (PL). Such management includes multiple occupational groups such as farmers, mangrove and wetland users.

EbA ensures healthy ecosystems and their flow of services that provide opportunities for sustainable ecological and economic outcomes while at the same time safeguarding people and ecosystems against the negative impacts of climate change and climate variability (Figure 1.6). I assessed the local adaptation actions through the lens of ecosystems services as proposed by the Millennium Ecosystems Assessment (MEA, 2005) which is elaborated in table 1.1.

Table 1.1: Types of ecosystems services and benefits

Ecosystem services	Type of services	Products and benefits of services
Provisioning services	Products obtained from ecosystems	Food, fuel, fodder, fruits, thatching, freshwater supply, grazing, genetic resources, etc.
Regulating services	Benefits obtained from regulation of ecosystem processes	Pollution control, regulation of biodiversity, water & air quality, water flow and flood control, pollination, carbon sequestration, etc.
Cultural services	Non material benefits obtained from ecosystems	Ecotourism, education and research, cultural heritage, recreation, religious values, etc.
Supporting services	Services necessary for the production of all other ecosystem services	Soil formation, photosynthesis, nutrient cycling, etc.

Source: MEA, 2005:40

Given the temporal and spatial uncertainties of climate change impacts it is important to see adaptation as a continuing process that is constantly subject to reflection and adjustment according to the changing dimensions of system stresses and responses over time. Some climate change impacts such as temperature and sea level rise happen slowly and their actual impact cannot be ascertained precisely at present, which makes it essential that adaptation planning is sufficiently flexible and multi-dimensional to deal with such uncertainty.

Much of the recent discussion of climate change adaptation has used a resilience framework with a focus on a system’s capacity to bounce back in response to climatic and non-climatic perturbations. Mark Pelling (2011) has sought to take the adaptation debate beyond this earlier focus by introducing a threefold scheme organized around the three concepts of resilience, transition and transformation. From the resilience perspective, Walker et al. (2004) explain adaptability as the capacity of people in a social–ecological system to build resilience through collective action while transformability refers to the capacity of people to move towards new social–ecological systems when ecological, political, social, or economic conditions make the existing system unsustainable.

According to Pelling (2011, 50), the resilient form of adaptation operates '…at the most contained level, seeking only change that can allow existing functions and practices to persist and in this way not questioning underlying assumptions or power asymmetries in society'. In contrast, transformative adaptation is defined as the '…deepest form of adaptation indicated by reform in overarching political economy regimes and associated cultural discourse on development, security and risk'. The transitional form is regarded as '…an intermediary level of engagement, focusing on the governance regime but through acts that seek to assert full rights and responsibilities rather than make changes in the regime'.

Pelling's focus on what he calls scope and range of change in values, institutions and behavior offers broad guidelines for shifts from resilience building to transformative adaptation via transitional strategies (Table 1.2). This framework identifies some critical attributes and hierarchies in three different but inter-linked forms of adaptation to climate change. The scope and policy focus at the first stage of resilience requires changes in technologies, management practices and organizations such as new and stress tolerant seeds, early or late varieties of crops, crop diversification, and changes in farming practices. It takes a largely managerial approach at the grass roots using technological adjustments rather contesting rights, governance and institutional and policy adjustments.

Table 1.2: Attributes of adaptation for resilience, transition and transformation (Pelling, 2011,51)

Hierarchy	**Resilience**	**Transition**	**Transformation**
Goal	Functional persistence in a changing environment	Realize full potential through the exercise of rights within the established regime	Reconfigure the structure of development
Scope	Change in technology, management practice and organization	Changes in practices of governance to secure procedural justice; this can in turn lead to incremental change in the governance systems	Change overarching political-economy regime
Policy focus	Resilient building practice Use of new seed varieties	Implementation of legal responsibilities by private and public sector actors and exercise of legal rights by citizens	New political discourse redefine the basis for distributing security and opportunity in society and social-ecological relationships
Dominant	Socio-ecological	Governance and regime	Discourse, ethics and

analytical perspectives	systems and adaptive management	analysis	political-economy

The transitional form goes beyond this and seeks changes in governance practices, contesting legal responsibilities of private and public actors and the exercise of citizens' rights. The transformative form requires overall changes in the wider national and even global political economy regime and a redefining of the relationship between citizen, state and environment. I use this three-stage adaptation framework for analyzing the adaptation schemes undertaken by the communities in Another and related framework is proposed by Kates et al. (2012) that draws on the concept of transformation. They argue that much adaptation is piecemeal and short term, what they refer to as incremental adaptation, which they describe as '…doing slightly more of what is already being done to deal with natural variation in climate and with extreme events. Such adaptation may not be sufficient to deal with certain climate-related events or processes that have the potential to overwhelm even best practice at this level. They provide an adaptation continuum with distinct stages based on various features, which include intended goals and the robustness of adaptation packages to environmental and climate changes. While incremental adaptation has limits in that it may be unable to address the effects of robust environmental changes on society and environment, transformational adaptation involves much larger intervention packages in terms of their novelty, scale, temporality, resource use, and institutional arrangements (see Chapter 8).

Adaptation readiness

An important consideration in adaptation planning is the readiness of local communities to carry forward adaptation actions on the ground. Adaptation readiness is a new concept in the broader adaptation literature complementary to adaptive capacity that focuses on ensuring the existence of enabling governance, policy and institutional environment and related capacities to facilitate planning and implementation of adaptation actions (Ford and King, 2013).

It is based on the argument that unless all supportive factors are enabling and ready at national, sub-national or local (community) levels, effective adaptation strategies are unlikely to be implemented and, if they are, they will be less sustainable over time. Ford and King (2013:5), who have done the pioneering work on this topic, define adaptation readiness as:

> …the extent to which human systems (e.g. nations, regions, businesses, communities, etc.) are prepared to adapt, providing an indication or measure of the likelihood of adaptation taking place.

They propose a framework that points to the existence of several barriers that may affect the implementation of adaptation schemes even where the necessary adaptive capacity is in place. In their view, adaptation is not only a technical matter but includes political, social, institutional and governance issues. Trust and commitment are considered central to successful adaptation and it is important to build up the appropriate institutional framework that maximizes these core values. The concept is particularly useful in the current research as many members of the local communities studied have no or low trust in local government and local level central government officials. Raihan et al., (2010) documented that local communities in Bangladesh claim that the upazila and district level government officials seldom pay visits to their locality and help solve their day to day problems related to their livelihoods, health, disaster and other issues. Corrupt practices in disaster relief and rehabilitation activities in cyclone Aila[1] response and recovery activities in the coastal zone created distrust among communities and institutional actors which affected adaptation readiness on the ground and impaired the taking place of effective adaptation (Raihan, et al., 2010: Mahmud and Prowse, 2012).

[1] Cyclone Aila hit the southwestern coast of Bangladesh on 25 May 2009.

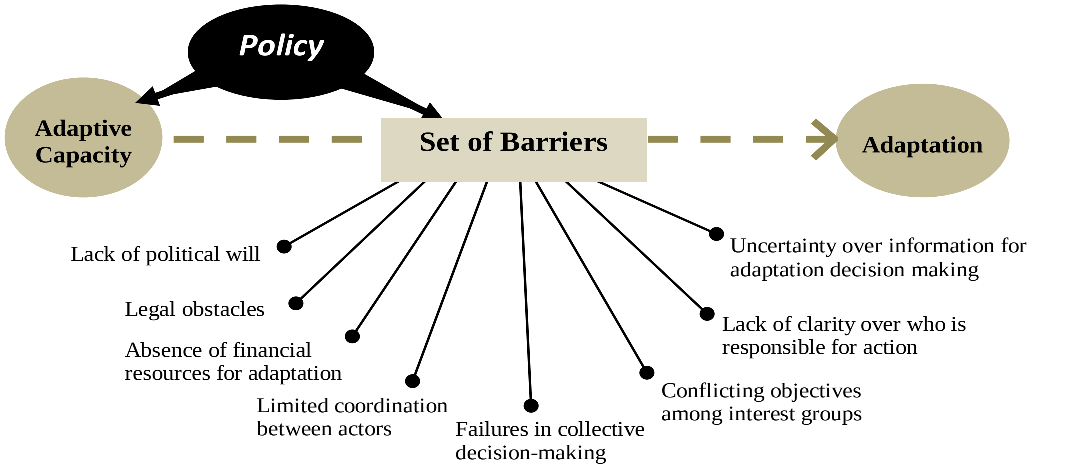


Figure 1.7: Conceptualization of the links between adaptive capacity and adaptation in an adaptation readiness framing (adapted from Ford & King, 2013)

The concerns expressed by Raihan and his colleagues informed this research in that it looks at local or community level adaptation readiness aspects and analyses various relevant issues. These include awareness of and compliance with relevant state laws and acts, performance of relevant government agencies mandated for local development, community attitudes towards adaptation and their trust in local and central government officials and their capacity and transparency in implementing adaptation schemes.

Adaptation readiness goes beyond evaluating adaptive capacity, which gives a picture of the theoretical potential of adaptation, and is concerned with whether supportive measures and conditions exist for adaptation. In general sense it is argued that if a system has enough adaptive capacity, it is more likely that the system can better adapt to environmental changes in a given setting. However, a system may have adaptive capacity but whether that capacity can be translated into adaptation action is another matter. There may be institutional and other constraints and barriers on translating adaptive capacity into actual action within a particular system of interest (Figure 1.7). Adaptation readiness is concerned with the overall preparedness of all related social and institutional systems to support planning, designing and implementing adaptation actions on the ground. This concept cross-cut the resilience-transformation continuum discussed earlier as it refers to the translation of adaptive capacity into actual action for either resilience or transformation.

Ford & King (2013) propose a national level framework for adaptation readiness comprised of six overarching factors that contribute to enhancing adaptation readiness. These are political leadership, institutional organization, adaptation decision making and stakeholders engagement, availability of usable science to inform making, funding for adaptation, and public support for adaptation.

Drawing on Ford and King, I used a set of six different readiness factors and related indicators for assessing local level adaptation readiness (AR) in the context of thestudy sites Figure 1.8.

Place of my research

This chapter introduced the broad objectives of the research and its place within current debates and themes on climate change adaptation in Bangladesh and internationally. It looked briefly at some of the key ideas and concepts in adaptation research and their relevance to the current study. The concepts of climate change and climate vulnerability were discussed followed by an examination of the concepts of vulnerability, adaptation, adaptive capacity, and CBA, EbA and adaptation readiness. Attention was given to gaps in research and policy on climate change adaptation in Bangladesh. The rest of the study focuses on the ways in which the inhabitants of two coastal villages understand and respond to changes in their socio-ecological environment. Chapter 2 describes main research approaches, methods and tools used in the study. Chapter 3 introduces the study area in the southwestern coastal zone of Bangladesh including its biophysical and social environment. Information and data presented in this chapter are drawn locally through primary survey. Chapter 4 draws on primary and secondary data to describe the local area context in terms of impacts of previous development interventions in the research

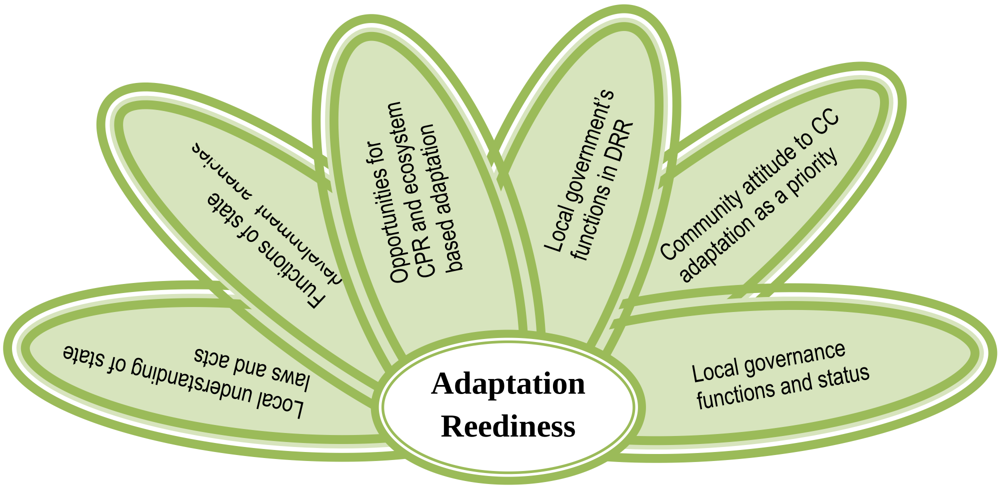


Figure 1.8: Conceptual model of local level adaptation readiness adopted for the research

sites themselves and wider region as a prologue to a discussion of the impacts of a new generation of threats associated with climate-related changes.

Chapter 5 examines community perceptions and understanding of climate change as a new generation of threats to local people's lives and livelihoods. It presents findings based on extensive primary data gathered through a KAP survey of village communities, local government representatives, primary school teachers and local staff of NGOs working in the area. Chapter 6 describes community observations and concerns relevant to the effects of climate change and climate variability on the livelihoods of various occupational groups in the study area. It shows that the villages and the different occupational communities they contain have different concerns over various climate induced problems affecting their lives and livelihoods and the relevance of these differences for local adaptation programme development.

Chapter 7 analyses the livelihood vulnerability of the communities of the two project villages considered as case study sites for the research. The livelihood vulnerability index developed for the two villages is based on primary data collected from the relevant villages supplemented by climate related data from the local Meteorological Department. Chapter 8 presents community efforts, sometimes supported by outside agencies, to adjust to or cope with the local environmental changes brought about by climate variability and change. It also examines the annual development plans of local government (UP) and governmental agriculture extension services at local level including a brief analysis of barriers to adaptation in the area.

Chapter 9 focuses on issues relevant to "local adaptation readiness" in the area. It seeks to highlight the extent to which the project communities and mainstream development agencies of the central government are aware of the adaptation measures needed to adapt to the impacts of a new generation of threats and uncertainty associated with climate change and climate variability. This chapter is largely based on primary data collected through applying KAP survey. Chapter 10 summaries the key findings of the project and makes some recommendations for future research. The next chapter summarises the study approach, methods and tools.

Chapter 2:
Methodology

Introduction

This chapter describes the overall research approach including the flow of information and data sources and analytical aspects that I adopted in conducting the field research during the course of my study. It begins by describing the research approach, criteria for selecting case study villages and the different qualitative and quantitative methods and tools used, which included GIS base mapping of land use change in the study villages. The period of field research was from mid-2010 to early 2012. Finally it presents the data analysis methods used.

Research Approach

The research was carried out in the southwestern coastal zone of Bangladesh at the southern edge of the Lower Ganges Delta (LGD) that merges with the Sundarbans Reserved Forest (SRF). Case studies on two place-based communities in the sub-district of Shyamnagar under Satkhira district form the core of my research approachand the sources of primary data. I selected two case study villages purposively from a range of possible sites in the area in alignment with my research objectives (Miles and Huberman, 1994). The case study villages were intensively studied and I generated robust data sets on different social and occupational groups on livelihoods, land use changes, disaster and climate or weather induced threats and the like (Curtis et al., 2000).

I was assisted in my field work by two part time Research Assistants (RAs), Mr. Shahidul Islam and Mr. Nur Hossain of CNRS (Center for Natural Resource Studies), a Bangladeshi pro-environmental NGO that operates in different parts of the country including Shyamnagar where I conducted the research. Mr. Islam is a graduate in social science and has over 10 years of work experience in the area of community-based natural resources management (CB-NRM) at the field level. Mr. Hossain holds a diploma in agriculture with 3 years work experience in agriculture and micro-credit. Hossain transferred to another part of the country and was replaced by Mr. Pintu Biswas (Diploma in Agriculture). As paid employees of

CNRS their living and travelling costs were paid. However, we often shared meals, the costs of which were met by me.

During initial orientation session the RAs received training on various technical and methodological aspects of the study and field work. One particular question asked by one of the RAs was the purpose and relevance of the research. My response was that the research had both academic and policy aims and that the relevance of the research to these aims would become clearer as the project progressed. I started my field work with an open mind aiming to explore the project's research questions, which necessitated the use of a variety of research approaches and techniques. To this end, apart from using quantitative methods, I relied heavily on qualitative methods of data gathering which allowed me to explore more deeply local issues related to historical change, changes in land use and livelihoods patterns, and community responses to disasters and local environmental changes caused by climate and non-climate related stressors and extremes. Figure 2.1 summarises the detailed data collection steps and methods.

My case study approach included Focus Group Discussions (FGDs), Key Informants Interviews (KII), transect walks, participants observation, pair wise rankings, trend analysis and participant observation. These were applied in different time periods with different sub-sets of communities in project villages. For example, I conducted field work in Fultala village earlier than that of Chakbara village as Chakbara had been severely affected by cyclone Aila in May 2009 and the whole village remained inundated with tidal saline water until early 2011. Initially I conducted several KIIs with elderly people of the village including women involved in different occupations such as fishing, shrimp post larve (or shrimp PL) collection, shrimp farming, honey collection and crab collection. This gave me a broad understanding of the context of the village in relation to disaster vulnerability, impacts of cyclone Aila, embankment management, land use and livelihood changes over time and livelihood dependence of people on the resources of Sundarbans Reserved Forest (SRF), including primary understanding of climate (or weather) variability related issues. Based on this primary understanding of the relevant context of the areas in relation to my research objectives, I finalized the data collection tools, checklists and drafted questionnaire for quantitative surveys.

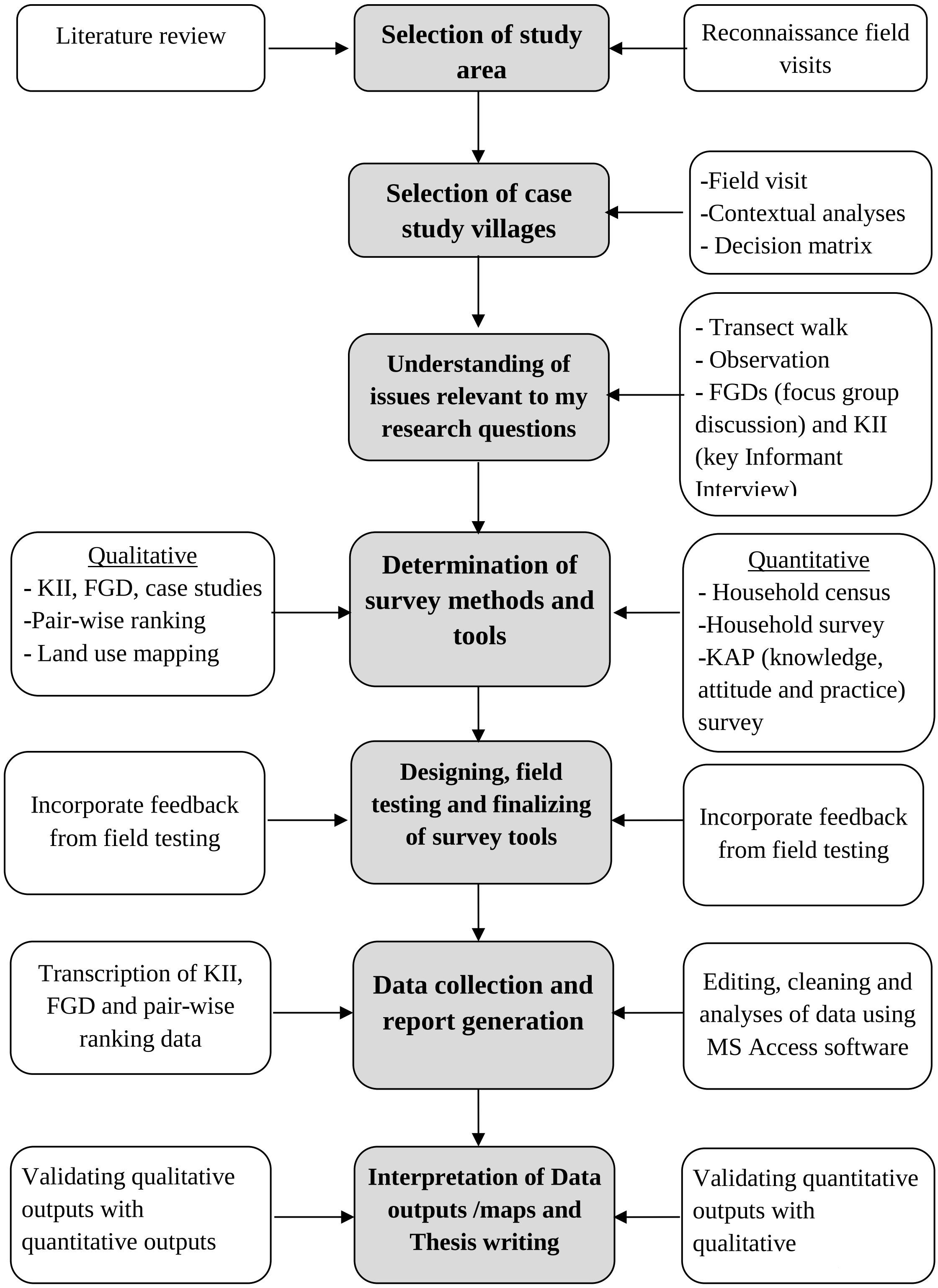


Figure 2.1: Schematic presentation of research methods and tools used in the study.

Selection of case study villages

With a view to select project villages for conducting in-depth studies I visited several villages in Shyamnagar upazila (sub-district) and gathered information on village and place based communities. The seven villages visited were both similar and different in some respects and on the basis of these preliminary investigations I developed a decision matrix that helped me select two case study villages-Chakbara and Fultala- in two unions of the sub-district (Table 2.1). I chose two villages that were spatially close to each other (12 km) but were differentially located in a range of other variables such as exposure to flood, livelihood sources, and wealth. Chakbara is located in Gabura union and has an island-like appearance as it is surrounded by large rivers at the southernmost tip of the sub-district and bounded directly by the SRF on the south and southwest. The village is distinctive in that a majority of the land is under salt water shrimp farming and mostresidents are dependent on natural resources derived from the rivers and the SRF. The village has 200 households engaged in a range of occupational activities. Soil and water salinity is a major concern of the village due to its location on the bank of a large tidal river, which makes it highly exposed to multiple coastal hazards. Cyclone Aila severely affected the village and it remained inundated with saline water for several months. By contrast, the second village, Fultala, is located on the mainland under Mirjapur union in Shyamnagar sub-district and relatively less exposed to coastal hazards as it is three km away from a tertiary tidal river protected by embankments. Over 90% of village land is under traditional rice farming and salinity far less of a problem than in Chakbara. No villagers relied on the SRF for their livelihoods although the forest is less than 3 kilometers from the village.

Table 2.1: Two selected project villages based on reconnaissance field visits in June-July 2010

Villages	Features	Remarks
Chakbara (Gabura Union)	- Located along the south-western edges of Kholpetua River inside the embankment and opposite to Neeldumur ferry ghat - 187 households with diverse occupations viz. shrimp farming, fishing, crab, nypa/wood, honey collecting , shrimp PL catching, fish trading, *gher* labouring, petty trading, etc. - Highly vulnerable to cyclone, erosion and	-Major land use is salt water shrimp farming -Villagers are more depend on extraction of various resources from rivers and SRF -Highly exposed to coastal hazards

	coastal flooding - Severely affected by the cyclone Aila in May 2009, embankment breached and the entire village remained inundated for 18 months	
Fultala (Munshigonj union)	- Located in the mainland on both sides of Dhaka-Munshigonj highway nearly 3km off from coastal rivers -237 households, most rice farmers with 11 involved in shrimp farming, wage laboring, petty trading, rickshaw pulling - People in this village do not go to SRF for livelihoods - Highly vulnerable to drainage congestion, rain based flooding and drought	-Major land use is rice farming -Higher dependence on farming, wage laboring -Less vulnerable to cyclone hazards compared to that of Chakbara

Survey methods

The qualitative research approach played a central role in describing and understanding people's and social or occupational groups' particular situations, experiences, and meanings beforedeveloping and/or testing more general theories and explanations (Frankel & Devers, 2000). It allowed me to explore the socio-ecological context, widen my understanding of issues around climate change, and gradually guided me to develop a more 'experience-rich' perspective relevant to the research objectives. My approach is well captured by Sofaer (1999):

> The qualitative research … is often developmental; it begins with exploratory study and gradually moves toward more structured research design as knowledge increases (Sofaer 1999).

Qualitative research involves the systematic use of avariety of empirical materials, case studies, personalexperience, life stories, interviews, observational, historical, interactional, and visual texts that describe routine and problematic moments and meanings in individual lives. It uses a broad spectrum of interconnected methods to provide a betterunderstanding of the research questions (Massucci, 2013). On the relative value of qualitative versus quantitative methods of field data collection, Carvalho and White (1997) comment:

> The quantitative approach typically uses random sample surveys and structured interviews to collect data – mainly, quantifiable data – and analyzes it using statistical techniques. By contrast, the qualitative

> approach is defined as one that typically uses purposive sampling and semi-structured or interactive interviews to collect data – mainly, data relating to people's judgments, attitudes, preferences, priorities, and/or perceptions about a subject – and analyzes it through sociological or anthropological research techniques.

They conclude that both methods have strengths and weakness. The strengths of quantitative method include making data aggregation possible, providing data and results whose reliability is measurable and allowing simulation of different policy options. The weaknesses include sampling and non-sampling errors, missing what is not easily quantifiable and failing to capture intra-household issues. By contrast, the strengths of qualitative methods are that they allow for a more contextually grounded and richer definition of concepts such as "drivers of change" in complex social ecosystem systems, they give more insight into causal processes, and provide more accurate and depth of information ('thick description') on certain questions. Their weaknesses include lack of generalizability and difficulties in verifying information. Carvalho and White (1997) and McGee (2000) characterize quantitative approaches as having breadth and qualitative approaches as having depth. This study combines both approaches in an attempt to ensure a balance between the diversity of local experiences and changes and the specific and in-depth particularities of such experiences and changes.

Qualitative Methods

Key Informant Interview (KII)

Climate change is a new topic of research, more particularly, in rural setting where the word climate seems abstract to the majority of local communities. As a means of tapping local people's understandings of climate or weather related problems and issues, one of the methods used was that of the KII. Being an outsider, I first explored the study villages and their environs, paying particular attention village livelihoods, and their historical and present-day experiences of natural and human-induced hazards, disaster events and processes and the wider issue of climate change. A KII is an established qualitative survey tool that involves face to face discussions/interviews with local persons who have good knowledge of the area, can provide important insights into local worlds and can also assist as gatekeepers, facilitating access to people, events and information (Jimenez, 1985). Using an open-ended, semi/unstructured checklist based interviews, KII enabledme as an outside researcher to gain many insightsinto local problems and issues, to raise questions, and to analyze phenomena from different perspectives (Bogdan and Taylor, 1975; Okamura, 1985). These informal interviewswere important in designing FGD checklists, adjusting the number of focus groups to be discussed and finalizing the structured interview schedule (Bryman, 1988).

In the first year of research, I conducted 29 KIIs using semi structured interview checklists with representatives of various institutional stakeholders at the field level (Table 2.2). A range of techniques are available when conducting KII. These are informal talks, personal interviews, formal written questionnaires, telephone interviews, group interviews or community forums and public hearings (McKillip, 1987). I relied on informal talks and personal interviews of the key informants using a flexible checklist.

I and my RAs conducted all the semi-structured interviews except those with field level BWDB (Bangladesh Water Development Board) officials which were done by the RAs. For the local and international NGOs, I focused on their current activities on disaster risk reduction and climate change adaptation, their understanding of local vulnerability and initiatives taken by local communities in managing hazards and other concerns. With government officials from departments of forests, agriculture and fisheries I emphasised on their observation of climate related problems in the locality and their current programmes/ activities to address climate related problems in fisheries, agriculture and forests. Among the main issues of concern among both officials and local people were shrimp farming versus rice farming, climate, fisheries and agriculture, the status and abundance of various non-timber forest products (NTFPs) of the SRF (fish capture, crabs, honey, nypa palm, catkin grass) and problems related to access to SRF. The latter included the management of fisheries in the SRF and the problem of increasing numbers of tiger attacks and were the key discussion points with the local forest department staff.

At the outset of all interviews, I disclosed the purpose of the interview and objectives of my research work before proceeding further. We used checklists as a guide while interviewing respondents at government, NGO and community levels including facilitating FGD sessions. Table 2.2 provides a summary of the number and types of main stakeholders involved in the KIIs.

Table 2.2: Institutional stakeholders for key informant interview (KII)

Institution /projects	**N=29**
Local/National NGOs	6
International NGOs	3
Local Agricultural officials	4
Local fisheries official	1
Local Forest Officials	2
Local BWDB officials	2
Donor supported project staff	2
Primary school teachers	5
Local Government representatives	4
Local fish traders /*Mohajans*	3
Local land surveyors	2

The interview time was around 70 minutes with the government officials and local stakeholders (fish traders, UP members, land surveyors, school teachers) and around 90 minutes with NGO field level staff, although some sessions lasted longer. An example of the interview approach can be illustrated with the following example. Where a person stated that soil salinity was still a problem after two years, he was asked questions such as: "how did you know that there is still salinity in the soil"? "To what extent does salinity affect crops and which crops are more sensitive to such salinity?" I used checklists to conduct the interviews in Bengali and the discussion outcomes were hand written on note pads and later transcribed onto lap top computer. In most interviews, I asked questions and my RAs took notes.

Focus Group Discussions (FGDs)

The focus group discussion (FGD) is one of the most commonly applied rapid assessment tools in the PRA tool kit, in which participants brought together for a group discussion discuss the matter at hand. In this study, people of the same occupational group discussed issues and concerns following a guiding checklist of key themes drawn up by the researcher. When combined with other qualitative tools (viz. transsect walk, historical trend), FGD provides more indepth information on various social and developmental issues (Morgan, 1997). I conducted FGD sessions with different occupational groups in project villages and relied substantially on the outcomes of FGDs to widen my understanding of the issues. Based on my field observation through transect walks, rapid appraisals and semi structured interviews, I identified nine different occupational groups in the two project villages for future FGDs (Table 2.3).

The FGD sessions were conducted at village level as well as at the CNRS office located at Munshigonj Bazar, 3 km from Fultala and 9 km from Chakbara. My first attempt to hold the FGD session with women in Chakbara village failed due to the intervention of a male person from the village. He took it upon himself to speak for the women. We repeatedly requested him to stop and to allow the women to speak to which he replied that they knew nothing about the issues under discussion. I stopped the session and brought the women to the CNRS office to continue the FGD.

Each FGD session lasted around three hours, including introduction and explanation of the purpose of the session. The actual time taken exceeded in most cases our original intention of completing FGD sessions in two hours. In addition to invited attendees of six to eight people, in most sessions sometimes up to five other persons sat in voluntarily. Sessions were carried at the CNRS office at Munshigonj Bazaar of Shyamnagar upazila and at village level. Participants who came to CNRS office were offered a lunch and transport. Group discussions in Bengali were recorded instantly on large brown paper sheets by the RAs and later transcribed into English on my laptop. Table 2.3 lists characteristics of the FGD participants. The bulk of participants were men, although women from rice farming and shrimp PL collecting households were also involved.

Table 2.3: Participants of FGDs and pair wise ranking of climate induced problems

Occupational groups	**Village**	**N= 60 (FGD participants)**
1.Rice farmers	Fultala	7
2.Women (Rice farming households)	Fultala	8
3.Shrimp farmers	Chakbara	7
4.Shrimp and rice farmers	Fultala	7
5.Sea going fishers	Chakbara	6
6.Women shrimp PL collectors	Chakbara	6
7.Fishers fishing in rivers and SRF	Chakbara	7
8.Honey collectors	Chakbara	6
9.Crab Collectors	Chakbara	6

With the FGD participants I conducted a pair wise ranking exercise of climate induced problems facing different occupational groups in the villages. Pairwise ranking is an effective PRA tool in social development studies to identify or assess priority problems or solutions from a number of options or alternatives. Some researchers also use this tool in climate change adaptation research in prioritizing climate related problems and priority adaptation options (Ndathi et al., 2011; Codjoe et al., 2011). I divided the FGD topics into two parts. In the first part, I discussed the climate related problems they observed and encountered in their daily lives, including in their work. In the second part, I used the pair wise ranking tool to prioritize climate related problems by different occupational groups. The major part of chapter 6 is based on the findings of the FGD and the pair wise ranking exercise.

Case studies and participant observation

I conducted several case studies on specific issues relevant to the two project villages. These included the drivers of changes in village land use over time such as embankment construction, breaching and maintenance in Chakbara village, land grabbing and conversions of state owned canals and rivers in Fultala village and their impacts on local social ecological systems.

The case studies brought to the surface some of the main institutional structures and practices that underlie the activities of village people. They help to reveal the unequal distribution of valued resources and how this inequality is manifested in daily practice. For example, *dadon* is a traditional money lending system in the country usually practiced in remote areas where levels of poverty are high. In the coastal areas the *dadon* system is an age old practice where official or formal loans and credit systems are inadequate or absent. In the case of fishers, *mohajans* or money lenders usually provide advance credit to poor fishers and other resources with exorbitantly high interest rates and with other conditions. To understand how this system works, I conducted a case study of fisheries *dadon* system and held several meetings with *mohajons* as well as *dadon* receiving fishers. The results of this case study can be found in chapter 7. In addition to case study interviews, I made systematic field observations and KII with the help of village level maps (CS maps and hard copy Google maps).

Participant observation was applied at various times, especially in observing climate resilient rice farming practices where farmers were trained to identify harmful insect pests under a CNRS project on community based adaptation in agriculture. Farmers showed me the insects harmful to rice and named the pesticides commercially recommended to control such pests. I also observed women in Fultala village where they collected wild vegetables from the edges of wetland, fallow crop fields and pond banks for cooking. I learned that in the past there were some 15 different types of wild vegetables available in the area regularly collected by the women for cooking but were under threat due to land use changes and salinity problems. I also learned that higher temperatures than normal caused problems for shrimp and white fish in the *ghers* of Fultala village caused by shallow water depths. These few examples illustrate the relevance of the case studies and participant observation in the project research process.

Quantitative methods

I also conducted quantitative surveys in two study villages to gather relevant data for the livelihood vulnerability index (LVI) to determine the extent of village level vulnerability to weather/ climate variability and change. These surveys generated considerable numeric data used to quantify the outcomes and to complement the qualitative techniques used.

Village census

Two sets of quantitative survey were conducted at the village level. The first was a household census in the two project villages aimed at collecting data on selected attributes from every household in the villages (Table 2.4). The household census data from Chakbara (247 households) and Fultala (178 households) helped to develop a household profile of the communities in both villages and to sort them by social and occupational groups. These occupational groups were then involved in the FGD sessions discussed earlier.

Table 2.4: Data collected through household census from two study villages

Broad areas	**Types of data collected through census**
Household demography and education	Number of family members by age and sex, level of education by age and sex
Occupation /Livelihoods	Primary and secondary occupations by age and sex, ownership of fishing nets and gears
Ownership of Land and land types	Acres of land owned per household, size of land by types viz. homesteads, crop land, ponds, shrimp farms, fallow
Housing, health and	Number of family units per households, housing materials and

sanitation	types of latrines, illness of family members in last one year
Access to capital and crisis period	Loan and *dadon* taken in last year, months facing crisis, struggle for food
Livelihood skills	Types of skill training received and key livelihood problems
Disaster exposure and response	Access to early warning messages, extent of exposure to disasters

Households Questionnaire Survey

After conducting the household census samples were drawn by using a simple random numbers table. A total of 45 households were selected from each village for the more detailed survey. I collected various socioeconomic, disaster and climate related data for the LVI based on Hahn et al. (2009) from their work in Mozambique. The household survey was designed to capture data on three climate change vulnerability contributory factors, namely, exposure, sensitivity and adaptive capacity (IPCC, 2001). Before administering the household survey, I field tested the questionnaire and made necessary adjustments based on the findings of field testing and feedback received from the RAs. Details of the LVI and types of data collected through household survey are presented in Appendix1.

Knowledge Attitude and Practice (KAP) survey

A quantitative survey was used to capture data on knowledge, attitude and practice (KAP) of the wider community groups in the area. The objective of KAP survey was to document the information base on the knowledge, attitudes and practices regarding climate or weather change among the wider communities in the project area over timeKAP studies have become increasingly popular globally in research on climate change (Rawlins et al., 2007; CME, 2011; CIMC, 2012). KAP participants included village communities, local government representatives, primary school teachers and field staff of NGOs. The number and type of participants in the KAP survey were:

i)	Communities of two villages	: 90 households
ii)	Primary school teachers	: 21 teachers from 21 schools
iii)	Local government representatives	: 24 UP members from two unions
iv)	Field level staff of NGOs	: 20 NGOs

Structured pre-coded questionnaires were used to conduct the KAP survey. The questionnaire had three broad sections: current knowledge of stakeholders on climate change issues; their attitude to relevant climate change issues in relation to local perspectives; and current local practices that either address or have potential to address climate change induced problems in the area. The KAP findings are presented in chapters 5, 6, 8 and chapter 9.

Village Level Land Use Change Mapping

The project villages have both undergone changes in village characteristics and land use patterns over time. To capture the historical changes in the village, I carried out detailed mapping of the villages using maps and checklists. The mapping of various villages attributes were done using micro level parcel maps (CS – Cadastral Survey maps) collected from the Directorate of Land Records in Dhaka and used in documenting at village level land use patterns existed in1970. Relevant village level attribute data were recorded in data record forms as well as various attribute data/ signatures wiredrawn on the maps directly using different color pens. The CS maps with marked signatures (polygons, lines) of attributes were then scanned and digitized on screen using GIS technology (ArcGIS 9.3 and ArcView 3.3 softwares). The final maps were produced by the GIS Analyst at the CNRS through colour codes of polygons and lines and the areas of polygons were quantified for making inter-village comparisons with relevant recent attributes. The mapping activity in the villages and environs was carried out by the RAs with the help of local land surveyors (locally called *Amin*).

To document the current (2012) land use patterns and resource systems of the villages, mapping was done using recent Google maps (2012). The old CS maps and recent Google maps were then compared to depict the changes in village attributes, including land use, between 1970 and 2012. Before starting the fieldwork, Google maps of project villages were digitized onscreen based on the identifiable image signatures (such as ponds, settlements, rivers, and canals, which are easily identifiable in satellite images). The digitized Google maps were then verified in the field for accuracy. I used two types of base maps for capturing village attributes: the CS maps of 1970 to capture land uses in the past, and a Google map of 2012 for mapping the current situation. Figure 2.2 shows a partial view of Fultala village with steps that I followed to produce the land use change maps using the CS maps and Google maps.

Addressing sensitivity in the field

The project adopted several techniques to minimize or avoid unwanted problems, disturbances and non-responsiveness of respondents. For example, people who occupied *khas* land and built homes illegally on river banks, road side slopes and boro pits/ ditches were unwilling to answer questions related to the legal status of their homes and their rights over land and ditches. Most claimed the land was recorded in their names and thus they were legal owners. We cross-checked this information regarding legal ownerships of such land with other villagers and found that most of the houses were built on *khas* land illegally, and the road side borrows pits were illegally grabbed through bribing local officials and other influential people.

Another sensitive issue was that of banditry in the SRF. Bandits have been known to take people hostage and demand ransom money from fishers, honey collectors and other SRF resource users. FGD participants in Chakbara were hesitant to talk about the issue as they feared reprisals. The research team itself was possibly under threat as we were told that there were many agents/allies of the bandits among the local population. In order to minimize the concerns, we asked about security related issues when in the SRF for fishing or collecting other resources. We changed the wording of questions in the questionnaire and checklists and avoided the use of terms such as "bandit".

The research team was all male which presented some difficulties in a society with strong patriarchal norms about contacts between men and women. In some families, even elderly women were hesitant, unwilling or shy about talking to men from outside the village. In Fultala I talked to women sitting on the veranda while the women sat inside their rooms. There was a cloth fence between the room and veranda so conversation was possible

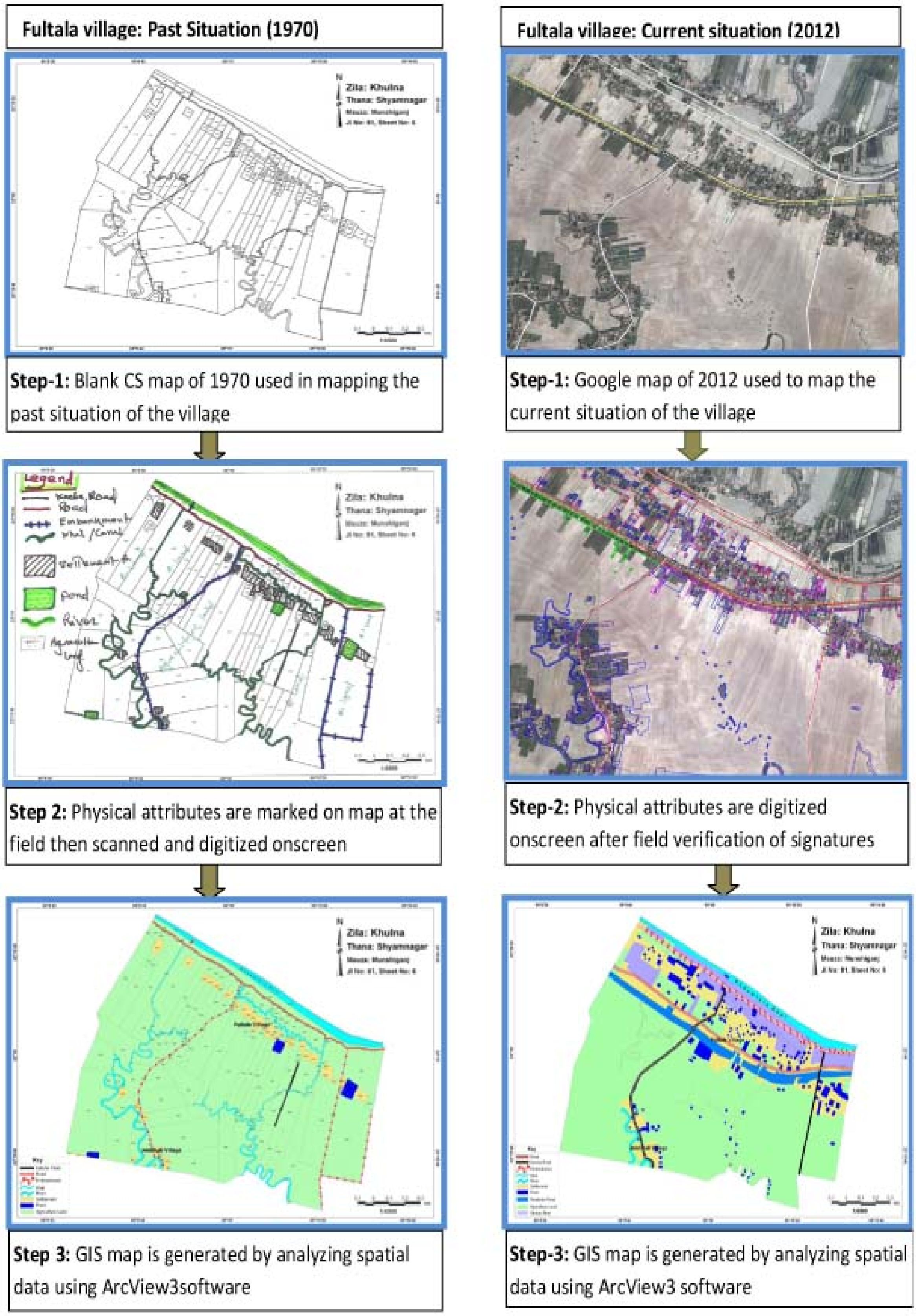


Figure 2.2: Methods of generating village level changes of attribute data over time (from 1970 to 2012) using CS maps and GIS tools: A partial view of Fultala village (as a sample)

My RAs did not face such restrictions as they had long term working relationships with the majority of the households and were allowed by both men and women to conduct KII and FGDs with women in the study villages. In some cases, we used beneficiary/ participating women members of CNRS projects to help organise FGD sessions with women. Figure 2.3 shows some photographs of field data collections.

Methods of Analysis

In addition to the research methods discussed above, I reviewed published materials from available secondary sources to provide a theoretical background to the study. An institutional analysis was done at local level on the roles and responsibilities of various actors engaged in grass roots development. The LVI analysis was based almost entirely on primary data collected from the two villages through the village census and household survey. The household survey data were coded manually and entered into the computer after manual editing and computer aided cleaning tools (logical checks) and the data were then analyzed using MS Access software. The LVI study outcomes are presented in chapter 5. Similarly, the KAP survey data were also manually coded and computerized using MS Access software. Findings of KAP survey are presented in chapter 6 and 7.

The analytical findings based on qualitative data are presented in chapters 4 to 7. Resource mapping outputs at village level that captured changes in physical resource systems over time were computerized and spatial analyses of village attribute data were done by applying the GIS tools (ArcGIS9.3 and ArcView3.3). Findings of the GIS-based data and maps are presented in Chapter 4. A summary of key methods and tools applied to gather primary and secondary data is presented in Table 2.5.

Table 2.5: Key Methodological Framework and Relevance to Thesis Chapters

Methods and tools	**Broader outputs /Key milestones**	**Relevance to Thesis**
KII, FGD, observation, transect walk	-Village selection decision matrix based on location, land use, occupation, livelihoods, disaster proneness -Two study villages selected as units of current research with place based communities	Basis for and sources of primary data for the thesis
Review of literature related to climate change, vulnerability and adaptation	-Understanding of theories related to weather, climate, vulnerability, adaptation and disasters -Theoretical considerations and framework for the current research work developed	Chapter 1& 2 and chapters (6, 7, 8, 9)
100% households (HHs) census (Chakbara-178	-HH demography, land holding, occupational pattern, Key livelihoods, Disaster exposure	Chapter 3 and 7

HHs and Fultala-247 HHs	-HHs profile developed by occupations, provide inputs for drawing samples for HHs survey	
FGD, KII, trend analyses, observation and literature review	-Description of changes in local resource systems, land uses due to past development interventions -Extent of land use changes and impacts of such change on local social ecological systems	Chapter 3 and 4
Village mapping using CS and Google maps and GIS analyses of spatial data	-Changes of village resource systems over time from 1970 to 2012 and corresponding changes in land use delineated and mapped	Chapter 4
Household survey using semi structured questionnaire (45 HH in each village)	-Detailed data on HHs vulnerability to weather and non weather stressors, livelihood capitals -Livelihood Vulnerability Index (LVI) for two village communities developed	Chapter 3, 4 and 7
FGD, Pair wise ranking with village communities (45 HHs in each village)	-Nine occupational groups identified weather stressors linked to their respective livelihoods -Community concerns relevant to different weather impacts prioritized by occupational groups	Chapter 6
KAP survey on weather issues (45 HHs/ village, 20 NGO staff, 24 UP members, 21 school teachers)	-Knowledge , attitude and practice of local stakeholders relevant to weather and climate issues -Knowledge and understanding of local communities and stakeholders on weather CC issues documented	Chapter 5, 6,7, 8 and 9
Transect, case study, KII NGOs, UPs, govt. officials communities	-Understanding communities' local adaptation efforts to cope with changing weather -Community level adaptation efforts documented	Chapter 3, 4, 8,9
Review of all chapters and relevant literature	-Understanding of key findings and messages -Key findings reviewed for drawing conclusion	Chapter 10

Figure 2.3: Photographs of field data collection: Clockwise: 1) My Research Assistant (Sharif) interviewing a women respondent; 2) My Supervisor (Prof. Bob Pokrant) and I in a meeting with farmers of Fultala; 3) I am in an FGD session with women in Fultala (conservative family-women sitting inside the room); 4) Research Assistant (Nur Hossain) in FGD with women farmers of Fultala; 5) Research Assistant (Sharif) and I in an FGD session with farmers in Chakbara, 6) My Supervisor I in a discussion with Chakbara villagers.

Conclusion

This chapter has described the project's research approaches, methods and tools used to gather data and information from primary and secondary sources and the methods of data analysis and interpretation. It briefly mentioned the socio-cultural sensitivities I encountered and how I sought to overcome them. The next chapter provides a description of the research site and the various resource systems upon which village livelihoods are based.

Chapter 3:
Biophysical and Socioeconomic Environment of the Study Area

Introduction

This chapter gives an overview of the environmental and social context of the study area. In describing the environment, emphasis is placed on the biophysical and socio-economic components including changes in the socio-ecological environment brought about by various shocks and stresses that have impacted on the area from time to time. I start by giving an overview of the coastal zone of Bangladesh in general followed by a description of the study area located along the southwestern coast tidal plain of the lower Ganges delta. I discuss the ecological setting of the two villages their socio-economic organization in the Shyamnagar sub-district under Satkhira district. Information presented in this chapter is based on secondary sources and primary data collected through household survey, focused group discussions (FGDs) and Key Informants Interviews (KII) with village residents and other individuals at local and national levels.

Coastal zone of Bangladesh

Bangladesh has a coastline of 710km, which faces the Bay of Bengal (BoB) in the south. It has diverse morphological features ranging from dynamic unstable coasts to more settled land, areas with high elevated hilly terrain to low lying coastline below mean sea levelsubject to recurrent tidal flooding (CZPO, 2005). The coastal zone of Bangladesh (hereafter CZ) comprises of 19 districts and 147 sub-districts out of a total of 64 and 460 respectively covering an area of 47,201km^2 which is 32% of the total landmass of the country (PDO-ICZMP, 2004; CZPO, 2005). Based on the proximity to the sea or lower estuary and exposure to hazards, the coastal zone is divided into two sub-zones, an ‘exposed coast’ (areas at the extreme south and bounded by the sea directly) and the ‘interior coast’ located north of the exposed coast, bounded by land or rivers and away from the sea (PDO-ICZMP, 2003). Of the 147 coastal sub-districts, 48 under 12 districts represent the ‘exposed coast’ and considered highly vulnerable to coastal hazards (cyclones, storm surges, sea level rise, salinity, coastal flooding, erosion) compared to that of the ‘interior coast’ (Figure 3.1). The coastal zone of Bangladesh can also be sub-divided spatially into three sub-zones, based on morphological features (Pramanik, 1983; Islam, 2001; Islam, 2004):

- <u>Eastern coastal zone</u> - stretches from Bodormokam, the southern tip of mainland Teknaf sub-district to the Feni river estuary in Feni district. The zone is narrow and possesses higher elevated land and hilly areas with soil features dominated by submerged sands and mudflats (Islam, 2001). Most of this zone is stable compared to other sub-zones and thus erosion and accretion is minimal in this part of the coast.
- <u>Central coastal zone</u> - extends from the Feni River estuary point to the eastern corner of the Sundarbans Reserved Forest (SRF) – the world’s largest single mangrove forest and is more dynamic in nature with continuous erosion and accretion. The River Meghna is the drainage outlet of a large catchment of three mighty rivers in South Asia viz. the Ganges, Brahmaputra and Meghna (GBM) which drain water from an area larger than the size of Bangladesh – over 92% drainage catchment of the country is outside its borders. Annually an estimated 2.4 billion tons of silt are deposited in the Bay of Bengal by the GBM River systems (Milliman and Meade, 1983).
- <u>Western coastal zone</u> - covering greater Khulna district to the Raimongal River on the southwest border with West Bengal, India. The entire area is part of the floodplain of the Ganges River and thus called Ganges Tidal Plain or lower Ganges delta. The SRF covering 6,017sq.km is located in this sub-zone (FD, 2004). This sub-zone is relatively stable compared to the central coast but suffers from higher salinity and tidal flooding. Average land elevation of this sub-zone is below 1.5 m mean sea level and thus susceptible to tidal flooding.

This complex coastal zone with varying morphology, hydro dynamics, environmental and resource endowments, including patterns of community livelihoods across the coast line, is protected by earthen embankments constructed in the nineteen sixties in order to protect people, crops and assets from cyclones, coastal flooding and salinity (Schmidt, 1969).

The densely populated coastal zone accommodates 35.1 million people, the majority of whom are landless poor, and many live in geographically vulnerable areas such as coastal embankments and some small and dynamic island that are highly exposed to climate extremes. Some of the unsettled coastal islands where people live are still below the mean sea level and are subject regular tidal inundation and thus not suitable for long-term human habitation. Rich and diverse fisheries, fertile land, profitable aquaculture potential, mangrove forests, cattle grazing land in newly accreted land, and salt production have attracted mainly poor people to settle and make their livelihoods in the coastal zone (MoEF, 2005). Although land is fertile, there is high salinity for 4-5 months a year during winter when rainfall is very low. During the monsoon, people cultivate mainly monsoon rice (amon rice) in most of the coastal land. Except for parts of the southwestern and southeastern coasts, people can grow two to three crops a year within the embanked areas adopting farming of diverse non rice crops such as chili, pulses, soybean, cucumber and water melon (CCC, 2009.b). Apart from the agriculture and livestock activities, aquaculture is another profitable and lucrative livelihood in the coastal area and much of the land in the southwest and southeast are now under fish (carps and catfish) and shrimp aquaculture (Paul and Vogl, 2011). Livestock (mainly buffalo) rearing in newly accreted *chars* (island) in the Bay of Bengal has been a common practice in the coastal zone by the better-off but has also created opportunities for the poor to get jobs as ranchers. In most cases, these poor buffalo grazers are helped by the buffalo owners to get permanently settled in these newly accreted islands, which requires a lengthy legal process in obtaining official transfer of the land. . The landless who take care of the buffalo herds in the low lying newly accreted char land in the coast (lower estuary) take huge risks in living in such locations where government support is largely absent (Rahman & Biswas, 2013). Often these low-lying lands are unprotected by embankments and highly unstable and unsuitable for human habitation. In the land adjoining the SRF, people from upstream areas settled and cleared many areas of the forest in the past, particularly during British rule (1770s-1947). They survived on agriculture, fishing and harvesting the various resources of the SRF.

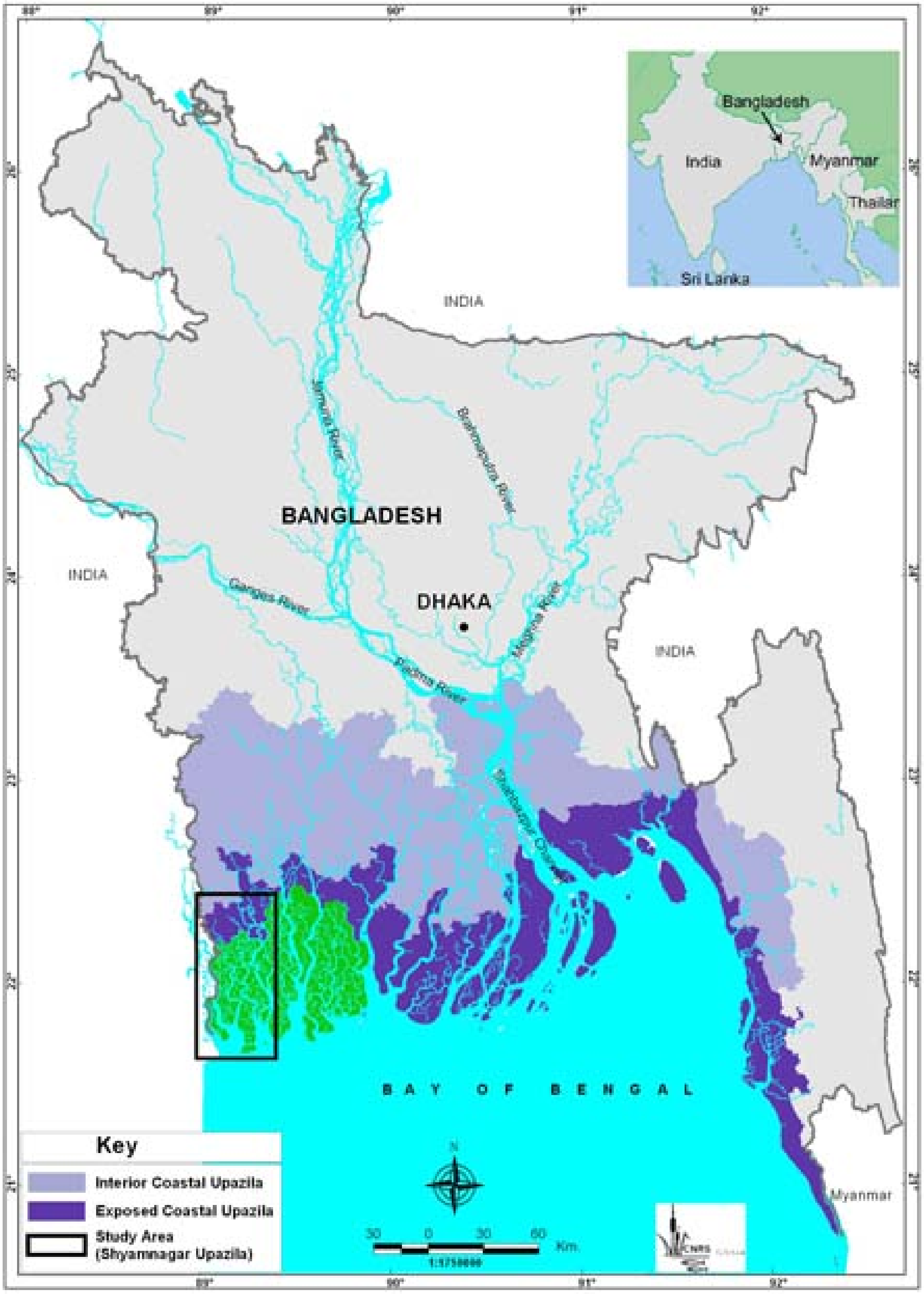


Figure 3.1: Map of Bangladesh shows study area

In the low lying coastal area most of the household have a small size pond dug to make houses on raised plinths. Later, these ponds were brought under aquaculture and other uses. Coastal aquaculture further flourished with the start of salt water shrimp farming in converted rice paddies called *ghers*[2] in areas within the coastal polders where salinity of water is higher. Salt water shrimp farming first started in the southeastern district of Cox's Bazar and in the southwestern district of Satkhira where salinity levels were high enough to support shrimp farming. The coastal zone of Bangladesh not only supports the people in production based livelihoods but also creates wider opportunities for communities to subsist on extractive resources viz. fishing, collecting timber and non timber resources from coastal waters and SRF. The SRF is regarded as a rich natural treasure for its potential to serve people with its multiple resource systems year round. A rich diversity of fish, shrimp and crabs, nypa palm, honey, wax, fuel, wood, grasses & thatching materials are some of the resources of SRF that have been benefiting the communities over centuries (FAO, 1994; Chowdhury & Asrafi, 2008). The SRF alone provide direct livelihood support to over 300,000 Bangladeshis (Hossain, 2001). Besides, this dense patch of mangrove swamp also serves as the natural protective barrier against cyclones and storm surges.

Apart from the livelihood benefits and disaster risk reduction services, the SRF is a world heritage site, and the first Ramsar site in Bangladesh that provides home for diverse flora and fauna unique in the country and in the region. These include the Bengal Tiger, marsh crocodiles, spotted deer, dolphins, sea turtles nesting sites and many species of resident and migratory birds. All these natural habitats, mangroves and unique biodiversity of flora and fauna still survive despite having been repeatedly disturbed by multiple natural and human-induced hazards in the form of cyclones, storm surges, erosion, salinity, expansion of settlements, agriculture and shrimp farming, and wood cutting.

The coastline along the southern boundary faces the Bay of Bengal is subject to tropical cyclones (CZPO, 2005) with a major tropical cyclone hitting Bangladesh coast every 3 years. This means that communities often have little time to recover from one cyclone before the next one arrives (MoEF, 2009). Over the last 100 years 508 tropical cyclones formed in the Bay of Bengal of which 17% hit Bangladesh coast with variable impact in the form of human deaths and injuries and property

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[2]*Ghers* are shallow ponds in converted rice paddies made to farm shrimps and white fish in coastal saline prone areas of Bangladesh

damage. The great Bhola cyclone in 1970 alone took 500,000 lives with an instant loss of other assets including crops and infrastructure. The 1991 cyclone also caused the death of over 140,000 people with major loss of crop and other asset losses. Two recent cyclones that hit the country in 2007 (Sidr) and 2009 (Aila) caused less human death compared to previous cyclones, but left huge damage of physical assets and coastal production systems. Sidr alone caused loss and damage of over US $ 1.6 billion.Rahman and Biswas (2013) analyzed data on cyclones for the last 200 years and found that the number of occurrences of major cyclones has increased in the recent decades from only three during 1846-1896 to thirteen during 1897-1947 rising to 51 during 1948-1998.

The Bangladesh NAPA (National Adaptation Programme of Action) highlighted that the coastal zone will be particularly vulnerable to the combined effects of climate change, sea level rise, subsidence, and changes of upstream river discharge, cyclone and coastal embankments (BCAS/RA/Approtech, 1994; WB, 2000). This will produce four key physical effects: saline water intrusion; drainage congestion; extreme events; and changes in coastal morphology which would further intensify the vulnerability of the coastal population (WB, 2000). Apart from natural hazards, the coastal zone of Bangladesh, particularly the southwestern coast has also been impacted by various anthropogenic shocks over time that influenced changes in land uses and livelihood patterns of the people..

Introduction to the study area

The study area is located at the southwestern coast of Bangladesh in Shyamangar upazila (sub-district) under Satkhira district protected by the SRF (Sundarbans Reserved Forest)on the south (Figure 3.1). The area was selected due to the convergence of various processes relevant to climate and non-climate hazards, which have affected people’s livelihoods. The analysis of peoples’ vulnerability to climate and non-climate stressors provides an opportunity to understand local people’s perceptions of climate change and the steps they are taking to adapt to changing local social and ecological circumstances. The Shyamnagar upazila is located at the southern end of Satkhira district and is exposed to the sea as well as the SRF to the south. The study area is located at the southernmost part of the upazila close to the SRF while the east, north and western sides are bounded by land used for salt water shrimp farming, settlements and roads. The northwestern part of the upazila shares a common border with India while the southwestern part is bounded by the Indian part of the Sundarbans.

The entire coastal area of this upazila is protected by embankments along the rivers. In making the embankments, many canals and small rivers were either completely closed or water flow was regulated by sluice gates. There is erosion and accretion of land along the rivers. In some areas the SRF is expanding and moving towards the settlements, by eroding the coastal embankment. In an effort to make adjustments to the erosion, the embankments are realigned almost every year in some of the river points as seen along the Chunar River at of Burigoalini and Munshigonj unions and Dumuria and Chakbara villages of Gabura union.

I carried out in depth case studies in two villages named Chakbara under Gabura union and Fultala under Munshigonj union of Shyamnagar upazila. (Figure 3.2).

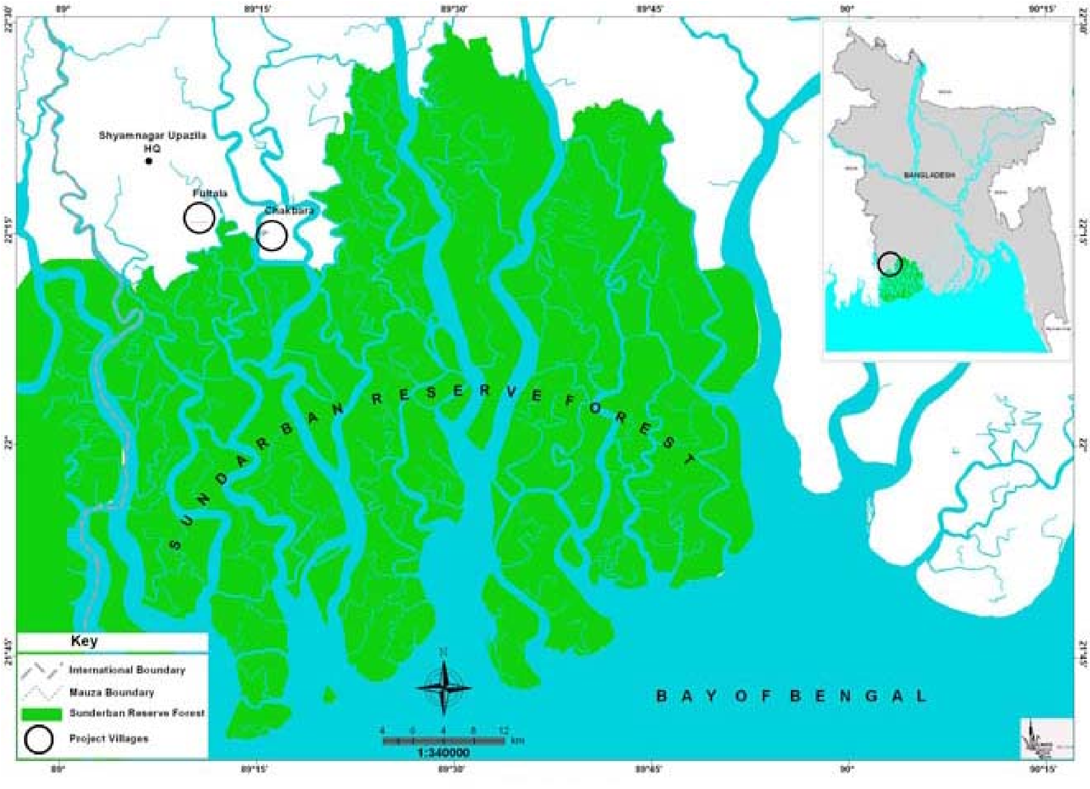


Figure 3.2: Project villages

Being located in the vicinity of the SRF, people from Chakbara, especially the poor have higher dependence than Fultala on fisheries and various other forest-based natural resources for their livelihoods. Although currently overexploited, a good numbers of people still depend on the diverse resources (fish, crabs, shrimps, honey, nypa palm, grasses, woods, etc. are the major resources) of the SRF. Apart from livelihood resources, SRF also provides home to rich wildlife fauna including the Bengal tiger, deer, boars, monkeys, marsh crocodiles, dolphins and varieties of birds. Considering the unique biodiversity value and high exploitation of resources, three designated areas of the SRF at southern end have been declared as wildlife sanctuaries and a World Heritage Site and the first Ramsar site in Bangladesh. The periphery of SRF (10 km radius) is declared as an ecologically critical area (ECA) by the Government of Bangladesh under the Environment Conservation Act 1995 (MoEF, 1999).

The then East Pakistan Water and Power Development Authority (EP-WAPDA) constructed permanent embankments along the entire coast line between 1967 and 1968 in order to protect the area from tidal surges, the intrusion of saline water and to protect the amon rice crop, which was the only rice crop grown in the area at that time. However, the protective embankment and water control structures facilitated salt water shrimp farming in the area, which had a negative impact on amon rice cultivation.

The growth of the shrimp culture industry was so rapid that in a few years it engulfed the entire area and almost completely changed the land use from rice cultivation to salt water shrimp farming. Salt water shrimp farming started more than 25 years ago in Munshigonj and Burigoalini unions between 17 and 18 years ago in Gabura union. Currently, shrimp farming covers most of the cropland of Gabura union except some areas where due to land elevation watering is difficult and whereamon rice is cultivated in monsoon. Before shrimp farming, people used to grow amon rice and vegetables. Freshwater white fish species such as *shol* (Channa striata –large snakehead), *taki* (Channa punctata- small snakehead), and *boal* (Wallago attu– large catfish) were fairly common in rivers, canals and beels in this island union. Rice farming, fishing and the SRF were the key sources of livelihood before the introduction of shrimp *ghers*. In its early days, shrimp farming was controlled by urban investors and local rich people who were politically powerful and able to influence the local poor as well as local administration including the local government (union parishad). At that time, small land holders were pressured to rent out their land on *hari* (rent) to large shrimp farmers instead of doing shrimp farming individually. Many outside large investor/ farmers pulled out after the outbreak of viral white spot syndrome in the late 1990s that created spaces for many smallholders to get back their land. MMany small farmers now farm shrimps by themselves.

By contrast, in the village Fultala, located in the coastal high saline zone, the major land use is rice farming, vegetable cultivation, fish culture in ponds and road side ditches including limited shrimp-cum-rice farming. The village is well connected to growth centers by motorable road and thus the communication system is far better than that of Chakbara. People in Fultala do not go to the SRF but depend more on local agriculture based wage laboring, rickshaw pulling, earth cutting and seasonal migration to distant places. Fultala, due to its geographical location on the mainland, is less exposed to coastal hazards.

Rivers, embankments and people

The use of embankments in the coastal area to protect rice is an old practice. During the British colonial era, an embankment was small in dimensions, usually about 1.4 m wide and 1.8 m height. Every year, usually in the month of July-August, in some places the embankments were breached by tidal water. The representatives of the Zamindars[3] (traditional landlords) used to visit the embankments during monsoon to oversee local people/ farmers who repaired weak areas and raised the embankment height if needed. The Zamindars made such work mandatory for the local people. Usually if a farmer had 5 *bigha*[4] of land (0.61 ha), he was given an area of approximately 4.6 m embankment to maintain. It was the Zamindar's retainers who determined which embankments were to be maintained and by whom and rule breakers were prevented from farming to ensure compliance.

The River Kholpetua, flowing east to west on the northern edges of the villages Chakbara and Dumuria, was previously narrower and deeper. Elderly people of the village stated that some 50 years ago the depth of river was over 15 m near Chakbara and Dumuria villages, and the width of the river was just half what it is

[3]A Zamindar was an aristocrat, typically hereditary, who held enormous tracts of land and held control over his peasants. The Zamindars reserved the right to collect taxes (often for military purposes). The Zamindari system was originally a way of collecting taxes from peasants during Mogul times. After 1793, the British sought to turn them into progressive land owners while paying limited tax. For many, improving the land and waters under their control was less important than delegating the working of the land to the peasantry from whom they derived rent.

[4] 1 *bigha* equals to 0.33 acre of land (0.134 ha)

now. In the past water currents were slower because of the presence of multiple active river channels, which allowed tidal waters to go upstream. People started observing sedimentation, erosion and widening of rivers immediately after the start of the withdrawal of water from the Ganges by the Farakka barrage on the Indian side of the border in 1975. Rivers started widening and informants stated that rivers in the SRF area became shallower and wider and more dynamic while their upper reaches that used to feed the SRF with freshwaters became drier and some became dry and moribund.

Although local people used to regulate coastal flooding by making small seasonal bunds, elderly people in project villages could recall that the first embankments were constructed by the Zamindars during the British regime. Elderly villagers reported that in 1916 the first embankment or bundh was constructed in this area by the local Zamindar, Hemnatha Shaynnal, who lived in Kolkata. The employees of Mr. Shaynnal came to the area and organized local people to construct the bundh. The width of bundh at that time ranged from 1.4 m to-1.7 m with the height variability between 1.8 and 2.1 m. The alignment of the first bundh constructed was about 105 m north (inside the Kholpetua River) from the present embankment alignment. Villagers used to call this embankment “Moniber First Bundh”. The word “Monib” means “owner or ruler” and “bundh” means dyke. The slopes and scaffolding area of the embankment were full of mangrove trees and bushes so that the dyke did not get eroded easily. People often sighted tigers on the embankment and crocodiles in the river near to Chakbara and Dumuria villages. They cultivated rain fed amon rice in the raised land and fished in the low-lying beel areas for most of the year.

In 1926 when the first Moniber bundh was threatened and almost washed away by tidal waters, a second bundh was constructed 37 m north from the alignment of existing embankment which was named “Moniber Second Bundh”. During the Pakistan period (1947-1970) local villagers continued to repair the embankment as and when required. Usually the Chowkider (Watchman or Gatekeeper) monitored the embankment and whenever repairs wererequired he informed the local UP Chairman (called President of the UP during Pakistan regime, locally elected with responsibility for looking after local development issues). The Chairman distributed the responsibility to repair respective allocated portions to local villagers based on landownership and the financial conditions of households. The village leaders

(*Mattabbors*) called all the villagers and started the repairwork, which was monitored by the local Chairman. Every year people repaired the bundh during the pre-monsoon (March-April) and closely monitored the conditions of bundhs from the beginning of the monsoon (June) until rice was harvested in November.

In 1953 the Third bundh was constructed, some 27 years after the construction of the second. It took about 2 years to complete through engagement of local people and hired labourers.

In 1968, the EP-WAPDA constructed a new embankment along the current alignment as part of its new coastal embankment construction plan. The dimensions were wider (27 m base with 3 m top and 3 m height). This was the third embankment in the current alignment constructed in one year around the entire Gabura union. The Muniber Bundh was retained when the new embankment was constructed. While constructing the embankment, WDB also installed four sluice gates in Gabura union for drainage purposes. After construction, repair work (earth filling to raise the height) was done in the mid-1980s. Since the 1960s, no major shifts of alignment were needed except in some places due to localized erosion of river banks.

While the Gabura union has continued to have major problems maintaining the embankments to protect them from cyclones and tidal inundation, Fulata village has suffered from illegal occupation and conversions of rivers and canals and shortages of freshwater for irrigating their rice crops.

Social and Institutional Settings of the study area

There are nine UPs (Union Parishads) in this sub-district[5]. Each union is administered by a body of elected representatives comprised of nine ward members, three women members and an administrative secretary and the whole council is headed by an elected Chairman. All Chairmen of the unionsunder a sub-district are coordinated and guided by the Upazila Nirbahi Officer (UNO – the Chief Executive of the upazila). As per the constitution of the Government of Bangladesh, UPs are the lowest tier of the local government system administered centrally by the

[5]Union Parishad or Union Council is the local government body and the lowest administrative boundary governed by locally elected representatives for a period five years

Ministry of Local Government and Rural Development (MoLGRD). The UP is the grass roots nodal point for various government committees and structures for providing day to day support and services to the communities of respective constituencies. For example, the lowest tier of the National Disaster Management Committee (DMC) is at the UP level and the UP Chairman heads the Union Disaster Management Committee (UDMC) vested with the responsibility of planning and execution of disaster related activities at the union level.

At the upazila level there is the Upazila Development Coordination Committee (UDCC) where all UP chairmen and all government agency officials are members. It is chaired by the elected upazila Chairman and is administratively coordinated by the UNO as representative of central government. Respective line agency officials such as the Department of Fisheries, Department of Agriculture Extension, Department of Cooperatives, Women Affairs, etc. render their services to the communities in coordination with the UPs. Besides, there are special departments like the Forest Department (FD) and the Water Development Board (BWD) that are represented in the Shyamnagar upazila but these departments do not operate in all upazilas of the country. In general, the administrative processes and institutional set up is more or less identical in all the upazilas of Bangladesh. However, community level social, economic, cultural and livelihood attributes vary from sub-district to sub-district, union to union, village to village depending on their social and economic characteristics, which are largely determined by land and asset holding, education and occupation and one's position in local political networks.

Household characteristics of study villages

Chakbara has a smaller population than Fultala. There are 178 households in Chakbara with a population of 783, while Fultala has 247 households with 1,100 people (Table 3.2). Average family size was 4.4 people per household in Chakbara and 4.45 in Fultala (household census from 2010). However, the number of female headed households was greater in Chakbara–13.5% or 24 households compared with only 4% (10 households) in Fultala. More than half of households (54%) in Chakbara village do not have their own homesteads. They either live on *khas*[6] land,

[6]State owned land, by law, landless poor get preference in accessing cultivable *khas* land on long term basis

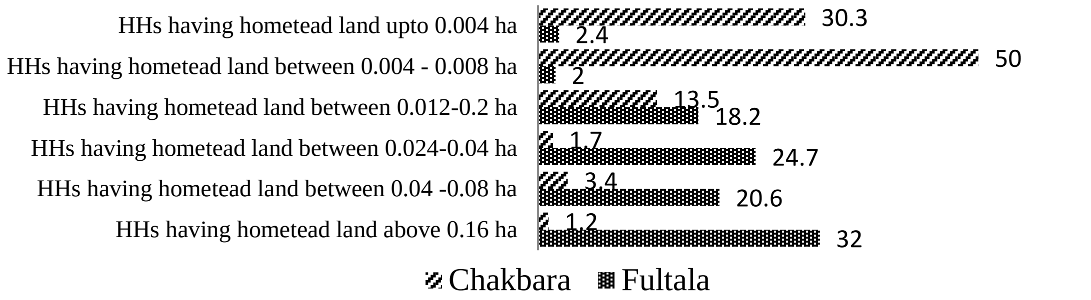
on embankments or on friends' and relatives' land. In Fultala, only 17.4% of households do not have their own homestead land. This indicates higher poverty and landlessness in Chakbara village. A major reason for this difference is that in Chakbara, most land has been converted to shrimp farming and remains under water (*ghers*[7]) for much of the year. In Fultala rice farming dominates and there is more land available for expansion of homesteads.

Regarding educational status, significant differences were found between the two villages. Census data shows that 41% of household heads in Chakbara were illiterate compared with only 15% in Fultala. The villages are sharply different in terms of occupational status and livelihoods features. In Chakbara nearly half of the household heads' (44.4%) primary occupations or livelihood means is shrimp post-larvae collection (male and female headed households combined) while in Fultala 51% are crop farmers of rice and vegetables. With regard to villagers' second most important occupation, in Chakbara 13% of households are shrimp farmers while in Fultala nearly 18% are dependent on wage laboring in agriculture. In the case of female-headed households, occupational dependence varied by gender and village. With regard to primary occupation, 62.5% of female- headed households in Chakbara are dependent on shrimp post-larvae collection while in Fultala 60% of female-headed households are engaged in household activities rather than direct income earning outside the home (Table 3.2). In both villages, women are engaged in off-farm activities, particularly wage work, as their second most important occupation – 21% of female head households in Chakbara are engaged in off-farm activities compared with 20% in Fultala.

In rural Bangladesh, size of homestead land is an important indicator of householder well being and social status. Wealthy families have higher land ownership, a good income from agriculture, aquaculture, service and/or business investments. Wealthy families have larger homes on more land. In Chakbara 30% of families or almost every third family has homestead land of up to 0.004 ha only compared with 2.4% households in Fultala (Figure 3.3). Every second family in Chakbara has homestead land from 0.004 - 0.008 ha compared with only 2% of families in Fultala. The data shows that over 50% of families in Fultala village have homestead areas over 0.04

[7]*Ghers* are shallow ponds made by converting rice paddies for shrimp farming in the coastal zones of Bangladesh

Figure 3.3: Households with size of homestead land in study villages
(village census: n=247 Fultala and n= 178 Chakbara)



ha compared with only 5% of households in Chakbara village (Figure 3.3). Land scarcity is an important factor in accounting for village differences in land and homestead size. Chakbara is located on low-lying land with shrimp farming covering much of the area.

The villages vary widely in terms of the construction materials of houses. Concrete houses are costly and durable and are an indicator of a higher standard of living. While both villages have a high proportion of households whose homes are made from non-concrete materials, which indicates a general lack of prosperity in both villages. Fultala is better off in this regard. In Fultala, 5.3% and 13.4% households had concrete floors and wall materials compared to 0% and 1.7% respectively in

Table 3.2: Households socioeconomic features of two project villages

HHs features	Name of Villages	
	Chakbara	Fultala
No of HHs	178	247
Total population of villages	783	1,100
Family size	4.4	4.45
Female headed HHs	13.5 %	4.0%
HH have own homestead land	46.1%	83.4%
HHs heads with no formal literacy	10.1%	14.6%
HH heads can only write his/ her names	30.9%	2.8%
HH heads aged above 60 years	15.7%	14.2%
Top most primary occupation of HH heads (total)	44.4% - Shrimp PL catching	51.0% Rice Farming
Second most primary occupation of HH heads (total))	12.9% Shrimp farms	17.8% agri. laborers
Top most primary occupation of HH heads (female headed HHs)	62.5% - Shrimp PL catching	60% HH activities
Second most primary occupation of HH heads (female headed HHs)	20.8% off-farm wages	20% on-farm wages
Top most secondary occupation of HH heads (total)	63.5% fishing	31.6% earth cutting
Second most secondary occupation (HH heads (total)	41.6% earth cutting	21.5% on-farm wages

HHs features	Name of Villages	
	Chakbara	Fultala
Dominant wall material (main house)	64.0% wood	71.3% earth
Brick wall (Main house)	1.7%	13.4%
Concrete floor material (main house)	0%	5.3%
Straw roof (main house)	0.0%	21.5%
Catkin roof (main house)	29.2%	0.8%
Asbestos roofing (main house)	26.4%	32.0%
Tin roof (main house)	36.0%	30.0%
HH having no land, ponds, *ghers*	73.0%	21.9%
HH Having no ponds of their own	82.6%	34.8%
HHs having no latrines of their own	39.3%	2.4%
Cases of diarrhea recorded in last one year	131	22
HH took loan in 2010-11	54.5%	42.9%
HHs took *dadon* last year (2010-11)	45.5%	22.7%
HH received no training up until 2011	78.7%	78.9%
HH received training on DRR by 2011	2.2%	0.8%
HH received training on aquaculture by 2011	7.3%	1.6%
HH received training on SRF management	0.6%	0.0%
HH affected by cyclone Sidr in 2007	99.4%	12.1%
HH affected by cyclone Aila in 2009	98.9%	96.8%
HH get disaster warning regularly	35.4%	32.4%
HH received no disaster warning	1.1%	17.0%
HH received no early warning for cyclone Sidr (2007)	2.8%	20.6%
HH received no early warning for cyclone Aila (2009)	1.7%	42.5%
HH faced problem due to dacoits	51.7%	0.8%
HH faced problem due to Forest officials	50.0%	0.0%

Source: Household census (100%) in two study villages (Chakbara and Fultala), 2010

Chakbara. In Chakbara, nearly two thirds (64%) of households used wood (collected from the SRF) as wall material compared with only 10.5% in Fultala while 71% of Fultala households had earthen walls compared with only 1.7% in Chakbara. Regarding roofing materials, 21.5% of Fulata households had straw made roves (the straw coming from rice farms) compared with none in Chakbara. 29.2% of Chakbara households had *chhon* (catkin grass collected from the SRF) made roves compared with less than one % in Fultala (Table 3.2). This reflects variable dependence on locally available natural resources (housing materials) that not only shape their livelihoods but also their dwelling houses. The majority of Chakbara households received housing support from NGOs and government after cyclone Aila in 2009-10 as more families (36%) had tin roof houses than in Fultala (30%).

Thus, over 21% of Fultala households had roofs of straw derived from rice farming. No households in Chakbara had straw made roofs as a result partly of the lack of availability of straw from rice paddies. Chakbara villagers are more dependent (29%

of households) on *chhon* (catkin grass) made roof house as this grass is available in the SRF. Only two households in Fultala had catkin grass for roofing. Landless and poor Chakbara villagers living close to the SRF extract various non-timber products (wood, catkin) from the nearby forest to make their houses while relatively better off people in Fultala village use other available alternatives such as clayinstead of forest products The variable dependence on the SRF for basic resources makes the villagers variably sensitive to climate stressors. Scientific modeling suggests that a one meter rise in sea level will destroy 75% of the SRF and the resources upon which many depend. Similarly, increased salinity intrusion is likely todegrade the quality soils of Fultala village, with major impacts on farming as well as availability of materials for house building. Dealing with these risks makes it important for local peoples to think of alternatives to these essential basic materials in adaptation planning.

A good number of households in the study villages do not possess any land-based livelihood assets such as cropland, fish ponds or shrimp *ghers*and thus fall under the extreme poor category, subsisting on forest and land-water based extractive resources, wage laboring in agriculture and shrimp *ghers*, earth cutting and various other seasonal petty occupations including out-migration. The higher number of households that fall under the extreme poor category indicates higher vulnerability to various shocks. Nearly three quarters of total households (73%) in Chakbara have no crop land, fish ponds or shrimp *ghers*, which indicates high poverty and high vulnerability compared just over one-fifth (22%) in Fultala.

Extractive and production-based activities are both highly sensitive to various climate and non-climate stressors and thus people from both villages have high levels of vulnerability to shocks, even though their livelihood means are different. This situation also indicates that there exists high variability among geographically concentrated coastal communities in terms of their livelihoods, nature, extent and types of exposure, sensitivity to stressors and thus their level of adaptive capacity to cope with hazards impacts.

Availability and access to financial capital often help poor and marginalized families to diversify their income opportunities and family incomes. In Bangladesh, there are various formal and non formal micro finance facilities available. Local people have access to two different forms of credit systems, loans from wealthy people (often called *mohajon*) in the locality usually with high interest rates of around 100% annually – also called *mohajony* loan) and micro credit from NGOs, with around 15% annual interest. Extreme poor households are usually excluded from access to NGO loans.

The other means of accessing capital is through the *dadon* system. Here a trader provides an advance to fishers, crab collectors, shrimp farmers and rice farmers on condition that he or she must sell their produce or harvest at a lower price than the market price that particular trader known as *dadonder*[8] or *mohajon*. Many commentators consider the *dadon* and *mojhajony* loan system as exploitative due to its high interest rates and stringent terms and conditions. NGO micro credit is considered less exploitative because of its low interest rate and flexibility in use of funds. However, such loans follow a strict regime of weekly repayments, which can be difficult for some borrowers (FGD with study villagers, 2010).

More Chakbara households are dependent on loan and *dadon* systems than in Fultala. As reported 55% and 43% households in Chakbara and Fultala respectively had borrowed loan in the last year (2010-11). During the same period, 46% and 23% households from Chakbara and Fultala respectively received *dadon* for various purposes. Although *dadon* is considered as a debt trap for the poor, there remain hardly any other options for the extreme poor who are not considered reliable clients by NGOs to get micro credit.

The household census data shows that until mid-2011, nearly 80% of households did not receive any training to enhance their skills or assets, which indicates the poor performance of both government and NGOs. In the case of disaster management, only 2.2% and 0.8% households of Chakbara and Fultala villages respectively received any relevant training. With regard to livelihood enhancement, only 7.3% and 1.6% households from Chakbara and Fultala respectively were trained in fish culture and only 0.6% households of Chakbara received any assistance with SRF management. Until mid-2011, no training was given to communities on climate change impacts, adaptation and climate resilient livelihoods. In summary, local

[8]*Dadonders* or *mohajons* are usually the traders. Those who provide loans to fishers are the 'fish traders' and those who lend to crab collectors are 'crab traders'. They have offices at fish/crab landing centers and buy fish or crabs from fishers or collectors (mostly from those who borrowed *dadon* /money from them) and sell them to other retailers or wholesalers.

peoples have relied largely upon their own skills and resources to maintain their livelihoods.

Key livelihood activities

Communities in the two study villages engaged in diverse extraction and production based livelihood activities yearround (Figure 3.4). Fishingin the rivers and canals inside and outside the Sundarbans is one of the oldest occupations in the area. In the past, lower caste Hindu communities (such as *Bagdi, Munda*) dominated fishing, which was regarded by the majority Muslim population as both a low caste and low class occupation. More recently and partly as a result of increased shrimp farming, which requires less labour than traditional rice growing, many Muslim poor have shifted into fishing, which has led to increasing competition with traditional Hindu fishers. In addition, the fishing industry as a whole has seen the introduction of new fishing gear and craft, which has contributed to a further intensification of fishing effort.

The fishers in the area can be grouped into three broad categories based on their scale of operation, mode of fishing and fishing grounds. First, there are the sea-going fishers who fish in the lower estuary or Bay of Bengal (BoB). Second, there are fishers who operate mostly in the rivers and canal, both inside and outside the SFR, and use several fishing. They often go as far as 30km from their villages and many of them spend 2-5 days on each fishing trip. Third, there are local forest or *bada* fishers who fish mostly in small rivers and canals inside the SFR and usually within 15 km. from their villages. Among the *bada* fishers, there are traditional Hindu, particular *Bagdi*, and Muslim fishers. There are over 100 from Chakbara and Dumuria villages who fish in the lower estuary and in the BoB just south of the SRF with some venturing further off-shore in winter when the sea is calm. They use two types of fishing gear, *bindi jal* (Set bag net) and *goisha jal* (large gill net) with a large mesh size. Common fishing locations in the lower estuary include Manderbaria, Talpatti, Vehala, Kaila areas on the south west sides of the Sundarbans, about 35-40km from their villages and it takes about 48 hours by manually powered boat to reach there. They fish for such species as *datina* (Lutjenus spp), *bhol* (Epinephelus fasciatus), *vetki (*Sea perch- Lates calcarifer), and *med (Marine c*atfish – Nemapteryx nenga). Most depend upon *dadon* from *mahajons* of

Kalbari fish landing centre. They usually make two fishing trips per month lasting 7-10 days depending on the situation. Sometimes, they get good catches in the first 3 to 4 days but canspend 7 days fishing in the lower estuary. In between trips, the fishers stay at home for 2/3 days and then go on the next trip.

Shrimp PL (Post Larvae) collection is one of the most common livelihood activities of poor households in the area. Men, women and children catch PL from rivers, canals and from inside and adjacent to the SRF almost year round. Demand is high as shrimp PL as hatcheries are unable to supply enough. There are two types of shrimps cultivated in *ghers*. One is the salt water species called *bagda* and the other is *golda* or *chhati* prawn (Macrobrachium rosenbergii). *Bagda* (Panaeus monodon)is a sea dwelling species but uses estuary and mangroves as breeding and nursery grounds, while *golda* is freshwater dwelling but also uses estuary and mangroves for breeding and nursery purposes.

The PL collectors use two types of fine mesh nets. One is the small push net used by children and women who drag the net along the shores. The other is the large *bindi* net (bag net) operated by boats in rivers or canals. PL collectors have been playing a major role for decades in developing and sustaining the shrimp industry by supplying PL to the *gher* farmers. There are hundreds of shrimp PL collectors in the area and many of them depend exclusively on this for their livelihood, at least for part of the year. However, PL collection from the wild has negative impacts on biodiversity and aquatic production and in 2000 Government banned wild shrimp fry collection. Since then the FD has stopped issuing permits for PL collection inside the SRF. However, the practice continues, as there is no monitoring compliance apart from the FD cancellation of PL catching entry permits. There is also no programme from the government and NGOs to assist PL collectors in minimizing by-catch.

Mud crab (Scylla serrata*)* collection is another local economic activity that started about 20 years ago. Crab collectors are usually the poor, who collect them in the SRF and require an entry permit from the FD. Initially, those who collected crabs did so for their own consumption and for sale in local markets. However, there has been a growth in the market for crabs in Khulna and Dhaka, which includes exports to Southeast Asian countries such as Singapore, Japan, Hong Kong, and Taiwan. In 2005-6, the sector earned over US $ 3.6 million (Ferdoushi et al., 2010). No stock assessment or any kind of population study of mud crab has been done, so concerns have been raised about its sustainability. The FD does little more than issue entry permits for crab harvesting. Given the exposure and sensitivity of crabs to climate change impacts (drought, salinity change) and the increasing number of people involved in crab collection, it is uncertain how long it will take to deplete crab resources. Catching of crab from the SRF is prohibited from December to February and May to June to protect brood stocks (Ferdoushi et al., 2010).

Nypa palm or *gol pata (*Nypa fruticans) collection in the SFR has been going on for generations. Locally, the collectors are called *bawalies.* Poor coastal people use *gol pata* to make thatch for their homes and there is a good market in Khulna and other coastal districts for housing and fencing materials. According to one estimate, 113,888 tons of *gol pata* is harvested annually from the SRF (Ahmed, 2006). These *bowalies* also collect honey, grasses and catch fish from the SFR in different seasons.

Honey collection from the SRF has a long history and was mainly collected for sale. It is a seasonal occupation practiced by *mowalies*. They collect entry permits from the FD by paying a government fee of BDT 550 (US $ 7) per person for one month. The FD issue permits for collecting during 1 April to 30 May each year.

The honey collected from the *Kholshi* (Aegiceras comiculatum) tree is the best quality (Rahman et al., 2001) but is sensitive to higher salinity and production declines if salinity reaches 15ppt (Jalil, 2002). The honey collectors also collect other forest resources in other seasons so most *mowalies* become *bowalies* at other times of the year. Many fish in other seasons.

Crab fattening is a relatively new practice started about 20 years ago. Poor people catch juvenile crab/soft shell crabs from within the SRF or buy from local markets as rejected items, and rear them in small earthen ponds fenced with bamboo splits. In two to three weeks the crabs attain marketable size and are sold at local markets. Different NGOs have been providing technical and financial support to the poor in crab fattening as an income generation scheme. Usually women members of the family take care of crab pond management activities. Although crab fattening has a good income earning potential for the poor and women, having no land is a barrier to taking on such work. Most of the *khas* (state owned) land in the area that could be used for such work has been taken by shrimp farmers and there is hardly any common land upon which the poor could diversify their incomes.

Shrimp farming has become the major land use in the study area. Almost all the cropland and beels have been converted to shrimp *ghers*. In Chakbara, 100% of the land previously used for rice cultivation is now devoted to shrimp farming. Although shrimp farming is economically profitable for some and earns important foreign exchange, it has had many negative environmental and social impacts in this area and across the country (Paul and Vogl, 2011).

Fish trading is a common practice and the wholesale fish market (or fish landing centre) at Kalbari village under Burigoalini UP located at the bank of Chunar River near Munshigonj Bazar was established in 1996. The market is a fish-landing centre and a selling point for fish, crabs, and shrimp. There are 17 large whole sellers (*aratders*) and about 50 small temporary traders. The traders are businessmen and thus not involved in fishingand shrimp farming. They sell fish as middlemen and get commission at 3% on total sale proceeds. The higher the quantity of fish landed, the greater the commission they get. Besides trading, most lend money to poor fishers and crab collectors on stringent terms and conditions, as discussed earlier. Fish trading is considered a more remunerative and less physically demanding job than fishing and crab collecting, which are laborious, risky and considered of low status. The *mohajans* maintain strong connections with relevant institutional stakeholders such as the Forest Department, Department of Fisheries, Police, upazila administration, Union Parishads and NGOs. They have good knowledge of local fishers and fisheries as their livelihoods depend upon them.

Summary

This chapter described the biophysical and socioeconomic environment of the coastal zone and the two study villages and their environs. There have been several physical changes over the past 40 years in the area, most of which have been due to unplanned development interventions in land and water resources. In recent times local people have begun to notice changes in local weather patterns, which have added to the other non-climate stressors they have to deal with. The description of the physical and economic environment of the study villages and their changes over time provides the context for the remaining chapters. The next chapter provides a more detailed account of the changes in the socio-ecological environments of the two study villages over a 40 year period.

Figure 3.4: Activity Calendar: livelihood production and extraction activities of Chakbara and Fultala villagers in 2011

Chapter 4:
Biophysical Changes in the Area, and Local Vulnerability

Prologue

Walking across a narrow herring bone road in Fultala village, that connected Chandipur village in the east to Kultali village in the west through Fultala helped me get a broader overview of local ecological and livelihood conditions of the people in this dynamic coastal landscape. Although the road eased means of transportation, it segmented the wetland (Fultala Beel) basin into northern and southern halves, which had already been impacted by land grabbing, conversions, fragmentation, siltation and shortages of freshwater. On top of these, cyclone Aila in 2009 inundated the beel and caused the death of freshwater fish species that used to colonise the beel and provide income and nutrition for the people living in adjoining villages including Fultala. I saw a farmer ploughing to remove hisboro rice (winter rice) seed beds, which contained standing seedlings colored yellow and looking unhealthy. He blamed the salinity that damaged his rice seedlings and then complained that cyclone induced soil salinity still persisted 2 years later. He went on to blame the people who got hold of the state owned canal and converted it to fish ponds, crop land and settlements, which would otherwise have been used as a source of freshwater for farming and fishing for the wider communities. He finally blamed the politicians and bureaucrats who facilitated privatizing, and the death of the canals which used to be used as common pool resources (CPRs) in the area.

I understood the agony of the farmer and I came to four conclusions. First, increased salinity is affecting the soil and water and thus farming and fishing in new areas along the coast, which has increased the vulnerability of people not only because of the cyclone's immediate impacts but also by its longer term residual impacts (prolonged soil salinity). Second, current state policies and institutions had facilitated and legalized the grabbing and control of rivers and canals by the local elites at the cost of a healthy environment, fishing opportunities, farming and food security. Given this record, how could the state contribute to building resilience in the face of climate change impacts? Third, in the absence of community associations *and common spaces for the local people to contest policy-state driven environmental degradation, loss of CPR bases, poor governance and exclusion of poor would continue unabated and that would affect the possibility of building more resilient societies in areas highly exposed to climate change stressors. Fourth, we need to know how aware the people of these remote coastal villages are of global climate change and its implications for their livelihoods and related assets.Such awareness is one part of a wider need to provide institutional readiness to face the challenges of climate change, particularly in the coastal zone where a multiplicity of climate and non-climate stressors are interwoven creating incremental impacts upon local social and ecological systems. With this perspective, I decided to examine in greater detail the natural and human-induced physical hazards thathad impacted upon the local area prior to recent concerns over climate change and variability impacts.*

Introduction

This chapter, and Chapter 7, describe the vulnerability of the people living in the southwestern coastal zone areas with reference to my study area. In describing the vulnerability context, I first discuss past development interventions, mainly in various water sectors at a macro level, outside the study area (exogenous in nature) and comment upon the impacts of those distant activities on water dynamics in the Lower Ganges Delta (LGD), which have created pressures on local social and ecological systems. Information on the exogenous forcing of changes resulting in increased vulnerability comes largely from secondary sources and interviews with elderly people. I then present data on micro level changes, which have happened over the years within and adjacent to the study villages (endogenous forcing) and the implications of such changes for the vulnerability context of local people. Data and information used to describe the endogenous changes were collected using household surveys, FGD, KII and resource and land use mapping (past and present) with the local communities. This chapter can be treated as an examination of the pre-climate change period in an attempt to ascertain the main vulnerabilities associated with exogenous and endogenous development interventions carried out in the past. Chapter seven provides a detailed analysis of the livelihood vulnerabilities of the two village communities to weather-induced change impacts, drawing on the three dimensions of exposure, sensitivity and adaptive capacity.

Past interventions: Exogenous forcing in the water sector and local vulnerability

Over the past 50 years several development interventions have interfered with the natural water flow regimes in the upstream as well as in the downstream river systems that have severely affected the social and ecological systems in the LGD, including the SRF. The construction of permanent coastal polders initiated by the then EP-WAPDA in the 1960s aimed at protecting rice and other assets from salinity and tidal flooding along the entire coastal zone of Bangladesh. From the mid-1960s to the early 1970s, the project constructed 4,184 km of coastal embankments in 92 polders and protected 1.1 million hectares of cropland (Schimdt, 1969).

The coastal embankment project helped protect farmers from salinity intrusion and tidal flooding within the polder areas, which in increased cropping intensity and yields. Depending on land suitability and hydrological regimes, farmers within the polder areas were able to cultivate two to three rice crops a year (Schimdt, 1969). The salinity and flood protection measures, underpinned by the introduction of High Yielding Varieties (HYV) of rice in early 1970s, benefitted farmers, share croppers and landless agricultural wage labourers. The latter used to get farm based employment opportunities almost the year round.

However, these benefits did not last long. As a result of ignorance of the ecological aspects (hydro-morphology) of the active delta, construction faults and poor operation and maintenance works in many places, from the early 1980s the area began to experience drainage congestion, embankment failure, salinity infestation, water logging and associated environmental and social problems (Shampa & Paramanik, 2012). Shampa & Paramanik (2012) describe how the polders restricted the lateral dispersion of tidal floods into floodplain basins that acted as conduits for surge water from the lower estuary to travel further northward. This resulted in increased salinity in areas previously free from such a problem. The construction of embankments around coastal floodplains (tidal plains) led gradually to a build-up of silt on river beds and raised the rivers above the floodplain basins.

Siltation also blocked the drainage channels outside the polders. The floodplains were lowered, which caused subsidence and increased drainage congestion and permanent water logging in many areas of the Lower Ganges Delta (LGD). Rice farming and other activities were affected and many people left the region to seek work (Shampa & Paramanik, 2012).

The construction of permanent dykes replaced the seasonal small scale localized dyke construction. The permanent coastal embankments thus eroded the locally adopted tidal river management (TRM) system of water control, rice farming and land formation as these seasonal bunds used to facilitate the deposition of silts on low lying floodplain basins in the dynamic coast (IWM, 2005).

The project aimed at increasing the area of irrigated agriculture by pumping water from the Ganges River in the dry season at Bheramara point to three southwestern districts of Kustia, Magura and Chowadanga. Although the project had limited initial success, it failed toachieve all its objectives mainly due to reduced dry season flow of Ganges River (ADB, 1998). In implementing the project, a number of secondary and tertiary river systems were cut off from their source rivers (the Ganges and Gorai Rivers), which affected many secondary and tertiary river systems and resulted in a shortage of freshwater flows in the downstream of the LGD.

The GK project at the upper reach and the coastal embankment project at the lower reach of the LGD started at the same time but were not well synchronized in terms of maintaining flow regimes from the north to south, or across the interactions between the tidal and non-tidal river systems in the middle reach of the LGD. As a result, the problem of siltation of rivers and consequent drainage congestion and permanent inundation of cropland and settlements began to be noticed in the middle and lower reaches (between the two projects) from the early 1990s. The problem was later compounded by upstream water diversions from the Ganges River in the mid-1970s through the Farakka barriage in India.

Water diversions from upstream river systems and resultant vulnerability

The LGD experienced a major hydrological shock with the construction of the Farakka Barrage on the Ganges River, 17km upstream in India from the Bangladesh border (Figure 4.1). Mirza (1997 and 2004), Islam and Gnauck (2008) and Sen (2010) reported severe impacts downstream from the Farakka barrage, which diverted freshwater flows away from Bangladesh. These impacts include a reduction in water flow especially in the Gorai-Madhumati-Kobadak River systems in the

LGD. Dry season water flow was reduced from 3700 m^3/s in 1962 to only 364m^3/s in 2006 - a tenfold decrease in water flow (Islam & Gnauck, 2008).

Historically, the Gorai-Madhumati Rivers and its distributaries fed the LGD and SRF with freshwater from the Ganges River. The barrage and other water sector projects have altered the biophysical and socioeconomic features of the entire river basins downstream, including changes in the salinity map of the LGD and a change in land use patterns of the area.

The district of Satkhira has been one of the worst affected districts in the lower catchment of the Ganges delta and is now a high saline zone. There has been top-dying of major tree species in the SRF, particularly the *Sundari* (Heritiera fomes). Overall, the barrage has resulted in reduced river flows, high siltation, dying of river channels, and high salinity levels (Mirja, 1997; MoEF, 1995). These changes have contributed to an alteration of the rice farming regimes of the southwest and to the availability of a range of plants and animals, including fish, a major source of protein.

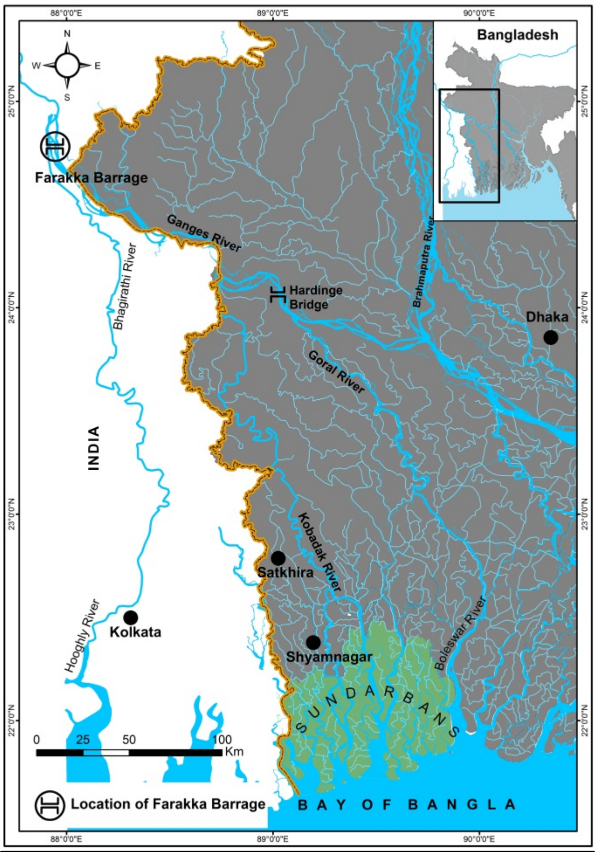


Figure 4.1: Location of Farakka Barrage
Dry season water flow in Ganges is diverted by Bhagirathi and Hooghly Rivers in West Bangal and the secondary & tertiary rivers in LGD between Gorai & Indian Boarder on the west are closed/died and lack of flows for most part of the year which negatively impacted on the South-western coastal zone with highest impact on social-ecological systems in the study area (Shyamnagar, Sub-district).

Land use changes in the 1980s and 1990s

The combined effect of costal polders and reduced freshwater flows from upstream has led many farmers to shift from rice to brackish water shrimp production for export. High demand and good prices in the international markets underpinned by incentives from the government facilitated rapid expansion of shrimp farming from the late 1970s to early 1980s in Satkhira and Khulna areas in the southwest as well as in southeastern district of Cox's Bazar. Over the last 30 years, the growth of shrimp farming has led to the conversion of the majority of rice growing land within the polders to shrimp *ghers*. Shrimp farming area has expanded from 51,812 ha in 1983 to 217,390 ha in 2009, indicating a 320% increase in area in 25 years (DoF, 1983; DoF, 2009).

Initially, shrimp farming was the domain of powerful landlords and outside investors who often forcibly leased small fields from the marginal farmers on an annual rental basis (*hari*). For many rice farmers, it was difficult (or impossible) for them to continue rice farming due to seepage of saline water from the adjacent shrimp *ghers,* which damage the rice crops. This change in land use further aggravated the problem of increased salinity in the area. During the pre-shrimp period (before 1980s), salinity was mostly confined to rivers and canals in the dry season and had little effect on cropland and homesteads. Repeated salt water shrimp farming over 30 years adversely impacted the local environment. Water logging affected rice and vegetable crops, homestead gardening, grazing areas, livestock, trees, and floral and faunal biodiversity (Alam et al., 2005; Ito, 2002; Primavera, 2006 and Islam, 2009). Shrimp farming also reduced the demand for labour as it is less labour-intensive than rice farming. Thus, a 40 ha rice plot creates work for 50 labourers while shrimp farming using the same land area requires only 5 labourers (Shiva, 1995).

The effects of past development interventions on water supply and quality can be summarized in three ways. First, coastal polders in the south together with the GK project at the upper catchment of LGD created the first level of adverse impacts that affected the tidal and non-tidal river systems, flow regimes, subsidence of floodplains and drainage congestion and salinity intrusion. Second, the water related problems were further aggravated by the withdrawal of Ganges water by the Farakka Barrage since 1975. Since then, surface and ground water availability and freshwater flows to the LGD have been severely impacted which facilitated rapid salinity intrusion further north in new areas with negative impacts on the environment and livelihoods. Third, a large expansion of salt water shrimp farming in modified rice paddies affected local social and ecological systems as it excluded many poor sharecroppers and wage labourers from the farming system and further intensified salinity and loss of biodiversity in the area. These external forcings were compounded by endogenous development actions.

Past interventions: Endogenous forcing and local vulnerability

Changes in village land use

During my fieldwork, I observed many local level activities and actions within and around the study villages (endogenous) that brought about changes in the biophysical and socioeconomic characteristics of the area and which directly and indirectly contributed to an increase in local vulnerability for some sections of the population. Figures 4.2 summarises the changes in the physical asset bases in both villages from 1970 to 2012.

There are similarities between the two villages with regard to specific physical or demographic changes such as a reduction in crop land and an increase in the size of settlements. New land uses include shrimp farms, borrow pits (road side ditches usually dug out to raise road levels) and canals, new fallow land, and expansion of natural mangroves. In Fultala, borrow pits were created as a result of the construction of roads connecting the area with the district towns while in Chakbara a few hectares of fallow land was created because of the impact of cyclone Aila that rendered some land saline and unproductive (Table 4.1). Cyclone Aila hit the southwestern coast of Bangladesh on 25 May 2009 and damaged crops across 0.13 million hectares of land, damaged or destroyed 61,377 houses either fully or partially and affected around 3.9 million people (DMB, 2009). The growth of natural mangrove in Chakbara occurred on the bank of the river Kholpetua as a result of seeds floating from the SRF and settling on two sides of the river bank. Local youths fenced the area and protected it from grazing (Figure 4.2).

Dramatic change in land use is seen in Chakbara, where all agricultural land was converted to other uses, mainly shrimp farming. Local people in Chakbara reported that some crop land used for amon rice cultivation existed up until 2011 on the eastern part of the village but were converted to shrimp *gher*s after cyclone Aila with the last rice fields converted to shrimp *gher*s in 2012. Currently, households of Chakbara are completely dependent on rice from markets. In contrast, cropland in Fultala village fell by 25% over the last 40 years and was used mainly for the expansion of settlements and ponds. The area turned over to shrimp cultivation in

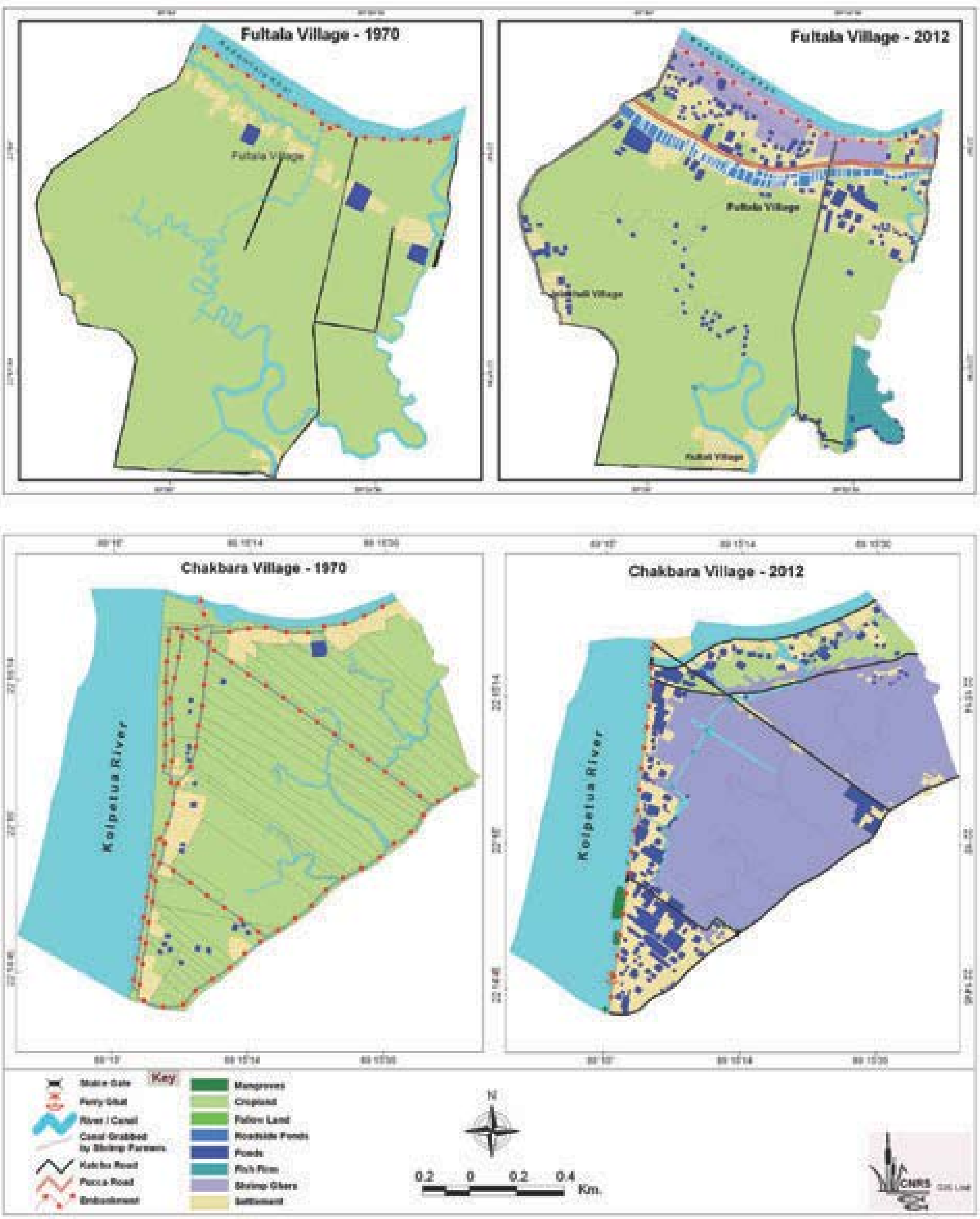


Figure 4.2: Changes of physical assets in Fultala and Chakbara villages: 1970-2012

Fultala since the 1980s has been small affecting only 19.91ha or 4% of the total land area of the village (Table 4.1).

Table 4.1: Changes of physical asset bases of Fultala and Chakbara villages: 1970-2012

Physical assets	Before - 1970		Current - 2012		Changes over last 40 years	
	Ha	%	Ha	%	Area (ha)	% of change
			Fultala village			
Crop land	421.96	87.48	322.58	66.88	-99.38	-23.55
Natural canal	20.11	4.17	12.64	2.62	-7.47	-37.15
Settlement	14.57	3.02	74.2	15.38	59.63	409.27
Road/dyke	7.66	1.59	9.89	2.05	2.23	29.11
River	15.24	3.16	7.37	1.53	-7.87	-51.64
Ponds	2.79	0.58	21.03	4.36	18.24	653.76
Shrimp *gher*	0	0	19.91	4.13	19.91	0
Borrow pit canal/pond	0	0	8.95	1.86	8.95	0
Fish ponds	0	0	5.75	1.19	5.75	0
Total	482.33	100.00	482.32	100.00		
			Chakbara village			
Crop land	76.31	52.25	0	0.00	-76.31	-100.00
River	57.45	39.34	56.57	38.74	-0.88	-1.53
Settlement	6.7	4.59	15.23	10.43	8.53	127.31
Road/dyke	3.29	2.25	1.17	0.80	-2.12	-64.44
Natural canal	1.71	1.17	0.92	0.63	-0.79	-46.20
Ponds	0.59	0.40	9.82	6.72	9.23	1,564.41
Shrimp *gher*	0	0.00	56.23	38.50	56.23	0
Fallow land	0	0.00	5.69	3.90	5.69	0
Natural mangroves	0	0.00	0.42	0.29	0.42	0
Total	146.05	100.00	146.05	100.00		

Data source: Land use change mapping done in two villages under the present research in 2012.

Both villages have grown in size since 1970 with Chakbara growing by 127% and Fultala by 410% (Table 4.1 and Figure 4.3.a, Figure 4.3.b, Figure 4.4.a and Figure 4.4.b). A major reason for the difference in the growth in the two villages is availability of land suitable for house building. Chakbara is a low lying high saline prone area and major parts of the village are under shrimp cultivation. Shrimp farming accounts for 39% of the total village area, but if the river area is dropped from the calculation, it rises to 63% compared to only 4% in Fultala village. Another reason is the suitability of land for house construction. Chakbara is built on low lying land and some residents have dug ponds in order to build houses on raised plinths. In addition, a main source of water for drinking and washing is from ponds (stored rainwater), especially during the dry season, and government provided assistance with pond digging. Over time the ponds have taken up more space and crowded out house building opportunities. Household census data show a high degree of land scarcity with 80% of all households having homestead areas of less than 0.008 ha. This compared unfavourably with Fultala with around 4% of households with such small homestead areas. On average households in Chakbara have only 0.013 ha of homestead area per household compared with 0.077ha per household in Fultala, which is six times higher. In the longer term, the scope for the physical expansion of Chakbara is less compared with Fultala.

Although covering a small in area, natural canals have been reduced in size by 37.15% and 46.2% in Fultala and Chakbara respectively. In Chakbara, the canals

Figure 4.3.a: Asset bases in Fultala village in 1970

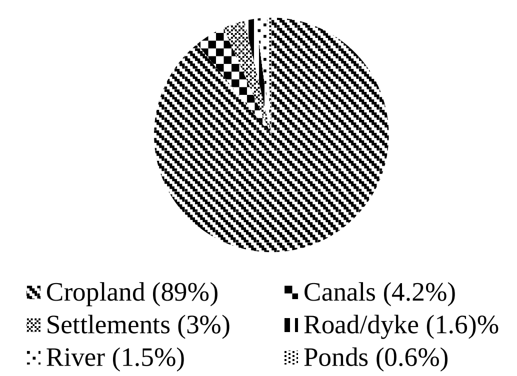
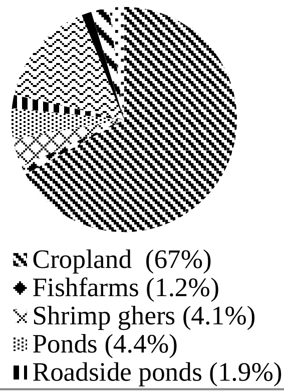


Figure 4.3.b: Asset bases in Fultala village in 2012



were merged with shrimp *ghers* while in Fultala they were converted to cropland, ponds and settlements. The Kultalikhal that was once linked to the beel and crop land of Fultala and Kultali villages has been converted by the khal leaseholders to crop land and ponds where it passes through the beel and crop land and converted to settlements where it passes through villages. A part of the Kultalikhal (see map in figure 4.2) was re-excavated in the 1990s to store monsoon water to irrigate rice, but was then leased out to local people who divided it up for private fish culture. Thus, it lost its function as a common pool resource (CPR) for local people as a publicly available source of water for rice farming and for fishing. In some places, canals were taken illegally by the owners of adjacent land who claimed themselves as *de facto* owners and converted them to either ponds or crop land.

In most villages, crop land is private property while the rivers, canals, and roadside canals are owned by the state (*khas* land) and managed under government line agencies and controlled at field level by the sub-district and district level administrators. The ecological services and products of wetland (rivers, canals, beels, borrow pit canals) have traditionally been central to the economic, social and aesthetic lives of local people, especially poorer members of the community (MEA, 2005).During my field work, farmers in Fultala said that in the past they used water from Kadamtali River, Kultalaikhal and road side borrow pit canals and ponds for irrigating rice and other crops in the dry season. Land grabbing and privatization of *khas* land has deprived them of these services. The examples provided here are indicative of a wider trend across the country where common pool resources have been privatized, which together with a growing population seeking ever diminishing resources, has resulted in growing asset inequality. In Kultali and Chakbara this has meant that opportunities for growing three rice crops a year through the use of salt-tolerant rice varieties have diminished and are available to fewer people.

River narrowing and its consequences

The wide river has been reduced to a narrow and winding canal and is almost biologically dead. It was once navigable the year round by small to large size boats

Figure 4.4.a: Asset bases in Chakbara village in 1970

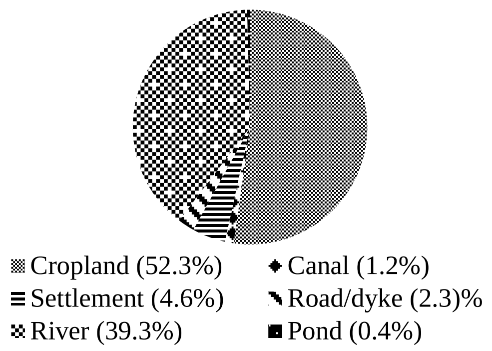
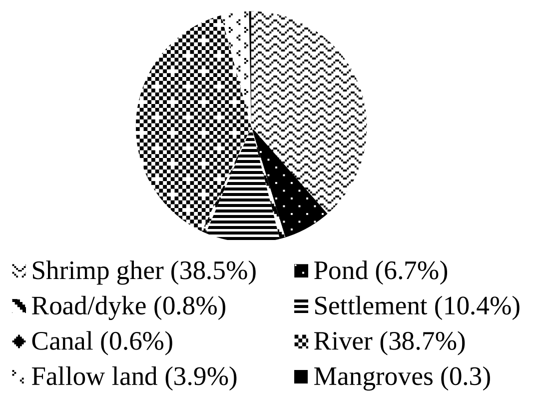


Figure 4.4.b: Asset bases in Chakbara village in 2012



and was until the 1950s the only means of transportation of people and goods. It has lost its riverine character and is today called Kadamtalikhal instead of Kadamtali River. Elderly people in Fultala village recounted that in the early 1900s the whole area was part of the SRF and the river originated from Chunar River on the southeast point of Munshigonj Bazar (a growth center) and meandered northwest through the deep mangroves to be reunited with the Chunar River at Jabakhali point after traversing 21 kilometers. In the middle of the river's course, a growth center called Golabari is located at a junction of rivers from where a branch traversed southwesterly and met with the River Jamuna (a local river). At this time, the river was 21km long, approximately 107 – 122 m wide and about 6 m deep. It was one of the key navigation channels for carrying various products from the Sundarbans to various growth centres and towns in the southwestern part of the Ganges delta. Lines of boats carrying nypa palm, goran wood, fish, honey, catkin grass, rice, raw materials used the river almost the year round. This river was also a route for deer hunters going to the Sundarbans. Traditional Bengali boat races (“*nouka bayice”*) on the river were also common in the post-monsoon. Most of the people had small boats of their own for personal and commercial uses and navigation was an economic and livelihood activity of many people. During the wet season when the earthen road was difficult to use, people preferred to move by boat. The River Kadamtali was thus an integral part of the social, economic and cultural life of the people in the area. This all changed with the advent of development interventions in water sector projects in the mid 1960s.

With the construction of the Kadamtali Sluice gate and an embankment at Jabakhali in the 1960s, large boats were unable to use the river as there was no provision for a wier to bypass the sluice gate. However, small boats continued to ply the river after construction of the sluice gate by carrying them across to reach the rivers. In 1967, another sluice gate was constructed at the mouth of Kadamtali River near its confluence with the Chunar River at Munshigonj Bazar point, which had been the cutoff point for the navigation in the Kadamtali River. This stopped navigation completely. The changes that have happened to the river due to human interventions over time are presented in Table 4.2.

The embankments and sluice gates were constructed to prevent tidal flooding and increase rice production within the protected area. Soon after construction, two rice crops were possible using freshwater from the river. However, local influential people took control of the char land at the river bank for rice farming and settlement. In Fultala village area 13 families, with the support of local elites, built homes on the river embankment, which led to a further reduction of the river width and depth and its subsequent drying out. One ex-UP member in the area acted as the key player in allowing people to settle illegally on river banks.

Table 4.2: Impact of development interventions on the Kadamtali River: 1949 to 2010 (Source: Interview with three elderly farmers in Fultala in 2011)

Time line	Development interventions	Features of the river	Use of river
Before 1960s	No intervention Natural setting	-River was wide and flowing; width ranged from 350 to 400 feet in dry and wet seasons	- Small and large boats for passengers and goods; -Boats carried nypa palm, fish,

		respectively; depth varied from 8 to 15 feet; - River water was saline in dry season.	wood, from Sundarbans and carried rice and other materials; - Annual boat races on the river -River based livelihoods.
Mid 1960s	Sluice gate built at south Kadamtali and embankment at Jabakhali	- River flow regulated and disrupted due to sluice gates; -Water inside the river from southKadamtali to Jabakhali point was sweet while most parts of it turned in to saline.	-Large boats unable to navigate; small boats continued; -Increased salinity of water meant only saltwater fish survived. In monsoon some freshwater fish came to the river from beels but usually died due to salinity.
After 1967	More dykes and sluice gates constructed at south end of the river	-Depth and width of the river reduced and water turned sweet due to sluice gate; -Kadamtali River became a narrow canal.	-Small boats continued but numbers reduced; -Rice farming continued for couple of years after sluice gate construction; -River water used for irrigating winter rice.
1968-1985	Rice farming continued in the upper section of the river where salinity less	-River water sweet in monsoon with salinity in the dry season for 2 months; - Freshwater fish species were abundant in the river.	- Water used for rice farming (2 crops year) in middle reach, no farming in downstream due to salinity (Munshigonj area); - Fishing, bathing, washing, cattle bathing, were the main uses of river water;
1985 onwards	Start of shrimp farming on both sides of the river	-River water under stress from shrimp *ghers;* -River water turned to saline for most of the year.	- People rapidly converted their rice paddies to shrimp *gher*s; - 30 pump machines installed supplying water to shrimp *ghers*from the river;
1998 to 2010	Privatization of Kadamtali khal	-River further reduced in depth and width; -Salinity further increased; through manipulation of sluice gate: rice farming using river water ceased; - Water supplied to shrimp *ghers* only.	-River controllers selling water to shrimp *gher* operators and creating pressures on fishing activities; -CPR regime of the river lost; -Khal diminishing in width through illegal appropriation; - River likely to disappear in coming years without remedial action.

Since construction of sluice gates and embankments in mid 1960s, the river has reduced in width and depth and gradually lost its CPR characteristics as the river became private property. The land administrator handed over control of leases to wealthy locals and did not consider the benefits of the river as a natural asset and a CPR base. Once in control of sections of the river, leaseholders sold water to *gher* operators at US % 4.81-9.62/ha. The negative changes to the local environment and the wider society as a result of CPR privatization increased the vulnerability of poor people who once used the river for fishing, irrigation, bathing, washing

Collective Action, Disaster Risk Reduction and Vulnerability

The vulnerability of local people as a result of socio-ecological changes over the past 50 can be illustrated by embankment breaching in Chakbara village mainly due to cyclones, storm surges or high tides, poor maintenance and illegal structures. Based on accounts provided by elderly people in Chakbara, a summary of embankment breaching over the last 50 years (1972 -2009) is documented below:

1972 – Breached at Khalishabunia village (west of Chakbara) and inundated two villages. The villagers collectively fixed the embankment but it again breached during high tides. Later the Bangladesh Water Development Board (BWDB) fixed the embankment.

1976 – Breached in September and inundated Chakbara and Jelekhali villages for about 15 days and affected crops and assets including some houses. The villagers collectively fixed the embankment in two weeks. Later BWDB repaired the embankment after three months.

1988 – Breached at 6 points but damage small (3-5 feet only). Besides breaching, surge water over topped the embankments at several points. Local UP Chairman along with villagers fixed the embankment in 2 days and later BWDB strengthened it further after 3 months.

1994 – Breached at Chakbara and several villages were flooded and the most affected villages were Jelekhali, Chakbara and Khalishabunia. The UP Chairman took quick initiative and fixed the problem with help from local people.

1998 –Breached at Napitkhali village and inundated 3 to4 villages causing severe damage. The embankment was quickly fixed by local people under the guidance of the UP Chairman and later BWDB repaired the embankment.

2001– Breached and inundated Ghagramari and Jelekhali villages, which affected 60% of shrimp *ghers*. Local people fixed the embankment in 2 days with the guidance of UP Chairman.

2007 –Cyclone Sidr breached the embankment at three points with initial width of breaching points of 4.6 m but at low tide this increased to around 61 m at each point. Local people collectively tried to fix the embankment over seven days but failed due to strong tidal effects. Two months later BWDB fixed the embankment.

2009 – Cyclone Aila breached the embankment at five points and the entire union comprising of 15 villages remained inundated for 12-18 months from May 2009. This was the most catastrophic naturally-induced event in the history of Gabura union. Tidal saline water damaged homesteads, houses, shrimp *ghers*, fish ponds and roads. People took shelter on embankments and many families moved to neighboring sub-districts, district towns and to Khulna, Jessore and Dhaka. However, this time the community was unable to respond quickly to fix the embankment and later strong monsoon tides widened breaches even further. Finally 18-20 months after cyclone Aila (May 2009), BWDB contractors fixed the breaching points of the embankment.

The description here shows that for part of the time local people with UP assistance were able to act collectively repair embankment breaches but were unable to do so in 2009. It is unclear why, after cyclone Aila, it took 18 months to repair the embankment, especially when the breaching points were small and easily manageable.

The majority of the local people in Chakbara and Fultala objected strongly to the time it took to fix the embankment (Figure 4.5). Of the surveyed households in Chakbara village, 96% people, based on their previous experience, opined that it was illogical that such a long time was required to make repairs. All the 12 UP members of Gabura union who participated in the survey also strongly objected to the time taken. People of Fultala village and UP members of adjacent Munshigonj union gave similar responses. This issue was politically sensitive, which became clear when I spoke with people in Chakbara village near the breaching point (repairing work was ongoing), who took shelter on the embankment. One Chakbara villager commented:

> When the embankment was breached at this point it was only a meter and half width, we could have easily fixed the point instantly and even it was also possible next day through collective action when the width of

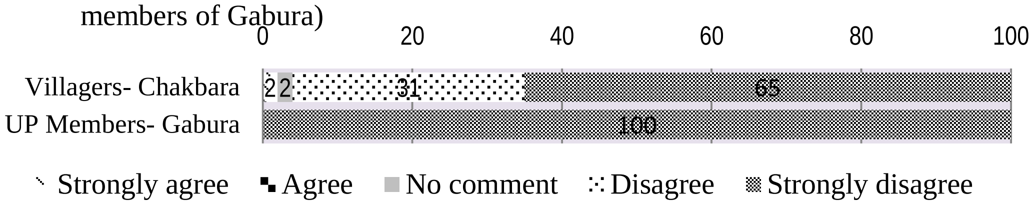
> breaching further widened and people were ready to fix the breached point. However, we were discouraged and told not to fix, rather wait to get it further widened so that we get more relief materials and a fat budget from the government for fixing the embankment …

At this point, another person told the informant not to say anything further about this and everybody became silent. People had to wait and see the destruction caused by the strong tidal inundation, and later a large budget was approved. By then the breaching points had become very wide due to strong tidal forces. The work was then deferred until the next dry season but further administrative delays meant that it was 18 months from the date of breaching to the final repair of the embankment, during which time many people had suffered greatly. Communities of Chakbara and UP members of Gabura also considered that it took too long to repair the embankment (Figure 4.5).

The example given illustrates the complexities of governance in Bangladesh where local politicians, district officers, government agencies, contractors and vendors participate in networks of influence and control across communities and up to the national level. In the case discussed, embankment construction, repair and maintenance are the domain of the BWDB (Bangladesh Water Development Board), which works closely with local UP Chairmen in implementing all activities at grass roots level through engaging licensed and registered contractors or vendors. In informal discussions with several local people, it was stated both explicitly and indirectly that delays in repair were the result of political interference to increase government funding at the local level for the benefit of the more powerful.

Further discussions with older people revealed that while coastal embankments were necessary to save crops and other assets from cyclones, storm surges, tidal flooding and salinity intrusion, the collective actions taken in the past which engaged both local people and UP politicians had broken down by 2009. For example, many local people believed that as shrimp farmers were badly affected by cyclone Aila, it should have been their responsibility to repair embankments as they were wealthier and had more political influence. It was asked why the wider community should take the responsibility for embankment fixing rather than shrimp farmers who failed to come forward to offer any specific assistance.

Figure 4.5: Percent of communities and UP members' responses on "taking 18 months is a long time to fix embankment after cyclone Aila-2009 and is longer than required" (n=45 Chakbara and n=12 UP members of Gabura)



The example is indicative of a wider change in land use patterns that have altered the social and economic relations between members of the community. In the past when rice farming dominated the local economy, land owners engaged poorer members of the community as share croppers and agriculture wage labourers. There was grazing land for people to graze their livestock and poor people borrowed rice from farmers during the lean season or at times of family crisis.

These connections or strong networks of social capital acted as the glue for collective action, as almost every household was connected to rice farming in one way or another. These connections had weakened over the years and were dramatically exposed during and after the 2009 cyclone. A result of the erosion of community based collective action during times of disaster coupled with increased institutional corruption increased the vulnerability of poor people, created a growing number of jobless and resulted in increased demands being made on the SRF. This was especially pronounced in Chakbara, which is almost entirely shrimp farm-dominated and with a greater traditional dependence on the ecological services and products provided by the SRF. However, there have also been some counter-trends in agriculture in Fultala village that have benefited the farming community and enhanced their adaptive capacity.

The rice farmers of Fultala village: transformation and vulnerabilities

Historically, the people of Fultala grew rice during the monsoon and vegetables the year round. Both men and women were heavily engaged in agricultural tasks. The women interviewed stated that the division of labour between men and women was clear prior to the introduction of high yielding varieties of rice. Common local varieties of rice cultivated in the area were *geti, gopal vogue, horkoch, charal, patnai, chinikani, datshail, koijuri, ghunsi, khacchuri, holde batali, geri muri* and *boyer vote*. The cultivation practices of these varieties were simple, and followed a linear activity calendar linked to rainfall patterns explained by the women FGD participants in Fultala:

> At the first rains of the Bangla month *jaisthya* (mid-May to mid-June), they prepared the seed bed, first week of *ashar* (mid-June to mid-July) ploughed the land and started transplanting rice seedlings from first week of *sraban* (mid-July to mid-August) and harvesting started from mid *agrahayan* and ended in the same month (mid-November to mid-December). They did not do any weeding nor did they apply any fertilizer or pesticide in the rice field. Every year they had to follow more or less the same farming calendar that was synchronized with the climatic factors such as timely rainfall in pre-monsoon and monsoon.

If the pre-monsoon and monsoon rainfall was adequate, it washed out the soil salinity from crop fields and created a favourable condition for rice farming. At other times of the year, the land was too salty and people could not cultivate, leaving a vast tract of cropland fallow, which remains the case today.

With the advent of new rice strains, the low yielding local varieties were gradually replaced by high yielding varieties (HYVs) in Fultala and across the country. The HYV amon varieties were also rain-fed and followed the same sowing and harvesting calendar as that of local varieties. However, HYVs required weeding, fertilizing and pesticides, which made farming more labour intensive. As a result, local environmental resources and the gender-based division of labour started to change in Fultala (Table 4.3). Women became more involved helping their male partners in the crop fields in weeding and fertilizing activities. When the farmers were busy with HYVs amon rice farming, another winter season and labour-intensive high input-based irrigated HYV variety (boro rice, locally called *goromer dhan*[9]) was introduced in the area in mid 1990s. This variety required much more irrigation and farmers began to grow it in ponds, canals and road side borrow pits where freshwater was available. This new rice variety followed a different calendar, growing in the winter when rainfall is low and salinity at its peak. Farmers prepared seed beds in early *poush* (mid-December to mid-January), transplanted seedlings from early *magh* (mid-January to mid-February) and harvested in *baishak* (mid-

[9]*Gorom* means warm that we feel in summer and *dhan* means rice, this variety is planted in winter (January) and harvested in summer (around April).

April to mid-May) each year. However, these activities required more water, which constituted a barrier to irrigation of the double cropping of rice in Fultala. However, in discussions with local women, they stated that extra water from other sources was not easily available as it had been taken by others (both legally and illegally) and farmers were then charged for it or it was used for other purposes. While these new HYV varieties increased rice production and contributed to some degree to greater food security, there were some negative impacts on local biodiversity. HYV rice needs intensive wedding that uprooted many aquatic flora which affected fish and naturally grown wild vegetables. Similarly, the application of fertilizers and pesticides polluted the environment. A second level impact occurred with boro rice cultivation as water was extracted from ponds, ditches, canals and beels, thus reducing water volume and affecting fish stocks. The various impacts of this shift to HYV rice are summarized in Table 4.3.

Table 4.3: Changes of crop varieties and the local environment in Fultala: 1980 to 2012

Year	Rice varieties in the village	Farming requirements	Climate risk and sensitivity	Remarks
Early to late 1980s	Local aman varieties – rain-fed monsoon rice (low yield).	Seedbed and sowing Tilling land; Transplanting seedlings and harvesting; (Largely male members involved in farming activities).	Low risk and low sensitivity (having had predictable and enabling rainfall pattern).	Least impact on local environment; High abundance of local fish, aquatic vegetation in beels(food and fodder); Many poor families eat varieties of wild vegetables during crisis period.
Late 1980s to present	Introduction of HYV amon varieties as rain-fed monsoon rice (medium yield).	Seedbed and sowing, tilling land, transplanting seedlings and harvesting; + Weeding, fertilizing and applying pesticides; (Female members joined the male members in some field farming activities).	Medium to high risks and medium to high sensitivity (low/ delayed monsoon rainfall and sudden high rainfall).	Rice yields increased, medium impact on local environment; Weeding, fertilizing and pesticides impacted on the abundance of freshwater fish, aquatic vegetation Currently freshwater fish and aquatic vegetation is almost gone; Poor people hardly get fish and aquatic vegetation for meeting their crises period.
Mid-1990s to present	Besides HYV amon, HYV Boro was introduced as winter rice in places with irrigation facilities	Seedbed and sowing, tilling land, transplanting seedlings and harvesting; + Weeding, Fertilizing and Applying pesticides; +	High risks and high sensitivity (higher salinity, lack of sweet water for irrigation, no or very low pre-monsoon rainfall).	Rice yields increased further, higher impacts on local environment, irrigation caused shortage of freshwater and social conflict, fertilizers, pesticides impacted local fish, aquatic vegetation,

	(high yield).	Irrigation (Higher involvement of women in farming (weeding, fertilizing + responsibility for manual irrigation).		land tilling by tractors damaged aquatic vegetation, *mele* (mat making plant); Cyclone-induced salinity killed remaining stock of mollusks, fish and vegetation in beels, canals and ponds.

Source: FGD with women members of farming households in Fultala in 2011.

Farmers in the pre-HYV period did not need to make contingency plans for rice farming as climate factors (timely rains) in most years followed a regular pattern and were more predictable compared with today To this end, Delwara Begum, a woman from farming household of Fultala village said:

> In the past, there was no need for making any plan for cultivating local varieties of amon rice. Everything around rice farming was a kind of regular job. Rainfall pattern used to follow a systematic rule - we knew when it would rain and what we have to do. Every year we had to just repeat the same farming practices. But now with the introduction of HYV varieties coupled with erratic behavior of rainfall pattern we are in trouble, often our plans fail – currently we do not get adequate rains in time we need for farming.

Another housewife, Sufia Begum of Fultala village said:

> Now every year we make plan and get ready for planting but there is no *jaisthay vannya*[10] thus we cannot prepare the seedbed in time and therefore, we cannot sow seed during *amabotir joe*[11] usually happens during 5th to 10th of Bengali month of *ashar* (mid- June to mid-July) which compelled us for delayed planting of seedlings, thus we get lower yields and small quantity of hay but the cost of production remains the same or even higher.

[10]In the past there used to be heavy rains by end of the Bengali month *jaisthay* usually after 20th which used to wash out salinity from the soil and to facilitate the process, people use to cut the bunds to drain the rainwater. Later, people again rebuilt the embankment to hold water for preparing the seed bed and sowing seeds.

[11] After the *jaisthaya vannay*, there used to be heavy rains in early *ashar* (next month) usually during 2nd to 10thof*ashar* called *amabitir joe* that contributed to enrich soil moisture suitable for tilling.

She added that if there was no rain in the later part of the season in the month of *kartik* (October-November), rice yields were lower.

Women's narratives about transformative farming systems in Fultala are relevant to the research in three respects. Firstly, the HYV rice (both amon and winter rice) though it increased rice productivity and food security, demanded extra work (for weeding, fertilizing, watering and pesticides applications) that took women from their homes into farming activities and created extra work for them (see Figure 4.6). Secondly, improved rice varieties affected the local natural environment and biodiversity upon which many poor depended for their livelihoods. Thirdly, illegal land grabbing, particularly of canals and road side borrow pits not only squeezed the CPR base but also affected food production. Finally, in more recent times there has been a more irregular rainfall pattern, which increased pressure on women to manually irrigate the rice fields during drought and affected food production in the area.

The Story of shrimp PL collectors of Chakbara: Availability of PL and

Figure 4.6: Men and women harvesting rice in Fultala village

vulnerability

Chakbara provides a different local example of the changing pattern of land use and the role of weather-related changes in the occupational and other activities of local inhabitants. By the mid-1990s, over 90% of the village crop land wwas converted to shrimp *gher*s leaving the rest for rice farming, until 2009 when Aila struck. By mid-2012, this land was also converted to shrimp *gher*s and currently 100% of former rice crop land has been converted to shrimp *ghers*. A major consequence of this was that former farm workers sought new forms of employment, some becoming fishers while others became shrimp PL collectors, shrimp farm workers or took up SRF-dependent livelihoods. Many migrated to the cities in search of work.

Land use change and joblessness have placed increased pressure on natural resources (fishing, shrimp PL collection, crab collection) in the SRF and adjoining rivers since the start of shrimp farming some 25 years ago and degraded the resource base of the area (Paul and Vogl, 2011). Increased salinity has severely affected the availability of freshwater fish in the village. Ms. Nahar, a shrimp PL collector of Chakbara said:

> We used to get 3/4kg of varieties of freshwater fishes like *koi* (climbing perch), *shol* (snakehead), *magur* (walking catfish), *shing* (stinging catfish), *taki* (snakehead) in a day from a small *nala*[12] next to our house. But now we do not get these fish species any more – fresh water fish is severely impacted and on the verge of extinction from this island union.

Men, women and children from many families in Chakbara took up shrimp PL collection in rivers and canals (Figure 4.7). Increasing numbers of PL collectors combined with the absence of any government or NGO shrimp stock improvement and management activities contributed to a decline in shrimp fisheries in the coast manifested as reduced availability of PL. Female PL catchers reported a decline in income from sale of PL as wild stocks declined and hatchery supplies increased. PL collectors increased their fishing effort to get more PL to compensate for the price fall and thereby increased further pressure on estuarine and marine ichthyodiversity (Paul and Vogl, 2011). They commented that monsoon rainfall had influenced PL availability. For example, Ms. Rijia Begum of Chakbara, a PL collector for 20 years, said:

> If we have enough rains in monsoon months we get more PL. Rainfall triggers all sorts of fish to swim upwards in the rivers and Sundarbans. In the years having low rainfall there is less fish that swim upwards and less fish availability including the shrimp PL. There was low rain in the

[12]Small canal or drain usually excavated by people for irrigation or drainage purposes

year cyclone Aila hit our area and we got few PL and thus had low income. We now understand which year we get more fish and shrimp PL based on the frequency and intensity of storms and rains.

Regarding the low availability of shrimp PL, Hajera Begum, another shrimp PL collector from Chakbara said:

> I have been collecting shrimp PL over the last 20 years. In the past, in one PL catching net I used to get 500-600 *bagda* PL over a period of 2/3 hours during the high tide in the month of *baishak* (mid-April to mid-May). While now during the same month and over the same time, I get only 200-250 PL – currently, there is more than 50% reduction in PL availability.

She emphasized two reasons for this, more people engaged in PL catching and the current erratic pattern of rainfall.

Based on information from female PL collectors in Chakbara, it is clear that the level of income from shrimp PL collection has been reduced, due to lower availability of PL from natural sources as well as a low market price. Based on discussions with women PL collectors, it is estimated that income had dropped by 80% due to low availability of PL and low market prices (Table 4.4).In addition, the women were sensitive to changes in rainfall as it affected their capacity to collect PL. When rainfall is good in the pre monsoon and monsoon they get more PL in rivers.

Table 4.4: Declining availability of shrimp PL and associated income

Time line	PL caught during rainy days in *baishak-jaisthaya* (No. of PL/day)	Distribution of *golda* and *bagda*PL(%)	Market rice (BDT[13]/1000 PL)	Average income (Tk/day)[14]
Before 1995	500-1,000	Bagda – 70% Golda – 30%	Bagda – 500-2000 Golda – 1000-3000	995
Current (2010)	200-500	Bagda- 80% Golda - 20%	Bagda – 200-700 Golda - 250-1000	170 (income reduced by 83%)

Source: FGD with women in Chakbara village, January 2011

[13] One US $ = BDT 78.00 (2014 rate).

[14]Considered that for *golda* and *bagda*, 50% of the catch sold at the lowest and 50% sold at highest prices.

From discussions with Chakbara villagers, I have categorized their perceptions of how village life has changed into three time-related categories: the time before shrimp culture or the pre-shrimp period; the time after shrimp farming began (the shrimp period); and the time after the 2009 cyclone Aila. Based on the narratives of women PL collectors, these events, especially for the poor households, can be interpreted as “Happened to be good” for the ‘pre-shrimp period’, “The Not So Good” for the ‘shrimp period’ and “The Downright Bad” for the ‘Post-Aila period’ (Table 4.5).

Table 4.5: Changes of land use and livelihoods of Chakbara village

Time scale	Features and temporal changes	Remarks
Before salt water shrimp culture (before 1990) Defined the period as **“Happened to be Good**”	-People cultivated amon rice, women grew homestead vegetables to meet own demands including income from selling; -High abundance of freshwater fish in beels and khals open for fishing by all (common pool resources); -People reared cattle, goats and poultry; -Poor women worked in rich people’s houses and got rice to meet a part of food demand. Many poor people survived on gleaning rice from fields after harvesting; -Men worked as farm laborers, fishers and forest resource collectors; -Rice farming, cattle rearing, fishing and forest resources formed the basis of livelihoods.	-People relied on natural resources; -Women involved in households works and homestead gardening ; -Managing rice (staple food), even for the poor was not difficult; -Had better environment and better household economy; -People collectively faced hazards – no visible conflict comparable with that between shrimp farmers and rice farmers or fishers or wage laborers.
Shrimp farming	-Most beels/ rice land converted to shrimp	Increased environmental

Figure 4.7: Women collecting shrimp PL from river

Time scale	Features and temporal changes	Remarks
period (from 1990 to 2009) Defined as "**The Not So Good" period**	*gher*s.Limited rice farming continued in land not suitable for shrimp; -Homestead vegetable cultivation squeezed – could not meet household demand; -Rapid disappearance of livestock animals from the area due to loss of grazing fields and salinity; -Loss of freshwater fish from the beels and reduction in plant and crop diversity due to higher salinity; -Landless people lost jobs from rice farming, became fishers and engaged in SRF resource collection creating pressure on limited natural resources of SRF; -Women started work in shrimp *gher*s and in PL collection, which caused loss of biodiversity; -Women reported low availability of shrimp PL due to declining rainfall over the last 7/8 years.	degradation; -Women's work extended: household work plus PL catching, shrimp *gher* labouring low availability of PL affected livelihoods of the poor; -Children worked in shrimp PL collection, which impacted on their education; -Socio-economic divisions widened.- the "rich shrimp farmers" versus "poor fishers or wage laborers"; -Social cohesion among people in managing disasters reduced.
Post-Aila period (From May 2009 to 2011) Defined the period as "**The Downright Bad"**	- Cyclone Aila-induced damage first of its kind in the known history of this village, villagers had to abandon their houses due to saline water inundation and live on embankment for more than a year; -All ponds, shrimp *gher*s remained inundated for more than a year and polluted soil and water; -Small scale shrimp farmers lost income and became poor with poor shrimp production over three consecutive years (2009, 2010 and 2011); -Most homestead tree species died due to prolonged saline water inundation; -Drinking water ponds in the area contaminated resulting in severe scarcity of drinking water -Due to cyclone and embankment breaching, shrimp culture stopped for three years; -Many people starved to cope with the situation.	-More pressure on natural resources (fish, forests, shrimp PL, crabs) and declining productivity; -Small shrimp farmers turned to earth cutting and, fishing for survival; - Class division widened with regard to disaster management, opportunistic fishing in damaged shrimp *gher*s, relief and rehabilitation activities; -Disasters increased, overall livelihood now become harder and living in this island is now become risky.

Source: FGD with women members of Chakbara in 2011.

The discussions shows that poor women PL collectors linked what they saw as changes in weather patterns related to rainfall and drought with the availability of shrimp PL in rivers and for a time were able to earn a living, although a poor one. Recent changes in wild PL availability intensified labour inputs. The growth of hatchery PL and changes in weather patterns combined to put great pressure on poor households who were forced to rely more on resources from the SFR. These observations prompted a more detailed analysis of community perceptions and understanding of weather and weather-related changes and the extent to which these can be linked to debates over climate change.

Summary

This chapter has shown that over the past 40 years a combination of various exogenous and endogenous interventions and practices in the water sector impacted upon local water regimes, land use and social-ecological systems. During that time village environmental resources and land uses underwent major changes, including the disappearance and shrinkage of canals, rivers, and crop land and the expansion of areas of settlements and ponds. Shrimp *ghers* emerged in the 1980s as a major land use, particularly in Chakbara village where 100% of rice crop land were converted to shrimp *ghers*, which affected the livelihoods of rice farmers and wage labourersand led to changes in local ecological systems and their biodiversity as a result of increased salinity. Fultala, a village largely dependent on agriculture, was shown to have experienced the adverse effects of leasing and conversion of canals, road side borrow pits and rivers on local environments and rice farming. All these past interventions and reduction in size of productive cropland and wetland have collectively increased the livelihood vulnerability of local people before the effects of changing weather regimes become visible. The next chapter focuses on the changing weather patterns in the area and discusses local people's perceptions and understandings of these changes.

Chapter 5:

Community Perceptions and Understanding of Changing Weather

Introduction

This chapter focuses on community perceptions and knowledge on weather and climate and climate change related issues. I document the perceptions and knowledge of place-based communities in the project area, including the local government representatives, field staff of NGOs and primary school teachers. Targeting these other stakeholders groups was particularly important as they are likely to play a major role in facilitating transformation in the lives of local people, and thus their understanding of climate issues is important to help communities develop effective adaptation strategies. Finally I present time-series national meteorological data on rainfall and temperature for the study area to judge whether community perceptions of weather changes align. Relevant data were collected by administering a knowledge, attitude and practice (KAP) survey, focus group discussions, and key informant interviews. The temperature and rainfall data for Satkhira district were collected from the head office of the Meteorological Department, Dhaka.

Communities and their understanding of climate change

The leading global scientific body that deals with global climate change, the Intergovernmental Panel on Climate Change (IPCC), has confirmed that human-induced climate change (CC) is now unequivocal and a reality. IPCC also confirms, based on modeling and empirical observation that CC is occurring at a faster rate than previously anticipated (IPCC, 2012). Rise of global temperatures at a faster rate than normal is triggering changes in climate attributes and affecting the normal rhythm in the structures and functions of physical and natural systems of the earth. This in turn, exerts differential impacts on global ecosystems and human society with developing countries particularly susceptible to adverse impacts of climate change and climate variability. According to Working Group One of the IPCC 5th

Assessment Report (WG1 IPCC), global surface temperatures will likely increase by 1.5^0 and 2.0^0 compared to the period 1850 to 1900 by the end of the 21^{st} century and the concomitant global warming will have serious impacts on physical, natural, social and economic systems. The coast zone of Bangladesh is being affected by high tidal water levels. Increased and erratic patterns of precipitation, increased droughts, melting of glaciers, shorter and warmer winters, sea level rise (SLR), and increased incidence of severe cyclones are considered to be linked to climate change caused by human activity (IPCC, 2007). Each of these physical changes due to CC has multiple impacts on ecosystems and human society. Their collective impacts could be great with the potential to jeopardize current and planned development outcomes (Stern, 2006). It is also clear that Bangladesh is likely to be severely impacted by CC and it is essential to build effective adaptation strategies upon a solid foundation of knowledge of community understandings and perceptions of CC.

The central focus of this research is how coastal peoples view, understand and respond to the weather and weather-related hazards that affect them.[15] To do this I targeted two coastal villages of Chakbara and Fultala comprising of various occupational groups as well as other local development actors such as local government or UP members, NGOs and primary school teachers. These latter play important local leadership roles in several areas of community concern, including disaster management and development planning. UPs have their own annual development plans and implement development activities at the local level with funding from the central government. The NGOs are civil society organizations that work very closely with the communities and deal with their day to day problems related to livelihoods, capacity development, disaster risk reduction, conflict management and so forth. The primary school teachers are respected persons in the society and people often seek their advice. For the climate related knowledge survey, I interviewed 90 village households (45 from each of the two villages), field staff of 20 NGOs, 24 UP members (12 from each of the two UPs) and 21 primary school teachers in two concerned UPs.

[15]When referring to local climatic conditions, the word ‘weather’ will be used. Local people use the Bengali version of this word and it is important to distinguish it from climate, which has a wider reference.

Understanding local people's views of CC requires an examination of their linguistic practices and their everyday use of language in relating to the natural world. While the Bangla term for climate change, *jalabayu paribartan,*[16] has become more common at elite levels of society and among NGOs, local people are less familiar with it and it cannot be said to have taken deep root in everyday speech.Thus, to approach the topic I used the Bangla term for weather or *abohawa*. However, even this term proved too abstract for many. Much more useful was to allow villagers to speak of concrete situations they face, such as rice planting, and how that is affected by rainfall and other climatic factors. For example, one villager spoke of how the *abohawa* (weather) had affected his rice production:

> …last year my rice production was poor due to *khora* (drought)…this year heavy rains early in the season (*okal bristy*) damaged rice seed beds…I cannot get the full harvest, crop agriculture is getting worse day by day.

The villager here uses the specific Bangla words for drought (*khora*) and "heavy rains early in the season" or erratic rains (*agam kasthe* or *okal bristy*) to denote climate or weather attributes. The use of long-standing words and concepts remains central to everyday talk around climate-related events and processes. However through NGO training and awareness campaigns on climate change, villagers are gradually becoming more aware of the existence of the new language of climate change without necessarily understanding its full meaning and importance. This will become clearer later in the chapter.

Community, climate and Livelihood

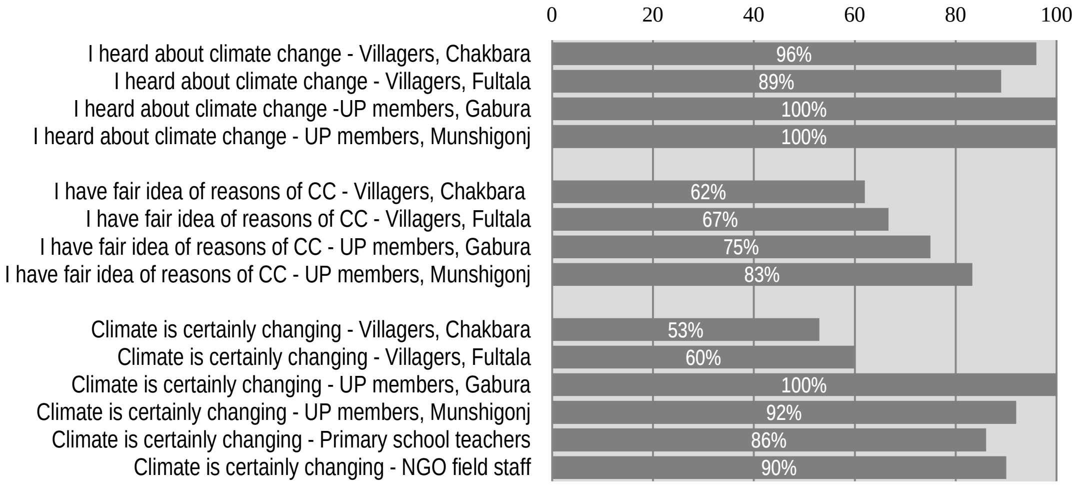
I wanted to know if local people had just "heard" the new words and concepts or whether they had been able to translate them into actual village practices that would prepare them for the new generation of threats which have begun to manifest themselves locally or may do so in the future. The KAP (Knowledge, Attitude and Practice) survey findings revealed that the majority of villagers (96% in Chakbara and 89% in Fultala), including the UP members, were familiar with the phrase

[16] In Bangla, *jalobayu* means climate and *paribartan* means change.

Jalabayu Paribartan (or climate change) as they had heard it from multiple sources (Figure 5.1). However, the majority (70-79%) had only heard the phrase recently during the period from 2007 to 2011, which corresponds with the two devastating cyclones, Sidr and Aila in November 2007 and May 2009 respectively. These events triggered concern and debate about their cause, and to what extent they were linked with changes in local weather patterns. Through local discussions, media reporting and government activity in the coastal region, the language of climate change began to enter everyday consciousness possibly on a scale not seen before.

Villagers confirmed that the NGOs and electronic media (mainly TV and radio) played key roles in informing people about *jalobayu paribartan*. Over 60% and 45% of people of Chakbara learned about climate change from media and NGOs

Figure 5.1: Percent of villagers' (n=90) and UP members' (n=24) awareness on changing weather/ climate factors (2012)



respectively compared with 60% and 20% respectively in Fultala. Other information sources such as newspapers, reporters, friends and neighbors, and school teachers reached a limited audience. While the communities at large had some familiarity with the issue and language of climate change, further inquiry revealed a more complex picture of the extent of community understanding of the issue.

The majority of local people claimed to have fair knowledge of the drivers of climate change when asked about its causes (Figure 5.1). UP members claimed greater understanding than villagers and 75% and 83% of UP members in Gabura and Munshigonj respectively said they knew the “reasons for changing climate” compared to 62% and 67% of villagers in Chakbara and Fultala. Further inquiry revealed that the majority of villagers (53% from Chakbara and 60% from Fultala) agreed with the statement that climate change is “certainly" taking place (Figure 5.1). Among UP members, 100% and 92% of them in Gabura and Munshigonj respectively agreed that they consider the climate is changing. The level of awareness on changing climate is also found higher among the field staff of NGOs (90%) and primary school teachers (86%). Although more than half of the villagers had some awareness of climate change, nearly 50% remained unclear about what constituted a climate change issue. These broad responses tell us something about the extent of penetration of the climate change narratives into local lives. However, they provide no detail of what such knowledge consists of and means to local peoples.

To understand this further, I documented community observations about changes in local weather and environmental change that convinced them that the changes experienced were outside their normal experience and could be connected to wider climate change. Such observed changes included increasing tidal heights, more frequent natural disasters, hotter summers, prolonged drought and more erratic patterns of rainfall, which have been linked to longer term climate change (MoEF, 2005; MoEF, 2009).

Community observations about such changes varied. For example, the majority (80%) of people from Chakbara agreed that tidal height had increased compared with only 11% of Fultala villagers (Figure 5.2). One explanation for this is spatial. That is, Chakbara villagers live on the ocean edge and are more sensitive to small changes in tidal heights than villagers in Fultala. Chakbara is surrounded by large rivers where tidal influence is stronger and the community is highly susceptible to inundation by salt water from high tides and embankment breaching or over topping as has occurred several times in the past. Fultala is a mainland village and relatively removed from this hazard. Villagers also noted an increased frequency of natural disasters of different types including what they considered a greater frequency of cyclones in the Bay of Bengal area in recent times (Figure 5.2).The FGD participants from project villages discussed recent cyclonic events in the BoB areas:

> In November 2007 we had the cyclone Sidr, then in next 6 months, cyclone Nargis formed and made landfall in May 2008 and in the same

> year after five months cyclone Rashmi hit in October and in next six months cyclone Bijli hit in April 2009 and then after a month another cyclone Aila hit us in May 2009. So in 18 months period we experienced five cyclones and one damaging depression from the BoB, seemed abnormally high within such a short period of time – one cyclone in every three + months.

During the cyclone Aila in 2009, the majority of the villagers of Chakbara had to leave their homes and stay elsewhere for some 18 months due to saline water inundation of their homesteads, houses, cropland and shrimp *gher*s. The whole area was subject to inundation with tidal saline water from rivers twice a day (tidal water) through the breached embankment. The people of Fultala village reported that their crop land were saline-affected due to inundation in 2009 from cyclone Aila . The residual impact of saline water inundation of cropland continued to affect rice production until the end of 2012. Besides cyclones, the rice crop was also damaged due to intense rains and consequent flooding during the 2010 monsoon in low-lying area and by drought in the late monsoon (2010), which damaged rice at higher elevations. So the farmers with cropland at low and high elevations were affected due to climate variability (cyclones, high rains and drought). Based on the soil salinity in cropland of Fultala village, farmers assumed that another five years would be required to get the salinity fully washed from the soil provided that another cyclone did not inundate the area again.

The villagers of Fultala experienced 100% loss of amon rice seed beds due to intense heavy rain-based flooding and inundation over two weeks in early August 2011. Most of the farmers had to replant and were late in transplanting seedlings. They ended up with over 50% lower yields than normal and the cost of production was much higher. The shrimp farmers also experienced losses from fish escaping from flooded *gher*s. Some protected their *gher*s with net fencing but the shrimp and fish died after heavy rains which affected gher water quality and local eco-systems.

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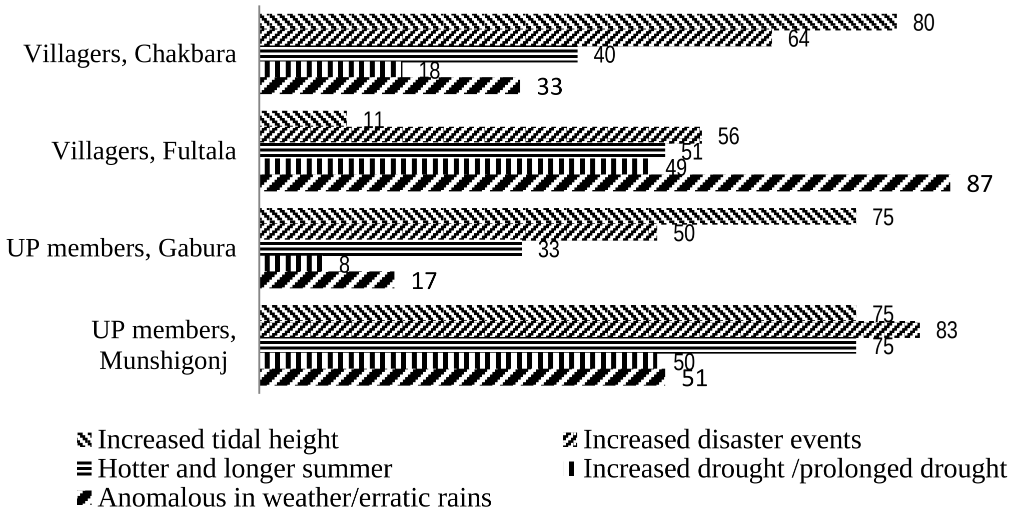
Regarding recent changes in the extent of drought, half of Fultala residents stated that there had been changes in the frequency and duration of low rainfall conditions in the monsoon season (Figure 5.2). Monsoon rains are crucial for rice farming and Fultala farmers said there had been no rainfall from 12 April to 26 May 2012, which affected their summer vegetable crops. There was a little rain for 15 minutes on 17 May followed by drought up to 22 June 2012, with some rainfall in adjacent villages on 18 June. With such little rain, 44% of Fultala villagers reported they could not do any vegetable farming.

While Fultala residents were affected by drought, in Chakbara there was a greater reliance on shrimp farming, fishing, shrimp PL catching and the collection of various resources from the SRF. Cyclone Aila resulted in embankment breaching, which prevented Chakbara residents from beginning shrimp cultivation and rice farming (in a limited area) from mid-2009 to mid-2011. For them, drought was much less of a problem and only 18% of village residents mentioned drought as a weather change compared with 49% of Fultala residents .

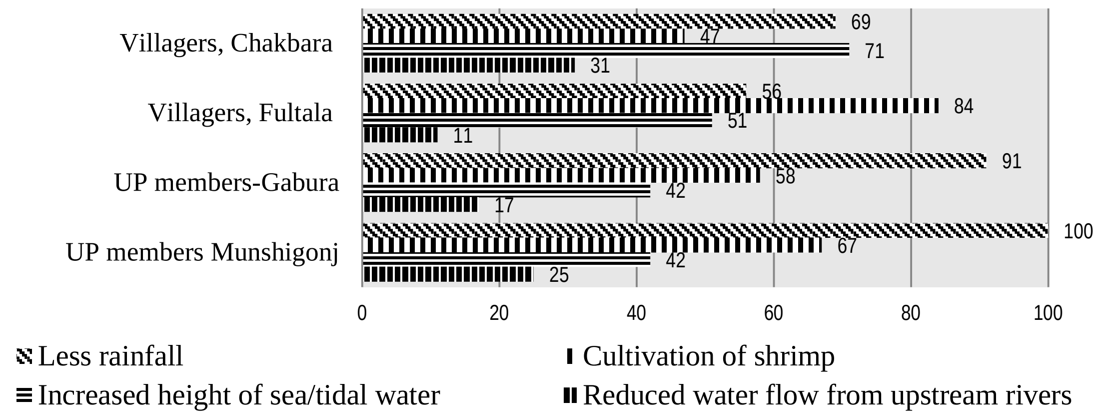
Figure 5.2: Percent of villagers' (n=90) and UP members' (n=24) ' observation of changes in local weather factors (2012)



In the case of intense heavy rain-based flooding in the area, the majority of the people of Fultala (87%) observed recent changes in rainfall patterns. They said the weather was less predictable and that when the rains do come they take the form of heavy showers over several consecutive days, causing localized flooding that damaged crops, shrimp *gher*s and livelihoods.

The people of Fultala experienced the loss of rice due to intense heavy rainfall and consequent flooding in 2010 and 2011 and reported erratic rainfall as one of the indicators of changing weather in the area. Some 33% of the people of Chakbara

Figure 5.3: Percent villagers' (n=90) and UP members' (n=24) observation of reasons for high salinity, survey was done in 2012



were of the same opinion. Community observations and responses in support of their understanding of changing weather were consistent with official weather parameters in the area linked to their livelihoods (Figure 5.2).

Another major issue of concern to local people in the villages and along the coast was raising salinity. Opinions varied as to the causes. In Chakbara, 71% of respondents blamed increased inflows of sea water, suggesting a link to sea level rise, as the main driver of higher salinity in the area (Figure 5.3). Two thirds (66%) pointed to lower rainfall in recent times and 47% blamed shrimp farming. Some 31% said reduced freshwater flows from upstream rivers had facilitated rising salinity in the area. In Fultala, 84% of respondents blamed shrimp farming as the main contributing factor to higher salinity followed by 58% who pointed to lower rainfall as the main factor. Of least importance was reduced upstream river flow (Figure 5.3). These data suggest that the greater exposure of the people of Chakbara to high tides, cyclones, storm surges and embankment failure accounts for their greater perceived sensitivity to these factors. In Fultala, despite the limited amount of shrimp farming, they regarded it as the main cause of rising salinity levels.

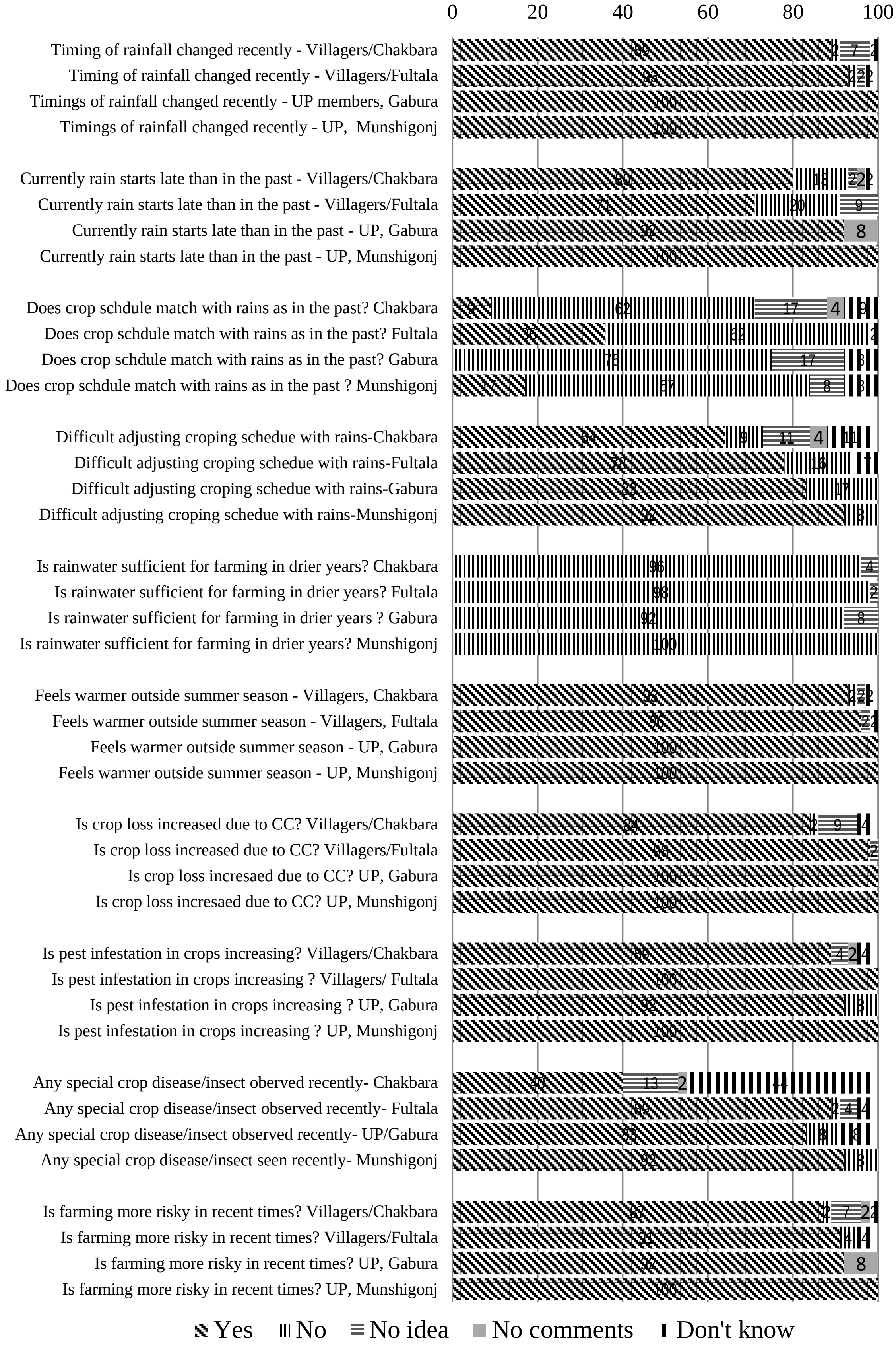
UP members stated that reduced rainfall in recent times had led to increasing salinity along the coast and that this was on a greater scale than in the past. In the past, the rains started during the pre-monsoon (April-May) which washed out salinity. But reduced rainfall in recent years in the pre-monsoon period had allowed saline water to spread.

These observations from local people and UP members were based on their long-term experiences, rather than any scientifically grounded evidence base. They compared what they regarded as normal weather with what they had become used to experiencing in recent years. The changes had affected their production systems and presented them with new challenges in adjusting farming systems to current weather patterns.

Another observation made by local people was that insect populations had increased in recent years. In particular, they mentioned about Stem Borer of rice or *kalomatha majra poka* (Chilo polychyrysus), *current poka* or Brown Plant Hopper (Nilaparvata lugens) and Rice Leaf Folder (Cnaphalocrocis medinalis*)* which damage rice. Farmers gave the insect the name of *current poka* as it attacked in groups and spread quickly and instantly damaged rice plants like an electric current.

Figure 5.4 summarises local peoples' and UP members' views on the impact of changes in rainfall patterns and the growth in insect infestations. The data presented does not differentiate among farmers by their asset base, but from discussions with them and personal observations, those with access to stored water in ponds and ditches were able to get moderate yields in drought years. However, practically all local villagers claimed that crop production had been affected due to water stress in drought years and that this had threatened their capacity to plan their cultivation cycles.

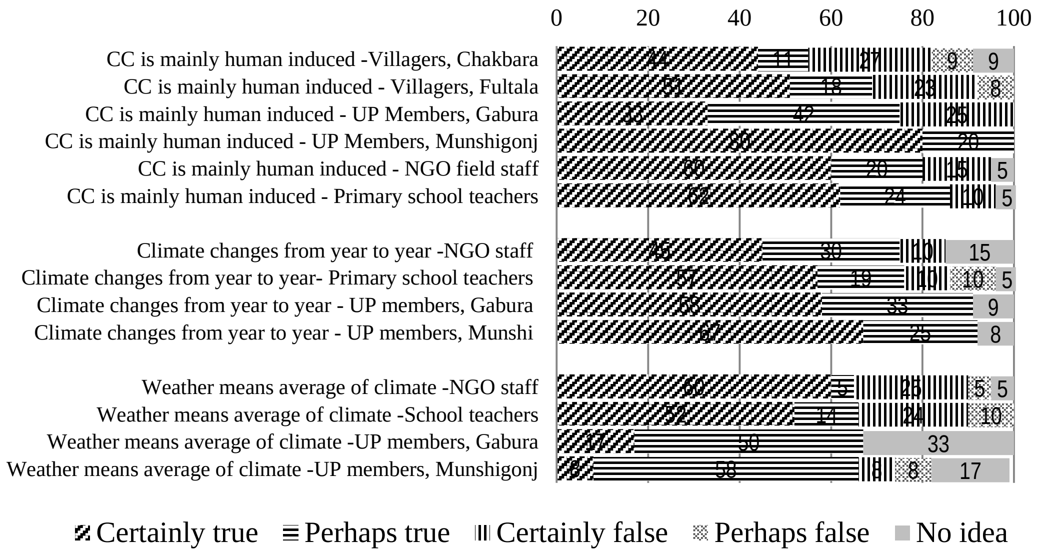
Figure 5.4: Percent of villagers' (n=90) and UP members' (n = 24) observations on rainfall patterns and farming system, 2012)



Community perceptions on changing weather/climate patterns

Community members were asked whether the current weather and weather-related changes they observed locally had been due to human activity or were naturally caused.[17] A majority in both villages claimed that the changes were caused by human actions.[18] For example, 55% and 51% of households of Chakbara and Fultala said that changes in weather were due to human causes. The majority of NGO staff (80%) and school teachers (86%) perceived that the current changes in local weather or climate were caused by human actions and linked to historical patterns of industrialization in the rich countries and increasingly in countries such as India, Brazil and China (Figure 5.5).

Figure 5.5: Knowledge and Perceptions (in %) of Changes in Local Weather Patterns and Related Issues (n=90 villagers; 24= UP members; 20= NGO staff and 21= school teachers), 2012



In order to assess the depth of understanding of the idea of climate change, I asked staff of local NGOs, primary school teachers and local government representatives (UP Members) to respond to a number of statements related to weather and climate. For example, they were asked to agree or disagree with what were false statements such as ‘the climate of a place changes from year to year’ and ‘weather means the

[17]We prompted that abnormalities in rains, rising temperature, frequent cyclones and flooding are signs of climate variability and change and asked them if they knew the reasons.

[18]Villagers mostly referred to deforestation, shrimp farming, high salinity, industries, brick kilns, grabbing and conversions of canals/ rivers as human activity that affected weather balance.

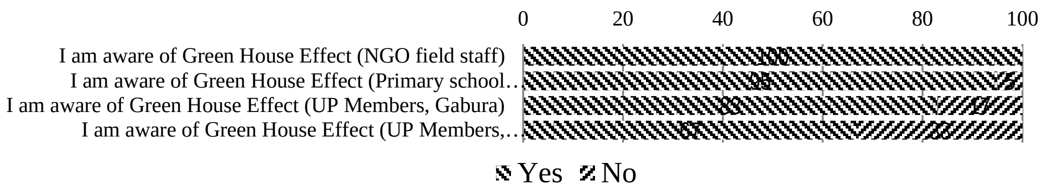
average of the long term climate data of a given place'. Analyzing the responses, out of 24 local government representatives who participated, none gave the correct response concerning the meaning of the term "climate". This was despite 75 to 83% of UP members stating earlier that they had a fair idea of the reasons for climate change (Figure 5.1 and Figure 5.5). Only 10% of the field level staff of NGOs and primary school teachers responded correctly.

Regarding the concept of 'weather', more than half of the participating NGOs and primary school teachers (60% NGO staff and 52% primary school teachers) responded 'yes' to the false statement "weather means the average of long term climate data of a given place" (Figure 5.5). The level of knowledge of UP members of "climate" and "weather" was also very poor (Figure 5.5). Thus, while a high proportion of community members of all groups said they believed the climate is changing, fewer connected this to human activity, and even fewer understood basic concepts such as weather and climate.

I then examined what NGO staff, primary school teachers and UP members understood by greenhouse gases, the greenhouse effect and their links to global warming and climate change. The reason for the focus on these groups was that they were important resource persons linking local people to the wider government and international community responsible for developing policies to deal with climate change. The majority (60% - 100%) said they had a fair knowledge of the issues but further investigation revealed that their level of awareness was limited. For example, they had "heard" the phrase greenhouse effect but did not know what it actually meant (Figure 5.6). In order to determine their level of understanding about the greenhouse effect and related ideas, I asked them to respond to five multiple choice questions (Figure 5.7).

Only 30% of NGO staff agreed with the statement that greenhouse gases were gases in the atmosphere that trapped heat while 55% stated that it referred to air pollution

Figure 5.6: Awarness (in %) of NGO staff (n=20), School teachers (n=21) and UP members (n=24) on Green House Effect, 2012

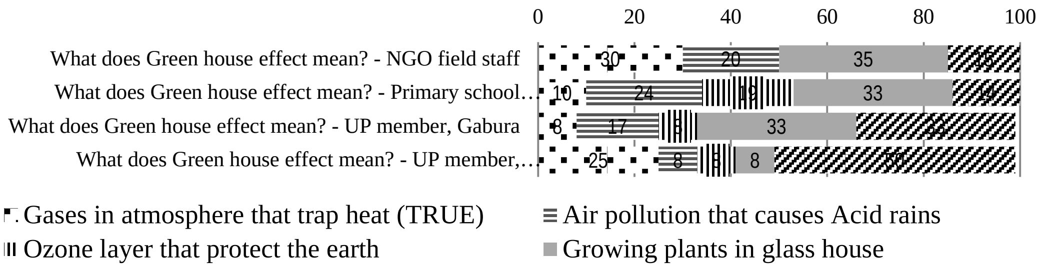


causing acid rain or plants grown in greenhouses (Figure 5.7). Only one in ten of primary teachers responded correctly. UP members in Munshigonj showed a better understanding although the majority (75%) either responded incorrectly or had no understanding of the issue.

In the case of the question of what constitutes a greenhouse gas, 57% of NGO staff and 60% of primary school teachers identified carbon dioxide as a GHG. However, only 15% recognized methane as a GHG (Figure 5.8). A third of NGO staff and 60% of primary school teachers said oxygen and hydrogen were GHGs. Local government representatives in the two unions identified carbon dioxide as a GHG (42% and 50% respectively) but none were aware that methane is a GHG.

The variable understanding among NGOs, school teachers and local government representatives of the meaning of key concepts in climate change suggests the need for improved training of what are important community resource persons. It is such people who will be engaged in developing and implementing adaptation strategies and while it is not necessary for them to become climate experts, a basic understanding of the broader drivers of climate change is important in ensuring that adaptation measures mesh with broader mitigation initiatives. Although local knowledge on CC issues was found to be poor, grassroots observations of changing local weather patterns reflected or were consistent with expert views on the likely impacts of global warming.

Figure 5.7: Understanding of NGO staff (n=20), school teachers (n=21) and UP members (n=24) on greenhouse effects (in %), 2012



There is much agreement that climate change will result in increasing temperatures, hotter summers, shorter and warmer winters, and erratic rainfall in Bangladesh (MoEF, 2009). Survey data from the local communities also indicates they have observed several changes in local weather patterns, including temperature rise, longer and hotter summers, greater intensity of drought, erratic rainfall (intense heavy rainfall), frequency of rough sea weather conditions, rise of tidal heights, and salinity intrusion in the coastal area (Figure 5.9). In addition, the majority also noticed a decrease in the duration of the winter season and volume of rainfall in monsoon months (June-July).

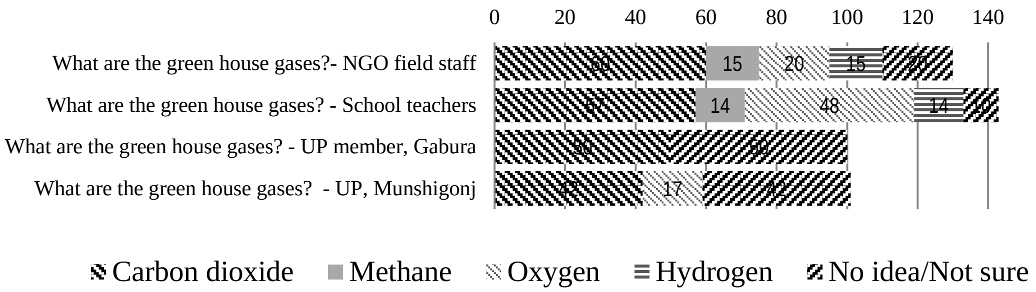
Based on the survey and FGD sessions in November 2010, I identified ten different weather- related attributes important to the local communities These attributes were temperature, duration of summer, volume of rainfall in monsoon months, intensity of drought, erratic rainfall /intense rainfall, duration of winter, tidal heights, rough sea weather conditions, soil and water salinity and intensity of cyclones (Figure 5.9).

For example, with regard to temperature, soil and water salinity and frequency of cyclones, 100% of community members confirmed increases compared to the situation 20 to 30 years ago. On four attributes nearly 100% confirmed increases with some minor disagreement. Thus, in Fultala village, which does not lie on the coast, only 2% people were unsure if tidal heights had risen and a further 2% did not respond to the question. Similarly, the majority of community members (92% to 100%) agreed that summers had become longer. A majority also agreed that there had been more erratic and heavier rainfall, which had caused damage to agricultural crops, fisheries and shrimp aquaculture.

Regarding the volume of rainfall during the Bengali rainy season from mid-June to mid-August (the Bengali months of *Ashar* and *Sharban*), between 82 and 87% of households in the two communities had observed reduced rainfall in recent times compared to some 20 years ago. Between 83 and 96% stated that the winter season had shortened.

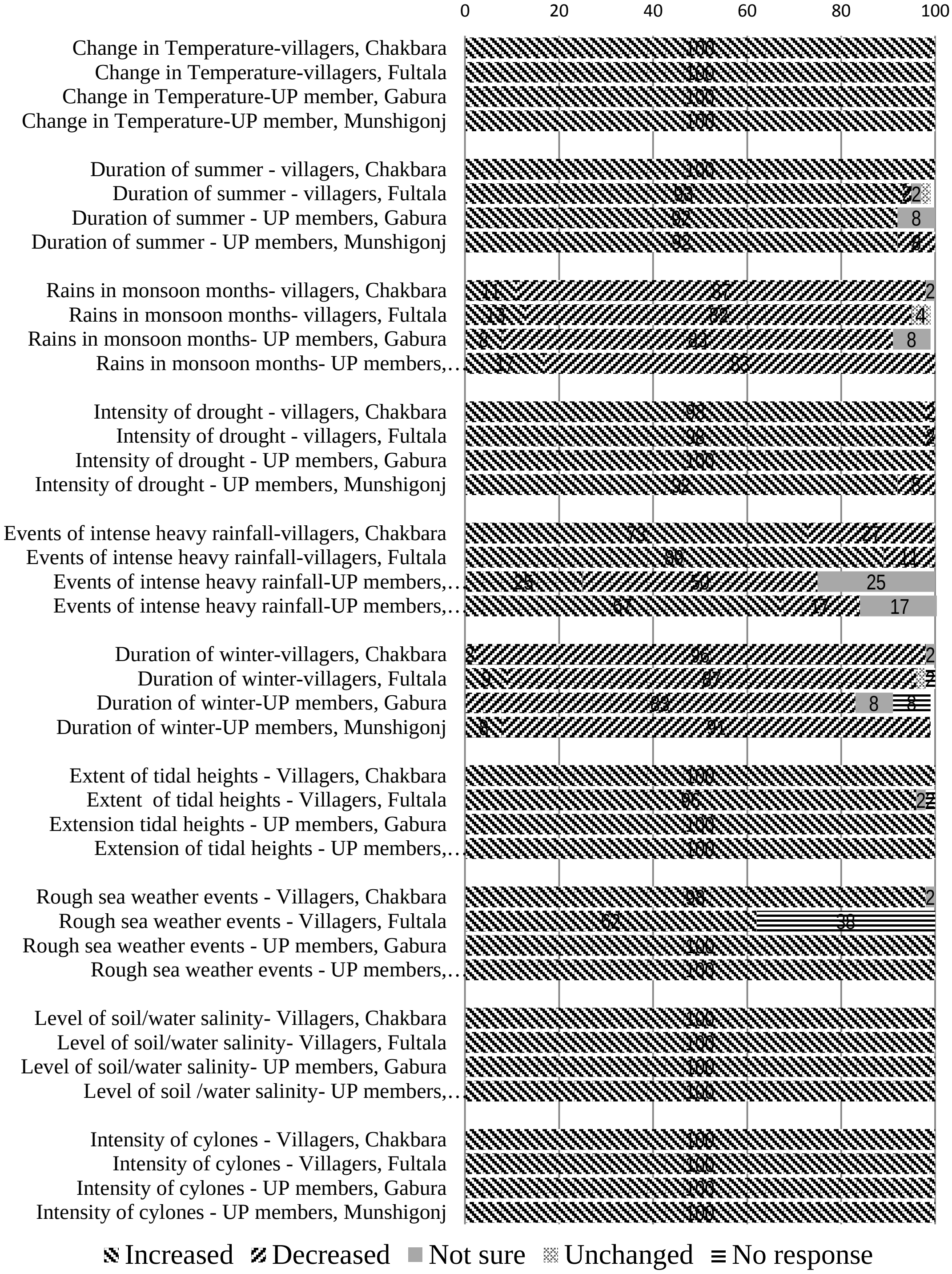
Villagers, NGO staff, primary school teachers and local government representatives also commented that temperatures had risen in other seasons. Historically, the

Figure 5.8: Knowledge (in %) on NGO staff (n=20) and UP members (n=24) of Greenhouse Gases (2012)



Bengali year is divided in to six seasons with each season lasting two months, starting with summer (mid-April to mid-June) followed by the rainy season (mid-June to mid-August), autumn (mid-August to mid-October), dewy period (mid-October to mid-December), winter (mid-December to mid-February) and spring (mid-February to mid-April).

Figure 5.9: Observation of weather-related attributes (in %) by the villagers (n =90) and UP members (n= 24), 2012



However, the seasons and the features that define them have begun to change in the eyes of local people. Local communities identified or distinguished between three seasons in a year instead of the traditional six seasons. These three seasons are a lengthy dry summer, a drier and shorter monsoon period and a warmer and shorter winter. Similar observations have been made by Jennings and Magrath (2009) on seasonal variations in several South Asian countries including Bangladesh. Traditionally, local people used various biological, socio-cultural, ecological and climatic indicators to distinguish the six seasons. Table 5.1 provides a comparison of local community observations on the changes in seasons over a 20 year period.

Table 5.1: Changes of seasonal features as perceived by the local communities compared to 20 years ago (FGD with villagers of Chakbara and Fultala, 2012)

Seasons	**Corresponding Months**	**Temperature**	**Rainfall**	**Visibility of the season**	**Communities' Remarks**
Summer	*Baisak-Jaiysta* (mid-April to mid-June)	▲▲	▼▼ but ▲▼	▲▲	Temperature increased, Rainfall decreased, *kalbiyshaki* (storm) is not visiting regularly as in the past, high visibility of the season, season expanded beyond two months.
Monsoon	*Ashar-Sraban* (mid-Junetomid-August)	▲▲	▼ but ▲▼	▼	Temperature increased, much warmer like summer, rainfall late, reduced, intense & erratic, high annual variability, low visibility of the season seemed pushed back to autumn.
Autumn	*Vadra- Ashyn* (mid-August to mid-October)	▲	▲▲ but ▲▼	▼▼	Temperature increased, feels much warmer like summer. Rainfall increased & erratic, very low visibility of the season, appeared as extended monsoon.
Dewey	*Kartik-Agrahayan* (mid-October to mid-December)	▲	▲▲ but ▲▼	▼▼	Temperature increased and feels warmer than in the past, rainfall erratic, very low visibility of the season.
Winter	*Poush – Magh* (mid-December to mid-February)	▲	▼	▼	Temperature increased, warmer than in the past with short but intense cold spells, rainfall decreased, winter is visible but shortened in length.
Spring	*Falgun – Chaitra* (mid-February to mid-April)	▲▲	▼	▼▼	Temperature increased (warmer spring), Rainfall decreased, very low visibility of the season.

▲▲ = Increased (high); ▲ = Increased (low), ▼▼= Decreased (high), ▼= Decreased (low), ▲▼ = erratic pattern

In the past, local people were able to identify the six seasons by observing changes in various features of natural systems at different times of the year. Apart from the changes in weather factors, one such indicator was the presence of different birds at different times of the year. The members of various occupational groups in Chakbara and Fultala, including women, spoke of how the appearance of different types of birds heralded the beginning or continuation of different seasons. They said that this was no longer the case due to changes in the weather, land types and land use patterns. Below a more detailed account of these changes is provided.

Summer in the past (Mid April - Mid June)

The appearance of a bird named *bou katha kou* (Indian cuckoo) and their call in late night/ early morning indicated the presence of the hot summer. Another bird named *taltora* (swift) also appeared in the latter part of summer. Villagers understood the presence of summer by observing the flocks of *taltora* birds in the evening feeding on flying ants. At the end of the season, these summer birds gradually disappeared.

Summer today

None of these birds are seen today, especially in Chakbara where the current land use is shrimp farming. Villagers identified several causes of the decline in the appearance of these birds. These were the conversion of cropland to shrimp *ghers,* the destruction of trees and bushes from land clearing, persistent higher soil salinity, lack of sweet water, lack of ants and the growth of the local population.

Monsoon in the past (Mid June - Mid August)

Following the hot summer, the monsoon arrived and heavy rains ensued. People would plough the land with the onset of rainfall to saturate the soil and suitable for planting rain-fed amon rice. During the tilling of land for transplanting rice, flocks of a bird named *shalik* (pied moina) used to appear and eat the ground-based insects. They also rested on water hyacinth in the canals and fed on various insects. The appearance of *shalik* indicated the arrival of the Bengali month of *ashar* (mid-June to mid-July: the first month of monsoon season). Upon completion of rice transplantation by early August, these birds began to decline in numbers until mid-August when the monsoon ended.

The monsoon today

The almost complete disappearance of rice farming in Chakbara has meant that *moinas* are hardly seen in the area. Shrimp *gher*s destroyed the population of land-based insects and thus depriving the *moina* of their main food source. The increasing salinity of what were once sweet water canals and the decline of the water hyacinth and other bushy areas also contributed to the disappearance of this bird, which once indicated the appearance of monsoon.

Autumn in the past (mid-August - Mid October)

Following the monsoon, autumn was heralded by the appearance of a bird named *kana kua* (the Lesser Caucal). The call of the *kana kua* in the evening indicated sunset and people used the call to break their dawn to dusk fasting during the month of Ramadan. In the past, clocks, TV and radios were not common in rural areas and people relied on the natural clocks (such as call of certain birds at specific times) to schedule many of their activities. The presence of *sorail* (lesser whistling teal), *pankouri* (cormorant) and *dahuk* (water hen) in the wetland (canals, beel, ponds) also indicated the appearance of autumn after the monsoon.

Autumn today

Kanakua and *dahuk* have disappeared asa result of the disappearance of swamp areas now converted to shrimp *gher*s. *Sorail* and *pankouri* continue to visit but in much smaller numbers.

Dewy season in the past (Mid October - Mid December)

After the autumn, the cooler dewy season appeared which corresponded with the rice ripening and harvesting period and at this time flocks of *babuy* (weaver birds) arrived in large numbers and made their hanging nests on the leaves of tall palm trees. Flocks of *bele hansh* (cotton pigmy goose) and *batang* (common sand piper) in wetland and shore areas also indicated autumn. These birds began to appear in the later part of the dewy season and remained for the whole period of winter.

Dewy season today

No *babuy*are seen in the area as there has been a decline in palm trees for nesting and rice fields for feeding. Palm tree decline is the result of higher demand for palm trees as fuel in brick kilns and higher salinity, which the trees cannot tolerate. Fewer *belehansh* and *batangs* are seen compared with the past.

Winter in the past (Mid December- Mid February)

Following the mild dewy season, the cold winter arrived and in December and January flocks of birds called *hot-titi* (red winged lapwing), *chil* (kite) and *kullaya* (raptors) appeared in the paddy fields after the harvesting of rice in the preceding season. These were followed by several other *authithipakhi* or migratory birds which stayed for the whole winter period.

Winter today

Currently no *hot-tit, chil* and *kullaya* birds are seen as a result of there being little or no rice farming and the disappearance of rats and other wild food sources for such birds in the area. Migratory birds are still seen in the area during winter but in fewer numbers. Although fewer in number, local people still recognize the onset of the winter season with their appearance.

Spring in the past (Mid February - Mid April)

After the cold winter, the mild and soothing spring appeared with its gentle breezes and the call of the *kokil* (koel). Following the *kokil*, the long tailed *shama* (white-rumpedshama) would appear as an indicator of spring. Towards the latter part of spring, flocks of *ghugu* (doves) appeared, which indicated the end of spring and the start of the hot summer from mid-April.

Spring today

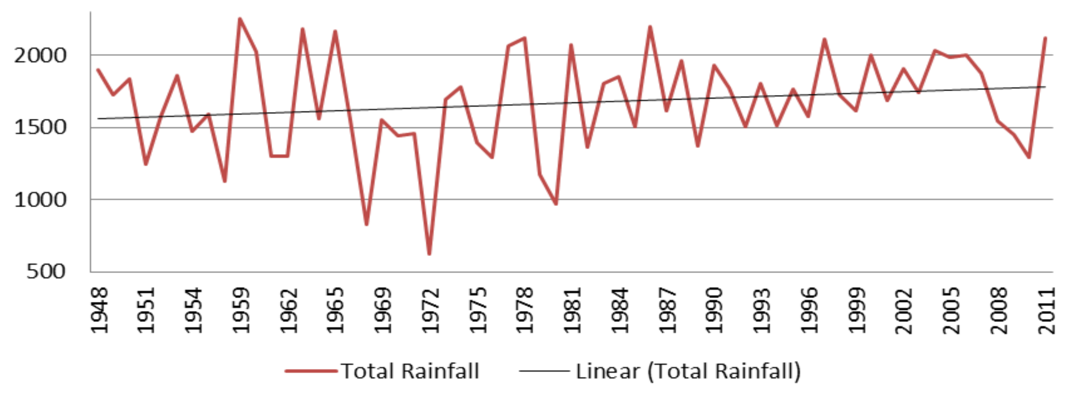
Currently some *koel* and doves visit the area but the loss of trees and homestead forests has reduced their numbers.

Overall, local people can no longer identify with the same degree of certainty the seasons by natural indicators such as different birds in different seasons. As a result, younger people in the study villages have lost some of the local ecological knowledge and the practices that went with it.

Trends in climate parameters

The discussion so far has centered on local people's observations of changes in their weather and non-weather environments. To what extent are these observations supported by meteorological data on rainfall and temperature changes? To examine this question I collected rainfall and temperature data for Satkhira district from the head office of Meteorological Department, Dhaka on historical trends between 1950 and 2010. In the case of annual average rainfall for the period 1948 to 2011, the data shows an increasing trend (Figure 5.10). This contrasts with local people's observation that monsoon rains have fallen during the last five to 10 years.

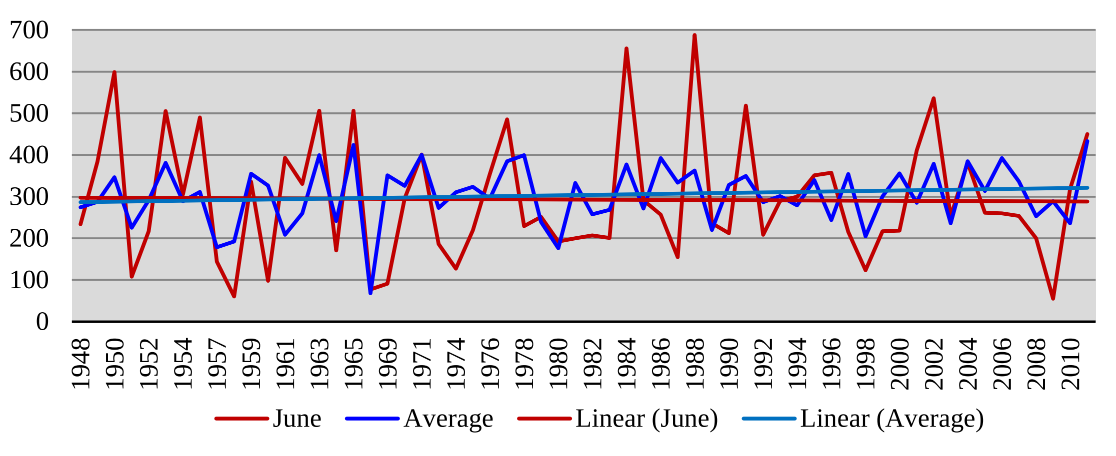
Figure 5.10: Average annual rainfall (mm) of Satkhira district, Bangladesh from 1948-2011



However, the rainfall calculations for the monsoon season are done differently by the Meteorological Department, which uses the four months of June, July, August and September as the main monsoon months. Local communities follow the traditional Bengali calendar of two months for each of the six seasons in a year, which means that from their point of view the monsoon or rainy season lasts for two months from mid-June to mid-August. Looking at the data for the early monsoon rainfall for the month of June (average) for Satkhira area, it shows a decreasing trend which is in conformity with the communities' observation (Figure 5.11).

According to the record of Met Office, the annual mean temperature also shows an upward trend over the past 60 years for Satkhira area. Figure 5.12 shows that the annual mean maximum temperature trend of Satkhira is also in line with the national

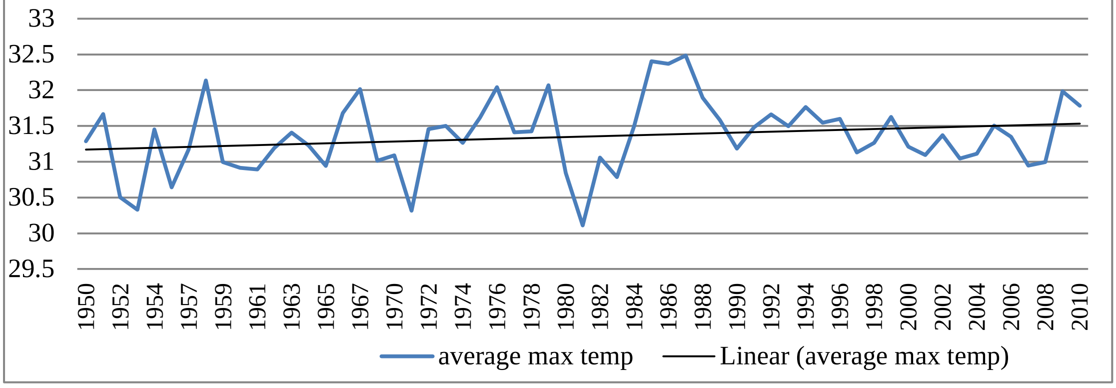
Figure 5. 11: Trend in average monsoon (June to September) and June rainfall (mm) in Satkhita district from 1948 to 2011



mean temperature upward trend over this period based on the Meteorological data. Analyzing the same data set, the annual minimum mean temperature of Satkhira area also shows an increasing trend (Figure 5.13).

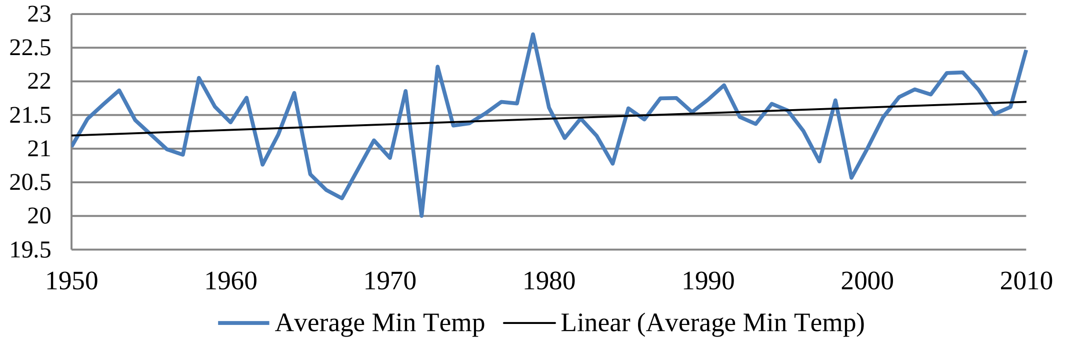
Mondal et al. (2013) analysed the time series data of Khulna (adjacent to the study area and found that since 1980 the average maximum temperature during the monsoon season was rising at 0.037°C per year and the average minimum temperature during the winter season was also rising at 0.047°C per year.

Figure 5.12: Average maximum tempertaure (^{0}C) of Stakhira district, Bangladesh from 1950-2010



In summary, the time series rainfall and temperature data for the study area show an increasing trend over the years consistent with that of the communities' observations as well as with national and international trends. However, local people reported to have observed more irregular rainfall patterns with sharper high rainfall and low rainfall extremes in recent times than in the past and thus faced greater uncertainty due to this erratic pattern of rainfall. Having demonstrated that the time series climate data (rainfall and temperature) are consistent with the observations of weather trend of local communities, it is important to examine how these changes are affecting local people's lives and livelihoods and how weather and weather-related changes are embedded within their livelihood activities, which are highly sensitive to such changes. This is the subject of the next chapter.

Figure 5.13: Average minimum tempertaure (^{0}C) of Satkhira district, Bangladesh from 1950-2010



Summary

This chapter has shown that while the study communities largely lack awareness and understanding of the more technical aspects of climate change, they are acutely aware of how their local weather and related processes are embedded in their lives and livelihoods. Knowledge of both the technical and non-technical aspects of weather *cum* climate varies by occupational group, education and social position. For example, fishing households differ in their understanding and awareness compared with rice farming households living in the same village or local area.

The evidence also shows that the secondary communities of NGO staff, primary school teachers and local government officials who play a role as knowledge brokers and transactors lack the required knowledge to educate and guide communities to tackle impacts of climate change. Evidence was also presented on local people's observations of the changing seasons with particular emphasis upon changes in the traditional Bengali construction of the seasonal calendar and the indicators of changes from one season to the next. A more detailed discussion was provided of bird visits as an indicator of seasonal change. Finally, meteorological data on changing rainfall and temperature patterns for Satkhira District for the period from 1948 to 2011 were presented, and it was shown that while there were some differences between the official trend data and local observations of rainfall and temperature trends, there was some degree of consistency within more limited time frames across more recent years. This chapter has focused on perceptions and understandings of weather and weather-related changes in the two study villages. The next examines in more detail how weather and weather-related changes have affected people's local environments and livelihoods.

Chapter 6:
Community, Weather and Livelihoods

Introduction

This chapter examines community observations and concerns about weather and weather-related issues focusing on variations across selected occupational groups such as fishers, fish traders, shrimp farmers, rice farmers and honey collectors and the effect of weather and weather events upon their livelihoods. It provides a basis for analyzing the livelihood vulnerability of local communities in the face of future climate change impacts and the planning of future climate change adaptation strategies.

Local fishers' observation of weather factors and coastal fisheries

Local fishers, like other occupational groups, have their own understandings of weather, based upon generations of experience rooted in local fishing practices. Part of these understandings includes reference to a number of key weather-related events and processes. Among the most important are what local fishers refer to as *dewa* or *brishty* (rains), *jhor-badal* (storms that accompany rains; cyclonic storms), *ghurni jhar* (cyclone), *joloscchas* (storm surge), *khora* (drought, particularly during pre monsoon and monsoon), *lomba khora* (prolonged drought) and *rooling*, from the English word 'rolling' (rough sea conditions). These events and processes play major roles in fishers' lives and livelihoods. Fishers have their own understandings of how rainfall patterns are related to the local biology and ecology of coastal fisheries. They are also aware that their livelihoods are affected by several non-weather related activities that can intersect with the weather and alter their capacity to fish sustainably.

Fishers explained that with the onset of rains, several species of fish from the sea and lower estuary migrate upstream through the rivers to spawn in the vegetated shallow areas within the mangrove forests, including the SRF. They reported that during years of higher rainfall, they catch more fish as a result of successful spawning. They observed that the same rule applied to crabs and shrimp, which were able to rejuvenate their populations in coastal waters. They commented that fewer rains over the last few years had manifested themselves in poor catches compared to 10 years ago. These observations provide some local evidence of the wider expert view that the recruitment of fish is likely to be strongly affected by climate variability, and that some fish stocks may become more vulnerable to overfishing. Reduced dry season flow rates in South Asian rivers could result in reduced fish yields due to impacts on spawning and larval dispersion of varieties of fishes (Easterling et al., 2007). Regarding rains and fishers' livelihoods, Mr. Musa, a crab collector and fisher from Chakbara village commented:

> If there is no 'water from God', we do not get things in abundance. '*Dewa*' is the 'water from the God' as a blessing to us. If there is *dewa*in time in required quantity, we get plenty of fish, crabs, shrimps, wood and honey and we can subsist on these resources with our children.

The fishers reported that over the last 10 to12 years, the use of harmful fishing gear such as *goisha jal* (large gill net), *charpata jal* (nets that are set in inter-tidal *chars* in high tide and catch trapped fish in low tide), *bindi jal* (set bag net) in river mouths at the lower estuary is so widespread that few fish can swim upstream for spawning. Among the various fishing nets, fishers pointed out that *goisha jal* is the most detrimental to fishing activity. They reported that the large gravid fishes get caught in *goisha jals* while en route upstream to spawn. They also commented that in addition to the use of *goisha jal*, *lomba khora* or drought has contributed to a decline in fish and fish species availability in the upstream areas of the SRF.

The fishers also noted that bad weather such as cyclonic storms made it difficult for fishers downstream to use *goisha jal*, which was good for fish stocks and flows, allowing them to swim upstream unimpeded to reach their spawning grounds. However, such storms also prevented them from fishing as they have to come ashore or take refuge inside the Sundarbans. Fishers used the term 'disaster' in some fishing contexts. For example, Debendra, a Hindu fisher from nearby Chandipur village who fished with Chakbara fishers stated:

> During *jolochhash* or *jhor-badal* we cannot go fishing for 2/4 days and we do not earn and often we had to starve. Therefore, we call this a 'disaster' even if all these *jhor-badals* do not damage our houses, *ghers*or other properties. We are dependent on fishing for day to day

> survival. If we cannot do fishing, even for a day, some of us are borrow money from the *mohajans* to buy rice.

After the cyclones Sidr and Aila in 2007 and 2009, fishers said they paid greater attention to cyclone warning or signals from the Metereological Office. They did not fish if signal 3 was made, denoting *rooling* or rough sea conditions. However, they mentioned that if the signal did not indicate a *jolochhash* or storm surge, they went fishing. The fishers said that a great concern was the possibility of *tufan* or high waves, which often formed during signal 3 conditions. Some fishers used small boats in the lower estuariesduring signal 3, a risky proposition as rivers are wide and waves are strong in high winds. Generally fishers considered that cyclone Aila had caused great destruction to their livelihoods but had created greater awareness among them about the need to take safety measures.

The fishers pointed out that if there are inadequate rains and storms, sea fish do not move upstream into rivers and forests for spawning. They claimed that because of poor rainfall in the last 7 or 8 years they caught fewer fish in upstream rivers and canals and in the SRF. If there was *lomba khora or* prolonged drought during the pre and early monsoon, a small fish locally called "*amadi"* did not migrate from the lower estuary or the sea to rivers and canals. Speaking generally about recent reductions in fish availability in rivers and canals within and adjacent to the SRF, Chakbara fishers who used *khal pata jals* participated in an FGD session reached in to a consensus and said:

> Fifteen years back we used to go to the forest with *khalpata jal* for a 7-day trip. It took 2 days to go to the fishing locations and 2 days to come back. We got only 3 plus days for fishing. With two *khal pata jals* and 6 persons over a period of 3 plus days during a '*gonmukh*[19]' period we used to get 8/10 *maunds* (1 *maund* = 37.5kg) of fish. But now we catch

[19]*Gon* denotes a time period related to lunar cycle in the coastal area. Each *gon* period lasts for five days. Usually, three *gons* cross cut a month (30 days). In case of a new moon, *gon* starts from one day before the new moon and continues for four days. The next *gon* starts two days before the full moon and continues for three days and so on. *Gon* is also related to tides; during *gon* period people experience very strong high tides with increased wave heights. According to local fishers, they get higher catches during *gon* period compared with the non-*gon* period. Local people call this as "*gonmukh*"

> for 5 days with 2 nets and hardly get 1 *maund* of fish – there is over 80% reduction in catch quantity in 15 years.

The local fishers also reported that some species of fish such as *paira (*spotted skate – Scotophagus arqus), *vetki (*Sea perch- Lates calcarifer), *bhol* (Epinephelus fasciatus), *kain magur (*Plotosus canius*)*, and *seelet* (Blackspot threadfin- Ploynemus sextarius) are rarely found in the area. They estimated that catches had dropped by around 70% compared to fifteen years ago. Some fish species such as *bhangal (*Mullets – Liza spp.*)*, *med (*Catfish – Nemapteryx nenga), *mochon* (Catfish – Arius sona) are rarely caught in rivers inside the SRF. In drought years, *kom brishty* (less rains) along with *lomba khora* (prolonged drought), raised water temperature and in those years large fatty fish (those with adipose tissue) did not come to the rivers as they did not like warm water in shallow rivers. The fishers say that the *mochon* fish has huge fat (metaphorically stated as *khasir moto charbi* or fat like goats) and preferred deep and cold water. They explained the warmer waters occurring as a result of siltation coupled with low freshwater flows from upstream, which made them shallower and warmer.

A similar observation was made by Cheung et al. (2009) that increasing water temperature causes some species to shift from shallow coastal waters into deeper cooler waters in the sea. Cheung et al. (2010) stated that the potential loss of catch due to such temperature-induced shifting of marine fish could be up to 40% in some fishing zones at a global scale. Increases in water temperature can affect the metabolic activities of fish and slow down their growth rate and reduce their size, with possible disappearance of certain capture fish species from coastal waters (Roessig et al., 2004). A recent study conducted in 132 countries suggested that Bangladesh is one of the four main countries likely to suffer from the impact of climate change in capture fisheries (Allison, 2009).

The local capture fishers also observed changes in fishing grounds over time. Twenty years ago they reported that they fished 15 km inside the SRF from the Munshigonj point and caught good quantities of fish. They pointed that their grandfathers used to fish at various locations within the SRF (Kukumari, Khalishabunia, Chunkuri, Chalte bare, Ulubare, Lambakhal, Jhinukkhali, Chela kathi, Sonakhali, most of which names are given by the fishers and other SRF resource users) and caught two to three *maunds* (1 mound = 37.5 kg) of fish daily per boat during the *gon* period. Today, fishers travel further south to the Bay of Bengal to seek out new fishing grounds. Many previously fished locations are now silted up and degraded. Recent reductions in monsoon rains also hampered fish from migrating upstream from the sea for spawning, feeding and growth in upstream rivers and mangroves. Cyclone-borne silts/sands are carried inwards by storm surges and deposited in rivers and canals beds, which has altered the quality of fishing habitats. Local fishers reported that after the cyclones many previously good fishing locations were abandoned and they considered that fish stocks had moved to other locations further downstream. One experienced fisher of Chakbara said:

> Twenty years back we used to get large size '*koi bhol (*Long fin grouper Epinephelus megachir) fish, each weighing 10-20kg in the canals inside the Sundarbans, but now we get smaller '*koi bhol*' fish weighing around 5 kg and theyare found only near the sea. There is a shifting of fish stock and fish are moving towards the sea due to degradation of habitats upstream. It is difficult for the poor fishers like us who cannot afford to arrange costly fishing gears and crafts needed for fishing in the sea or in the lower estuary.

Local fishers reported higher water levels in the rivers during high tides and that the salinity in river waters in the dry season had increased. It is important to note that the fishers attributed the high water level in rivers to siltation of river beds and the dying of rivers in the upstream rather than sea level rise (SLR). The causes of the increased siltation and river deaths were explained by a combination of various human interventions in the past such as the Ganges-Kobadak Irrigation Project in the upstream, the Coastal Embankment Project in the nineteen sixties and the Farakka Barrage project in the early nineteen seventies (Mirza, 2004).

Fishing operations are sensitive to seasonal weather patterns and fishers plan their fishing operations in different locations at different times of the year depending on weather conditions. The sea going fishers start fishing from *Ashiyn* (September-October) which corresponds with the beginning of calm weather after the monsoon and ends in *Chaitra* (by March) prior to the start of pre-monsoon storms and rough weather conditions. During monsoon, sea fishers of Chakbara do not fish due to high waves (*tufan*) and frequent rough sea conditions (*rooling*). The fishers observed that recent increases in ‘rough sea’ (*rooling*) conditions affected their fishing operations. These observations were supported by community and local government representatives (Figure 5.9).

Ahmed (2008) has documented the observations of coastal fishers in Bangladesh that there had been twelve rough sea weather conditions and warning signal number 3 issued during the peak 3 months of the *hilsa* (Tenualosa ilisha) fishing season in 2007 (from 22 July through 14 September) which, as per the standing order on disaster, compelled the fishers to return home. Chakbara fishers experienced rough sea conditions (signal 3) six times in 2009.

Sea going fishers interviewed commented that over the past five to six years, there had been an increase in sudden and instant storm events (*hotath jhor*) in the sea /lower estuary areas that lasted for 20 to 30 minutes. No warnings were given of such localized events and some fishers lost nets and floats. Fishers stated these events occurred two to three times a year, which they were increasing and in 2009 had resulted in the death of two fishers.

More generally, local people stated there had been less monsoon rains over the last seven to eight years. For example, they mentioned that there are now (2010) fewer and less regular rains during *Ashar* (mid-June to mid-July), the first month of the Bengali “rainy season”. Ten years ago, rain fell almost every day in June, July and August but today there had been a 40% reduction of monsoon rains.

Fishers had also observed changes in availability of wild varieties of “*gura chingri”* (small shrimps), which they caught using special gear in specific locations. A fisher from Chakbara said when there is drier monsoon, they catch fewer *chingri* (shrimps). If there is less rain, water remains clear (transparent) and fish and shrimp do not like to move upstream if the water is clean. Fishers gave an account of fish catches five years ago of 60kg of fish on average every day using *kathijal* during the period of *gon*. However, more recently the average daily catch during ‘*gon*’ had fallen to around 20 kg, one third of previous catches.

There had also been changes in catch composition. Less valued fish now dominate the catch. For example, the catch of 7th September 2010 at Paglahati fishing location inside the SRF on a '*gon*' day was 23kg. The species distribution of the catch composition in comparison to 2005, as mentioned by fishers, is given in Table 6.1.

Table 6.1: Comparison of fish catches in SRF canals: 2005 and 2010

Species	Catch - 2005		Catch-2010		Remarks
	Weight (kg)	% of catch	Weight (kg)	% of catch	
Gura Chingri (low valued)	30	50	13	57	Increased
Parshe (Liza spp. - high valued)	15	25	5	22	Decreased
Datina (Lutjenus spp. - high valued)	6	10	1	4	Decreased
Khaira (low valued)	3	5	0	0	Not found on the day
*Amadi (*Pointed tail anchovy- Coilia dussumieri)*,murichur, bhol* (low valued)	6	10	4	17	Increased
Total:	**60**	**100**	**23**	**100**	

Source: discussions with fishers of Chakbara in 2011.

In 2005 during 'gon', fishers caught high valued fish like *java* (Johnius elongates) and *vetki* (Lates calcarifer), *bhol* (Epinephelus fasciatus) in the same location. At that time, *koi bhol* (Epinephelus megachir) fish weighing 10-20kg each were common but are rarely found today. When asked to explain why there had been such a decline in catches, fishers gave several reasons, of which one was directly weather-related. Two talked of the use by downstream fishers of seine nets that prevent fish from swimming upstream, and the use of other types of nets (*goisha jal*) that capture migrating brood fish. A third concern was river siltation, which interferes with migration and breeding of fish. The final, weather-related, reason was diminished rainfall during the monsoon which had resulted in fewer fish migrating upstream. Thus, a combination of weather- and non-weather-related factors were considered by Chakbara fishers to have contributed to poorer fishing.

Fish traders' observation on weather, fish supply and trading

Fish traders are linked to fishers through their handling of fish catches and through provision of *dadon* or traditional credit. Their engagement in the fish trade means that they are indirectly affected by weather-related events. They commented that with drought and rising temperatures, their businesses had suffered and profits reduced by around 40% compared with ten years ago. In particular, the fish traders in Kalbari fish landing centre, Burigoalini union of Shyamnagar upazila identified five recent weather- related factors affecting their business (Figure 6.1). They explained that the recent increase in cyclone formation and frequent rough sea conditions (*shagor kharap*) had resulted in fewer fish to sell, while they still had to pay workers to handle and auction their fish. Some fish traders also dealt in shrimp, and heavy rains had flooded shrimp *ghers* and fish ponds, resulting again in reduced supplies.Traders also noted the reduction in monsoon rainfall and an increase in drought-like conditions, and their effect on fish catches and supply to markets.

The fish traders not only noticed decline in fish supplies, but also loss of species diversity in the area. They reported that availability of some species had reduced substantially with some landed rarely in recent years. Among the sea dwelling species, they mentioned *bhangal* and *paira* landings had reduced by 80%, *vetki* (<u>Latescal</u> <u>carifer</u>) and *mochon* reduced by 70% and *bhol* (<u>Epinephelus</u> <u>megachir</u>), *datina* (<u>Sparus</u> <u>berda</u>) by 60% and *java* and *med* by 50% compared to ten years ago. There had also been a reduction in availability of river dwelling species. *Taposhi* (<u>Polynemus</u> <u>paradiseus</u>) and *chali chingri* (a kind of small prawn) landings were 80% and 40% lower than in the past.

Citing an example, one fish trader checked his records, which showed that fish landings during *ashar* to *falgun* (mid-June to mid-March) in 2009 for some fish species had declined compared with seven to eight years ago.

- *Komplit* (spade fish –<u>Ephippus</u> <u>orbis</u>)- landed 1,376 kg in 2001/2 but only 11kg in 2009
- *Bhol* (grouper – <u>Epinephelus</u> <u>megachir</u>) landed 4,925 kg in 2001/2 but only 250 kg in 2009
- *Rupchanda* (pomfret – <u>Pampus</u> <u>chinensis</u>) landed 987 kg in 2001/2 but about 2 kg in 2009
- *Gang chela* (<u>Decapterus</u> spp.) fish landed 987 kg in 2001/2 but only about 40 kg in 2009

These data suggest that fish landings from the SRF had declined by three quarters in under a decade. A fish trader of Kalbari fish landing centre said:

> About 7/8 years during months of *chaitra* and *baishak* (mid-March to mid-June) which is the lean period, we used to buy one truck of fish (4 tons) per day from the catch from Sundarbans but this year (2010) I could not buy any fish in a week during the same period.

To this end, Mr. Moijuddin, another fish trader of Kalbari landing centre said:

> Ten years ago, I used to buy 15-16 tons of fish per day during peak months from this Kalbari fish landing centre and send them to four different parts of the country (Jessore-100km, Barobajar-112km, Jhenaida-140km and Barisal-250km). But this year (2010), I could buy only half a ton per day.

The longer and drier summers had increased water salinity, affecting both open capture fishing and shrimp farming with subsequent reductions in supply to traders. Like fishers, fish traders made similar observations about increasing temperatures with longer and hotter summers that had increased the cost of fish preservation. Higher temperatures meant increased ice use. A trader with 20 years' experience in fish trading said:

> 15 years back, during the summer months (April-May) we used to buy sea fish in the morning at around 8am and then put them in ice after 3 hours for preservation and our fish did not get spoiled. But now in the same months we cannot keep fish even for an hour without ice. It is just due to increased air temperature.

The situation has been compounded by reduced ice availability during summer months due to frequent power disruptions. Currently, more ice is needed in summer compared with six to seven years ago, some saying they needed almost double the ice in summer months for the same amount of fish. Another trader noted that while several years ago there were only about 10 traders at his landing centre, this had increased to about 100 traders all competing for ice supplies that had failed to keep up with demand, resulting in higher prices. One fisher trader observed:

> Five years back price of one *pata* (slab) of ice varied between US $ 1.15-1.28 in the monsoon months, and the price of the same amount of ice in summer (*chaitra-baishak*) rose to US $ 5.13 at the highest. But this year [2010] we had to pay higher costs even US $ 12.82 for a slab of ice in the summer - two and half fold higher than what existed five years back.

Regarding increasing air temperature and its impact on fish trading, Moijuddin, a trader for 20 years at Kalbari fish landing centre, said:

> This year in one consignment of fish to Barisal (about 250 km away) in summer, 80-90% fish got spoiled due to higher temperature and less icing. But I used to use the same amount of ice for a truck of fish 6/7 years back and that did not cause any problem. But now we need more ice in summer due to increased air temperature and thus both the costs and risks of fish preservation increased in recent time due to rising temperature.

Overall fish traders said they understood that temperatures had risen and that there were costs for them as a result. However, in FGD sessions with fishers and fish traders, respondents identified various weather and non-weather related drivers and stressors that affect coastal fisheriesand livelihoods of fisheries dependent households and were unable to attribute any changes to weather alone (Figure 6.1),

Honey collectors' (*mowals'*) observation of weather issues

Drought and temperature rise had affected the livelihoods of honey collectors called "*mowali*" who worked in the SRF in groups called *mowals.* The honey collectors came from surrounding villages and obtained entry permits from the Forest Department (FD) during April and May to collect honey from the SRF. They reported less honey in the forest in recent years because of erratic rainfall and drought in the pre and early monsoon (*khora*), which affected the flowering of mangrove trees resulting in fewer bees and less honey. The *mowals* also observed fewer bees in SRF following cyclones Sidr and Aila. The honey collected from the *kholshi* tree (a variety of mangrove tree in SRF) is of the best quality and fetches higher market prices. However, this tree is particularly susceptible to higher salinity and there are fears for their future if current rainfall patterns and increasing salinity continue (Zohora, 2011).

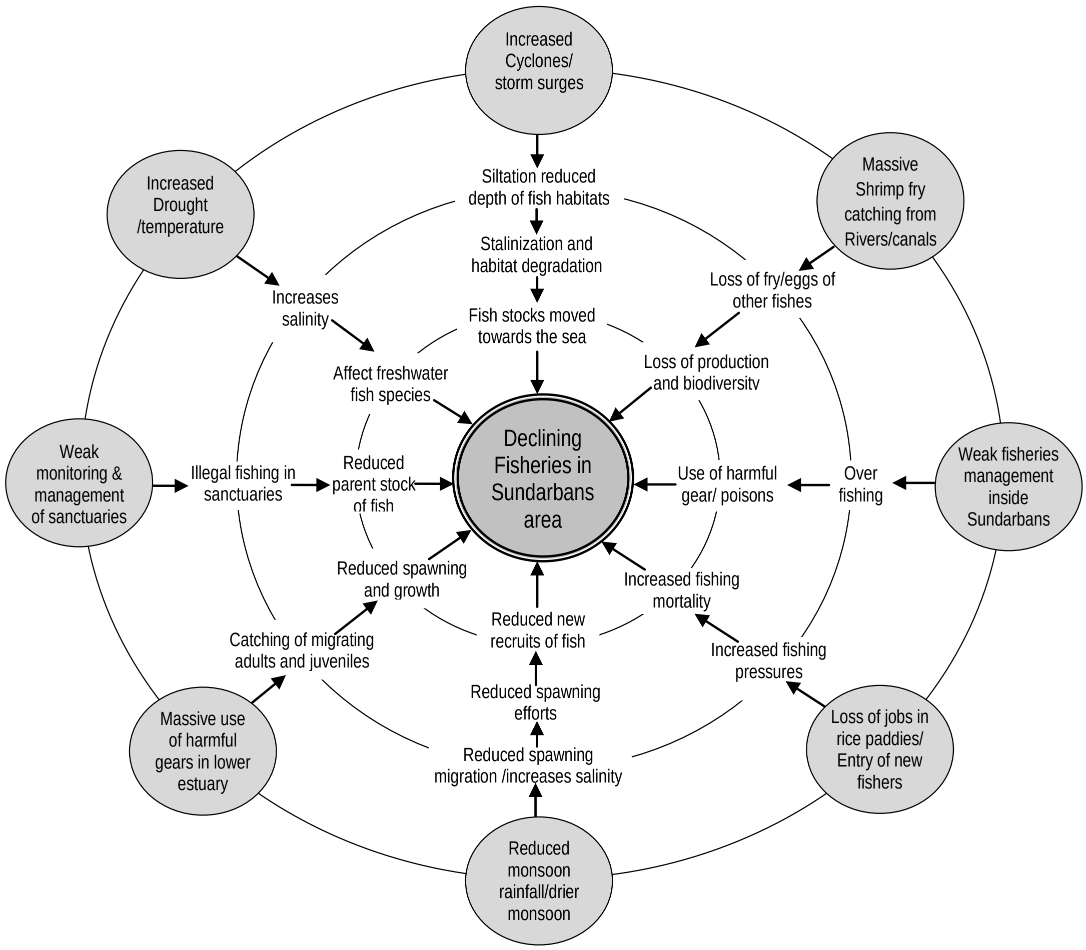


Figure 6.1: Drivers for declining fisheries production and biodiversity in the SRF area (source: FGD with fishers and fish traders Chakbara and Kalbari, Shyamnagar, 2010)

Shrimp farmers observation of weather related stressors

Turning to shrimp farmers in the locality, increased *kasthe* or intense rains over several days had caused considerable damage to their farms. Shrimp farmers' stock *gher*s in winter (January-February) with *bagda* PL and rear them for 4-5 months until the monsoon rains start and harvest most shrimp by June. At the onset of monsoon rains (from June onwards) the salinity concentration of *gher* water is reduced and salt water shrimp (*bagda*- Panaeus monodon) are harvested and sold. To realize the benefits of the freshwater during the monsoon, farmers stock their *ghers* with varieties of white fish species (tilapia, carps, and mullets) as additional crops along with *chhati* or *golda* (Macrobrachium rosenbergii), the giant freshwater prawn which has a high market value). These are reared to the end of the year (December). This practice also reduces the risks to farmers in the case of *bagda* (shrimp) disease and crop failure. *Golda* prawns (and some *bagda*) are grown with herbaceous tilapia fish and white fish when shrimp are large enough to escape predation. The polyculture of fish and shrimp is more common in Fultala than in Chakbara where *bagda* shrimp farming dominates due to higher water salinity.

Shrimp farmers reported that because of reduced monsoon rains since 2005, the salinity level of *ghers* had gone up, which caused fish kills, especially white fish. While the shrimp farmers experienced losses e to drought or reduced monsoon rains in some years, they also suffered from heavy rains in other years. The late monsoon *kasthe* (continuous heavy rains for several days) in 2011 affected fish and shrimp aquaculture farms in the area, including Fultala and Chakbara, in three ways (Figure 6.2; Table 6.2). First, the heavy rains after a period of long drought led to sudden fluctuations in pond ecosystems (ecological changes such as rapid fluctuations in pH) that caused mass mortality of both shrimp and white fish. Second, many ponds and shrimp *ghers*were inundated and the stocked fish and shrimp escaped from the ponds/*ghers*. Third, the dykes of many *gher*s collapsed due to heavy rains and many farmers who had planted vegetables on the *gher* dykes lost their additional crops. In addition, repairs to *gher* dykes increased production costs.

Agriculture farmers' observation of weather related stressors

Farming on the coast is becoming increasingly risky due to recent changes in weather patterns. The agricultural production system is very sensitive to small variability in the weather and farmers in the study villages had recently experienced crop losses in varying degrees due to weather variability (Table 6.2).

Table 6.2: Weather stressors affecting aquaculture and agriculture in Chakbara and Fultala villages during 2007-2012 (Source: FGD with rice and shrimp farmers, 2011)

Weather induced threats	**Impacts on coastal agriculture**	**Impacts on coastal aquaculture**
2007, November: Super cyclone Sidr	Damaged over 80% standing amon rice in study villages	Damaged over 80% fish and shrimp *ghers* and disrupted fishing operations
2008, September: abnormal high tide, coastal flooding	Amon rice damaged in other areas due to inundation of crop fields	Breached and overtopped coastal dykes and damaged fish/shrimp ponds
2009, May: Cyclone Aila with high storm surge	Increased soil salinity of crop fields and affected rice production	Damaged 80-100% fish/shrimp ponds/*ghers* and affected fishing operations
2009, August: Intense rain-based flooding	Damaged 60% amon rice in low land and late transplanting reduced yields	Flooded many fish/shrimp ponds/*ghers*
2009, October: Post monsoon drought	Moisture stress affected amon rice during flowering on higher elevation	Heat stress affected stocked shrimp in *ghers*
2010, April-June: Pre monsoon drought	Damaged 100% winter rice. Affected seed bed preparation for amon rice and standing aus rice	High temperature affected pond/ *gher* ecology, heat stress affected growth of stocked shrimp in *ghers*
2010, Residual effect of cyclone Aila	Residual soil salinity in cropland affected rice yields	Aquaculture ponds inundated by cyclone Aila affected due to salinity
2011, August: Intense rain-based flooding for two weeks	100% amon seed bed damaged, farmers again prepared seed beds, late planting and low yields	Over 80% ponds/ *ghers* flooded and all fish and shrimps died due to sudden fluctuations of water quality
2012, January: Severe cold spell with dense fogs (around 10 days)	Damaged tender rice seedlings, 90% farmers experienced loss of rice seedbeds due to cold snaps	Affected *gher* ecology, diseases of fish/ shrimps, inhibit fish/shrimp growths, high mortality, loss of dyke crops

Continuous heavy rainfall over a period of about two weeks (*kasthe*) during the latter part of the traditional monsoon season (first half of August[20] 2011) caused flooding and severe damage to rice crops in Shyamnagar area including Fultala (Figure 6.3). This situation was further aggravated by drainage congestion in Fultala. The main drainage channel had been the Kultali *khal* that flowed through the middle of the Fultala-Kultali *beels* and crop fields. During the monsoon, excess rain water was drained off through this *khal*.

However, for several years the government had permanently leased out major sections of this *khal* to many people who over time used the *khal* for house

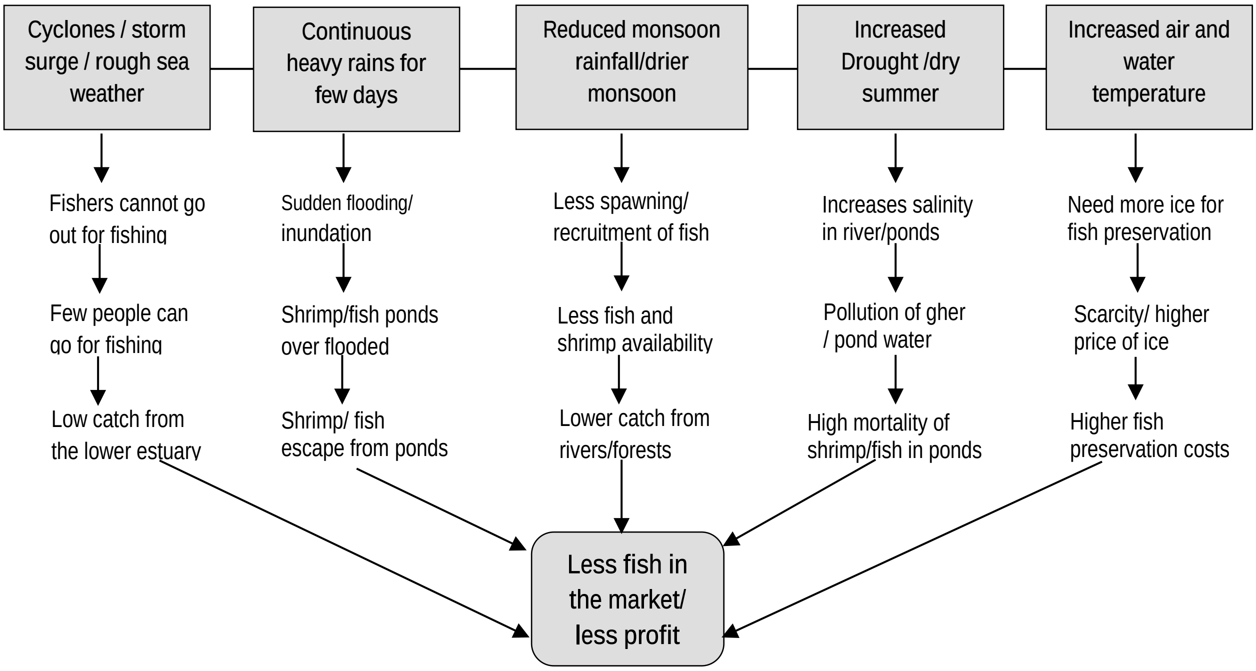


Figure 6.2: Fish traders' observation of weather factors affecting fisheries (Source: FGD with Fish traders at Kalbari fish landing centre, Shamanagar)

construction, crop land and fish culture ponds, which created drainage congestion and consequent crop losses. Early August is critical for the coastal people as this is the time for transplanting amon rice, which is the only rice crop in major parts of the southwestern coastal zone. The livelihood of the majority of the people of Fultala is dependent on amon rice, which is grown from the monsoon to post monsoon season. During 2011, late monsoon heavy rainfall inundated all seedbeds (*chator*) of amon rice in Fultala for more than two weeks, resulting in extensive damage. Farmers

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[20]According to the Bengali calendar, the rainy season starts from mid-June and ends in mid-August each year.

prepared the seedbeds for a second time, thus delaying rice transplantation. Vegetables farming also suffered a similar fate. Local farmers estimated 40% reduction in amon rice production in 2011 owing to *akash bonnya* resulting from the 12 day *kasthe* (intense heavy rainfall) in the late monsoon (August). Rice farmers commented that shrimp farmers had an advantage in that they could take quick action to adjust to the changes. For example, if their shrimp *gher* or fish ponds became flooded, they were able to protect fish and shrimp by using net fences or could restock their *ghers*/ponds quickly soon after recession of the flood water. In contrast, rice farmers had to wait until next year or get lower yields if they replanted new seedlings late in the season.

Local people commented on the impacts of reduced monsoon rains on local ecological systems, which gave rise to a number of livelihood problems such as shortage of drinking water, scarcity of water for agriculture, high salinity in *ghers*/

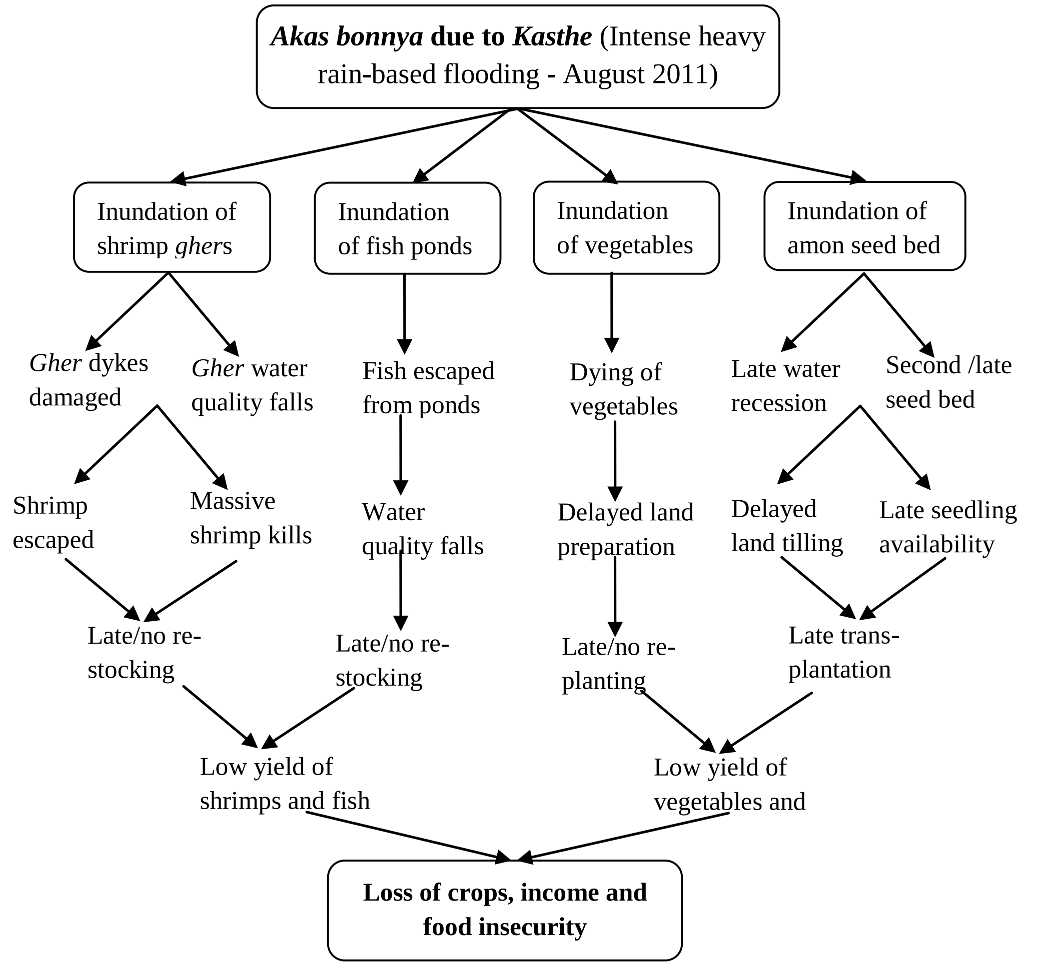


Figure 6.3: Effects of 12 day *akash bonnaya* on local livelihoods (FGD, Fultala villagers, 2011)

fish ponds, changes in fish migration and spawning in rivers and changes in the flowering of forest trees affecting honey production (Figure 6.4). Reduced monsoon rains over the last few years had made the soil and water saline to such a degree that growing vegetables had become impossible in many areas in the coast (Ahmed and Troell, 2010). This has implications for nutritional intake, human health and poverty. It is also clear that a single weather stressor such as reduced monsoon rains can have impacts on multiple sectors or resource systems (production and extraction

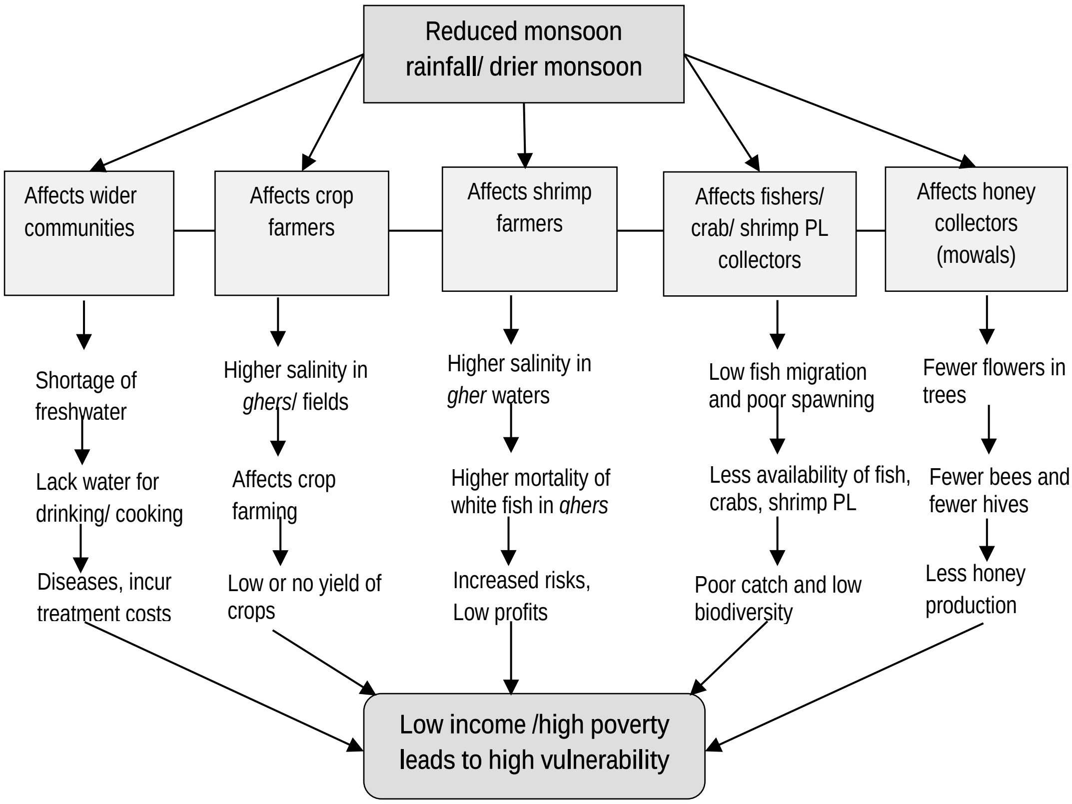


Figure 6.4: Impact of reduced rains on livelihoods of coastal communities (Source: FGD with fishers, mowals, and crop and shrimp farmers in Chakbara and Fultala villages)

sectors) upon which the majority of poor people subsist (Figure 6.3). Although each weather stressor has the potential to affect multiple sectors, its impact varies by livelihood resource systems and occupational groups.

Differentiated effects of various weather stressors on different occupational groups

Focus Group Discussions (FGDs) were held with different occupational groups in the two project villages to document the range of stressors that affected their livelihoods. The list of stressors was then grouped into two subsets: weather-related and non-weather-related. Eight weather related stressors were identified and are listed below:

- ***Increased temperatures*** - steady increase as a slow onset event and year round but felt especially during summer and monsoon.
- ***Prolonged drought*** – as a result of erratic rainfall, intermittent droughts occurring mainly during pre-monsoon and monsoon.
- ***Intense rainfall/ flooding*** – variable, unusually intense heavy rainfall inundated crop land, roads, fish /shrimp ponds, occurring mainly in late monsoon during the amon rice farming season.
- ***Rough sea conditions*** - more frequent in recent times during monsoon and late monsoon, instruction for the sea going fishers to come ashore and take safe refuge.
- ***Cyclones/ storm surges*** - variable, more frequent cyclone formation, usually in post monsoon but cyclone Aila hit during pre-monsoon.
- ***Increased water level during high tides*** - recent phenomenon and common year round but higher in late or post monsoon.
- ***Increased soil and water salinity*** – a slow onset event gradually increasing and extending further upstream especially in the dry season.
- ***Shorter and warmer winters*** - recent phenomenon, winter season reduced from two months to around 45 days, usually warmer than before but with some intermittent intense cold spell lasting a few days.

Although shorter and warmer winters were considered unusual, local people considered this as of lesser importance than other factors in the pairwise ranking of weather related problems. However, some agricultural farmers reported that the week-long cold spell in January 2012 affected winter rice seedlings (cold stress) and potatoes (late blight disease). Some expressed their concern that if the temperature in winter rises further, it might create problems for *rabi* (winter) crops in future. The other eight occupational groups did not report any negative impacts of cold spells or shorter and warmer winters on their livelihoods.

The impacts of specific weather stressors varied by different occupational groups largely due to their unequal livelihood dependence on different resource systems, strategies and options. Sea going fishers are more affected by frequent "*rooling*" in the sea (rough sea conditions). Rice farmers rated increased soil/ water salinity as a major problem as they experienced crop failure. Shrimp farmers considered increased salinity in their ponds/*gher*s as a major problem. A pair wise ranking exercise was conducted for eight climate related stressors with nine different occupational groups in the study villages to assess the effects of each of the weather stressors on each group (Figure 6.5). The occupational groups in the villages were:

- ***Rice farmers*** **–**all from Fultala representing traditional rice farming communities.
- ***Shrimp farmers*** **–**all from Chakbara, well-off by local standards and had previously been rice farmers and forest users who had switched over to shrimp farming.
- ***Shrimp/ rice farmers*** **–**all from Fultala, they farmed rice and shrimp together in *ghers* and had rice crop lands.
- ***Sea going fishers*** **–**all from Chakbara and who in the past were either fishers or rice farmers and had switched to sea fishing, which was more lucrative than river fishing.
- ***River/forest fishers*** **–**all from Chakbara and fish in nearby rivers and the Sundarbans with small boats.
- ***Crab collectors*** **–** all from Chakbara village, previously engaged in fishing or shrimp PL collection but crab collection becoming more profitable.
- ***Women (farming families)*** **–** all from Fultala, apart from household work, they took part in farming activities alongside male members.
- ***Women (shrimp PL collectors)*** **–** all from Chakbara, prior to shrimp farming they engaged in farming or wage laboring. Fultala has no PL collector.
- ***Mowals (honey collectors)–***all from Chakbara village, they collect honey for two months (April-May) and rest of the time subsist on fishing, shrimp PL catching, wage labouring, and shrimp *gher* work.

In general, increased temperatures have affected all the occupational groups but with greatest impact on shrimp farmers through deterioration in water quality of *ghers*. The crop/ rice farmers also experienced moisture stress, higher soil salinity and consequent poor crop yields due to increased temperatures. While fishers were not obviously affected in their fishing activities due to temperature rise, many of them have small homestead ponds or land where they cultivate shrimp, fish and vegetables, which were affected by temperature changes. However, river fishers said their income had declined due to shifting of some fish species such as the large catfish named *med* –Nemapteryx nenga from shallower areas to deeper areas, which they suggested was due to a recent prolonged drought and an increase intemperature.

As can be seen in Figure 6.5, rice farmers of Fultala rated soil salinity, prolonged drought and intense rainfall/ flooding as the major weather related problems that affected their livelihoods. Frequent rough sea conditions were rated as the most serious problem by the sea going fishers of Chakbara. Failure of fishing effort means increased debt, which for many poor fishers results in reduced incomes, less food, reduced social status, an incapacity to fulfill major family obligations, and asset sales and further dependence on money lenders. The shrimp farmers of Chakbara rated increased water height during high tides as the major problem for them (scored 7). The dykes are not very strong, with many weak points which can be breached if tide pressure is high and can damage their *ghers*. Shrimp farmers considered dyke breaching and inundation by saline water as more damaging than rainfall inundation as it takes less time to repair *ghers* if damaged by rainfall by draining out and refilling with river water.

High rainfall makes *gher* water sweeter as salinity is reduced, which kills salt water shrimp. Heavy rainfall run-off deposits organic wastes into the *gher*s from the catchments which de-oxygenate the *gher* water making it unsuitable for shrimp and fish. Once a *gher* is flooded and degraded, it takes over a month for water conditions to return to normal. During intense heavy rainfall in August 2011, shrimp escaped and died in over 95% of *gher*s in the area. Rain based flooding had also severely affected shrimp *gher*s two and three times from 2005 to 2011. Rainfall/rainwater is good for washing out salinity from croplands that helps farmers start cultivation of rice while at the the same time it causes negative impacts on shrimp due to the dilution of gher water salinity which causes shrimp kills. Therefore, a single weather event can have positive and negative effects on people depending on their livelihood options and production systems.

Crab collectors prioritized intense continuous rainfall, frequent rough sea conditions and cyclone/ storm surges as the major weather related problems affecting their livelihoods. During continuous rainfall, fewer crabs are caught in the SRF, which may be caused by lower salinity that leads to increased crab dispersal. During heavy rainfall, they found it difficult to manoeuvre their small boats in the forest and many crab collectors ceased working, which resulted in income losses. Similarly, during rough sea conditions they found it difficult to fix their traps and keep their boats stable in high waves. Crab collectors did not consider higher temperatures, salinity intrusion and drought as major threats to their livelihoods. Like other occupational groups, the crab collectors also ranked frequent cyclones and storm surges as a major concern. Crab collectors are poor and many live in poorly constructed houses on the dykes, making them highly exposed to cyclones and storm surges.

Due to shallowness of their *gher*s (about 1 m), higher temperatures affected shrimp, particularly in pre monsoon. The depth of *gher*s in Fultala is shallower than that of Chakbara and thus temperature rise did not affect *gher* farmers of Chakbara. However, if temperatures continue to rise, the *gher*s in Chakbara are likely to face problems in future. Generally, shrimp farmers are more concerned about heavy

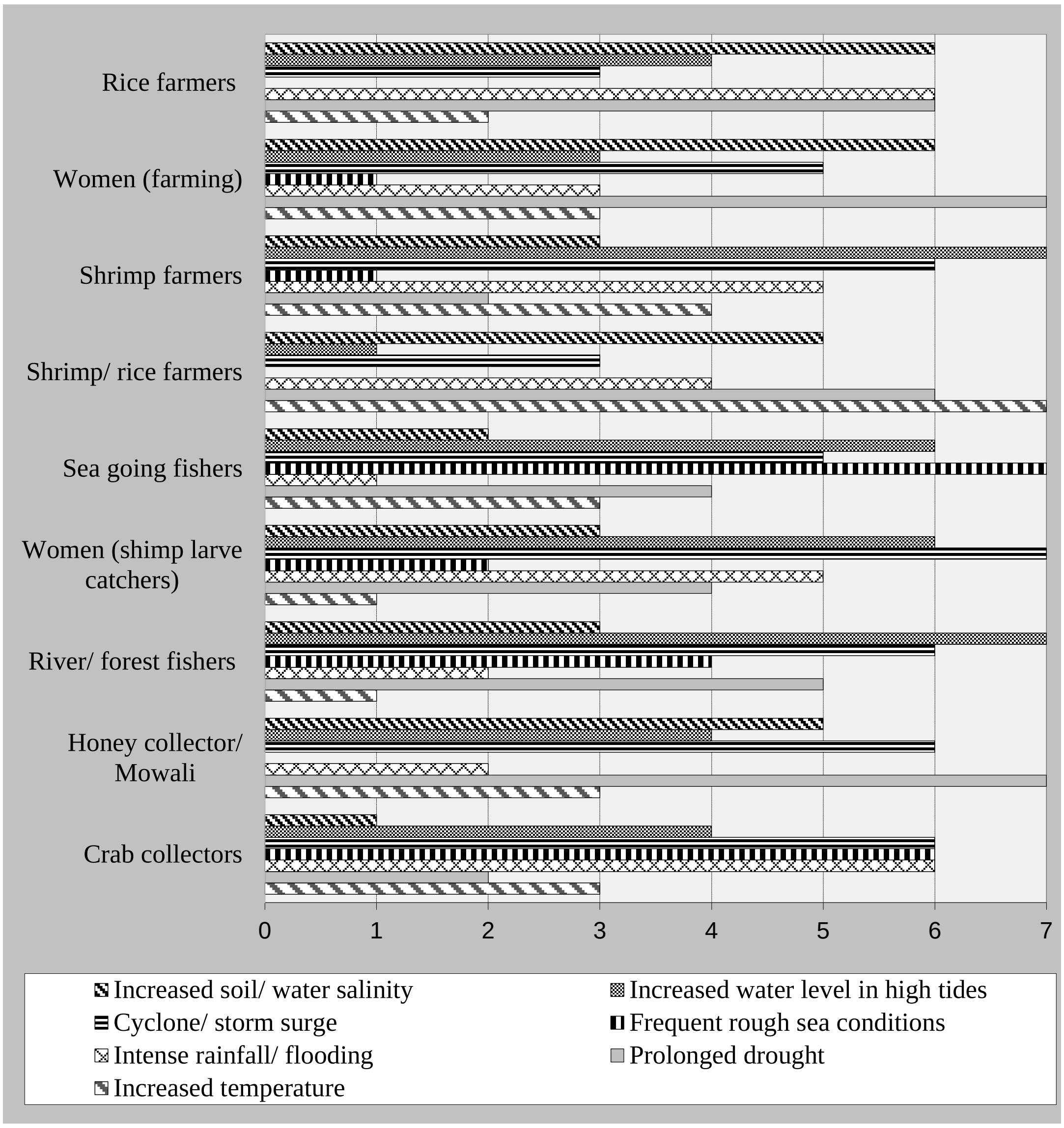


Figure 6.5 Weather stressors affect the livelihoods of occupational groups (scale ‘0’ = not a problem, scale ‘1’= least problem…scale ‘7’ = highest problem) Source: Pairwise ranking of problems by occupational groups (6-8 members per group) in 2012.

rainfall than drought as over the past six years they have experienced losses three to four times more often from heavy rains than from drought. Drought or low rainfall does affect production through lower yields. Table 6.3 shows the top three weather related stressors for the different occupational groups.

Women shrimp PL collectors of Chakbara experienced less availability of PL in the rivers during prolonged drought but ranked intense erratic rainfall/flooding as more of a problem. They explained that during drought they get fewer shrimp PL but were able to sell them at a higher price even with competition from PL hatcheries. They pointed out that PL collected from natural sources (rivers, canals) continues to command a high price from *gher* farmers as they are considered healthier and more robust. They commented that *gher*s are not harmed as much by drought as by intense rainfall and consequent flooding.

Table 6.3: FGD participants in pairwise ranking exercise on CC probelms

Occupational groups	Top most problems	2nd most problems	3rd most problem	Remarks
1. Sea going fishers	Frequent rough sea conditions	Increased water level at high tides	Cyclones/ storm surges	Loss of livelihoods due to failure of fishing efforts
2. Shrimp farmers	Increased water level in high tides	Cyclones/ storm surges	Intense rainfall/ flooding	All these affect shrimp farms or put them at risk
3. Honey collectors	Prolonged drought	Cyclones/ storm surges	Increased soil/ water salinity	Drought caused less honey in forests
4. Crab Collectors	Frequent rough sea conditions	Intense and heavy rainfall	Cyclones/storm surges	Less crabs in rainy days, hard to catch crabs in rough days
5. Forest/ river fishers	Increased water level in high tides	Cyclones/ storm surges	Prolonged drought	Cyclones, high tides damage house; less fish due to drought
6. Women (PL collectors)	Cyclone storm surge	Increased water level at high tides	Intense rainfall/ flooding	Damage of houses; flooding lessened PL demand and price
7. Women (farming)	Prolonged drought	Increased soil/water salinity	Cyclones/ storm surges	Drought + salinity +cyclones affect farming, land, ponds
8. Rice farmers	Intense rainfall / flooding,	Prolonged drought	Increased soil/ water salinity	Flooding, drought and salinity damage crops
9. Rice & shrimp farmers	Increased temperature	Prolonged drought	Increased soil/ water salinity	Temperature affects shrimps; drought + salinity damage rice

Source: Pairwise ranking exercises done separately with each group in two study villages in 2012

However, farmers usually do not stock their *gher*s during rainfall and it is then that the demand for PL falls. PL traders do not buy PL during continuous rainfall so with fewer buyers, prices go down.

Table 6.4: Livelihood impacts of three most prominent weather stressors on various occupational groups in two study villages (source: FGD and pairwise ranking in two study villages with 6-8 villagers of each occupational group in 2012)

Climate related stressors	Occupational groups experienced greater extent of threats from Climate stressors								
	Rice farmers	Shrimp farmers	Rice/ shrimp farmer	Women (farmers)	Women (PL catcher)	Sea going fishers	River/ forest fishers	Honey collector	Crab catcher
1. Cyclones/ storm surges		√√		√	√√√	√	√√	√√	√√√
2. Prolongeddrought	√√√		√√	√√√			√	√√√	
3. Intense rainfall induced flooding	√√√	√			√				√√√
4. Increased water level at high tides		√√√			√√	√√	√√√		
5. Increased soil/ water salinity	√√√		√	√				√	
6. Rough sea conditions						√√√			√√√
7. Increased temperature			√√√						

√√√ = Highest impact; √√ = higher impacts; √ = high impact

Looking at Table 6.4, cyclone/ storm surges created greater but variable impacts on all seven occupational groups of which the greatest impacts were on two groups, namely, women PL collectors and crab catchers. This is followed by shrimp farmers, river/ forest fishers and honey collectors and by women farmers and sea-going fishers. Prolonged drought causes water stress to agricultural crops and thus has a major impact on rice farmers and women involved in farming. The honey collectors also claimed that prolonged pre or early monsoon drought affected flowering in the forest and honey supplies. Apart from drought, rice farmers were severely impacted by intense heavy rainfall. Of growing recent concern to shrimp farmers and river forest/ fishers of Chakbara villages are high tides and the breaching and over topping of dykes. Increased soil salinity is a major problem for rice farmers in Fultala. After cyclone Aila, boro rice (*goromer dhan*) production was particularly affected in Fultala as soil salinity increased. Some farmers reported that in low lying areas where Aila-borne salt water remained stagnant for a long time, amon rice production reduced by around 20 percent due to salinity.

Community views on the relationship between weather and non-weather related problems

Apart from the direct weather related stressors, local communities face various non-weather related stressors that affect their livelihoods. These include shrimp virus/ disease, crop pests, reduced fish availability in rivers/ mangroves, scarcity of sweet water for drinking, cooking, and irrigation, embankment breaching, increased tiger attacks, non-availability of jobs, barriers in accessing mangroves, siltation and grabbing of rivers/ canals and increased banditry in the mangroves. Several of these non-weather stressors interact with weather stressors and may, in fact, be partly caused by weather stressors, as in the case of increasing tiger attacks and reduced fish availability in the rivers and canals of SRF including lower estuarine waters.

Weather and non-weather stressors in combination can create greater impacts on social ecological systems than either working in isolation (Pouliotte et al., 2009). For instance, The Farakka barrage, a non-weather stressor, has had major and generally negative impacts on the river and wetland systems and on salinity levels with adverse effects on fisheries, agriculture, livestock, SRF, biodiversityand overall livelihoods in the entire Lower Ganges Delta. One of the consequences of the barrage, in combination with other factors, has been salt water penetration 100 km or more inland along tributary channels during the dry season (Allison et al., 2003). This multi-factoral effect is important to keep in mind when discussing local impacts in the study villages.

Household census data on the nature and type of problems affecting the two villages revealed five priority problems (Table 6.5) Three out of five priority problems of Fultala were related to crop farming, namely, high insect infestation, increased salinity of crop fields and rain-based flooding of crop land. Increased insect infestation was rated as the most important problem (46% of households). Such infestation included traditional pest and new insects that caused more damage than in the past. However, it is difficult to say to what extent this is linked to changing weather patterns.

Table 6.5: Five Priority problems affecting the local livelihoods (Source: household census in Chakbara and Fultala in 2010)

Priority problems of the people of Fultala and Chakbara villages	Households mentioned (%)	Remarks
Village: Fultala – 247 households		
1. Increased insect infestation in rice crops	46.2%	Indirect weather factor
2. Salinity of crop fields after cyclone Aila	41.8%	Indirect weather factor
3. Job scarcity in the locality	26.3%	Non-weather related
4. *Akash bonnaya* or *kasthe* (rain-	16.2%	Direct weather (intense heavy

based flooding) affecting crops		rainfall) but drainage congestion due to conversion of canals (non weather) intensifies drainage congestion
5. Physical weakness to earn income	15.8%	Largely non-weather
Village: Chakbara – 178 households		
1.Dacoits (bandits) in the SRF and lower estuaries	55.6%	Non-weather
2. *Ghus* (Bribing) of Forest Officials	52.2%	Non-weather
3. Increased tiger attacks in SRF	26.4%	Indirect weather
4. Physical weakness to earn income	16.9%	Largely non-weather
5. Government stopped shrimp farming after Aila[21]	14.6%	Largely non-weather

Other priority problems mentioned by Fultala residents were 'local job scarcity' and 'physical weakness or less fit to earn income', which were not obviously and directly weather-related. As the village lies in a single crop area, opportunities for farming jobs were less compared to other areas where farmers were able to grow three crops a year. In addition, the area had limited commercial development, which means few non-farm jobs. In Fultala, 37 households mentioned physical weakness as a key problem for them. Of these, three quarters (76%) were extreme poor or poor families, 22% marginal farm families and 3% from small farm families. None were from medium and large farm households. Physical weakness referred to both presence of elderly household members and irregular and low availability of nutritious food.

The priority problems of Chakbara were different from Fultala. Four out of five were non-weather related. The most serious problem was dacoity or banditry in the SRF followed by "paying *ghus*" (bribing) to field level forest officials, which had become an accepted, if resented, practice. If an individual refused to pay, false cases were brought against him with the allegation that the accused person had harvested more resources than allowed under the entry permit. The third ranked problem was tiger attacks, especially after the Sidr and Aila cyclones. Local people stated that attacks had increased as a result of the impacts of cyclones that had killed a good

[21] Many villages in Gabura UP,including Chakbara, remained under tidal water after cyclone Aila (2009) for around 18 months due to the failure of the coastal dyke. Many local people and members of NGOs claimed that by making unauthorized pipe culverts, shimp farmers had weakened the dyke and made them exposed to easy breaching. As a result, government did not allow shrimp cultivation after the cylone-induced flooding.

number of tiger prey animals such as deer and boars, resulting in food shortages. Villagers believed that this forced the tigers to seek alternative food sources in local villages. As in Fultala, 17% of Chakbara households said physical weakness, possibly due to malnutrition, was their fourth greatest concern. Finally, the inundation of shrimp *ghers* was the fifth major priority problem for shrimp farmers as it had led to 18 months of little or no activity, which some shrimp farmers attributed to the slowness of the government to take action.

I also discussed local problems with local people in FGD sessions. The traditional *bagdi* fishing communities of Kalbari village, who often fished together with Chakbara fishers in the SRF, identified eight reasons for declining fisheries production in the area. Of these, they considered three as directly weather-related, three indirectly weather-related and two non-weather-related (Table 6.6). They suggested that all of the reasons should be included in any plans to improve the management of fisheries for the SRF and adjacent areas.

Table 6.6: The *Bagdi* fishers' priority reasons for declining fish in SRF (1 indicates the highest priority reason and then the numbers follow in declining order)

Reasons for declining fish	Priority	Weather or non-weather related
More people involved in fishing (loss of agricultural jobs due to shrimp farming) leads to over fishing and destructive fishing	1	Non-weather
Reduced monsoon rains– fish do not come upstream from the sea	2	Direct weather
Massive shrimp PL collection from the rivers and canals that destroy eggs and fry of various other fishes	3	Non weather
Drought raises water temperature which in turn causes increased salinity that hampers spawning of fish and hatching of fish eggs	4	Direct weather
Increased siltation of river and canals	5	Indirect weather
Increased temperature /drought	6	Direct weather
Higher water salinity in monsoon compared to the past	7	Indirect weather
In the past, upstream river and rain water used to get mixed with coastal waters, created suitable environments for fish to spawn but that environment has been changed and no longer functions	8	Indirect weather (or non-weather)

Source: FGD with 6 Badgi Fishers (2 women and 4 men) in Kalbari village in 2012.

In discussing solutions to problems identified, local people suggested that both weather and non-weather related factors need to be included in local development planning (Figure 6.6). Figure 6.6 shows that among the weather related factors, reduced monsoon rains, changes of season, increased temperature were noticeable in the area. These weather changes manifested themselves as increasing cyclonic storms, longer and warmer summers, shorter and drier monsoons and shorter and warmer winters, including visible and regular prolonged droughts. All these collectively had negative impacts on local social-ecological systems and increased local vulnerability. People also referred to various non weather factors they considered had intensified further local vulnerabilities. These included closure of rivers upstream and water diversions (reduced freshwater flows), extensive cultivation of brackishwater shrimp (causing soil and water salinity) and poor governance and institutional issues which affected development processes. Below are provideda few examples of their ideas for solutions.

In the case of rice farmers, they considered erratic rainfall, prolonged drought and salinity as priority weather-related problems but equally emphasized other non-weather related issues such as leasing arrangements and the conversion and illegal appropriation of canals. The canal had previously been a source of freshwater for irrigation and as drainage outlets for excess rainwater. Table 6.5 shows that Fultala farmers ranked salinity of crop fields and *kasthe* or *akash bonnya* (intense rain-based flooding) as priority problems. As a solution, they proposed that canals should be returned to their original role as drainage channels in order to ease flooding and wash outthe salinity from soils. In addition, they wanted the canals to act as storage for monsoon rain water so they could expand the land devoted to *groomer dhan* (winter rice) and vegetables. They saw these measures as increasing their food security and providing employment for the poor and other villagers.

In Chakbara, embankment breaching and prolonged inundation were central problems they faced. They underscored that poor maintenance of dykes by the BWDB, coupled with illegal pipe culverts in dykes for exchange of water between shrimp *ghers* and rivers by the shrimp farmers as something that needed to be dealt with. They were particularly critical of the government authorities for their failure to repair breached embankments.

In Fultala, there had been a major decline in freshwater capture fishing in beels[22], in canals and road side ditches/canals as a result of reduced rains, drought and salinity (weather related) and leasing, land grabbing and conversion of canals to crop land, fish ponds and settlements. This had changed water flow regimes with lost connectivity with the river systems. However, while these weather-related changes were of great importance, they pointed to non-weather factors such as poor governance, political interference and corruption as major drivers of changes in capture fisheries in the area.

Similarly, fishers mentioned drought (reduced pre monsoon and monsoon rains) and increased temperature (weather related) as impacting on fish migration upstream. However, they emphasized a lack of fisheries management in the SRF and in the lower estuary, which included three wildlife sanctuaries within the SRF, as the main institutional reasons for a decline in fisheries in the area. They also mentioned that the cyclone-borne siltation degraded some suitable fish habitats in the upper reaches of SRF (a weather related stressor) but gave greater emphasis to the indiscriminate use of harmful fishing gear downstream of the SRF in the decline in fish availability.

In summary, local fishers identified a combination of weather and non-weather changes and developments that had resulted in a decline in their natural resources base. They considered government policy to be most at fault in failing to properly manage fish stocks, fishing techniques, the actions of lower level forest officials and provide effective governance of fish sanctuaries. In the past, fishing was dominated by traditional lower-caste Hindu communities such as the *kaibartto, malo, jalodas, barmon,* and *bagdi* but the unrestricted entry of thousands of Muslims seeking work and employment over the past 40 years had resulted in considerable pressure on fish stocks, fishing environments and fishers' living standards (Pokrant et al., 1997). In Chakbara and its environs, the small *bagdi* fishing community (minority fishing dependent groups) had been particularly hard hit by these changes.

Summary

This chapter examined how different local occupational groups considered that changes in local weather and non-weather related factors had affected their local

[22]Beels are bowl shaped natural depressions in floodplains or tidal plains which may retain water year round or part of the year

environment and livelihoods. What is clear is that while all people in the study villages have been affected over the years by a combination of weather and non-weather events and processes, these have had a differential impact on and vulnerability of particular occupational and other groups. The importance of this finding is that even where communities live very close to each other, they are affected in different ways by physical hazards depending on the nature and type of hazard and by differences in occupation, gender, access and control of assets and other socially organized and determined processes and institutions. Understanding these processes and institutions is central to the development of policies on adaptive capacity and adaptation strategies. Local vulnerabilities, capacities and readiness to deal with potentially highly damaging climate change impacts must be seen through the lens of the complex interaction between social and ecological systems for policy to be successful. The next chapter takes this discussion further by examining the variations between the two study villages with regard to their vulnerabilities to weather-related stressors.

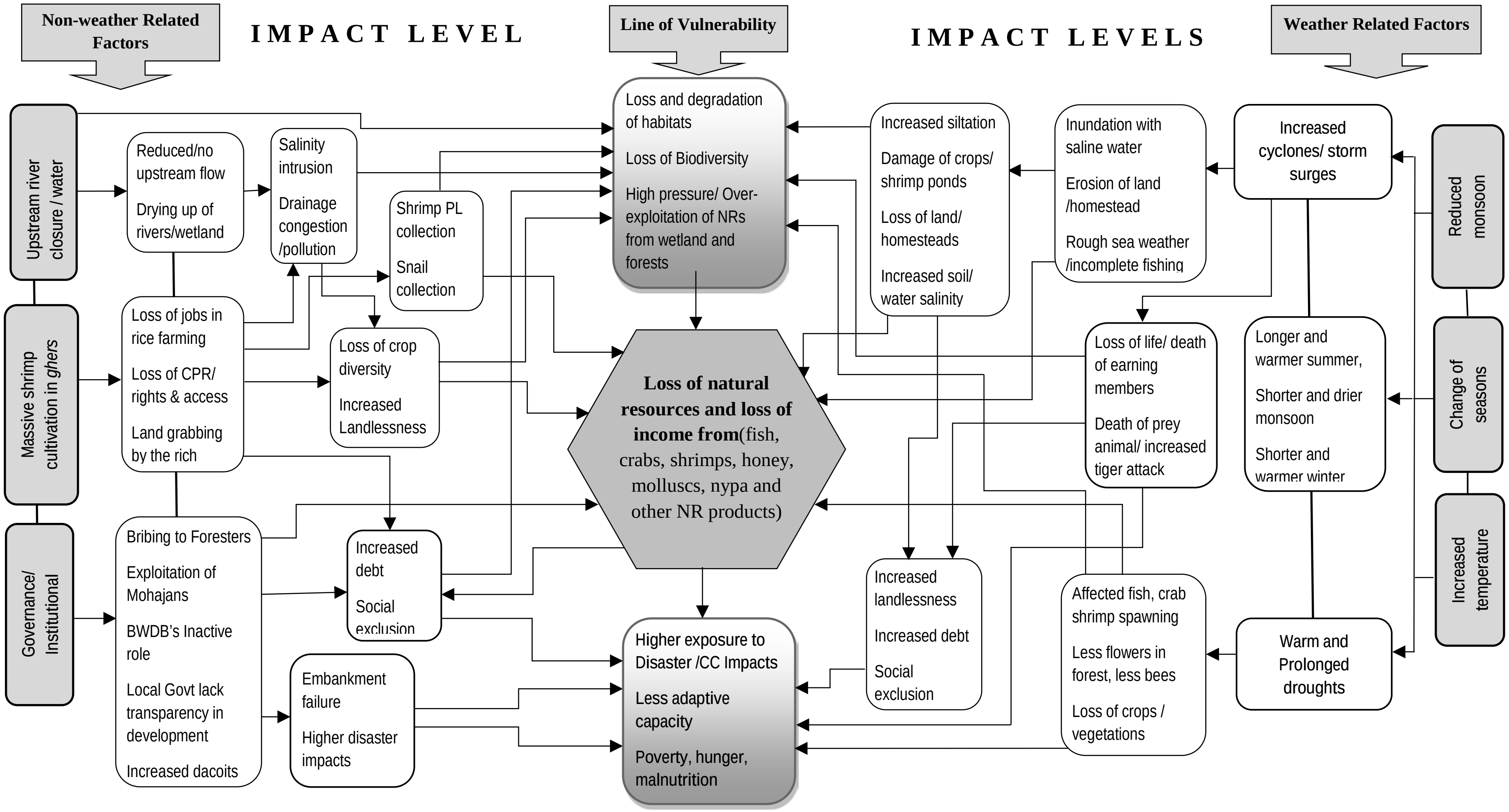


Figure 6.6: Vulnerability of poor natural resources users of SRF (Source: FGD with fishers of Chakbara and Kalbari, 2011)illages,

Chapter 7:
LivelihoodVulnerability of Local Communities to Weather/Climate Stressors

Introduction

This chapter presents the results of livelihood vulnerability assessment conducted in the two project villages. Its aim is to assess the variations between the villages in their vulnerability to weather related stressors.The range of indicators used are aligned to seven sub-components, which measure the vulnerability context of a system based on the extent of that system's exposure, sensitivity and adaptive capacity to cope with hazard events. Types and frequency of natural disasters and resultant damage experienced by village households are used as indicators of the "exposure" component of vulnerability while socio-demographic features, livelihood strategies and social networks and access to safety nets determine the "adaptive capacity" of village communities. Availability, quality and access to food, water and health services by the project communities collectively are used to indicate the "sensitivity" component of vulnerability. Relevant data for livelihood vulnerability assessment are collected from census and household surveys, conducted in the project villages including climate data (rainfall and temperature) collected from the Bangladesh Meteorological Department.

Vulnerability and its Multiple Faces

There are wide variations between the two project villages in terms of their problems and issues relevant to disaster, livelihoods and vulnerabilities even though they are located close to each other within a small geographical area of Shyamnagar sub-district. In the following discussion, the concept of vulnerability used is taken from the IPCC:

> Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effect of climate change, including climate variability and extremes. Vulnerability is the function of the character, magnitude and the rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2001).

Vulnerability is therefore a function of three interrelated contributing factors viz. i) types and magnitude of "exposure" to climate change impacts, ii) "sensitivity" of the target system (communities in this case) to a given amount of exposure and iii) coping or "adaptive capacity" of the target system to the impacts of climate change (IPCC, 2001).

With regard to the exposure factor, household survey data shows that the two villages are mainly exposed to cyclones and storm surges, frequent rough sea conditions, embankment failure, high salinity, erratic rainfall, rain-based flooding and prolonged drought. Exposure has both physical and social dimensions. For example, a coastal village may be more exposed to hazardous events such as a cyclone if located at the lower estuary bounded by large rivers or close to the sea compared to one located on the mainland and bounded by land or villages. The latter village may be less exposed to cyclones, storm surges, erosion, salinity intrusion due to its geographical (spatial) location but more exposed to other stressors such as rain-based flooding, drainage congestion or drought. Cutter (1996) defines this as "hazard of place" and suggests incorporating place as an important unit in hazard analyses. From the livelihood aspect, a fisher community may be more exposed to a hazard event such as "rough sea conditions" than that of aquaculture farmers because the former is exposed to that particular hazard due to their livelihoods dependence on fishing in the sea or lower estuarine waters. By contrast, the aquaculture farmer is more exposed to rain-based flooding, drought and high temperature which the fishers do not consider hazards with regard to their livelihood activities.

The extent of harm to a system or sub-system exposed to a particular hazard again depends on the "sensitivity" of the system (or sub-system) of concern to that particular hazard. For example, higher or increasing salinity of a coastal village causes more damage to rice farmers than to salt water shrimp farmers. It is therefore, important to analyze the level and extent of "sensitivity" of a system (or sub-system) to a particular type of hazard as well as their level of "exposure" to such hazard event. When a system has both high "exposure" and high "sensitivity" to a particular hazard, the extent of harm to that system depends on the "adaptive capacity" of that system (or sub-system) of concern (whether a person, family, community or a physical system like wetland, shrimp *ghers*). By this is meant the extent to which the system can resist or be harmed by the hazard. For example, higher soil salinity in

Chakbara village damaged the amon rice crops of all farmers who used non-saline resistant varieties while the few farmers who used saline-tolerant varieties were able to save their crops. The level of harm from exposure to a particular type of hazard event also varies according to the knowledge, skills and practices of the persons concerned. For example, a farmer who uses a part of his land for rice farming and a part for shrimp farming may be less likely to become exposed to hazard and thus have higher adaptive capacity to overcome specific disaster losses compared with a farmer who either grows rice or cultivates shrimp alone.

Exposure to any hazard and consequent extent of harm has temporal dimensions. For example, Chakbara village was affected by saline water inundation due to cyclone Aila in 2009 for a longer period– an average of 13 months (2009- 2011)- compared with Fultala, which was inundated for less than a month. This prolonged inundation to saline water increased the exposure dimension of vulnerability and higher exposure to hazardous conditions (saline water flooding) increased the extent of damage and made the system more vulnerable. This prolonged exposure resulted in 82% of households in Chakbara being unable to replant homestead vegetables due to high salinity in the soil while only 3% of households faced similar problems in Fultala where the average inundation period was less than a month. From the resilience perspective, prolonged exposure to hazards and resultant higher damage contributes to lowered resilience capacity of the affected system and sub-system (viz. communities or crop fields or fish farms). Thus, in order to plan adaptation interventions, community level specific data on the relevant components of the vulnerability context and their analyses are necessary.

Vulnerability of local communities

As mentioned in the previous chapter, the study villages are located in the same union parishad (UP), the same sub-district of Shyamnagar under Satkhira district and within the exposed coast of the southwestern part of the LGD. The exposed coast is located at the extreme southern edge of the mainland bordering the sea and thus is more vulnerable to climate related hazards like cyclones, storm surges, SLR, high tides, salinity and erosion. However, wide variations were observed in the extent of vulnerability among villagers. Assessment of vulnerability of given systems (viz.

geographical areas or communities) to hazards or shocks is a complex task, which involves analyzing multiple contributing factors varying in space and time.

Fussel (2007) distinguishes between what he calls the "sphere" or scale dimension of vulnerability and the "knowledge domain" of vulnerability (Table 7.1). Each of these dimensions of vulnerability can be categorized by their origin or source as internal or external. Internal (endogenous or in place) denotes vulnerability factors that are properties of the system itself (viz. specific community or ecosystem) and external (exogenous or beyond place) refers to factors outside the vulnerable systems (Fussel 2007). Based on my primary data, table 7.1 presents four categories of vulnerability contributing factors by "spheres" and "knowledge domain" as framed by Fussel (2007).

Table 7.1: Four categories of vulnerability factors according to the dimensions of sphere and knowledge domains

Sphere	Knowledge Domain	
	Socioeconomic vulnerability factors	Biophysical vulnerability factors
Internal	Livelihood options /strategies Social networks and safety net programmes Access to information and early warning systems Health /disease prevalence Food and Water (Adaptive capacity and sensitivity to change/hazards)	Dyke collapse Drainage congestion and flooding Shrimp farming/land use changes Soil and water salinity River/ canals grabbing and conversions (Exposure to change/hazard)
External	Forest conservation rules Dyke maintenance *Khas* land distribution Disaster management Social protection , health services Emergency response (Adaptive capacity and sensitivity to change/hazards)	Cyclones SLR, high tides Climate variability (drought, erratic rains, temperature) Loss of river flows Salinity intrusion (Exposure to change/hazard)

Adapted from Fussel (2007)

These vulnerability factors vary across physical and social settings - more explicitly by villages, unions, upazilas, district and sub-national scales based on local physical environments as well as socioeconomic functions and livelihood opportunities. These factors also vary over time – an area with higher vulnerability may become even more vulnerable or could become less vulnerable due to various factors (such as improved knowledge, changes in socio-economic conditions, improved institutional capacity, policy, processes and management). However, given these complex dynamics in the hazard-vulnerability nexus, I intended to assess the livelihood vulnerability of the two coastal village communities (Fultala and Chakbara) based on the vulnerability factors (Fussel, 2007) or components as framed by IPCC (2001).

Livelihood Vulnerability Index of Chakbara and Fultala communities

Since the focus of the research is on the social aspects of climate change and climate variability and community strategies to adapt to changing environments, I have adopted the Livelihood Vulnerability Index (LVI) tool to assess the vulnerability of the study villages. The LVI was developed and field tested by Hahn et al. (2009) in Mozambique. The tool combines a sustainable livelihoods approach with the factors that make people vulnerable to climate change and climate variability. The approach has demonstrated effectiveness in assessing vulnerability of communities to the impacts of climate hazards by collecting and analyzing relevant primary data from households aligned with the vulnerability factors that collectively determine the vulnerability of a system (IPCC, 2001). The IPCC vulnerability definition includes three contributing factors, which are exposure, sensitivity and adaptive capacity to climate shocks. In developing the LVI for the study villages, I used multiple indicators related to weather induced threats to assess the exposure of two village communities. Data on various socio-economic features of the households including local governments' functionsin safety net programs were used to analyse the adaptive capacity component of vulnerability. Other indicators such as water availability, health issues and food security were used to determine the sensitivity component of vulnerability. I used most of the indicators in Hahn et al. (2009) that suited local conditions in addition to some additional indicators. A total of 82 indicators were used under seven major sub-components of three contributory factors of vulnerability in determining the LVI (Table 7.2).

The approach involved two broad steps. First, determining the LVI based on household level primary data including meteorological data on climate parameters (rainfall and temperature) as part of a composite index comprised of seven major sub-components. Second, the seven component results were aggregated into three contributing factors of vulnerability, which were exposure, sensitivity and adaptive capacity.

Table 7.2: LVI-IPCC assessment components and indicators

IPCC contributing factors to vulnerability	Hahn et al. (2009)		Current study (2011-12)	
	Major sub-components	Indicators used (No.)	Major sub-components	Indicators used (No.)
Exposure	Natural disasters and climate variability	6	Natural disasters and climate variability	18
Adaptive capacity	Socio-demographic profile	5	Socio-demographic profile	8
	Livelihood strategies	3	Livelihood strategies	17
	Social networks	3	Social networks and access to safety net	8
Sensitivity	Health	4	Health	13
	Food	5	Food	11
	Water	5	Water	7
Total	Major components -7	31	Major components-7	82

Table 7.3 presents the major sub-component values by respective indicators under each sub-component determining the vulnerability. In describing the assessment findings I describe the “exposure” component first and then move on to “sensitivity” to stressors and then to the “adaptive capacity” component which deals with the capacity of the system to adjust to shocks or changed situations. The next section describes the overall LVI of the two village communities based on the aggregated outcomes of three contributory factors of vulnerability.

Exposure of the systems to weather induced stressors and extremes

Although both the villages are located in the exposed coast bordering the Bay of Bengal, because of spatial and land use variability, geographical position and livelihood options, the two communities have different levels of exposure to coastal hazards. Located at the lowest end of the mainland and surrounded by large rivers, which gives it an island like appearance, Chakbara experiences more frequent hazards with higher intensities than Fultala located on the mainland, 3-4 km from a tertiary river, the bank of which is also protected by embankment and thus less exposed to hazards. I used 18 different indicators to assess the extent of exposure of two village communities to disasters (Table 7.3). Survey data shows that over the last 6 years, communities of Chakbara encountered more than double the number of different hazard events compared to Fultala, which indicates the higher exposure of the former. On receiving early warning messages prior to cyclones, between 97% and 98% of Chakbara households reported having received early warning messages (EWM) compared with between 57% and 79% of Fultala households prior to the cyclones Sidr in 2007 and Aila in 2009 respectively (Table 7.3). Over 49% of Chakbara households reported that they stored drinking water after receiving EWM compared with 18% of households of Fultala. Almost every household in Chakbara has multiple water jars of different sizes to store water as the area is high saline prone and shortage of drinking water is common the year round but severe in the dry season. Thus, the scarcity of drinking water, higher exposure to saline water flooding and contamination of drinking water ponds have made the residents of Chakbara more aware of the need to store drinking water upon receipt of early warning signals prior to any hazard or disaster. By contrast, Fultala communities are located in an area less exposed to saline water flooding hazard, which has meant they are less likely to store drinking water on disaster signals.

Apart from receiving EWM and storing drinking water, Chakbara was severely affected by cyclone Aila (2009) and 89% households reported leaving their homes for embankments or other raised places or temporarily migrated for periods from 3 to 18 months compared to only 22% of Fultala households who left their homes for shorter periods (less than a month). During cyclone Aila, Chakbara was worst hit as 100% of households experienced damage to their homes compared to only 13% of Fultala households and the homesteads of the affected people remained inundated for 13 months on average in Chakbara compared with less than a month (0.72 month) in Fultala.

Exposure to disaster also affects employment and occupational patterns in varying ways. Study data shows that two thirds of the total households in Chakbara were unable to practice their occupations after cyclone Aila compared with less than one third of households of Fultala. In terms of other livelihood assets, Chakbara was worst affected, as 100% households experienced inundation of their fish ponds compared to 53% in Fultala. The average diversity indices on damage of assets were much higher in Chakbara than in Fultala both during and after the cyclone Aila (Table 7.3). Incidents of deaths, injury and conflicts due to cyclone Aila were found to be negligible in both villages with only one death in Chakbara. Apart from these indicators of exposure, I also collected local data for the last 60 years (1950-2010) on three weather parameters (average maximum and minimum temperatures and precipitation - rainfall) from the Dhaka Meteorological Department, which was used in the LVI assessment. No difference was found between the two villages in terms of temperatures and rainfall over that period (discussed in previous chapter). This lack of difference masks differences in their overall exposure rating caused by other factors.

In addition to its greater distance from the coast, Fultala village is comparatively less exposed to coastal hazards compared to Chakbara for several other reasons. First, it is located 3-4 km from a tertiary river with an embankment and the height and strength of a tidal surge is weaker in small rivers compared with large rivers found closer to the coast. Second Fultala is bifurcated by a raised paved road which acts as an embankment and gives double protection from storm surge induced flooding. For example, one part of the village on the east was protected from flooding due to the road, which meant that the houses and assets there were saved from coastal flooding during cyclone Aila. In Chakbara there are no such raised roads. Third, Aila hit in May when there were no crops in Fultala fields as amon rice cultivation starts from June-July. In contrast, shrimp *ghers* and fish ponds (95% of the total cultivable land in 2009) in Chakbara were stocked with shrimp and white fish which were all washed away causing considerable financial harm to aquaculture farmers and thereby increased their vulnerability. Finally, Chakbara remained inundated by cyclone induced saline water for 12 to18 months compared to less than a month in Fultala, which contributed to higher damage to Chakbara compared with Fultala and thus reduced their adaptive capacity (or increased vulnerability).

Besides the spatial dimension, vulnerability to disaster has a temporal dimension. As noted, cyclone Aila hit in May 2009 which caused severe losses to shrimp farmers as at that time the shrimp *ghers* were full of stocked shrimp, which were all washed away with the surge water. In Fultala the rice farmers did not face such crop losses as cycloneAila struck before the rice farming cycle. However, exposure and sensitivity to hazard are not limited to instant direct effect at the time of a hazard event. There is often varying degrees of residual exposure and sensitivity that even last for several years.Forexample, after cyclone Aila, Fultala rice farmers incurred losses of amon rice due to delayed but increased soil and water salinity from the earlier surge water (cyclone Aila). This affected local agriculture for another two years from the time of the cyclone. In the case of Chakbara, the delayed increase in the salinity of soil and water had much less impact on Chakbara as over 95% of land were under salt water shrimp farming, which required a certain level of water salinity for better growth and survival of shrimp. Only a few Chakbara farmers cultivated rice on less than 5% of the land area and this land was converted to shrimp *ghers* in early 2012 due to the residual effects of salinity induced by cyclone in mid-2009. However, homestead vegetable production in Chakbara was badly affected by salinity during the post cyclone years. Thus, temporal and spatial dimensions of hazard impacts are important factors to be considered as they contribute to differences in the degree and type of vulnerability for different occupational groups according to temporally determined impacts even where the affected communities live close to each other ("hazard of place").

Sensitivity of the system to weather induced stressors

Sensitivity refers to the responsiveness of a system or systems to climate induced hazards. IPCC defines sensitivity as the:

> … degree to which a system is affected, either adversely or beneficially, by climate variability or change (IPCC 2001:21). The effect may be direct (e.g., a change in crop yield in response to a change in the mean, rangeorvariabilityof temperature) or indirect (e.g., damages caused by anincrease in the frequency of coastal flooding due to sea level rise).

In this context, I considered three sub-components, which were health related issues, food security and availability and access to safe water particularly for drinking and cooking purposes to assess the study village sensitivity factor of vulnerability. In this vulnerability factor, I first discuss the sensitivity of the local communities to health issues and then move on to food and water aspects.

Sensitivity related to health issues

I used 13 different health related indicators under this sub-component of sensitivity. Key indicators included disease prevalence, access to safe latrines, distance, time and costs to access health facilities, training in health issues, child immunization rate and skills to prepare oral saline for treating diarrheal cases. Based on the indexed values it was found that the two villages varied with regard to sensitivity to hazards on health grounds. For example, in Chakbara, 60 percent of households reported that they had at least one family member who suffered from chronic illness compared with 55.6 percent of households in Fultala. Households with chronic illness are more sensitive to hazards, especially when located in a remote setting where emergency medical facilities are virtually absent, as was the case in Chakbara. Chakbara households reported a higher proportion (8.9 percent) of children failing to attend school due to illness compared to 6.7 percent of Fultala households. Regarding safe latrines (water sealed), only 53.4 percent of Chakbara households had safe latrines compared with 83.4 percent of Fultala households. Regarding ownership of latrines, again more households in Chakbara (39%) reported that they do not have any latrine of their own compared with 2% in Fultala. Use of safe latrines can reduce disease susceptibility and thereby keep people healthy and fit for work, which is particularly important for the landless poor as most of them engage in physical work to earn living. Moreover, reaching health services is costly and time consuming and it also disrupts daily work routines and can result in a loss of wages. Therefore, lower susceptibility to illness can positively contribute to reducing sensitivity to increased vulnerability to shocks. The survey data shows that 37% of Chakbara households reported at least one of their family members suffered from diarrhea in the survey year as opposed to only 6% of Fultala households. Although difference is not great, 91% of Chakbara households reported that members had suffered from various diseases due to cyclone Aila compared with 82% in Fultala.

In the case of access to health emergency services to see a medical doctor or visit a sub-district hospital, Chakbara residents travelled an average of 24.1km as opposed to 15.4km for Fultala residents. It took Chakbara residents an average of 138 minutes to reach the sub-district level medical facilities compared to only 42 minutes for Fultala residents. Similarly, transport costs were higher for Chakbara residents (BDT[23] 83.3; US$1.07/per person) compared with Fultala (BDT 30; US $ 0.38/per person). Education and training in primary health care and family hygiene can contribute to the reduction in health related problems and reduce the sensitivity of households to such problems before and after a disaster. More Chakbara households (73.3%) reported they knew how to prepare oral-saline solutions (for diarrheal treatment) compared to 64.4% of Fultala households. With regard to the frequency of

[23] One US dollar equivalent to Bangladesh Taka (BDT) 78.00 in 2014

primary health care training, only 4.4% of households in Chakbara and 2.2 percent of Fultala households reported that they received such training. However, regarding immunization of children, the majority of households in both villages (95.6% in Fultala and 93.3% in Chakbara) reported they immunized their children. Finally, the frequency of inability to work due to sickness was almost similar (around 45 percent of households) (see Table 7.3). In summary, Chakbara had an overall health index of 0.478 compared to 0.301 in Fultala which indicates higher sensitivity of the former to hazards on health related issues compared to the later (Table 7.4). However, vulnerability is also dependent on the sensitivity to availability of food.

Sensitivity related to Food security

None of the Chakbara households reported growing food (mainly rice) on their farms as all the crop land of the village had been converted to salt water shrimp farms. Households were almost entirely dependent on buying rice, except in some small areas where a few farmers grow amon rice within shrimp *ghers* during the monsoon when salinity concentration reduces. In contrast, 40% of households of Fultala relied on their own farm production for their staple food (amon rice). This can be considered as an enhancement of their adaptive capacity as these households have some food security from their land. There is a common saying in rural Bangladesh that “if we have rice at home, we can make up our meal with salt and chili“, suggesting that having rice at home is synonymous with food security. Although agriculture is sensitive to climate variability and change, at the same time it gives food security. However, having land does not necessarily mean having food security. This depends on various factors such as size of land holdings, production functions of the land, and exposure and sensitivity of the land and crops grown to hazard events. Whether landed farm households or landless, the majority of rural people can find it difficult to ensure the required amount of food for the family members consistently throughout the year. The majority of households in the study villages (Chakbara - 97.8% HHs and Fultala -91.1% HHs) faced difficulties in arranging adequate food for the family year round. However, periods of hardship varied by village. Survey data shows that on average the households of Chakbara found it difficult for 2.5 months to arrange food for their families compared with only 1.9 months for Fultala households. The longer households failed (or found it difficult) to provide enough food for the family, the more sensitive they were to becoming vulnerable to hazards. The majority of households in Chakbara were dependent on SRF for their livelihoods and paying bribes and ransom to forest guards and bandits also increased their vulnerability. Overall, more Chakbara households than Fultala households were sensitive to physical hazards or disasters.

Rural people usually save a portion of their crops to meet family needs during crisis periods but this was not possible in Chakbara. Fultala residents also had problems ensuring a regular saving of rice as they depended on one rice crop a year. As reported, they found it hard to save crops, apart from a few large farmers (4.4% of households) who had sufficient farmland that provided sufficient food to be able to store for lean times. Many small and medium farmers were compelled to sell a part of their farm crops to meet other family needs, making it impossible to store food and seeds. This indicates the importance of examining intra-village differences in assets as part of developing a vulnerability index. The situation was much worse in Chakbara where 87.8% of households were unable to save seeds compared with only 31.1 percent of Fultala households.

The two villages also differed in terms of provision of daily meals and nutritious diets. During crisis periods, households of both villages faced difficulty arranging three meals a day for the family members. Data shows that 62% and 53% households of Chakbara and Fultala reported that they were unable to provide three meals per day for their families (Table 7.3). Although the difference is not significant between the villages, the sensitivity of Chakbara to crisis periods seemed higher compared to Fultala. Regarding intake of protein-rich food such as fish, chicken, eggs, and milk, the monthly intake of fish and eggs was higher in Chakbara than Fultala while intake of chicken and milk was higher in Fultala. The higherconsumption of fish in Chakbara was a result of its closeness to the river and ocean and the high proportion of fishing households. The higher consumption of eggs in Chakbara was due to availability at cheaper price from village households. Chakbara is located far from local markets so many households sold eggs locally at cheaper prices than in Fultala. Fultala is located closer to the large market in Munshigonj. Moreover, vegetables were scarce in Chakbara due to salinity which may have encouraged people to eat more eggs. However, households in Fultala were able to sell and buy various products at reasonable price in Munshigonj market.

The overall indexed values for the eleven food security indicators show that Chakbara households were more vulnerable (0.724) than in Fultala (0.545) (Table 7.4). A major reason for this was differences between the two villages in land use and availability of food. Fultala suffered less from salinity and had a more diverse economic base consisting of rice farming and vegetable production for sale and domestic use. In contrast, Chakbara had fewer livelihood opportunities as a consequence of higher soil salinity. Fultala women said they collected from local wetland, roadside ditches, pond banks and fallow land near their homes over a dozen different types of wild plants to be used as vegetables. In Chakbara, few or no such opportunities existed due to salinity and scarcity of fallow land. The villages also varied in their sensitivity to water for drinking and cooking.

Sensitivity related to water security

Water for drinking, cooking and other household uses is a perennial problem in the coastal area as a whole and particularly acute in the study area mainly because of high salinity. Chakbara residents suffered the most due to shortages of freshwater for drinking purposes, particularly after Aila. Under normal circumstances, Chakbara residents would collect drinking water from ponds dug to hold rainwater in the monsoon and people relied on this water for the entire dry season. During the monsoon they stored rain water in small to large pots for drinking and cooking purposes. Cyclone Aila inundated the whole of Chakbara including homesteads, ponds, roads, and shrimp farms for 18 months resulting in serious freshwater water problems in the area. Immediately after the cyclone, government and donors working through NGOs supplied drinking water for every affected household in the village for more than a year starting, from late May 2009 to the onset of monsoon rains in June 2010 with the hope that people would be able to revert to their previous practice of rain water harvesting systems during the monsoon. In 2011 two cyclone affected ponds were re-habilitated to store freshwater. PSFs (pond sand filters) were set by NGOs to ensure a supply of safe drinking water to Chakbara. The PSF is a water purification device and was first demonstrated by DPHE (Department of Public Health Engineering)/ UNICEF in coastal areas in mid 1980s. Since then many coastal communities have used PSF water for drinking and cooking purposes (Ferdoushi & Bolkland, 2000). However, many coastal villages do not have access to PSFs due to inadequate coverage and services provided by DPHE and NGOs.

When I conducted the household survey in mid-2011, 82% of Chakbara households reported that they did not use PSF water as against only 9% in Fultala. In fact, cyclone Aila damaged many drinking water ponds in Chakbara for between 12 and 18 months from the end of May 2009 to early 2011. Moreover, 43% of households in the village reported that they had to drink water directly from open ponds due to the scarcity of safe water. 29% of Chakbara households reported less regular sources of safe drinking water compared with 16% of those in Fultala. This reflects differences between the two villages in levels of soil and water salinity andavailability of drinking water.

Time required to fetch water is also an important factor in vulnerability and survey data shows that on average it took 72 to 75 minutes for a Chakbara households to collect drinking and cooking water compared to 29 to 56 minutes in Fultala (Table 7.3). Part of the reason for this is the settlement pattern in Chakbara, which is lies alongside the river banks and stretches over a kilometer. Many people considered it took too long to collect PSF water and preferred to collect water from nearby ponds without PSF. Many Chakbara households travelled to the SRF for fishing and collection of crabs, nypa plam, honey and other resources and they often drank water from ponds inside the SRF dug by the Forest Department for wildlife. This traditional reliance on pond water may mean that it will take time for the people of Chakbara to drinking safe water from PSF.

In response to a question regarding use of PSF water, some household members stated they did not use the pond water from PSF too often as it was time consuming to pass pond water through the sand filter. One owner of a pond with PSF said people in the area preferred to collect the water quickly from ponds and to drink pond water directly without filtering rather than wait for PSF filtering. During my field visit in 2012, I saw the PSF in one pond was out of order for over a month. Local people were observed collecting pond water directly and said that they did not face much of a problem drinking pond water without filtering.

Due to salt water shrimp farming, soil and water in Chakbara is more saline than in Fultala. As a result, 95.6% of Chakbara households reported they were unable to collect water from their previous sources after cyclone Aila due to saline water inundation while no Fultala households reported so. Fultala villagers had better access to drinking water and cyclone Aila did not pollute their drinking water ponds.

Moreover, many households in Fultala had small homesteads ponds from which they obtained water for various household purposes (washing, cooking and bathing).

Fultala residents were better water managers than those in Chakbara. Villagers reported that whenever their PSFs failed to work, they collectively raised funds and fixed the problem. Fultala is a mainland village close to a growth center and well connected to sub-district towns. Village residents are better educated and seemed more aware of various development issues. The head office of a local NGO called "Leaders" is located there, which gives the villagers greater exposure to development issues and assistance compared to Chakbara which is located on an island setting far from growth centers and the local upazila town. More recently, the people of Chakbara have become more dependent on relief culture especially after the cyclone Aila, making them more dependent on government and NGOs.

Another factor contributing to a greater sense of common purpose in Fultala is that most households are involved in one major occupational activity, namely crop farming, either as small to medium-size farmers or share croppers or farm labourers, which helps create a greater mutual reliance on each other to obtain a living. By contrast, the communities of Chakbara are divided more by occupation with shrimp farmers, fishers who are further divided between sea-going, river and SRF fishing, shrimp PL catchers and crab collectors. While both communities are stratified by income and asset ownership, Chakbara has a higher proportion of poor residents. These differences came to the fore during cyclone Aila when local people failed to act collectively to fix the breached embankment. On the water security issue, the sensitivity of Chakbara households is more than four times higher compared to Fultala households (Table 7.4).

Adaptive capacity to cope with weather induced stressors

Drawing on Hahn's work in Mozambique (2009), I used four sub-components in examining the villages' adaptive capacity to deal with natural and human-induced hazards. The first three taken from Hahn were: socio-demographic issues, livelihood strategies and social networks. The fourth one was access to government's safety net programmes which added to the social network component. The social safety net programmes aimed at supporting the poor to meet crisis consisted of four components: old /aged allowance from the government; VGD (vulnerable group development) support; VGF (vulnerable group feeding) support and 100-days activities (launched by the government in lean periods to create jobs for the poor through cash for work). All these safety net activities are administered at the grass roots level through the UPs and upazila (sub-district) council, with the UPs determining which were given priority. These safety net packages played a role in building the adaptive capacity of poor households to meet family crises by helping them avoid the debt trap, reducing their need to sell off assets or to rent out land when work was scarce. However, while official regulations and guidelines existed to ensure an equitable distribution of assistance, in reality such decisions were often made informally on political grounds and through local social networks, which favoured some households over others and generally favoured better-off households and reduced poor people's adaptive capacity.

I now turn to the outcomes of related indicators on the socio-demographic sub-component of adaptive capacity, an important contributory factor in determining the vulnerability of a system to hazards.

Socio-demographic profile

Under this sub-component, Hahn et al. (2009) considered dependency ratios, percent of female headed households, average age of the head of female headed households and percent of households where the head of household never attended school as indicators of adaptive capacity. These indicators were supplemented by percent of households with members with no functional education, no functional education for female members, households with female children aged 10 to19 and households with members requiring assistance to move or walk. In this sub-component, I used eight indicators to assess the adaptive capacity of the households in two study villages (Table 7.3).

Based on these indicators and aggregated sub-component values, Chakbara was shown to be more vulnerable (0.285) than Fultala (0.227) from a socio-demographic perspective. More specifically, Chakbara had a higher dependency ratio (65.9) than Fultala (47.7) and more female-headed households (13.5 percent) than Fultala (4%). Regarding family educational status, 41% of Chakbara heads of households reported that they had never attended school compared with 17% in Fultala. In the context of education of family members (other than household heads), 76% of households in Chakbara comprised of members with some education compared with 84% in

Fultala. In the case of education of women, 32% of Chakbara households had female members with no education compared to 24% in Fultala. The overall educational status is better in Fultala than Chakbara. While the educational differences are not great, they suggest that Fultala households have a greater capacity to adapt to change than Chakbara, especially when combined with the other indicators.

In the case of the proportion of female children between 10 and 19 years of age, in Chakbara they comprised 25 percent of households compared with 21 percent in Fultala. Although the difference is small, Chakbara appears to be slightly more vulnerable than Fultala in this regard. Households with larger numbers of female children were considered vulnerable in several respects. Female children were more exposed to sexual harassment and thus more likely to stay at home and not be allowed to work outside the home. This meant they did not have to take shelter outside the home during disasters as much as in Chakbara where households were forced to move to embankments and remain there for more than a year in makeshift houses. Female children tend to drop out of school more often in rural areas although it was not possible to determine the female dropout rate for the two villages (BBS, 2010).Children worked on both villages but a much higher proportion of Chakbara children worked in shrimp fry collecting, which was both dangerous and unhealthy.

Considering the overall indexed values of the eight indicators on socio-demographic features, Fultala shows slightly higher adaptive capacity (0.227) than Chakbara (0.285). In the next section, I will discuss “livelihood strategies”, which is one of the three sub-components that determine the adaptive capacity of a system.

Table 7.3: LVI Sub-component values and their indexed values (source: 90 households surveyed in two study villages in 2012)

Contributory Factors by sub-component and indicators	Sub-component values				Indexed values	
	Chakbara	Fultala	Max	Min	Chakbara	Fultala
Socio-demographic profile						
Dependency ratio	65.9	47.7	300	0	0.22	0.16
Percent of female-headed households (HHs)	13.5	4	100	0	0.14	0.04
Average age of female head of HHs	0.022	0.019	0.014	0.04	0.69	0.83
Percent HHs where head of HHs did not attend school	41.0	17.4	100	0	0.41	0.17
Percent HHs have members have no functional education	24	16	100	0	0.24	0.16
Percent HHs have no functional education for female members	31.6	23.7	100	0	0.32	0.24
Percent HHs with female child aged 10-19 years	24.9	20.5	100	0	0.25	0.21
Percent HHs with members who cannot walk without help of others	2	0.87	100	0	0.02	0.01
Livelihood strategies and assets						
Percent HHs with member do not out migrate for work	62.2	46.7	100	0	0.62	0.47
Percent of HHs dependent solely on agriculture as a source of income	1.7	10.1	100	0	0.02	0.10

Contributory Factors by sub-component and indicators	Sub-component values				Indexed values	
	Chakbara	Fultala	Max	Min	Chakbara	Fultala
Average agricultural livelihood diversification index	1.0	0.7	1	0.25	0.96	0.58
Average profession of diversity index	0.4	0.3	1	0.13	0.29	0.20
Percent of HHs have member did not receive any skill training	78.7	78.9	100	0	0.79	0.79
Percent HHs had to loss/ change past occupation due to cyclone Aila	66.7	28.9	100	0	0.67	0.29
Percent HHs who received loan from NGOs last year	54.5	42.9	100	0	0.55	0.43
Percent HHs who received *dadon* last year	45.5	22.7	100	0	0.46	0.23
Percent HHs who do not have homestead land of their own	53.9	16.6	100	0	0.54	0.17
Percent HHs who do not have cultivable land of their own	93.8	36.8	100	0	0.94	0.37
Percent HHs that do not have chicken/ducks	26.7	11.1	100	0	0.27	0.11
Percent HHs that do not have goats	82.2	62.2	100	0	0.82	0.62
Percent HHs that do not have cattle/cow	100.0	55.6	100	0	1.00	0.56
Percent HHs that do not have fish ponds	82.6	34.8	100	0	0.83	0.35
Percent HHs do not have mobile phone	28.9	42.2	100	0	0.29	0.42
Percent HHs do not have Radio and TV	66.6	60.0	100	0	0.67	0.60
Average occupational diversity index	0.54	0.48	1	0.14	0.47	0.40
Social networks and safety net benefits						
Average help receive: provide ratio	1.4	1.3	4	0.33	0.29	0.26
% HHs who did not contact local leaders/UPs/NGOs for help last year	8.9	24.4	100	0	0.09	0.24
Percent HHs who did not receive old/aged allowances	93.3	100	100	0	0.93	1.00
Percent HHs who did not receive VGD allowances	93.3	100	100	0	0.93	1.00
Percent HHs who did not receive VGF allowance	31.1	100	100	0	0.31	1.00
Percent HHs did not work for ‘100days activity’	97.8	97.8	100	0	0.98	0.98
% HHs had problems in farming did not contact anybody for help	30.8	7.1	100	0	0.31	0.07
% farming HHs did not seek assistance from govt. extension agents	84.6	54.8	100	0	0.85	0.55
Health						
Percent HHs with family member suffer from chronic illness	60	55.6	100	0	0.60	0.56
Percent HHs where a family member had to miss school due to illness	8.9	6.7	100	0	0.09	0.07
Percent HHs who do not have water sealed/Ring Slab latrines	46.6	16.6	100	0	0.47	0.17
Percent HHs who do not have latrines of their own	39.3	2.4	100	0	0.39	0.02
% HHs who have members suffered from diseases due to Aila	91.1	82.2	100	0	0.91	0.82
Average distance of getting health facilities at sub-district level	24.1	15.4	30	12	0.67	0.19
Average time to reach health facilities at sub-district level	2.3	0.7	3	0.33	0.73	0.13
Average cost of reaching health facilities	83.3	30.0	300	15	0.24	0.05
Percent HHs did not receive training on primary health care	95.6	97.8	100	0	0.96	0.98
Percent HHs who did not immunize their children	6.7	4.4	100	0	0.07	0.04
Percent HHs who have no member can prepare oral-saline	26.7	35.6	100	0	0.27	0.36
Percent HHs who have member cannot work due to sickness	44.4	46.7	100	0	0.44	0.47
% HHs have members suffered from diarrhea in last one year	36.9	6.4	100	0	0.37	0.06
Food						
% HHs did not have access to food grown on their own land	97.8	11.1	100	0	0.98	0.11
Average number of months HHs struggle to find food	2.5	1.9	7	0	0.35	0.28
Percent HHs that do not save crops	100	95.6	100	0	1.00	0.96
Percent HHs that do not save seeds	97.8	31.1	100	0	0.98	0.31
Percent HHs that faced scarcity of food	97.8	91.1	100	0	0.98	0.91
Percent HHs that could not afford 3 meals during crisis period	62.2	53.3	100	0	0.62	0.53
% HHs could not afford fish in diet for more than 16 days /month	60.0	66.7	100	0	0.60	0.67
% HHs could not afford chicken in diet for more than 6 days/ month	55.6	51.1	100	0	0.56	0.51
% HHs could not afford eggs in diet for more than 10 days/ month	15.6	17.8	100	0	0.16	0.18
% HHs eat eggs that are not produced in their own farms	80.0	37.8	100	0	0.80	0.38
% HHs could not afford milk in diet for more than 5 days a month	91.1	80.0	100	0	0.91	0.80
Water						
Average time taken to collect drinking water	75.4	55.9	180	5	0.40	0.29
Percent HHs do not have access to PSF (pond sand filter - safe water)	82.2	8.9	100	0	0.82	0.09
Percent HHs that drink water from open ponds (- unsafe water)	42.2	0	100	0	0.42	0.00
% HHs that do not have consistent drinking water sources	28.9	15.6	100	0	0.29	0.16
% HHs could not collect drinking water from past sources after Aila	95.6	0	100	0	0.96	0.00

Contributory Factors by sub-component and indicators	Sub-component values				Indexed values	
	Chakbara	Fultala	Max	Min	Chakbara	Fultala
Percent HHs do not have access to safe cooking water	86.7	46.6	100	0	0.87	0.47
Average time taken to collect cooking water	72.8	29.4	180	0	0.40	0.15
Natural disasters and climate variability						
Average number of disaster events in the past 6 years	0.9	0.4	3	0	0.30	0.12
Percent HHs who did not receive early warning signal on cyclone Sidr	2.8	20.6	100	0	0.03	0.21
Percent HHs who did not receive warning messages on cyclone Aila	1.7	42.5	100	0	0.02	0.43
Percent HHs who had to leave their house due to cyclone Aila	88.9	22.2	100	0	0.89	0.22
Percent HHs who had their homes inundated in last cyclone Aila	100	13.3	100	0	1.00	0.13
Percent HHs who had their fish ponds inundated in last cyclone Aila	100	53	100	0	1.00	0.53
Average months homesteads remained inundated by saline water	13	0.72	18	0.03	0.72	0.04
Percent HHs that had lost previous occupation due to cyclone Aila	66.7	28.9	100	0	0.67	0.29
% HHs who could not re-start vegetable farming after 1 year of Aila	82.1	2.6	100	0	0.82	0.03
Average diversity of damaged assets index during cyclone Aila	8.4	1.9	14	0	0.60	0.14
Average diversity of damaged assets index after cyclone Aila	8.2	4.4	14	0	0.59	0.31
Percentage of HHs with disable or died due to Aila	2.2	0	100	0	0.02	0.00
Average diversity of conflict index due to Aila	0.11	0	1	0	0.11	0.00
% HHs who did not store drinking water after getting cyclone signal	51.10	82.2	100	0	0.51	0.82
% HHs have members did not receive training in disaster management	86.70	93.3	100	0	0.87	0.93
Mean standard deviation of monthly average of average maximum daily temperature (years: 1950–2010)	3.19	3.19	5.04	2.38	0.31	0.31
Mean standard deviation of monthly average of average minimum daily temperature (years: 1950–2010)	5.37	5.37	6.12	4.33	0.58	0.58
Mean standard deviation of monthly av. precipitation (years:1950–2010)	4.82	4.82	7.34	0.18	0.65	0.65

Livelihood strategies

With regard to livelihood assets and strategies, twenty relevant indicators were used in the analysis (a detailed description of indicators is presented in Table 7.3 and Table 1 in Appendix 1).Among the twenty indicators, nine relate to livelihood assets such as households possessing land (homesteads and crop land) of their own, and owning chickens, ducks, goats, cattle, fish ponds, cell phones, radio /TV and fishing gears.

Looking first at land holdings, households of Fultala were better off than Chakbara. Only 17% of Fultala households did not have their own land compared with 54% of Chakbara households (Table 7.3). Likewise, fewer Chakbara households (6%) had their own cropland Fultala households (63%). Land ownership is particularly important in determining a household's adaptive capacity in that it is not simply a means to earn a living through farming but also a fungible asset that can be bought, sold and leased, used as collateral, and underpin social status and influence. The fact that more people in Chakbara than Fultala have no homestead and crop land of their own makes them less able to respond to physical and human-induced hazards and shocks. Chakbara's adaptive capacity is also weakened by its poorer performance with regard to ownership of chicken, ducks, goats and cattle (Table 7.3).

Fish ponds are another important asset in the coastal zone as pond aquaculture provides financial and nutritional benefits. In this regard, 83% of Chakbara households reported they do not have fish ponds compared with 35% in Fultala. In the case of fishing gear, Chakbara households have slightly greater access (80%) than Fultala (71%). Chakbara households with fishing gear were more reliant on it as the majority (64%) fish commercially the year round while over 95% of Fultala households said they used their ponds for family consumption rather than as a main source of livelihood. Chakbara are under greater pressure in this regard as there is evidence of overfishing in the SRF area, upon which thousands of landless poor depend.

To a greater extent than pond aquaculture, open capture fisheries respond positively to increased rainfall, flooding, and water flows as they facilitate fish migration and spawning, larval dispersal and enhance habitat quality and quantity. Current projections on climate change suggest there could be benefits for local fishers in the event of increased rainfall. However, such a possibility to result in positive gains for fishers would require effective policy, management and institutional arrangements around capture fisheries, something that has often been lacking in the past. It points to the importance of integrating climate change into improved development planning at all scalar levels.

People's lives have improved through the increasing availability of mobile phones and radio/ TV, especially those living in remote communities. Benefits include better information and awareness of disaster early warning signals and messages. In this regard, some 71% of Chakbara households own cell phones compared with 58% in Fultala. Ownership of radio/ TV does not vary widely between the two villages, although Fultala has relatively better access to such media assets. It should be added that access to mobile phones play a central role in cross-village and town communication and in keeping families in contact with each other in the wider social sense.

Eleven indicators under this sub-component related to "livelihood functions" which in conjunction with "livelihood assets", as discussed above, determine the indexed values for the sub-component of livelihood functions. The relevant key indicators are households with out-migrating income earners, the degree of dependency on agriculture for income, the agricultural livelihood diversity index[24], skills training, occupational changes arising out of physical hazards such as cyclones, and ability to begin vegetable cultivation after a cyclone or other hazard. In the case of the two villages, more Fultala households (53.3%) reported that members of their households migrated out to other areas for work than Chakbara (37.8%). Householders considered that such work was important to sustaining livelihoods when local opportunities were limited. Fultala residents showed a greater capacity to engage in diverse income earning opportunities. During lean periods on the land, people from poor households migrate to other districts to work as brick kiln workers, agricultural labourers, rickshaw pullers, construction workers and the like. However, there is debate about the extent to which out-migration in search of work can be considered a positive adaptive strategy (Barnett and Webber 2010; Farbotko and Lazrus 2012; Kothari 2013; Tacoli 2009). In so far as out-migrants are able to earn a living through diversification of their livelihoods and bring back money and skills to the village, such migration is considered by many local people as of positive value. However, much depends on how long people stay away, how successful they are in obtaining jobs, and the extent to which village duties are ignored in the meantime. Out-migration can contribute to the transmission of HIV-AIDS (Hahn et al., 2009).

While Fultala appears to be less exposed to hazards than Chakbara, a small percentage (10%) of farming households depended on rice farming for a livelihood. Potentially this can increase their vulnerability as rice cultivation is highly susceptible to weather impacts as well as cyclical variations in rainfall and other weather-related parameters. However, the bulk of Fultala rice farmers reported they relied on multiple livelihood options, which can be seen as a means of spreading their risks and so enhancing their resilience, given their more limited land asset base. Besides, medium and large farmers reported to have better financial resource base than small farmers that help them cope with crop failure due to weather perturbations.

[24] Calculated as: 1/(Number of agricultural livelihoods) for each household with an average calculated for each village

Skill training can enhance the capability of households to improve their livelihood outcomes. Both villages are similar in the levels of skills training they have received. Another indicator under this sub-component was consistency in performing the same occupation or an uninterrupted means of livelihood, which can potentially enhance adaptive capacity. Data were collected on how many households were able to continue their previous occupation even after the disruptions caused by cyclone Aila. 67% of Chakbara households had to discontinue their previous livelihood strategies compared with 29% in Fultala. Therefore, in this respect, Fultala households were considered to have a higher adaptive capacity than Chakbara. Part of this higher adaptive capacity arises out of the lower sensitivity of Fultala households to hazards like cyclones and storm surges.

Another means by which households sustain their livelihoods is through official and informal credit systems that operate across Bangladesh. Access to loans is stratified in that the official lending agencies such as banks prefer to lend to asset rich households, which discriminates against the poor and landless. These latter are often forced to rely more on loans from NGOs and through the use of credit advances or *dadon* from local money lenders called *mohajans.* Credit provision is a subject of considerable academic and policy debate as there is a question of whether it simply helps people to survive rather than to improve their economic situation and make them more resilient within the existing political economic framework (Hammill et al., 2008).

There is evidence to support the notion that access to financial capital as and when required in the form of micro-credit often has positive effects on the livelihoods of poor households as it assists families to cope with a crisis and reduced the pressure to sell assets or land. For example, national NGOs such as BRAC, Shushilon, Leaders, Borsha, and Gonomukhi provide loans with a 25-27% service charge (compounded rate), which gives the borrower a flexibility to use the loan in making livelihood decisions, provided that installments are regularly paid back. NGOs also support borrowers through provision of seeds, disaster relief, health, sanitation and family planning services and advice about ways to link to government development projects. However, households that rely on micro-credit or other forms of loan or *dadon* indicate their weak asset base and poor economic condition. Thus villages with more households dependent on loans or *dadons* can be said to have weaker adaptive capacity to deal with weather and non-weather related hazards and shocks.

NGO conditions regarding interest rates and services charges are generally better than those provided by local *mohajons*. The *dadon* system, though useful for poor fishers or other resource users without access to NGO micro-credit or other forms of loans, makes them subject to less flexibility and harsher conditions. Usually, a fisher takes *dadon* twice a month for six months of a year under some terms and conditions that are locally set by the *mohajons.* The conditions include an interest rate calculated at 10% per week (for example, if someone borrows Tk. 5,000 (US $ 64.10), he/she pays Tk. 500 (US $ 6.41) interest per week plus the capital); *dadon* receiving fishers must sell their catch to their respective *mohajons;* and *mohajons* pay less for the fish compared to the prevailing market price. For example, fishers usually receive anywhere from 5 to 15% less than market prices. A fisher who catches 280 kg fish per month and who has a *dadon* loan at 5% interest, loses Tk. 8,400 (US $ 107.69) over a six month period. A final condition is that some *mohajons* collect *tola*or free fish from the catch, which is around 2 kg of fish from a fisher per week. This way, a *dadon*-receiving fisher has to pay around 500% interest per year plus capital as opposed to only 27% interest on NGO micro-credits.

Mohajons often play a wider patronage role than NGOs by assisting borrowers who need quick support to meet health costs, lack of food, marriage of daughters (almost equally for Hindus and Muslims), disaster loss and other social needs. However, this practice widens the scope of the *mohajon's* control over local people, extending into many areas of the borrower's social as well as economic life. Thus, compared with households that are not dependent on such loans, *dadon* receiving households have a weaker adaptive capacity to adapt to shocks over the longer term.

When local respondents were asked to compare NGO loans with "*mohajany dadon"*, they regarded NGO loans as softer in some regards than *dadon* payments but that the rigid weekly installment rules were often difficult to comply with. With *dadon*, payment schedules were somewhat more negotiable and could take the form of payments in kind. However, local respondents considered that they paid back more than with an NGO loan. Fishers found themselves between the devil and the deep blue sea as without loans from which ever source, they were unable to organize a 7-day or 15-day long fishing trip to the SRF and lower estuary. Formal financial institutions such as banks did not provide loans to poor people without collateral, which increased their dependence on *mohajons.* NGOs were less willing to take risks as they were aware that fishing was becoming riskier through fear of theft, deaths from cyclones and other dangers that made it difficult for fishers to pay back regularly if at all.

Summarising the relationship between livelihood strategies and adaptive capacity, it can be concluded that Chakbara households had a lower adaptive capacity (0.569) than those of Fultala (0.393), making them more vulnerable to the impacts of hazards. However, within each village, some households were in a better position than others to deal with any shocks or stresses.

Social network and access to safety nets

Strong social networking and rapport building capacity of households with neighbours and various public and private institutions can potentially increase the adaptive capacity of households to absorb shocks from hazards. Households with strong social networking capacity allows them to get support from friends and families and increases their access to government safety net programmes, which are locally administered by the UPs. The two villages differed in terms of the importance of these social networking capacities. For example, Chakbara households reported receiving more in kind support from friends and family than from other sources compared to Fultala with a receive : provide ratio[25] of 0.29 compared with 0.26 for Fultala. With regard to contacts with local government for assistance, 8.9% and 24.4% of households from Chakbara and Fultala respectively said they had not contacted the UPs in 2010-2011 for assistance. In the case of the extent of receipt of government safety net support programmes such as old age allowances, VGD allowances and VGF allowances, no Fultala households received any benefits in 2010-11 compared with 68% of Chakbara households that had received VGF support from the UP.

[25] Receive: provide ratio is calculated for each household as follows: (number of instances of assistance received +1)/(number of instances of assistance provided +1) with an average ratio is calculated

Interpreting these findings presents certain difficulties due to the nature of the political process in Bangladesh, which often lacks transparency, particularly at the local level. Under a properly functioning governance system, eligible households would normally receive various kinds of support from the UPs. However, in the absence of good governance with a weak and unorganized constituency with poor capacity to claim rights and entitlements, there existed spaces for misappropriation of state benefits by local politicians for their own use or for the political allies of the UP Chairmen and members. At the time of the research in the year following cyclone Aila, some local people suggested that the greater support to Chakbara was a product of local political affiliations and the public visibility of the plight of Chakbara and other villages in Gabura union after cyclone Aila. The area had regular visits by senior government officials, NGOs, donor representatives and media personnel. Under such circumstances local government representatives (the UP Chairman and members) were keen to be seen to provide Chakbara residents with their rights and entitlements. In addition, the sheer magnitude of the disaster made affected people desperate, and they demanded local government assistance. Whatever the precise determinants of the distribution of state benefits were at that time, Chakbara benefitted more than Fultala and government was seen to be responding to local needs in a proper manner. However, the increase in support to Chakbara by the UP immediately after the cyclone does not reflect the situation in normal times. Outside such emergencies, poor people receive little social safety net supports without bribing or being favoured by allies of the UP Chairman and other local members. In other words, official assistance is irregular and provides only short term coping support to Chakbara and other communities. Long-term social and other support, necessary to assist communities to plan longer term remain scarce or non-existent.

Another aspect of the social network sub-component is the extent to which households maintain contacts with local government bodies, field level government agriculture and fisheries extension agents and others in order to lay the groundwork for assistance when needed. It was found that 31% and 8% of rice farmers in Chakbara and Fultala respectively did not regularly use such channels when faced with the need for assistance with their rice crops. When they did seek such help they went to experienced farmers in the village, agriculture extension agents and fertilizer dealers. In order of preference, most farmers contacted the local experienced farmers for advice (54% in Chakbara; 50% in Fultala), followed by government agriculture extension agents (15% in Chakbara; 45% in Fultala) and then to local fertilizer dealers (8% in Chakbara; 26% in Fultala).

Making contacts and seeking assistance, guidance and technical support has the potential to improve local livelihoods, farm production functions and social support networks, which in turn help to increase the capacity to absorb shocks. Often in remote villages, progressive farmers tend to enhance their farm productivity and maintain contacts with the local extension agents and seek assistance to solve problems, enquire about improved seeds, pest management and so forth to improve farm productivity.

In the overall social networks component, the Chakbara communities (aggregated indexed value of 0.587) demonstrated slightly higher adaptive capacity compared to Fultala (indexed value of 0.638). This was mainly due to increased access to safety net benefits by the Chakbara households compared to that of the Fultala households. Villagers making contacts with local government officials for assistance was considered the indicator of social networks and in this sense more households in Chakbara made such contacts than Fultala. However, Chakbara households were less able to access technical support through local social networks connecting them to government services. In contrast, Fultala households used social networks to contact relevant government officials for technical assistance in farming related problems. This suggests that in examining adaptive capacity it is insufficient to use crude measures of social networking such as number of contacts with local government for services. The type and purpose of such contacts need to be taken into account. Thus, it can be argued that the Fultala households were likely to benefit more in the longer term through technical assistance in farming practices than Chakbara households who relied on government services for short term assistance to cope with emergencies.

Overall LVI of the villages

Table 7.4 shows that the overall LVI indexed value of major component for Chakbara is higher (0.528) than that of Fultala (0.356), which indicates that Chakbara has a relatively greater vulnerability to weather and weather-related impacts than Fultala (the higher the LVI indexed value, greater the vulnerability or lower the adaptive capacity). The values for all LVI major components are also presented collectively in a spider diagram (Figure 7.1). The scale of the diagram ranges from a minimum of 0 (which means least vulnerable) to a maximum of 0.8 (which indicates most vulnerable).

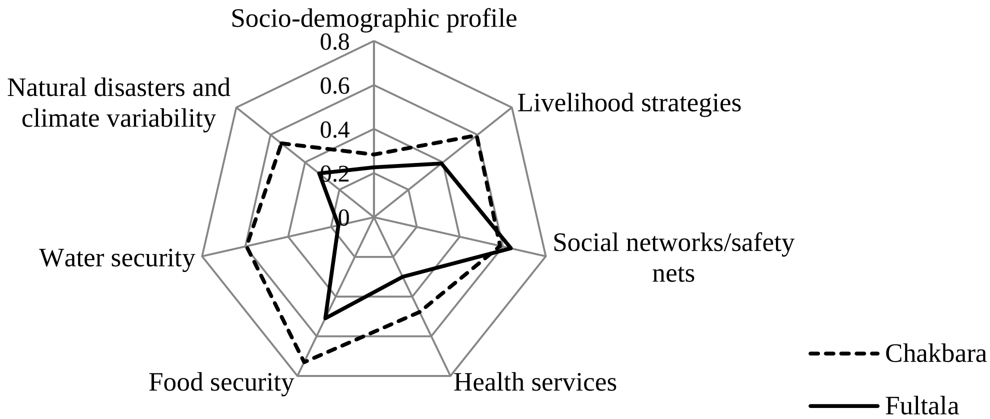
Table 7.4: Indexed major component LVI for Chakbara and Fultala villages (source: 90 households surveyed in 2012)

Major–sub comments	Chakbara	Fultala	Remarks
Socio-demographic profile	0.285	0.227	Adaptive capacity
Livelihood strategies	0.597	0.392	Adaptive capacity
Social networks and access to safety net	0.587	0.638	Adaptive capacity
Food	0.731	0.510	Sensitivity
Health	0.478	0.301	Sensitivity
Water	0.594	0.165	Sensitivity
Natural disaster and climate change impacts	0.538	0.318	Exposure
Overall LVI	**0.544**	**0.365**	

Figure 7.1 shows that both communities were vulnerable to food security issues with Chakbara more vulnerable. Thus, Chakbara households struggled to ensure a regular supply of food for an average of 11.8 months a year compared with 4.2 months for Fultala. Apart from fish, the intake of other protein-rich food such as chicken, eggs and milk were less available in the diets of the households of Chakbara than in Fultala (Table 7.3). The higher fish intake in Chakbara was due to the community's higher involvement in commercial fishing and their greater ease of access to diverse fishing places on rivers, canals, water bodies and SRF close to the village. In Fultala, the nearest fishing grounds had been appropriated for other uses such as rice farming, construction and private leasing to others. This meant Fultala inhabitants were able to fish only seasonally in *beels* and canals for a limited time. However, as Fultala households were generally better off than those in Chakbara, there is some evidence to suggest they were able to purchase fish more often than Chakbara.

With regard to water security, Chakbara was nearly four times more sensitive to weather/ climate induced impacts compared with Fultala, due largely to the absence of fresh water for drinking. In the case of access to health care, distance, cost and time to reach health facilities were a greater problem for Chakbara than Fultala. With regard to livelihood strategy, Fultala households had more land and livestock ownership than Chakbara. Both villages were found to be almost equally vulnerable on the issue of social networks and access to safety net programmes of the government. Chakbara had a slightly stronger position than that of Fultala largely due to its access to national safety net programmes, which were facilitated through the UP Chairman and members who were heavily involved in the response, recovery and rehabilitation activities after cyclone Aila. There was also a greater presence of various NGOs, government agencies and media in helping the cyclone affected families. Moreover, the central government instructed local government and other agencies to assist the affected people who had taken shelter on embankments for 12-18 months, which put pressure on them to perform more efficiently. However, under

Figure 7.1: Spider diagram of the major components of the Livelihood Vulnerability Index (LVI) for Chakbara and Fultala (the higher the LVI indexed value, greater the vulnerability or lower the adaptive capacity)



normal conditions without official monitoring, it is not certain that those in most need would havereceived such benefits.

Fultala households accessed social safety net programmes less often than Chakbara. There were two main reasons for this. Fultala demands for such assistance were lower than Chakbara’s and those households who did not receive support complained that they were discriminated against by UP members, that local leaders were unhelpful and that without offering bribes, support was not forthcoming. Besides, 12% of the eligible households of Fultala and 4% of Chakbara said they were not aware of such safety net programmes.

Comparing the overall LVI-IPCC index values for Chakbara and Fultala on three contributory factors of vulnerability, namely, exposure, sensitivity and adaptive capacity, out of seven sub-components of vulnerability, Fultala showed lesser vulnerability on six sub-components while Chakbara showed lesser vulnerability (or stronger adaptive capacity) in social networks and access to safety programmes. Combining the sub-component values into three contributory factors of vulnerability, Fultala was less vulnerable (LVI – IPCC= - 0.075) to weather induced stressors due to its lower exposure and lesser sensitivity to disaster and its higher adaptive capacity to cope with such stressors and extremes than Chakbara (Table 7.5 and Figure 7.2).

Table 7.5: LVI-IPCC contributing factors calculation for study villages **(IPCC, 2001)**

IPCC contributing factors to vulnerability	Chakbara	Fultala
Exposure	0.538	0.318
Adaptive Capacity	0.423	0.532
Sensitivity	0.598	0.350
LVI-IPCC	**0.069**	**-0.075**

Index values should be interpreted as relative values to be compared within the study sample only. The LVI-IPCC is on a scale from -1 (least vulnerable) to 1 (most vulnerable), Hahn et al. (2009).

Summary

The findings of the livelihood vulnerability index show that Chakbara had higher exposure and sensitivity and lower adaptive capacity to face disasters, making it more vulnerable than Fultala. This comparative assessment of vulnerability of communities in two project villages in the southwestern coastal zone of Bangladesh is particularly important as it demonstrates how communities located close to each other may nevertheless vary in their vulnerability and capacity to respond to hazards, which is likely to include climate change. The findings also provide a basis for the discussion in the next chapter on the two communities' efforts to deal with current and future weather and non-weather related threats.

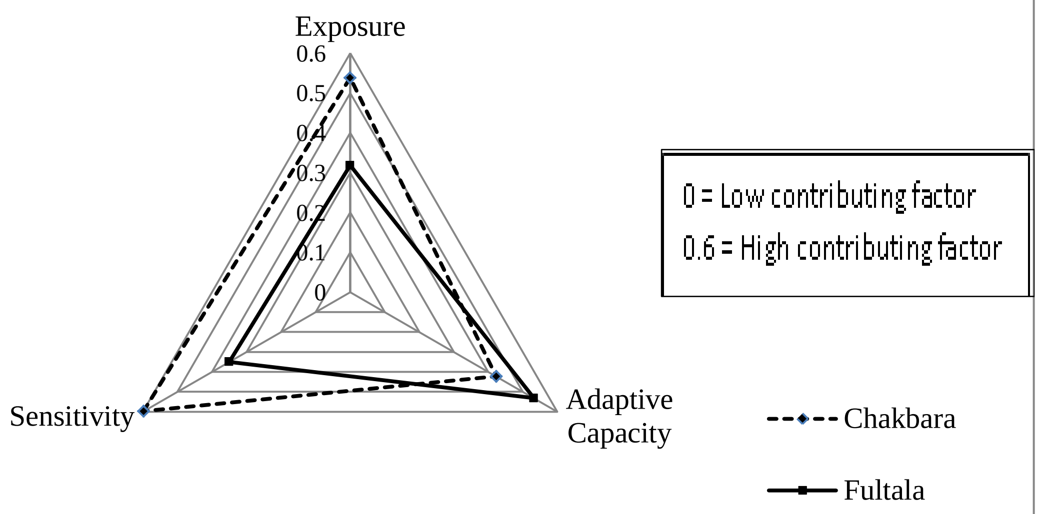


Figure 7.2: Vulnerability triangle diagram of the contributing factors of the Livelihood Vulnerability Index-IPCC (LVI-IPCC) for Chakbara and Fultala

Chapter 8:
Adapting to Weather-induced Local Environmental Changes

Introduction

This chapter has several objectives. First, it examines the initiatives taken by the inhabitants of Chakbara and Fultala villages (including case studies in two adjacent villages) to adjust to local environmental changes due to weather-related causes. It discusses the efforts made by the local communities, both with and without outside assistance, to adjust to local changes in fishing, aquaculture, water services, agriculture and coastal erosion connected with changing weather patterns. Second, it examines local government annual development schemes for the financial year - 2010-2011 and discusses their relevance to weather and weather-related hazards within the wider context of climate change concerns. Third, it analyses the activities of mainstreaming fisheries and agriculture extension agencies in the two unions over the past five years to determine to what extent there is any link between the government's development efforts and climate change adaptation initiatives. Fourth, an analysis is provided of several local adaptation initiativestaken in the villages. This analysis draws on the frameworks of community-based adaptation (CBA) and ecosystem based adaptation (EbA) and seeks to incorporate the 'resilience to transformation'adaptation framework developed by Pelling (2011) and the' incremental to transformative' framework developed by Kates et al. (2012). Relevant data were collected through FGD, KII and KAP survey with local communities, local government representatives, NGO staff and local public agency officials.

Community efforts to adapt to weather-related threats

Traditionally, the people of the two villages have considered cyclones, storm surges, salinity and coastal flooding as natural occurrences governed by super-natural forces. They have responded to such occurrences using a range of measures designed to deal with particular events such as a cyclone and their longer term consequences. What is meant here is that local people have operated within a cognitive framework of certain uncertainties so that they know with variable degrees of certainty from year to year when cyclones or flooding will occur, and develop measures to deal with them. Not only did they respond to such events, in the past they learned from them, which allowed them to improve their responses over time. In other words, adaptation was built into their collective habitus. It should also be noted that their capacity to deal with naturally occurring events and changes was mediated by the nature of the society and culture in which they lived, which shaped how, when and why they acted in the ways they did. . However, it is argued that climate change presents such communities with new and complex adaptation challenges, which go beyond what they have previously experienced.

In previous chapters it was shown that in recent years local people in the two study villages have noticed changes in weather patterns, with uncertainties about what these changes mean and how they should be responded to them. People have begun to take their own actions, sometimes assisted by government agencies and NGOs, to adjust to these changes in weather. Table 8.1 summarises ten community level adaptation actions taken in response to what people regard as the main weather-related stressors affecting them. It can be seen from table 8.1 that the weather-induced changes to which they responded were not entirely new. Rather, they were an intensification of previously experienced weather patterns combined with greater irregularity in their occurrence. One consequence of this was that villagers often drew upon traditional coping strategies rather than making innovative changes.

Household water security: Renovation of cyclone affected ponds

As a result of cyclone Aila, all Chakbara ponds were inundated with saline water and became unfit for household purposes or for fish/shrimp farming. The western part of Fultala was also inundated and affected 85 households. I collected data from households in two study villages and cross checked the data with concerned NGOs and neighbouring households. The response of 31 Chakbara households was to renovate their ponds, relying largely on their own resources without any financial support from outside. The exception was one household, which received BDT 6,250 (US $ 80.13) from an NGO named NG Foundation. The main method used was to make the ponds over three feet deeper by removing bottom soil and to raise pond dykes by 2 feet at an average cost of BDT 7,676 (US $ 98.41) per pond. One *khas* pond was renovated exclusively for drinking water in Chakbara with support from a large national NGO (BRAC) at a cost of BDT 60,000 (US $ 769.23).

I collected data from two study villagers regarding various adaptation measures they had undertaken in response cyclones and salinity issues. In Fultala, 54 households renovated their ponds after the cyclone. Some re-excavated pond bottoms by deepening ponds by 0.61-2.13m (average 1.07m) while some dewatered the ponds and sun dried them to free them from contamination with cyclone-borne saline water. They also raised pond dykes by an average of 0.46m. Out of the 53 households who renovated, 21 received financial support of from BDT 18,000 (US $ 230.78) to BDT 41,000 (US $ 525.64), depending on the size of ponds, from two NGOs, BRAC-20 and Leaders-1. BRAC, in its disaster rehabilitation package, included the cost of fish fingerlings and fish feed to re-start aquaculture operations as part of the cyclone recovery programme. The 32 households that did not receive such assistance spent an average of BDT 7,658 (US $ 98.18) from their own resources to renovate the affected ponds. Altogether of the 85 households with contaminated ponds, 53 (62%) were renovated/re-excavated and 32 were unable to renovate. The main cause of the contamination was cyclone borne saline water runoff and debris, which affected freshwater supplies, cooking and other household uses, including fish culture.

Adjustment to *gher* inundation resulting from cyclones and coastal flooding

From 2007 to 2012, shrimp farmers were affected by coastal flooding and inundation caused by cyclones, storm surges and intense heavy rainfall. FGD with Chakbara shrimp farmers revealed that in 2011 almost every shrimp farmer had to repair their *gher* dykes at their own cost. The farmers called for a raising of the protective embankment around the whole union as they argued that simply raising dykes would be ineffective in the face of another intense cyclone. Such a task was beyond them and they expected government assistance to accomplish this task. This illustrates that farmers were thinking ahead, rather than simply responding to a single cyclone, a combination of autonomous and proto-planned adaptation.

Table 8.1: Community level adaptation actions reviewed in this research

Adaptation actions	**Observed weather induced impacts**	**Adaptation type**	**Comprehensiveness**	**Remarks**
1.Renovation of ponds for freshwater and aquaculture	Ponds were contaminated with (unsuitable for use) cyclone borne-saline water and organic run-off	Reactive, mostly autonomous, somewhat planned (cyclone recovery)	Short term, weather vulnerability not assessed	With and without external support, unlikely to be sustained in next cyclone
2.De-contamination of *gher* bottom and dyke raising	Cyclone induced saline water polluted *ghers* and dykes collapsed	Reactive, autonomous, somewhat planned	Short term, weather vulnerability not assessed	Without support, unlikely to sustain in next cyclone
3. Making houses on raised plinths	Flooding of houses	Reactive, autonomous, somewhat planned	Short term, partially vulnerability assessed[26]	With and without support, somewhat sustainable
4.Salinity monitoring, cooling *gher* water by keeping aquatic weeds, deepening of *ghers*	Prolonged droughts plus high temperature increases salinity and killing of fish and shrimp	Reactive, autonomous, somewhat planned	Short term, local knowledge-based, partially vulnerability assessed	Without external support, unsustainable in further weather stresses
5.Changes of fishing locations from north to south	Degradation of fishing grounds due to cyclone borne sand depositions	Reactive and autonomous, somewhat planned	Short term, local knowledge-based, sharing with peers, vulnerability not assessed,	Without external support unsustainable
6.Changes of fishing gear and locations to avoid tiger attacks	Killing of prey animals due to cyclones	Reactive and autonomous, somewhat planned	Short term, local knowledge-based, sharing with peers	Without external support, unsustainable
7. Abandoning fishing trips	Adjustment to frequent rough sea conditions threaten fishers' lives	Reactive and autonomous, somewhat planned	Short term, local knowledge, vulnerability not assessed,	Without external support, unsustainable
8. Mangrove based erosion protection	Strong waves at high tides and erosion of dykes and settlements	Reactive, mostly planned	Short term, partially vulnerability assessed	Partialofficialsupport, somewhat sustainable
9. Canal rehabilitation	Dry season freshwater scarcity and loss of fisheries and agriculture	Reactive, mostly planned	Short term, partially vulnerability assessed	With partial support, somewhat sustainable
10. Adaptive agriculture,	Higher soil and water salinity	Reactive, planned, and autonomous	Medium term, involved govt. officials, weather vulnerability assessed	With partialcost sharing, somewhat sustainable

[26]Communities did not do complete vulnerability assessment against the hazard rather took adaptive measures against impacts they experienced

While shrimp farmers called for raised embankments, non-shrimp farmers were wary of them as they were known for making illegal private sluice gates and pipe culverts in the embankment to facilitate water exchange. Such unauthorized structures weakened the dykes and contributed to embankment failure and consequent inundation. The situation was expressed metaphorically by a cyclone affected poor fisher of Chakbara as:

> The embankments are our lungs, strong and good ones can save us from cyclones and storm surges then we can have safe breaths but if the lungs are perforated we cannot breathe and thus we die. Here the dykes become perforated due to putting hundreds of pipe culverts by the shrimp farmers and weakened the dykes and so it gets easily breached with surge water and inundates us.

Thus, what at first glance appears as an adaptation strategy that benefits both shrimp farmers and others can be maladaptive for some, such as fishers, whose spatial and social positioning in society puts them at risk of flooding as a result of culvert construction. It also suggests that hard engineering solutions to cyclones and flooding are insufficient to protect some community members.

Adjustment to coastal flooding: Houses on raised plinths

After the cyclone, most households, particularly in Chakbara, had to rebuild their homes. The majority received monetary support from the government and donors through NGOs and UPs. Houses were built on raised plinths with the hope that they would avoid severe inundation (Figure 8.1).

As per my survey data, a total of 83 households in Chakbara rebuilt their houses on raised plinths with plinth heights ranging from 0.69 to 1.83 meter depending on the land elevation, previous inundation depth and financial capacity of the households. NGO and Government financial support covered some but not all the costs of building. Government support was BDT 21,325 (US $ 273.4) per house. NGOs gave different amounts: Progoti provided BDT 32,000 (US $ 410.26), Islamic Relief, BDT 60,000 (US $ 769.23), and Caritas, BDT 110,000 (US $ 1,410.26). No households in Fultala received housing support as they were considered to have been less affected by the cyclone Aila. However, six households in Fultala raised their house plinths by 0.3-0.91musing their own resources.

Adjustment to drought-salinity related mortality of white fish/shrimps in *ghers*

In addition to flooding of shrimp *ghers*, farmers were increasingly faced with high temperatures, drought and high salinity during summer months (March to May). Shrimp farmers explained that traditionally they prepared their *ghers*, organized supplies of shrimp PL, and took disease control and water management measures. Prior to 2005, they did not include drought management in their planning. However, in 2005 there was a prolonged drought, which led to increased salinity of *gher* water, causing around 25% mortality of white fish and even some *bagda* shrimps (which are saline tolerant). Higher mortality was recorded in *ghers* with a water depth of 0.91m or less.

Figure 8.1: A woman making house on raised plinth to protect from flooding

At the time of the field work, shrimp farmers monitored drought regularly and during the drought period they maintained water depths in *ghers* at above 0.91 m . In the past, some local shrimp farmers kept weeds in the *ghers* to provide shelter for the shrimp during drought. After the rise in mortality in 2005, all the farmers began to keep some aquatic weeds in their *ghers* to keep the water cool. Some farmers reported that they had to travel 8 km to Patakhali village to collect such weeds. Now most shrimp farmers, particularly those with shallow *ghers*, monitored salinity of *ghers* regularly, especially in summer months. They measured water salinity manually by observing whether the *gher* water became '*garo'* (more salt concentrated than normal). When the water was '*garo*', they quickly exchanged *gher* water with river or pond water to normalize the water salinity and reduce mortality.

Besides the excavation of *ghers* as mentioned above, to remove organic pollutants carried in due to cyclone induced inundation, Fultala farmers excavated *ghers* to increase the water depths and to save fish and shrimp from drought and higher salinity. Shrimp *gher* depths in Fultala were on average 0.91meter compared with an average *gher* depth of 1.22 meter in the area. As a result of what they perceived of as a rise on water temperature in the summer months, most *gher* owners in Fultala had increased the depth of water by deepening the peripheral trenches of the *ghers* through excavation.

Adjustment to fish habitat degradation due to cyclones

After the two cyclones, fishers noticed that there were fewer fish in their former fishing grounds located in the upper reaches of the SRF. Elderly fishers reported that some of the lucrative fishing grounds had been silted up from sand and silt deposits on the river beds, which degraded the quality of fish habitats, particularly the deeper areas of rivers where fishers said there was more natural food for fish, which attracted more varieties of fish. The response of many fishers was to spend longer periods in search of new fishing grounds closer to the Bay of Bengal in such places as Behala, Koila, Raimongal, Mete, Ashashuni, Jalghata, and Mandarbaria.

In summary, the siltation of upstream fishing locations, decreased fish availability in general and the non availability of high valued species upstream, and increased tiger attacks led fishers to change their fishing locations. Thus, fishers were responding to both the direct and indirect effects of the cyclones.

Adjustment to increased tiger attacks after the recent cyclones

A second weather-related change was an increase in tiger attacks on local villages. Fishers explained that the attacks were due to the death of large numbers of non-human prey animals such as deer and boars from the cyclones and the associated flooding. Fishers and other community members provided three specific reasons why tiger attacks had increased. First, the tiger population had become concentrated in the upper part of the SRF as the lower or southern part was heavily damaged by the cyclones and the tigers were forced to shift to the north of the SRF in search of safety and prey. Second, the high mortality of deer, boar and other non-human prey animals pushed them to seek food outside the SRF in villages adjacent to the forest as well as among fishers who regularly fished along the creeks and streams of the SRF. Thirdly, the damage to shrimp *ghers* and rice crops led some local people to seek food and other resources in the SRF where they were more exposed to tiger attacks. No official assistance was provided to the local communities so they developed their own strategies of survival.

Over 60 percent of fishers changed the kind of fishing gear they used from *char pata* and *khal pata jals* (small bag nets fixed along the islandor river banks and in canals inside the SRF) to cast nets and lines. The use of *char pata* and *khal pata jals* required fishers to enter the water to fix the nets and collect fish, which exposed them to tiger attacks.Using cast nets and lines, they could stay on their boats, which lessened the physical risk. The 40 percent of fishers who did not switch to new types of nets changed their fishing locations instead, moving downstream where reported tiger attacks were lower. Some fishers changed both fishing gear and location.

However, this raised the operational cost of fishing as they were forced to spend more time and money in rougher weather conditions to catch fish. They received advice from other fishers from neighbouring villages on new fishing locations.

Fishers' adaptation response to rough sea conditions

Local fishers reported they were much more aware of the effects of cyclones on them particularly when fishing. Ifthey observed high winds and clouds in the sky (signal 3 conditions: cyclone alert), they took shelter inside the SRF while in the past they tended to ignore cyclone warning signals 7 or 8 (severe cyclone warning) as they did not fully understand their significance.The two cyclones had led them to take warnings more seriously. Although mandatory for estuary fishers to carry radios with them, those who fished inside the SRF said they did not take them as they feared being robbed by waterbandits. Instead they relied on observing the sky and clouds and feeling wind speed as measures of whether they fish or not, take shelter in the SRF or return home.

The fishers had observed increased frequency of rough sea conditions (signal 3) in recent times; sometimes two to three times in some months compared with one or no signal a month in the past. If a signal 3 was indicated, many did not go out fishing. Those already at their fishing grounds either came ashore or took shelter in the SRF. During rough sea conditions, tidal water currents increased in the rivers and often netswere damaged. Also, they observed that during storms tree trunks, branches, leaves and other materials flew at great velocity and damaged nets.

The problem with not fishing when the weather was bad was that although it helped save lives, it meant they had to take more loans to survive, which reduced their longer term resilience. Costs could be very high. First, they had to use the money they borrowed from the *mohajans* to meet the cost of fishing operations on family expenses (food and other essentials). Second, they were forced to borrow money from the *mohajans* for future family expenses and for the next fishing trip. Thus, they faced the double burden of income loss and increased debt.

Adjustment to coastal erosion through restoration of mangroves

I conducted a case study on mangrove based adaptation activity undertaken by the community of Shora village (near to Fultala village), Ramjannagar UP of Shyamnagar upazila to protect embankments and settlements from tidal waves. The activity was supported by the national NGO Caritas Bangladesh. Communities planted mangroves species along a 1.5 km long embankment (over 24.28ha of land) which created a small green belt that protected the embankment from water intrusion and created a mangrove-based micro ecosystem in the area (Figure 8.2). The FD supplied quality mangrove saplings and provided technical advice to communities on mangrove management. FD also signed an agreement with a 7-member village forest management committee (formed by Caritas) aimed to protect settlements from tidal surges, to motivate local communities to planting mangroves, to engage in biodiversity conservation and thereby

Figure 8.2: Mangroves planted to along embankment to protect land from tidal erosion

reduce risks related to weather induced hazards such as cyclones, tidal surges and erosion.

The FD suggested that the communities plant both mangrove *(Bain, Keora, Goran, Gewa, Kakra)* and non-mangrove (*Epil Epil*, *Babla*, *Akashmoni*, *Neem*) species to manage salinity and tidal inundation.The initiative was small and cost only some BDT 78,000 (US $ 1,000). Local people were also able to obtain fuel, fish, crabs and to harvest Keora seeds for making pickle for sale and domestic consumption.

This adaptation scheme improved ecosystem functions and offered ecosystems services of various kinds. These included provisioning services such as food, fuel, fodder, timber, etc (as provisioning services); regulatory services such as water flow regulation, erosion control, disaster risk reduction, and carbon sinks; and services such as soil formation, photosynthesis, nutrient cycling, natural habitats (for fish, shrimps, crabs) as supporting services. The input of the FD was important as it provided the technical support in species selection and management of mangroves.

Adjustment to scarcity of freshwater through rehabilitation of canal

I conducted another case study on community adaptation to the scarcity of freshwater in dry season for agriculture and fisheries, which was facilitated by Caritas Bangladesh in Jelekhali village (adjacent to Fultala village). In the past a more than 5km long canal had retained rain water in the area, which was the source of freshwater for irrigation and capture fisheries (Figure 8.3). The canal was under a common pool resource regime and thus the local people of Jelekhali used the water for crop irrigation and fishing. However, as a result of siltation and gradual encroachment on the canal, it had become almost dry. Some locally powerful people began shrimp farming in some deeper pockets of the canal by fencing them off. The canal lost its wetland characteristics as well as its common pool features, which resulted in the exclusion of poor from the benefits of the canal.

Figure 8.3: A canal is rehabilitated to store rainwater for irrigation and fisheries.

Caritas along with UP chairmen and members organized local communities and ehabilitated the canal so that there was a greater availability of freshwater for irrigation, fisheries and aquaculture, which improved livelihoods and helped build the adaptive capacity of the poor and marginalized communities in the village. Such wetland rehabilitation can be considered as a ‘no regrets’ adaptation as the restored ecosystems served the environment and local communities irrespective of changing weather patterns.

With the active engagement of local communities, local government and local administrators, Caritas facilitated the rehabilitation of the canal by repossessing the canal and removing the illegal encroachers (elite capture). Local farmers were able to double crop rather than rely on a single amon rice crop in the monsoon as the greater availability of water created the opportunity to grow an extra crop in winter. Besides, water logging due to drainage congestion in the area was reduced after re-excavation, which allowed the draining off of excess rainwater from the canal.

A seven member canal management committee formed under the project managed the scheme on behalf of local people. Some people started duck rearing in the canal, as it retained water the year round. Rice cultivation ensured the availability of hay (as fodder) that encouraged people to keep cattle. Integrated rice and fish (mostly *golda* prawn) farming added an extra income to many households living along the canal. At a cost of BDT 620,596 (US$ 7,956.36), the rehabilitated canal was considered a success for the wider social-ecological benefits it provided.

Adaptive agriculture - an NGO-farmer effort to create a climate resilient farming system

After cyclone Aila, hundreds of households were supported by government and international donors through NGOs with seeds to grow rice and vegetables to assist in the recovery efforts. Rice seeds were given indiscriminately without reference to whether those receiving had any land or whether the land was under shrimp *gher* or rice farming. The support was given mainly to the micro-credit borrowers of NGOs, many of whom either sold the rice seeds or ate them as puffed rice either because they had no land or thought it a waste of time to plant because of high salinity. Some farmers tried to cultivate the land but yields were poor due to high salinity and poor technology adopted in cultivation.

A national NGO named CNRS worked with local farmers in Fultala on agriculture based adaptation activities through a UNDP-GEF small grants programme titled community based adaptation (CBA) to climate change. The project began in August 2011 immediately after two weeks of intense heavy rains in early August which damaged 100% of amon rice seedlings and farmers had no choice but to re-seed. CNRS brought in a late variety of amon seeds and seedlings from the BRRI (Bangladesh Rice Research Institute) and demonstrated them to farmers. Different technologies of sowing were demonstrated, which were the direct transplanting of seedlings (normal practice) and direct sowing of seeds in the crop fields (to cover the delay). Production using both methods was above average and the rice was harvested earlier than other varieties in the area.

Several lessons were learned by the demonstration. First, it showed that when there were heavy rains in the late monsoon, damage to the amon seedbed or newly transplanted seedlings could be reduced through using late varieties of amon and direct sowing. Second, prior to the demonstration, farmers in the area were not aware of the late varieties of amon rice, which indicated a failure of the agriculture extension services and poor dissemination of the outcomes of the BRRI to farmers. Third, farmers continued to use the old farming techniques, which gave them low yields whereas with technological improvements their yields could be easily increased by 15-20%. Fourth, farmers were keen to adopt the technology and learn more about improved and stress tolerant rice varieties and how they could access them. Farmers interests was reflected when some local farmers exchanged the rice with the demonstration farmers at 6kg: 5kg ratio (interested farmers gave 6kg rice to demo farmers and in exchange received 5 kg rice of late varieties of rice), which they intended to preserve as seed for the next year. They considered that the new variety (locally not available) was better adapted to flooding even when sown late in the season. The example indicates that local farmers sought new and improved varieties of seeds to adapt to changing or irregular weather, which was a positive sign in that it promoted agriculture based adaptation in saline and flood prone areas. This example of farmer interest in innovation parallels the UK’s Overseas Development Institute’s framework for building adaptive capacity (ODI, 2010).

In the following year, CNRS moved to the high salinity prone Chakbara village of Gabura UP (one of my study villages) where winter rice farming had not been practiced for the last 25 years due to high salinity resulting from shrimp farming. CNRS selected three interested farmers with access to sources of freshwater in ponds adjacent to crop fields. CNRS assisted farmers in the use of a saline tolerant variety of boro (winter) rice (BRRI dhan 47) in December 2011 (Figure 8.4). CNRS made a digital salinity meter available at the field level and taught farmers how to monitor the water salinity. It also provided quality seeds, a salinity moitoring device, and technical support on improved rice cultivation methods such as advice on fertilizing, weeding and pest management, watering and salinity management. The farmers were also provided with hands-on training on how to germinate the seeds, prepare the seedbeds, look after them and transplant seedlings in a way which maintained required spaces between the rice plants, including use of granular urea (a nitrogenous fertilizer). After transplantation, CNRS's field agronomist paid weekly visits and monitored salinity, pest infestation and growth and colour of rice plants and suggested actions to deal with any problems. Farmers were advised to drain water from fields when salinity was high and to re-water with pond water, which was generally less saline than water in the crop fields.

The CNRS assisted farmers to identify pests and appropriate pesticide use. In this way the whole four month crop cycle was monitored and when harvesting took place in early April 2012, yields were 6.5 tonnes/ha which was above the national average of 6 tonnes. This demonstration of winter rice created much enthusiasm among the people of Chakbara and adjacent villagesas they began to believe that it was possible to grow winter rice in saline prone areas through the adoption of new varieties and techniques which they had not had in the past. After harvesting in April, some farmers planned for a second crop of summer rice (or aus variety) in April to June prior to the next amon rice (monsoon variety) season in July/August. CNRS supported six farmers to test summer rice as a second crop. However, pre-monsoon drought in that year (2012) led to all the rice being burned and damaged except for the field of one farmer who was able to get a good yield as his pond was deep enough to hold water for the entire dry season. CNRS organized a farmer's field day where people from other villages and the upazila and district level government agriculture officials were present. Crop cutting was done by the agriculture officials and they declared that the production of boro rice in this saline prone village was higher than the national average. Members of the community asked the government officials to take back control of the state owned (*khas*) canals in the village that had been leased out or illegally appropriated by others. They wanted the canals to be re-excavated to increase storage capacity of monsoon rain water so that more farmers could cultivate rice over two seasons or even three crops – boro rice in winter (January to March /early-April) followed by Aus rice (April to June/July) and then amon rice (August-November / December). By end of 2013, CNRS had approached IUCN-Bangladesh, which provided a grant to a farmers' association to rehabilitate a canal in Dumuria village where farmers of Chakbara and Dumuria could cultivate rice crops. CNRS also increased its support to over twelve farmers in Chakbara to cultivate high yielding amon rice in the 2012 monsoon season.

Figure 8.4: Boro rice cultivation in shrimp *gher* in Chakbara village.

Some people attended the field day program at Chakbara from Patakhali village in the adjacent union of Paddaypukur and approached CNRS for agricultural support. Following field visits by CNRS staff it was learned that the proposed land for rice farming were actually shrimp *ghers* but had been abandoned and remained fallow since 2009 as a result of higher siltation. Continuous siltation over several years had led to the *gher* area land being raised to a level that made it impossible to get water from river by gravitational force. On the other hand, the soil salinity of the land was too high to support rice farming. Seeing the success in rice production in Chakbara, a high saline village, farmers of Patakhali thus approached CNRS for assistance.

CNRS assisted 13 farmers of Patakhali, which was remote and required land and water transport to reach it. The village was dominated by shrimp farming and there were no cows or power-tillers used in rice farming. In order to rice farm, the farmers themselves tilled the land with shovels and transplanted four different amon rice varieties along with one local variety in 2012 under the guidance of CNRS and upazila agriculture officials who were requested by CNRS to assist the affected shrimp farmers to cultivate rice in their abandoned *ghers*. At first, rice grew better than expected but was then hit by a pest infestation, which disheartened the farmers. Repeated application of recommended pesticides did not work and upon inspection it was found that the local pesticide dealer had provided the wrong brand and sought to convince the illiterate farmers that the one he sold them was also for the same purpose. With the advice of upazila agriculture officials, farmers bought the correct pesticides from the regional town (the CNRS field agronomist accompanied them) and after being applied good rice yields were obtained for the first time since shrimp farming began some 25 years before.

During harvesting a mass gathering was organized in late November 2012 to ceremonially open the harvesting of rice and was attended by the district and upazila level agriculture officials along with communities from several villages, including the local government representatives (UP Chairman and members).

What this example showed was that land previously devoted to shrimp farming could be returned to rice cultivation. While farmers had either forgotten or did not know how to use the rice cultivation technology, with official and NGO support they were able to re-learn old techniques. Reforms were needed in the pesticide supply chain and with the assistance of the government’s Department of Agriculture Extension (DAE), farmers were able to obtain the appropriate pesticides, which reduced both financial and environmental costs. A problem faced by rice farmers was the absence of draft animals and power-tillers, which at the time of the field work was a concern.

In response to these issues, the NGO formed two agriculture farmers' associations, one in Patakhali and one in Chakbara-Dumuria villages as the farmers of these two villages shared the same crop fields. CNRS provided one power tiller to the Pathakhali farmers in late 2012 so that they could start winter rice cultivation and one low lift pump to Chakbara to irrigate the crop fields as and when required. The upazila agriculture office of the DAE also provided one good quality low lift pump to the Chakbara-Dumuria farmers' association for a nominal rent. CNRS set in train a series of actions to return *khas* land to rice farming through contacting the district administration responsible for approving the leasing of canals. One of the district magistrates visited the village and met with rice farmers and assured them of his assistance to free the canals from leasing. The participating farmers based on their two years experience in rice cultivation in different adverse conditions in three unions of Shyamnagar upazila raised several issues that affected their farming systems and asked the DAE officials, district administration (the Magistrate who paid a visit to see rice farming in shrimp *gher* areas) and NGOs to take action to resolve the issues to improve and sustain rice farming in the area.

Farmers' 8-point concerns for adaptive agriculture in the coastal zone

The local farmers who participated in the rice farming demonstration expressed both their satisfaction and continuing concerns with the previous two years (2011-2012) experience.In particular, in FGD, the farmers expressed their concerns about eight specific issues, which they felt needed urgent attention to facilitate adaptive farming in the weather stressed coastal zone. These issues included water management, erratic weather factors, enabling markets, pest management, technical backstopping, farm management, land and water use conflicts and quality seeds and inputs (Figure 8.5).

Water availability issue

A major problem identified was the high soil and water salinity along the coast, which affected rice farming. Dependence on the availability of freshwater, particularly for winter (rabi crops) and summer crops (kharip-1) had increased because of erratic rainfall with intermittent droughts. Amon rice, though a monsoon rain-fed variety, required some irrigation to cope with droughts during the early-monsoon and monsoon, which was reported as becoming more common. However, the two main sources of common irrigation water, canals and road side borrow pits, had been taken given over to other uses. Farmers raised the issue that unless sources of freshwater were made available, any efforts to adapt agriculture to changing weather conditions would likely be limited to short term coping strategies. Put another way, extra water and fairer access to it were required to make the farming system more resilient in the sense of returning it to a time when more water was available. As it was, the farmers feared a steady decline in their ability to farm even for basic survival under current conditions.

Addressing issues of uncertain weather patterns

Farmers identified several weather-related factors that affected their capacity to ensure sustainable livelihoods. They sought, with DAE and NGO assistance, to address questions of water availability for irrigation, stress tolerant seed varieties able to survive in saline soil and flooding, and drought conditions. They also said that cyclones and storm surges and tidal inundation were regular occurrences, which affected coastal agriculture and they needed outside assistance to deal with them.

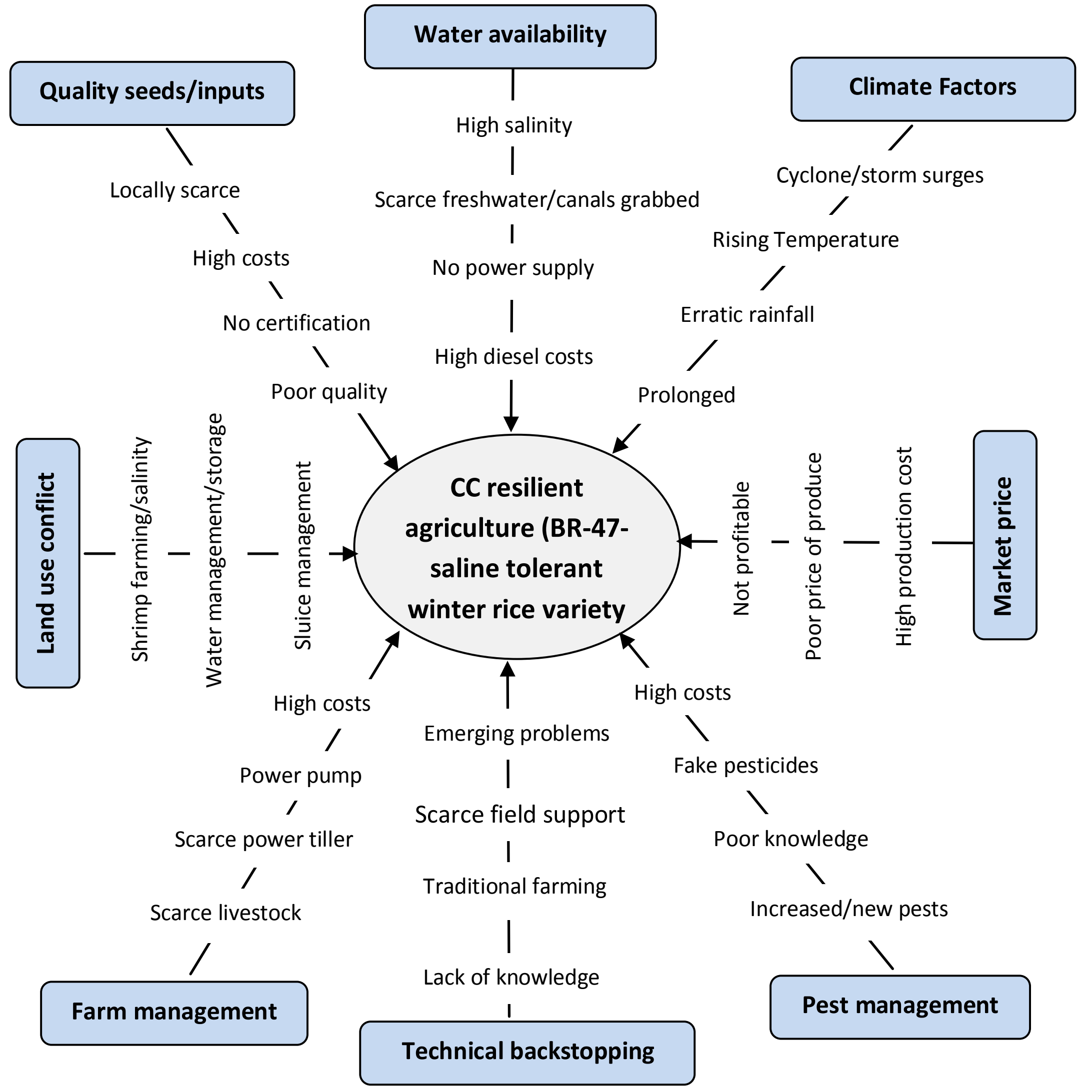


Figure 8.5: Barriers in agriculture-based adaptation: A case from saline tolerant winter rice farming in Chakbara village, Shyamnagarupazila, Bangladesh (Source: FGD with farmers)

Market prices

Farmers also pointed to the need to have better markets for their produce if they were to adapt to changing weather conditions. They argued that in the absence of regulation and control over commodity prices and lack of any incentives for risk taking, the high costs of farming inputs and low market prices meant low profits. What is interesting to note here is the connection the farmers made between adapting to changing weather conditions and attractive market conditions. They saw a clear relationship between climate and development imperatives, albeit directed at the commercial side of their livelihood strategies.

Quality seed and inputs

Fultala farmers continued winter rice farming after the cyclone with a rice variety (BRRI dhan 28) that was unsuitable for coastal saline areas, and their efforts failed. In Dumuria village adjacent to Chakbara, villagers tried using the BR 28 rice variety and repeatedly lost their crops. After the late flooding and damage to full grown amon seed beds, the Fultala farmers replanted using regular varieties, which gave them lower yields.

Pest management

Farmers reported high pest infestation in rice crops in recent times. Fultala farmers rated pest infestation as one of the most important problems they faced. The farmers in Patakhali reported serious pest infestation in their amon rice in 2012, which could not be controlled even after repeated application of pesticides. Later it was revealed that the quality of the pesticides was poor and attributed to local pesticide dealers who sold fake pesticides at high prices in remote areas. Farmers proposed that agriculture officials should regularly monitor and sanction input dealers if they sold such pesticides. It is unclear if the rise in pest infestation was related to changing weather patterns or caused by processes related to cultivation techniques such as planting times, crop spacing or field sanitation. The three most common insect pests that damage rice crops in Bangladesh are the stem borer (Dark-headed Borer –Chilo polychyrysus), Leaf Folder (-Cnaphalocrocis medinalis) and Brown Plant Hopper (BPH–Nilapavata lugens). Of these, evidence points to an increase in infestations by stem borers and leaf folders in both amon (monsoon) and boro (winter) seasons while infestations of the brown plant hopper remain unchanged in *amon* season for some years but are increasing in *boro* season (Haq et al., 2011) .

Recent research suggests that the BPH is susceptible to rising temperatures, which could mean that other factors than those mentioned are more important (Piyaphongkul et al., 2012). Chelliah and Heinrichs (1984, 107) have pointed out that increased BPH populations are a result of new BPH-susceptible rice varieties, excessive use of nitrogen fertilizers, continuous cropping, staggered planting, and the use of some insecticides. The BPH is endemic across Asia and rising infestations have been attributed to excessive use of insecticides. Thus, it may be reduced use of insecticides that can help control the pest. However, another important feature is the loss of beneficial predators (such as spider, birds, beetles, bugs, dragon flies) due to high salinity, loss of trees and increased use of pesticides, that naturally control the harmful insect.

Technical backstopping

With the growth of shrimp farming and the decline of rice cultivation in some areas, particularly Chakbara, there has been a decline in knowledge of the techniques of rice farming with high yielding varieties (HYV). In Fultala, farmers continue to use traditional technologies. CNRS's field agronomist claimed that rice production could only be increased by improving cultivation practices and technologies in the area.

Farm management

Farmers in Chakbara[27] and Patakhali expressed concern that there was a scarcity of draft animals locally, that power tillers and water pumps were unavailable, and that poor salinity control was having a negative effect on their ability to farm. Part of the reason for this was the remoteness of the villages and people had to cross a large river to reach them. This made it difficult to hire/ arrange power tillers from other areas. The lack of livestock was due to shrimp farming, which had taken up all former grazing land. In the first year (2012), the demonstration farmers of Patakhali were able manually to till and level their rice fields by themselves but they regarded this unsustainable in the long run (Figure 8.6).

Land and water use conflict

The land and water use conflicts in the local shrimp farming areas were over the manipulation of sluice gates by the shrimp farmers, shrimp farming and rice farming in canals converted for such uses, drainage congestion, population settlement, and the flooding of crop land. Resolving any of these conflicts can only happen through betterpolicy and legal interventions, which take time and are subject to all the various obstacles discussed earlier in the study. For example, the rice farmers of Fultala and Kultali villages who share cropland in the beelareahave been affected by drainage

[27] Farmers have land/ghers suitable for rice farming and do farming but are constrained due to lack of facilities/farm machineries such as draft power, pump machines, salinity meters, etc.

congestion and resultant crop loss for over 12 years because of canal leasing, conversion and restricted access to fresh water in the dry season. The rice farmers took legal action but failed because of what they referred to as political interference that favoured the leaseholders and land grabbers.

Figure 8.6: Manual land leveling in the absence of cattle.

Chakbara farmers joined with the demonstration farmers from Dumuria village to protest against land leasing, focusing on restoring to common use of water for irrigating rice crops. They collected signatures and lodged an application to the district land administration authority to take back control of land. After two months, the district authority instructed the upazila (sub-district) administration to undertake a field investigation on the issue. A committee was formed by the upazila administration and they paid field visits to various contested sites. The farmers' association informed me that the leaseholder tried to convince the investigation committee to prepare reports that favoured his continuing control. I was also informed that the local UP Chairman supported the leaseholder. The farmers asserted that the leaseholder bribed those involved to provide a favourable report to the leaseholder. At the time of the field work, no resolution had been arrived at.

Officially, a *khas* canal (as flowing wetland) cannot be leased to any person for the purpose of agriculture, aquaculture and conversion but can only be leased to fishers' groups for fishing purposes for a three-year term. But in reality most of the canals in the area were leased to individuals or illegally grabbed, converted and used for private purposes. The political landscape of canal leasing in the area is complex and multi level actors are involved in it. The local authority of land leasing lies with upazila land office and administrator if the size of land/ wetland is less than 8.09ha (20 acres) and with the district authority if the size is over 8.09ha (20 acres). In the study area, two methods were used by influential people to obtain canal leases and to appropriate waters bodies. First, in Fultala, in the name of the landless, local people obtained leases for up to 99 years and then convert canals to crop land or fragmented them for aquaculture or conversion to settlements. Second, leaseholders converted canal to shrimp *ghers*, which is common in Chakbara. In both cases, conflict arose among local people and took two main forms. First, there was conflict between the leaseholders/ grabbers and poor people who used to fish in canals for consumption and sale. Second, there was conflict between grabbers/ leaseholders and rice farmers who used canal water for rice farming. The other institutional actors such as local leaders, land officials, UPs, upazila and district authorities were generally aligned with the land takers through manipulation of the official leasing system. A lack of knowledge of and legal support for local people on state land leasing policies and processes coupled with the absence of collective action and poor governance meant that these illegal activities went uncontested. Sometimes, leaseholders contacted the Ministry of Land (MoL) officials at central government level using political intermediaries and obtained leases in this way.

Apart from local community/ household level adaptive measures I also reviewed the annual developed activities of two concerned local government bodies or UPs (Gabura and Munshigonj) for the fiscal year July 2010 - June 2011 with a view to assessing the extent to which their activities addressed community vulnerability to weather induced impacts and building resilience.

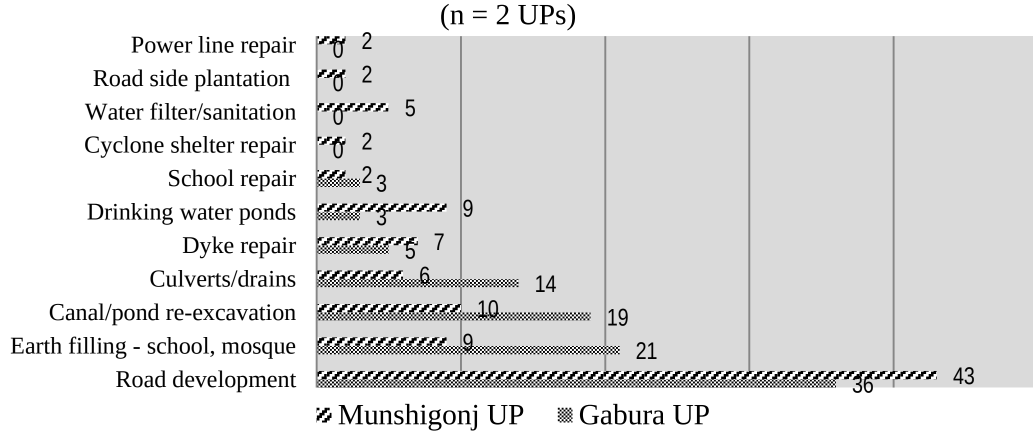
UP's annual development activities

The discussion so far has focused on villager actions in seeking to improve their livelihoods and protect themselves against both weather and non-weather related events. It now turns to an assessment of the development practices of the local UPs (Munshigonj and Gabura) in 2010/2011 in order to determine the extent to which their activities addressed community vulnerability to weather-related stressors. The UPs receive funds from the central government for local development activities on an annual basis. Based on data collected from two concerned UPs, their main development works implemented during 2010/11 can be classified into seven broad areas: i) development of roads, ii) earth filling, iii) re-excavation of ponds and canals, iv) construction of culverts/ drains, v) dyke repair,vi) excavation/renovation of drinking water ponds, and vii) school repair. Besides, the UP also undertook small works such as dykes/road side plantations, cyclone shelter repair, and sanitation. The latter two were done in Munshigonj union only (Figure 8.2). These activities were conventional development activities common to all Bangladesh UPs and did not include any focus on building local resilience to weather related problems.

If we compare UP priorities with those of the two study villages, it is clear they do not coincide. In Fultala (Munshigonj UP), villager priorities were insect pests, lack of freshwater for irrigation, salinity, canal grabbing, drainage congestion and flooding, and a loss of freshwater fish while the UP's development priorities lay elsewhere. Similarly, Chakbara residents were most concerned with bandits, harassment by forest officials, tiger attacks, lack of shrimp PL, and lack of freshwater for irrigation and drinking, salinity and embankment failure. None of these were given any priority in the UP development programme.

Besides local government activities, I also gathered information for the last five years on the activities/programmes of the Department of Fisheries (DoF) and Department of

Figure 8.7: Percentage of Schemes Implemented by UPs in 2010-2011
(n = 2 UPs)



Agriculture Extension (DAE) to ascertain their relevance to adaptation to weather induced threats at the upazila or sub-district level.

Fisheries and Agriculture Extension services of central government

The Upazila Fisheries Officer (UFO) of Shyamnagar reported theyhad no activities in Munshigonj and Gabura unions except some training sessions on fish/ shrimp farming organized by NGOs as resource persons. It indicates that hundreds of shrimp and fish farmers in the unions received no technical support and related services in aquaculture from the relevant agency of the central government.

The DAE is the mainstream public agency for agricultural development in the country with a major focus on extension of improved farming technologies, introduction of new crop varieties, farmers' capacity building, dissemination of new knowledge, technologies and farm mechanization in coordination with other relevant agencies and institutions. I reviewed the activities of the DAE in Gabura and Munshigonj from 2007/08 to 20011/12 and found that during that time the department established only 36 demonstration plots for boro rice (winter rice) in Munshigonj over a five year period and only one such plot in Gabura. It also set up 37 amon rice demonstration plots in two unions and two demonstration plots of *aus* rice (summer rice). The number of demonstration activities was very low in comparison with the size of the unions and the number of farmers wanting to practise and improve rice cultivation.

Besides rice farming, the DAE's demonstrated other non-rice crops that included their sensitivity to the salinity problem. However, this activity was very small. Over the last five years, the DAE made only seven demonstrations of onions (in 2008-09), one sweet gourd (in 2010) and one on mustard (in 2011), all except one in Munshigonjunion.The department's farmer training activities were negligible. They trained 86 farmers over five years in two unions (Munshigonj- 66 and Gabura-20) in the use of farming technologies (Munshigonj-13; Gabura-2), farm mechanization (Munshigonj-30, Gabura-9), and saline tolerant farming systems (Munshigonj-18, Gabura-9).

Overall, the development activities of DoF, DAE and UP did not fully coincide with those of local people, the activities they did engage in were limited, and included very little that linked development to weather-related concerns.

In the next section, I examine the local adaptation schemes /actions (see table 8.1) in relation to the four different adaptation frameworks mentioned earlier.

Analysis of local adaptation actions

Ten different adaptation schemes/ actions undertaken by the local communities were examined in order to assess whether they fell within the principles of i) CBA (community-based adaptation), ii) EbA (Ecosystems based adaptation), iii) 'Resilience to transformational' adaptation (Pelling, 2011) and iv) 'Incremental to transformative adaptation' (Kates et al., 2012). I begin with the CBA framework.

Adaptation schemes in relation to the CBA framework

Four basic elements of CBA are considered in assessing the nature and extent of local adaptation actions (Ayers and Forsyth, 2009; Dodman and Mitlin, 2013). These are:

i) Are the strategies generated through participatory processes and do they operate at local level?;
ii) Do they involve local stakeholders, development and disaster actors including poor and most vulnerable in planning and actions?;
iii) Are the actions based on local knowledge and site specific climate-induced threats aimed at building local capacity?;
iv) Do the actions adequately consider local risks and uncertainties including vulnerabilities

In the case of three schemes on the renovation of saline contaminated fish ponds, decontamination of shrimp *ghers*, and the raising of house plinths after cyclone Aila, the associated saline water flooding was carried out by each household using either its own resources or with the help of others (NGOs and government). In other words, community level and organized participatory planning and the development of adaptation strategies were not the case. Rather, NGOs, as per the direction of donors, prepared the budgets and plans and accordingly supported the selected households while the communities were mere recipients rather planners. The local UP as local development and disaster actor was limited to the selection of households. It was not involved or engaged in planning the schemes through an analysis of the root causes and the relevance of weather induced current and future risks and uncertainties. These adaptation schemes aimed at short term coping, rather taking measures to absorb future weather/ climate-induced shocks and uncertainties over the entire area. In summary, it can be said that these schemes were not in line with CBA principles.

Another scheme monitor salinity and cool *gher* water to protect fish and shrimp stocks from increased temperatures and increased salinity problems was started by individual farmers and later other farmers followed. This was done on an individual basis and there was no collective planning to design actions to address the problem.

Three other adaptation schemes involved some collective actions but were limited to fishers only. The schemes were location of new fishing grounds after old grounds had been abandoned because of cyclone activity; a shift in fishing gear use and fishing locations to avoid tiger attacks; and the cessation of fishing trips in rough sea conditions.

In carrying out these schemes, local fishers shared experience and knowledge among themselves and developed their own strategies, which conforms to a degree with the principles of CBA. However, they were short term and designed to deal with current and more immediate concerns and did not involve other local development and disaster actors in planning actions towards sustainable adaptation. While they did not fully conform to CBA principles, there exists the possibility for the further incorporation of relevant adaptation attributes.

The remaining schemes related to mangrove based erosion protection, canal rehabilitation, and cooperation between NGOs and farmers in adaptive agriculture practices. They were based on community level planning (at the village and occupational level), involved an examination of the root causes of the problems being faced, and the development of local vulnerability assessments to increase the adaptive capacity of local communities. They also engaged the services of local development and disaster actors such as the DAE, FD, UPs in planning and execution of schemes and capacity building and NGOs acting as facilitators.

These examples provide a mixed record of adaptation planning involving autonomous individual actions, some combined individual and collective action, cooperation with official agencies and NGOs and a willingness to think beyond immediate concerns. In the next section I examine adaptation schemes based on the principles of EbA.

Adaptation schemes in relation to EbA framework

As mentioned in chapter 1, four different ecosystem services are considered to be important in assessing the extent to which local adaptation schemes are consistent with EbA principles (MEA, 2005). In the analysis that follows, the ten adaptation schemes are assessed in terms of the facilitation of fourecosystems services:

i) *Provisioning services* - Food, fuel, fodder, fruits, thatching materials, freshwater supply, grazing, genetic resources;
ii) *Regulating services* - Pollution control, regulation of biodiversity, water & air quality, water flow and flood control, pollination, carbon sequestration;
iii) *Cultural services* - Ecotourism and recreation, education and research, cultural heritage, religious values;
iv) *Supporting services* - Soil formation, photosynthesis, nutrient cycling, natural habitats, etc.

Of the ten local adaptation schemes considered, five were found to be in line with an ecosystems based approach to adaptation. These were the renovation of polluted ponds, the de-contamination of shrimp *ghers,* mangrove based erosion protection, canal rehabilitation and adaptive agriculture in saline prone fallow land or shrimp *ghers*. The remaining five schemes addressed general livelihoods and adjustments in methods of accessing resources and did not directly contribute to ecosystem services.

All EbA-related five adaptation schemes contributed to restoring and enhancing ecosystem components and services for the benefits of local communities and ecosystem health. For example, pond and *gher* renovation schemes contributed to restoration of ecosystems health through improving theavailability of freshwater in ponds and removal of pollutants (from ponds and *ghers*), which helped to restart fish and shrimp farming (improved quality of *gher* ecosystems) and the use of water (ponds) for other productive purposes. In general, the restoration of wetland (ponds, *ghers*, canals) and mangroves facilitated opportunities for improved aquaculture, enhanced water supply for irrigation (bringing fallow land under crop production in the dry season) and for other uses by the communities, improved freshwater fish availability in restored canals and better fishing opportunities for the poor. More mangrove plant resources improved provisioning services to communitiesthrough supplying fish, shrimp, crabs, mollusks, water, fuel, fruits and vegetables.

These schemes also provided regulatory and supporting services through photosynthesis (algae and aquatic vegetations in ponds, *ghers* and mangrove trees) and the control of air and water quality, the absorption of pollutants and greater control of flooding by holding excess rainwater in ponds, *ghers* and canals. More benthic organisms in wetland and mangrove areas supported maintaining nutrient cycling and water quality. The introduction or re-introduction of rice cultivation through adaptive farming schemes in fallow saline affected land and *ghers* increased the provisioning services to land and *gher* ecosystems through the provision of food, straw and fuel.

The five schemes were small in nature and scope but illustrate how the adoption of an ecosystem approach together with greater community engagement can contribute to improved ecosystem service provision and an increase in adaptive capacity.

Adaptation schemes in relation to the 'resilience to transformation' framework

I analysed ten local adaptation actions using Pelling's three-stage adaptation framework to assess whether these actions contributed to resilience building only or were (potentially) more transformational (see chapter 1: table 1.1). Table 8.2 elaborates each of ten adaptation schemes against the indicators of the framework and found that all schemes to a greater or lesser extent fall under 'resilience building that is, allowing the system to bounce back to its previous condition or to maintain functional persistence after the shocks. The schemes largely had the consequence of maintaining the functionality of the social-ecological systems rather than move towards Pelling's 'transitional' stage with realization of greater citizen rights within the existing political system or towards the more robust ‘transformational’ stage, which involves changing the structure, discourses and political economy of development landscapes (see Table 8.2). However, this was not entirely the case, as the example below illustrates.

In the case of the actions of the NGO-farmer group, they began with a largely resilience approach based on technical interventions but shifted to questioning and even challenging the wider legal and institutional framework that was used by more powerful agents to appropriate land for their own uses. The action started small with a few farmers of one village who managed to respond successfully to the loss of their amon rice seed beds because of late monsoon intense heavy rain-based flooding by introducing late growing varieties. In the following winter rice season, with the support of CNRS and local agricultural officials, the farmers successfully demonstrated to other farmers that they could cultivate winter rice (boro) in saline affected *ghers* at a higher production rate than the national average. In the following monsoon, some farmers in other villages approached the project farmers who demonstrated how amon rice farming could be successful in abandoned shrimp *ghers* through proper seed bed preparation, transplantation, fertilizing, pest management, salinity monitoring and water management. Later, groups of farmers established associations to develop local farming strategies and plans to identify available sources of freshwater, which could be stored in canals by making bunds for use in rice farming. Without this action, leaseholders would have continued to drain water bodies to catch fish using unsustainable methods.

This result was achieved through tripartite negotiations between the local government representatives, leaseholders of canals, shrimp farmers and rice farmers with NGO assistance. The Chakbara-Dumuria farmers’ association obtained a low lift pump machine from the upazila agriculture office, local agriculture extension agents paid field visits to support farmers and the NGO provided one power tiller and one low lift pump to two farmers’ associations, which had been formed under the program.

However, the issue of how to transfer the leases of state owned canals from shrimp and fish farming to rice farming remained unresolved. This was the most serious political problem facing the farmers as it challenged existing power arrangements in the local area and ultimately the whole system of lease allocation, which traditionally favoured those with political influence up to the highest levels of government.

Using Pelling's three fold schema of adaptation, the initial actions of the farmers can be seen as an attempt to build local resilience by

> …seeking only change that can allow existing functions and practices to persist and in this way not questioning underlying assumptions or power asymmetries in society (Pelling, 2011:50).

This was followed by attempts to claim what were legitimate legal rights regarding the use of land and water resources. Pelling refers to this as 'adaptation as transition'. In this the farmers challenged the actions of seed dealers, public officials and ultimately the national government to abide by the law. The farmers were not asking for anything new but simply the proper application of the law.

The example is complicated by the fact that smallholders and landless labourers did not always share the same economic interests and there were power asymmetries between them that shaped their capacity to act. Thus attempts to change land use from private aquaculture to community based agriculture favoured smallholders and some sharecroppers without directly assisting the completely landless to take up farming. In this sense, the challenge by the farmers to the state and its various local agencies to implement the law fairly constituted '…an extension of resilience adaptation to include a greater focuses on governance…'(Pelling, 2011:68) rather than a failure by farmers to question the legitimacy of the state in order to transform it.

In summary, most of the schemes were small in nature and mostly undertaken by individuals and their families rather than involving greater collective or community level organization and mobilization that extended over wider landscapes or ecosystems. However, three schemes, of which one was discussed earlier, did have more potential to graduate from the resilience building stage to the transitional stage of adaptation. In addition to NGO-farmer adaptive agriculture scheme, these were the canal/ wetland rehabilitation for freshwater, agriculture and fisheries andthe mangrove restoration for erosion control, biodiversity and livelihoods.

Table 8.2: Place of adaptation schemes in "Resilience to Transformation" framework

Hierarchy	**Resilience**	**Transitional**	**Transformational**	**Position in the 3-stage adaptation continuum and probable rank within the corresponding stage (1-5)**[28]
Hierarchy of Framework goal,scope, policy focus and analytical perspectives / Local adaptation schemes	***Goal***- *Functional persistence in a changing environment* ***Scope***- *Change in technology, management practice and organization* ***Policy focus***- *Resilient building; Use of new seed varieties* ***Analytical perspectives*** *- Socio-ecological systems and adaptive management*	***Goal***- *Realize full potential through exercise of rights within the established regime* ***Scope***- *Changed governance practices; procedural justice; lead to incremental change in the governance systems* ***Policy focus***-*Public & private sector implement legal responsibilities and exercise of legal rights by citizens* ***Analytical perspectives*** *- Governance and regime analysis*	***Goal***- *Reconfigure the structure of development* ***Scope***- *Change overarching political-economy regime* ***Policy focus*** *- New political discourse redefine the basis for distributing security and opportunity in society and social-ecological relationships* ***Analytical perspectives*** *- Discourse, ethics and political-economy*	
1.Desiltation of ponds to remove cyclone borne run off debris/salinity for household water use	Maintain pond-based water supply system; resilience building, adaptive management	Not claiming rights to have available water for the community, no governance action or regime analyses	Not claiming for alternative sustainable freshwater water supply system in the area	"**Resilience form**"– bouncing back after the shock **(2)**
2. Minor excavation to de-contaminate *gher* bottom and raising of dykes with removed soil	Re-start shrimp farming, short term, renovation cannot protect inundation in heavy rain-based flooding or another cyclone	Not asking compensation nor contesting corruption in protecting local people, no policy focus, governance and regime changes and legal rights	Nointegrated policy for shrimp farming, water management and DRR to safeguard from climate and other hazards and stressors	"**Resilience form**" of adaptation – bouncing back after the shock**(1)**
3. Making house on raised plinths to protect flooding	Protect house from flooding, changes in technology, resilience building, adaptive management, adjust to ecosystem changes	Not asking permanent solution, contesting corrupt practice in DRR; not asking legal rights and changes in governance regimes	No policy and action for resilient settlements in the coast, dyke management and adequate flood shelters	"**Resilience form**" of adaptation to protect houses from certain level of flooding **(3)**
4.Salinity monitoring, cooling *gher* water by keeping aquatic weeds and deepening of shallow *ghers*	Continue shrimp farming in changing weather; short term; adaptive management	Not asking incentives and technical supports, not seeking improved governance and legal rights	No enabling policy and technical backstopping system that protect the industry from hazards	"**Resilience form**" aim to maintaining farming systems **(2)**
5.Changes of fishing locations in far south of the coast due to degradation of previous fishing grounds by cyclone borne siltation	Continue fishing; resilience building; changing locations; adaptive management, ecosystem based approach	Not asking for compensation, alternative livelihoods or safety net supports; not contesting poor NRM,not seeking improved governance and legal rights	No plan for enhancement of SRF fisheries; no new policy to tackle weather impacts on fisheries and SRF biodiversity	"**Resilience form**" aim to maintain fishing operations **(2)**
6.Changes of gears and fishing locations to avoid tiger attacks	Continue fishing by changing gears and locations, resilience building, adaptive management	Not asking protection from tiger attacks or for injuries and deaths; not claiming citizens rights and governance	No policy and plan to manage tigers to reduce human-tiger conflicts and provide security to fishers	"**Resilience form**" to maintain fishing by the fishers themselves **(3)**

[28] (1) very minimum level, temporary, very likely to collapse in next hazard; (2) minimum level, short term, may collapse in next disaster; (3) moderate, medium term, may sustain next hazard with readiness; (4) strong, long term within existing systems, have potential to graduate to next stage; (5) very strong, long term, capable of moving to next stage

Hierarchy	Resilience	Transitional	Transformational	Position in the 3-stage adaptation continuum and probable rank within the corresponding stage (1-5)[28]
Hierarchy of Framework goal,scope, policy focus and analytical perspectives Local adaptation schemes	***Goal***- *Functional persistence in a changing environment* ***Scope***- *Change in technology, management practice and organization* ***Policy focus***- *Resilient building; Use of new seed varieties* ***Analytical perspectives*** - *Socio-ecological systems and adaptive management*	***Goal***- *Realize full potential through exercise of rights within the established regime* ***Scope***- *Changed governance practices; procedural justice; lead to incremental change in the governance systems* ***Policy focus***-*Public & private sector implement legal responsibilities and exercise of legal rights by citizens* ***Analytical perspectives*** - *Governance and regime analysis*	***Goal***- *Reconfigure the structure of development* ***Scope***- *Change overarching political-economy regime* ***Policy focus*** - *New political discourse redefine the basis for distributing security and opportunity in society and social-ecological relationships* ***Analytical perspectives*** - *Discourse, ethics and political-economy*	
7. Abandoning fishing trips in rough sea weather conditions	Suspend fishing trips, in rough sea conditions, adaptive action, no alternative options	Not asking protection, compensation or alternative livelihoods, or even effective warning systems, no claim for rights	No enabling policy and technical backstopping system that protect the fishers from rough sea conditions	"**Resilience form**" of adaptation – retain in fishing **(1)**
8. Mangrove afforestation to protect wave erosion	Protect settlements /assets from erosion by mangroves; resilience building, adaptive management, ecosystem based adaptation (EbA)	Not claiming rights to have protection from tidal flooding, nor asking for embankment raising or realignment but community-NGO-local government collaboration added value	No political commitment and actions for regular monitoring and maintenance and funding for sustainable protection measure for settlements	"**Resilience form**"; has potential for improvement by claiming rights and better governance **(4)**
9. Canal rehabilitation to ensure freshwater for irrigation and fisheries	Functional agriculture and fisheries in changing weather, resilience building, adaptive management, EbA	NGO-led activity in one canal but other local canals are grabbed, leased and privatised affecting biodiversity, water farming systems, no claims for rights	No plan to change canal leasing and restoration policy that protect and maintain wetland for environmental and community benefits	"**Resilience form**"; has potential for change through governance **(4)**
10. Stress tolerant rice farming in saline prone gher areas, improved seeds and technologies including capacity building	Continue rice farming in changing weather; new technologies & seeds; form farmers associations for collective actions, resilience building and EbA	Claiming de-leasing of canals to district authorities; got supports from DAE, asking DAE to take action against fake agricultural inputs (pesticide, fertilizer, seeds) sellers; more need to move to better governance, citizens rights	Inform DAE for re-shaping agriculture practices in coastal zone, no initiative to influence change in political economy of coastal agriculture; scope of this initiative is too small for transformation	"**Resilience form**"; close to "transitional" stage but need more work on governance, regime analyses and citizens rights **(5)**

In addition to Pelling's framework, Kates and his colleagues (2012) proposed what they call an incremental to transformative adaptation framework, to understand adaptation planning. The next section discusses the applicability and usefulness of this approach to the schemes in the study.

Adaptation schemes in relation to the "incremental to transformative" framework

Kates et al. (2012) argue the need for a new approach to adaptation to climate change that has much in common with Pelling's. Most current adaptation strategies they consider incremental in that they are '…extensions of actions and behaviors that already reduce the losses or enhance the benefits of natural variations in climate and extreme events' (Kates et al., 2012: 7156). They call for a shift to transformational adaptation, which covers three types of adaptation related to increased scale and intensity, degree of novelty or innovativeness and radically transformative of a place or location.They regard such adaptation particularly important in places with high levels of vulnerability andsubject to extreme climate change, such as Bangladesh.

All ten schemes in the study fall within the incremental framework in that they involved making known and tried adjustments to weather perturbations and extremes. None manifest any of the six main features of transformative adaptation outlined by Kates et al. (2012). These are larger scale of action, new to the area, involving large-scale transformation or shifting of locations (migration), well-planned collective actions, technology driven and bringing about changes in institutional settings. Table 8.3 shows that three of the schemes, namely, mangrove restoration, canal rehabilitation and NGO-farmers adaptive agriculture in the saline-prone coastal zone have the potential to graduate to a more transformative stage provided that they can obtain larger external funding, implement more rigorous planning based on detailed analysis of weather related vulnerabilities, engage local communities and stakeholders in planning, and integrate climate policies into development planning more attuned to a future with greater uncertainty in weather and weather-related patterns.

Table 8.3: Place of adaptation schemes in Incremental to Transformative framework (Kates et al., 2012)

Hierarchy in adaptation	**Incremental adaptation**	**Features of Transformative Adaptation**						Status of adaptation actions in the framework
Framework features / Local adaptation schemes	*Adjusting to human induced climate change (more than natural climate variations)*	*Larger scale or intensity of climate impacts*	*New to an area or a resource system*	*Transform places or shift locations*	*Collective and planned or autonomous; address other issues*	*Technology driven; could be social (collective actions, fund mobilisation)*	*Bring changes in institutional settings, norms and priorities*	
1.Desiltation of ponds to remove cyclone borne run off debris/salinity for household water use	Greater than natural variations in weather; intended to address impacts of cyclone Aila	NO (larger scale of weather extremes)	NO - not new in the area	NO (no shift of location)	NO - Individual, autonomous, only water crisis focused	NO- traditional and manual, mostly self driven	NO (no change in institutional settings & norms)	Incremental
2. Minor excavation to de-contaminate *gher* bottom and raising of dykes with removed soil	Greater than natural variations in weather; intended to address impacts of cyclone Aila	NO (larger scale of weather extremes)	NO - not new in the area	NO (no shift of location)	NO - individual, autonomous, reactive; only *gher* quality focused	NO - traditional and manual, mostly self driven	NO (no change in institutional settings & norms)	Incremental
3. Making house on raised plinths to protect flooding	Greater than natural variations in climate – intended to address impacts of cyclone Aila	NO(medium scale of weather extremes)	NO (height of plinths higher than before)	NO (no shift of location)	NO(individual, planned); only focused on house protection	NO-traditional technology	NO (no change in institutional settings & norms)	Incremental
4.Salinity monitoring, cooling *gher* water by keeping aquatic weeds and deepening of shallow *ghers*	Greater than natural variations in weather– intended to address increased temperature, drought and *gher* salinity	NO (very small scale – limited)	YES - new for shrimp *ghers*	NO (no shift of location)	NO- Somewhat planned, reactive; only *gher* water focused	NO- traditional, individual scale but influence others	NO (no change in institutional settings & norms)	Incremental
5.Changes of fishing locations in far south of the coast due to degradation of previous fishing grounds by cyclone borne siltation	Greater than natural variations in weather– intended to address impacts of cyclone Aila	NO (small scale, fishers use certain gear types)	NO (not new but it was CC induced)	YES (Shift of location)	YES - planned, reactive but limited to few fishers; only fishing focused	NO change in technology but joined with other fishing groups	NO (no change in institutional settings & norms)	Incremental
6.Changes of fishing gears and locations to avoid increased tiger attacks due to killing of prey animals by cyclones	Greater than natural variations in weather- intended to address increased tiger attack	NO (not massive tiger attacks)	NO (fishers usually change locations)	YES – shift fishing locations	YES (collective action, planned) but only focused on tiger attack	YES- changes of fishing gears; but minor change to a few fishers	NO (no change in institutional settings & norms)	Incremental
7. Abandoning fishing trips to avoid loss due to rough sea conditions	Greater than natural variations in weather – more frequent rough sea conditions	NO(medium intensity of rough sea conditions)	YES (but fishers often fish in bad weathers)	NO (drop fishing or take shelter)	NO (individual efforts); only to avoid bad weather	NO (not adoption of technology)	NO (no change in institutional settings & norms)	Incremental

Hierarchy in adaptation	**Incremental adaptation**	**Features of Transformative Adaptation**						Status of adaptation actions in the framework
Framework features / Local adaptation schemes	*Adjusting to human induced climate change (more than natural climate variations)*	*Larger scale or intensity of climate impacts*	*New to an area or a resource system*	*Transform places or shift locations*	*Collective and planned or autonomous; address other issues*	*Technology driven; could be social (collective actions, fund mobilisation)*	*Bring changes in institutional settings, norms and priorities*	
8. Mangrove afforestation to protect wave erosion	Adjustment to high tides and wave erosion of coastal embankment and settlements, incremental to normal climate variations	NO (micro scale – only in a village)	NO (not new to the area)	NO (no shift of place)	YES (somewhat collective, planned but limited to a village); livelihood as co-benefit	Green technology, community-NGO-UP joint initiative	YES-local committee formed, linkages developed but short term	Incremental (have potential for further progression)
9. Canal rehabilitation to ensure freshwater for agriculture and fisheries	Drought and water scarcity, incremental to normal climate variation	NO (small scale – only in a couple of village)	NO (not new to the area)	NO (no shift of place)	YES (somewhat collective, planned but limited to a village), focused on fish and crops	Green technology, community-NGO-UP joint initiative	YES- local committee formed, linkages developed but short term	Incremental (have potential for further progression)
10. Stress tolerant rice farming, improved technologies (saline and flood tolerant varieties rice and non rice crops)	Greater than natural variations in climate, adaptation intended to address higher salinity, drought, erratic rainfall and flooding	Small scale but high intensity problems	YES (new seeds and technology)	NO (no shift of location)	YES (collective action, only rice farming	New and adaptive technology	YES- farmers group formed, linkage built with public &private actors, claim rights, got supports from DAE, NGOs	Incremental (started at 1 UP and extended to 3 UPs (high potential for further progression)

Weather or climate related perturbations and extremes are a new generation of threats in the lexicon of development. The associated risks and vulnerabilities for social ecological systems at specific spatial and temporal scales are not fully known (Stern, 2006; IPCC, 2012). This inherent uncertainty impairs adaptation planning and interventions to address site specific problems caused by weather/ climate induced threats. Key questions have arisen at agency and state levels about how best to approach the appropriate adaptation strategies to improve longer-term adaptation outcomes. The most common approach has been one of resilience, in which the aim is to ensure that systems stressed and shocked by weather-related hazards are able to bounce back to a previous stage in a modified form. While such resilience building can strengthen the adaptive capacity of local communities, less attention has been paid to taking more robust actions that go beyond technical and system-maintaining solutions along the lines proposed by Pelling (2011) and Kates et al. (2012). Pelling argues strongly for a political economy approach that focuses on the realization and stronger institutionalization of citizen's rights within the established regime (his transitional phase) followed by a reconfiguration and more radical re-thinking of the objectives and practices of development. This latter notion of transformational adaptation seeks a change in the governance of development with a radical devolution of decision-making to local communities and regions. As Pelling (2011, 63) puts it:

> …transformational adaptation describes those actions that can result in the overturning of established rights systems and the imposition of new regimes.

Kates et al. (2012) adopt a similar if less directly political approach to what is needed to provide longer term protection to local communities affected by weather-related hazards. They define current approaches to adaptation to human induced climate change as "incremental" as they involved extensions of already existing and sometimes proven strategies. Their transformative framework focuses on multi-scalar and more intensive change, new adaptation measures and collective changes in location or whole-scale shifts of vulnerable populations. They stress the importance of local leadership and collective action but stop short of the more potentially radical proposals contained within Pelling's transformational framework.

Summary

This chapter has shown that local communities are trying to adapt to different weather related adversities and impacts, either on their own initiative or with some support of outsiders such as government agencies and NGOs in the areas of water, aquaculture, fisheries, flooding, agriculture and erosion. It was found that most actions were undertaken at the individual or household level and were largely reactive, autonomous and incremental (Kates et al., 2012). They were not based on weather vulnerability assessments and lacked any sustainable community-based planning. Some schemes such as pond, gher and canal rehabilitation, mangrove restoration and adaptive agriculture did adopt some aspects of the ecosystems- based adaptation framework (EbA) and were able to contribute to the enhancement of ecosystem services and community resilience.

For the most part, local adaptation actions aimed to achieve short term objectives that at best enhanced levels of resilience and at worst simply allowed individual households to cope, that is, to rely on known methods of accommodation rather than more reflexive practices aimed at longer-term transitional or transformational adaptation (Pelling, 2011). The NGO-farmers joint initiative in adaptive agriculture suggested the growth of a greater political awareness of the need to challenge existing political and economic arrangements, but at the time of writing it was uncertain what the outcomes would be. In contrast, the annual development plans of local government and the DAE illustrated the poor state of local planning to address weather related vulnerabilities of local communities compared with other local concerns. Finally, these findings suggest a lack of readiness among local people and development actors to take robust steps to adapt to increasing weather induced threats. This is the subject of the next chapter.

Chapter 9:
Adaptation Readiness to the Effects of Changing Weather Patterns

Introduction

It has been argued that research on climate change adaptation and the move towards more climate-resilient approaches to development policy and planning have been limited by a focus on building adaptive capacity. This may be seen as the provision of the institutional and other means to create the potential for taking adaptive action. What is also required is what has been called ‘adaptation readiness’ or:

> ...the extent to which policy processes and governance structures which determine when, how, and if adaptation occurs, are in place (Ford and King, 2013).

The chapter draws upon this framework to assess the degree of readiness or preparedness of the two communities to take adaptive action. As indicators of adaptation readiness, it considers:

i) community understandings and awareness of various government laws and acts that govern the management and utilization of natural resources in the area;
ii) community views on how to adapt to weather related hazards; local and central government programmes and activities designed to enable adaptation strategies;
iii) the availability of common pool resources (CPRs) as a basis for community-based action;
iv) community experiences with the state of safety net and disaster risk reduction services and the governance at local level by the public and private agencies, including the elected local government bodies or UPs; and
v) the quality and experiences of local NGO staff and UPs in working with local people and their views on barriers to adaptation barriers.

The relevant data are derived from KAP survey, case studies, FGD and KII across the two village communities, local government, primary school teachers and local public agencies.

Adaptation, Adaptive Capacity and Adaptation Readiness

Several developing countries, including Bangladesh, are moving towards what has been referred to as climate-resilient development or the mainstreaming of climate issues into development planning. Bangladesh introduced its national climate change strategy and action plan (BCCSAP) in 2008 and in 2009 it revised a key aim, to integrate adaptation planning into the wider development policy framework (MoEF, 2009). Since then two major funds have been established to assist with the incorporation of climate adaptation into development planning. They are the Bangladesh Climate Change Resilience Fund (BCCRF) operated by the Bangladesh government, development partners and the World Bank; and the Bangladesh Climate Change Trust Fund (BCCTF) financed by the Bangladesh Government.

An example of how development planning can be made more climate-resilient comes from agriculture. An adaptation programme aimed at coastal agricultural development involves altering the normal design of such programmes to take into account current and anticipated future climate related threats, which in the current study, include erratic rainfall, frequent flooding due to *akash bonnaya* (intense rain based flooding), more prolonged pre or monsoon drought (*lomba khora*) and increasing temperatures, which in conventional agricultural development programmes are given less or no priority. A programme would involve the assessment of local level climate vulnerability (current and projected) to farming systems and the development of local interventions based on the findings of such an assessment.

The climate-resilient development planning also recognizes the need for cross organizational, technical and disciplinary approaches that seek to avoid fragmented and sector specific interventions. For example, in the Bangladesh case, several governmental agencies are tasked with addressing salinity and water related issues. Thus, the DAE (Department of Agriculture Extension) has to collaborate with the BWDB in relation to dykes, sluice and drainage management issues, with the DoF manages shrimp farming induced salinity that affects crop agriculture, and with local government and local administration (including the Ministry of Land - MoL) to deal with freshwater availability, wetland protection and conflict resolution related to crop versus shrimp farming, land tenure, salinity and other issues. For improved and climate and pest resilient rice varieties, the DAE has to collaborate with the Bangladesh Rice Research Institute (BRRI) and Bangladesh Agricultural Research

Institute (BARI), and with private seed companies. For social mobilization, awareness and capacity building and farmer empowerment, involvement of NGOs is required.

To make such inter-agency coordination effective at the grass-roots level, local communities must have a clear understanding of which agency is mandated for which activities/ services, be aware of the relevant state laws and acts that govern and facilitate local development initiatives, have sufficient knowledge of the technical and other requirements of proposed interventions, and possess the political and social skills and networks to ensure implementation and outcomes that meet community expectations. In other words, they must possess an overall readiness to act.

This idea of adaptation readiness is a new concept in the climate change lexicon that seeks to link adaptive capacity to the political and other realities on the ground that can hinder or facilitate effective adaptation (O'Brien et al., 2006; Adger and Barnett, 2009; Moser and Ekstrom, 2010). A system, be it a community, region or country, can be unprepared to adapt to weather induced threats even if it has strong adaptive capacity. Ford and King (2013:5) define adaptation readiness as

> …the extent to which human systems (e.g. nations, regions, business, communities, etc.) are prepared to adapt, providing an indication or measure of the likelihood of adaptation taking place.

Adaptation readiness is thus conceptualized as a framework for assessing whether a system is actually able to implement appropriate strategies of adaptation. It deals with the translation of policy and planning into actual practices (Ford and King, 2013). (See figure 1.6 in Chapter 1).

Local Adaptation Readiness

Adaptation readiness has cross scale dimensions with local actions nested within larger organizational, spatial and temporal scales. However, in Bangladesh, key elements of such readiness are lacking. For example, the DoF has no role in fisheries management and development within the SRF due to its institutional isolation within the architecture of current national policy. The FD has the sole authority for the overall management of all SRF resources, including fisheries, but it has no fisheries personnel or fisheries unit within its organizational structure. The DoF has the national mandate for the country's overall fisheries management but is unprepared to implement, for example, a fisheries focused adaptation programme for the southwestern region without a major change in overarching policy and a redefinition of the institutional roles of the respective departments and agencies. In this sense, the current institutional and policy settings are inadequate to realize what Pelling (2011, 50) refers to as 'adaptation for resilience', the most basic and least controversial aspect of current adaptation thinking.

Another example of the need for greater attention to adaptation readiness is provided by developments in early 2013 when the IUCN, through its multi-country programme on Mangroves for Future (MFF), took up a pilot ecosystem based adaptation project aimed at rehabilitating a *khas* canal in Gabura union, adjacent to Chakbara, to reserve rainwater for agriculture and aquaculture. However, all *khas* canals in the area were under long term private leasing arrangements given to individuals by the powerful Ministry of Land (MoL). Leaseholders were unwilling to allow excavation and community use of the canals even after pressure from local communities. The MFF project, even though it is in line with Bangladesh's national water policy, which focuses on making water available for food production and community use, clashed with the MoL *khas* land policy, which is more concerned with revenue raising than environmental protection.

These examples indicate that even if a system has adequate adaptive capacity or the institutional potential to act, the actual adaptation may not take place because of a failure to realize adaptation readiness (Ford and King, 2013). In this context, I consider six areas which can contribute to building more effective adaptation or adaptation readiness at the grassroots level.

The first area concerns local understanding of relevant state laws and acts such as the Embankment Protection Act, Environment Protection Act, and the Fish Conservation Act, which governs the development activities of the state as well as help to build effective and empowered constituencies. The second relates to the current functions of the mainstream public agencies and their institutional integration. These reflect the state of local governance which cross-cuts all the other areas as without good governance, adaptation actions are unlikely to be sustainable. The third concerns the functioning of local government in disaster risk reduction in its relationship to the UDMC and the fourth relates to community attitudes to climate change adaptation and community adaptation priorities. A fifth area concerns the protection and management of common pool resources (CPRs). Locally available CPRs such as wetland, forests, and roadside borrow pits, and char land are all state owned resources and have high potential for resilience building if they are protected and managed sustainably in a pro-poor manner. Roadside borrow pits were open to all in the past and were used by local people, mostly the poor, as CPRs for fishing and irrigation for winter rice and vegetable production. As such, they allowed people to earn an income and secure their livelihoods, thus enhancing their resilience. The sixth area is that of the state of social safety net and emergency disaster response activities at local (UP) level, which if they function properly and are free from corruption, have the potential to facilitate and sustain adaptation actions.

Ford and King (2013) highlight six adaptation readiness factors. These are i) political leadership, ii) institutional organization, iii) adaptation decision making and stakeholder engagement, iv) availability of usable adaptation science to inform decision making, v) funding for adaptation, and vi) public support for adaptation, which are more aligned to policy and institutional capacity levels. Some of these factors correspond to the six readiness factors considered in this study at local levels. The first is political leadership as indicated by the role of the UP in disaster and adaptation, CPR management and political interference in access to and distribution of adaptation funds. The second is institutional organization, which relates to the functions of relevant government agencies, the capacity and understanding of adaptation by institutional actors and the, facilitation of social safety net activities. Third is stakeholders engagement, which can take the form of community engagement in local development planning such as dyke management with the BWDB. The fourth concerns public support for adaptation, which includes community attitudes to prioritizing adaptation, the absence of usable science to inform adaptation decision making and awareness building activities.

There is general consensus among adaptation researchers and policy makers that adaptation works best where relevant institutions work in a collaborative and transparent manner with local communities to meet mutually agreed upon priority needs to adapt to the impacts of weather induced adversities (Jones, 2010). Such institutional capacity across levels of government and between government, NGOs and local people is regarded as a central aspect of adaptive capacity as it is required to better facilitate adaptation programmes jointly with development agencies from the public and private sectors, including local government bodies. However, such capacity is a necessary but insufficient condition for bringing about desired changes. It needs to be complemented by adaptation readiness.

First, I present findings on local peoples' awareness and understanding of relevant government laws and acts and their implementation as they constitute a form of local empowerment central to effective adaptation actions. Greater awareness and understanding of particular laws and acts can play an important role in strengthening citizens' rights in two main ways. Informed citizens can pressure government to implement properly existing laws and policies as well as working towards changing such laws and policies to meet changing environmental and social conditions. This is what Pelling refers to as transitional and transformational adaptation (Pelling, 2011). At the minimum, people should know what their current rights are under the existing legal structure in order to give them the legal means to pressure for change. For example, it is illegal to construct homes or other structures on embankments, to catch juvenile hilsha fish (*jatka*), and to appropriate public land for private purposes. All these laws are regularly flouted by local people from diverse economic backgrounds.

Local understanding of relevant national laws and acts

There are several relevant and complementary state rules and acts that collectively govern the resource management systems and the actions taken at grassroots level by state agency officials, local government, NGOs and local communities. These rules are meant to guide the equitable and sustainable use of water or fisheries resources. Table 9.1 summarises some of the key rules, acts and regulations relevant to coastal management. The survey findings show that local communities, including local government representatives and NGO staff, lack the required knowledge and understanding of the various government laws, rules, acts and regulations that are in place.

Table 9.1: Relevant rules, acts and regulations crucial for adaptation in the coast

State acts, rules, regulations	Goals	Lead Responsible entity
Embankment Protection Act	Protect communities and assets from cyclones, storm surges, salinity, tidal inundation	BWDB and local government (UPs)

Environment Conservation Act	Protection of overall environmental resources of the area including pollution control	DoE centrally and locally through administration and other concerned agencies
Khas Land Distribution Act	Distribute cultivable fallow state land to landless families	Local administration at sub-district and district levels
Fish Protection and Conservation Act	Conservation and enhancement of fisheries resources in natural ecosystems	DoF along with local administration and police
Shrimp PL fishing regulations	Conserve natural stock of shrimps, fish and other aquatic biodiversity	DoF and FD (within SRF)
Crab harvesting regulations	Ban on crab harvesting from SRF during January-February to allow for their natural breeding	FD (within SRF) and DoF outside SRF

A good example of the lack of knowledge of relevant regulations and laws is provided by the Bangladesh Water Development Board (BWDB), a government agency mandated to construct, operate and maintain all water control infrastructures according to relevant government acts such as the Embankment Protection Act, 1952. Part V1 under sections 56, 57 and 58 of the act state that there are penalties for unauthorized interferences damage to embankments, the diversion of rivers and grazing cattle on embankments (GoB, 2010).

However, the field survey reveals that more than half of villagers (52% in Chakbara and 54% in Fultala) were unaware of the act (Figure 9.1). UP members also had either no knowledge of the act or a poor understanding of it. Local people reported that many structures (pipe culverts) had been constructed on the embankment by the shrimp *gher* operators in collusion with the BWDB field level officials, something which weakened the embankments. Many landless people had also made their homes on the embankment out of desperation, although such an action contravened the relevant law. In seeking shelter they had to pay bribes either to locally influential people or to BWDB field level officials. There are two aspects of importance here. First, many people were unaware of the provisions of the act or of the act itself. Second, more powerful interest groups, particularly shrimp farmers, in local communities manipulate the law on embankment use to their own advantage through corrupt relations with the BWDB, the mandated public agency. Educating local people about their legal rights would not necessarily stop illegal and corrupt practices from continuing, but it would contribute to local people's understanding of how their rights were being abused from a legal point of view. Such socially available knowledge is of great importance in contributing to the building of stronger collective ties among people with like interests.

The second government act is the Bangladesh Environment Protection Act, 1995. This act operates across the mandates of almost all public line agencies, which are expected to comply with the act in designing their respective development programmes. The survey findings show that two thirds of households in both villages (67% of Chakbara and 65% of Fultala) reported they were unaware of the law. Only a few UP members claimed to have some knowledge of the act (8% in Gabura and 17% in Munshigonj) and the remainder had little to moderate understanding. This means that without better awareness of the act, people cannot judge the extent to which it is actually practiced. This is particularly important for marginal farmers and the landless.

Landlessness is common across the whole of coastal Bangladesh. Many of the landless engage in resource extraction activities that require access to common land and water bodies. However, these have diminished considerably in recent decades as a result of legal and illegal activities. Such common land and water bodies, also known as *khas* land, have not been protected and properly distributed to landless families although the relevant state regulations provide clear directives in this regard.

The study found that 38% and 62% of the villagers of Fultala and Chakbara had no or little knowledge of the *khas* land distribution and regulatory system. A majority of UP members (83% in Gabura and 92% in Munshigonj) also possessed little to moderate knowledge, although the UP has responsibilities in the management of such land. *Khas* land grabbing and conversion often create environmental problems and the poor become the major victims of such environmental degradation. In Fultala, there is a history of leasing and illegal grabbing of the state-owned Kultali Khal, which has affected share croppers and wage labourers the most. Despite the Land Department being required to maintain the Kultali khal as CPR for the benefit of landless and marginal farming households for fishing and farming, it has been leased out to a small number of political well-connected people for private use.

Villagers reported no visible activity of the responsible public agencies to protect *khas* land in the area (Figure 9.2). They commented that most of the *khas* land (canals, land and small rivers) were either leased out to wealthy people or shrimp farmers or were grabbed by the wealthy and their allies. The majority of UP members and villagers considered that the relevant government agencies were ineffective in protecting and distributing *khas* land according to the requirements of the relevant act. This mal-distribution of *khas* land deprived the poor from enhancing their adaptive capacity through having greater control of such land to produce rice and vegetables and to engage in fish and shrimp aquaculture or capture fishing. It also had the indirect and negative consequence of increasing the social and environmental pressure on the fragile SRF.

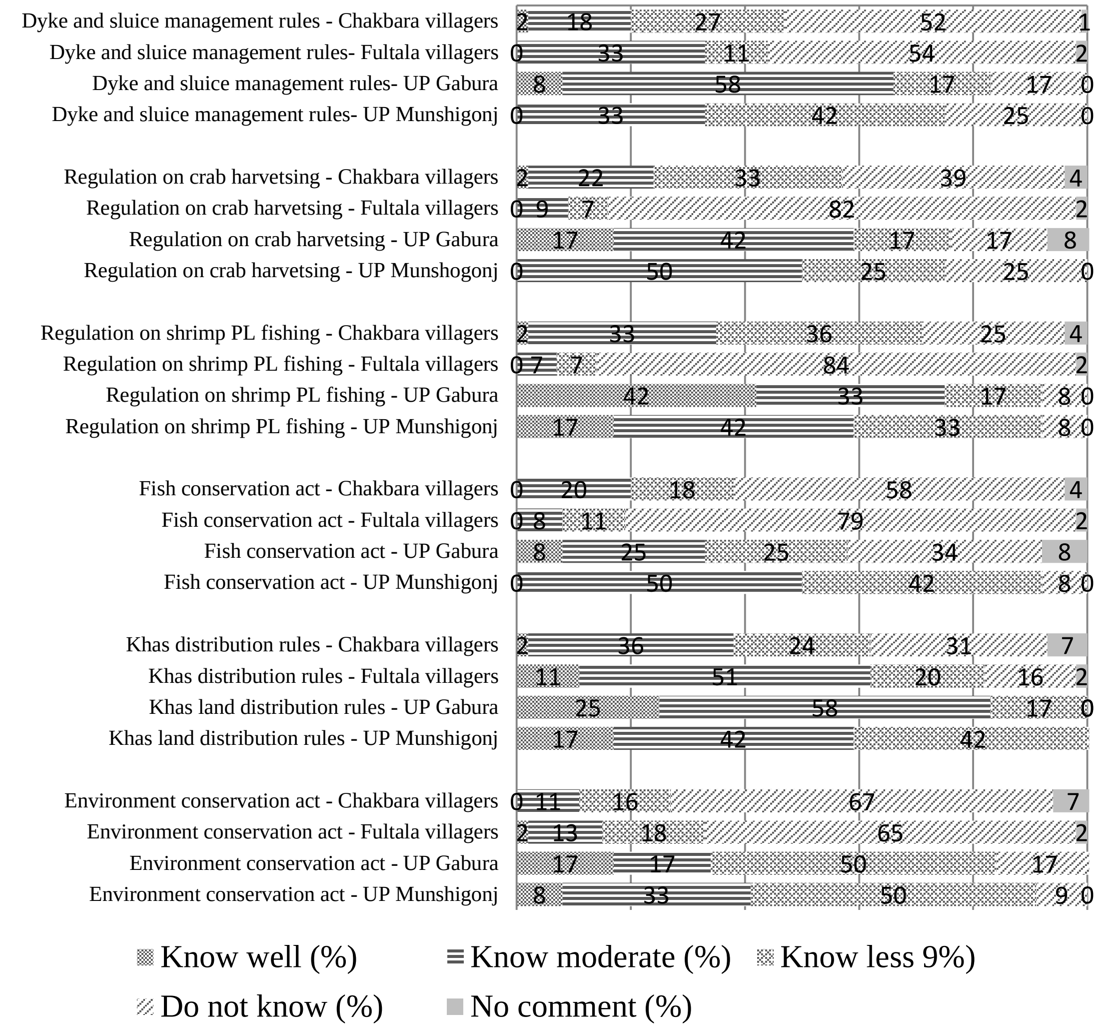
The Fish Protection and Conservation Act of 1950 aimed to ensure fisher access to fish and fishing grounds on rivers, canals, beels and flooded land, the SRF and coastal wetland. These fishing grounds have been the subject of struggle between the fishers themselves and powerful state-backed interests before and since that time. Under the British it was the zamindars and the colonial state itself that controlled access. Since 1950 it has been the state acting as national landlord and leasing out access to private interests that has dominated fisheries policy. In 1950, the then East Pakistan government enacted the Fish Protection and Conservation Act 1950 (amended in 1982) that comprises various regulations aiming to conserve fisheries. These include bans on catching specific types of undersized fish and on poisoning water to catch fish, which is very common inside the SRF. This act is administered by the DoF, in collaboration with sub-district administration, police and local government bodies.

Some 58% of Chakbara households expressed their ignorance of what the Fish Conservation Act was supposed to do, even though a majority of them were fishers (Figure 9.1). In Fultala, 64% of households reported their ignorance of the act’s purpose and content. One third of UP members in Gabura union reported having no knowledge of the Act, although they were required to execute the act in their respective areas.

The fisheries act incorporated a ban on shrimp PL collection from the wild in order to protect the biodiversity of inland, coastal and marine ecosystems. Shrimp PL catching from the wild (rivers, canals and within the SRF) with fine mesh nets (locally called mosquito nets or net *jals*) has been a major political issue in coastal Bangladesh as it was argued by some environmental groups and shrimp hatchery owners that such collection destroyed fisheries biodiversity and depleted natural stocks of shrimp in the coastal waters.

Recent studies reveal that to catch one shrimp PL, as many as 1,666 fry of other wetland species (including macro zooplankton) are lost as by-catch (Hoq et al., 2001; Ahmed & Troell, 2010). This by-catch loss is high because the coastal waters, especially mangroves, are home to a variety of marine and freshwater fish species where they feed, breed and mature (Iftekhar & Islam, 2004). Local fishers of Chakbara reported that large fish species like *pangus* (Pangasius pangasius - large catfish), *med* (large estuarine catfish- Arius caelatus), *vangra*, *chaka chingri*, *datina*

Figure 9.1: Communities' knowldge on development rules and acts: a survey of villagers (n = 90) and UP members (n=24) was conducted in 2012



and *vetki* (Barramundi) which were once commonly found in rivers around the villages had become very rare. Household survey data shows that 44% of the households in Chakbara were involved in shrimp PL catching as their primary occupation and 63% of women headed households survived on shrimp PL catching. Although illegal since 2000, it has continued unabated along the entire coast of Bangladesh. Regarding the government's shrimp PL ban, 7% and 35% of the households in Chakbara and Fultala respectively reported they had limited knowledge of the act. UP members had better knowledge, with 59% and 75% members of Gabura and Munshigonj respectively stating they had a moderate level of awareness of the act. However, their knowledge of the ban did not prevent them from allowing PL collection to continue.

Besides fish and shrimps, mud crab (Scylla serrata) has supported the livelihoods of coastal people. Initially neglected socially as poor man's work, it has become a big fishery and both poor and rich are involved in the trade. To sustain the natural crab stock, the GoB imposed a two month ban in the months of January and February, which corresponded with the peak breeding time of crabs, in order to sustain the crab fishery. Accordingly, the FD stopped issuing entry permits for crab collection during these two months. However, the ban has proved to be ineffective in curbing crab catching efforts due to a lack of effective monitoring as well as a lack of awareness by crab collectors of the ban and its purpose. Over 38% and 80% of households in Chakbara and Fultala respectively expressed their ignorance of the crab ban, which meant people continued to catch crabs without entry permits. UP members were better informed but saw it as the responsibility of the FD.

It can be argued that the local ignorance of laws and acts reduces a community's capacity or readiness to claim rights and entitlements, which, in turn, hinders the likelihood of effective adaptation. This is not to say that local people live in complete ignorance of the law, as many flout regulations that they are aware of simply because they believe they have little or no choice. In this, they are often aided and abetted by the better-off traders and locally powerful business people who form part of the domestic supply chains connecting the resource extractors to local, regional and national buyers and processors.

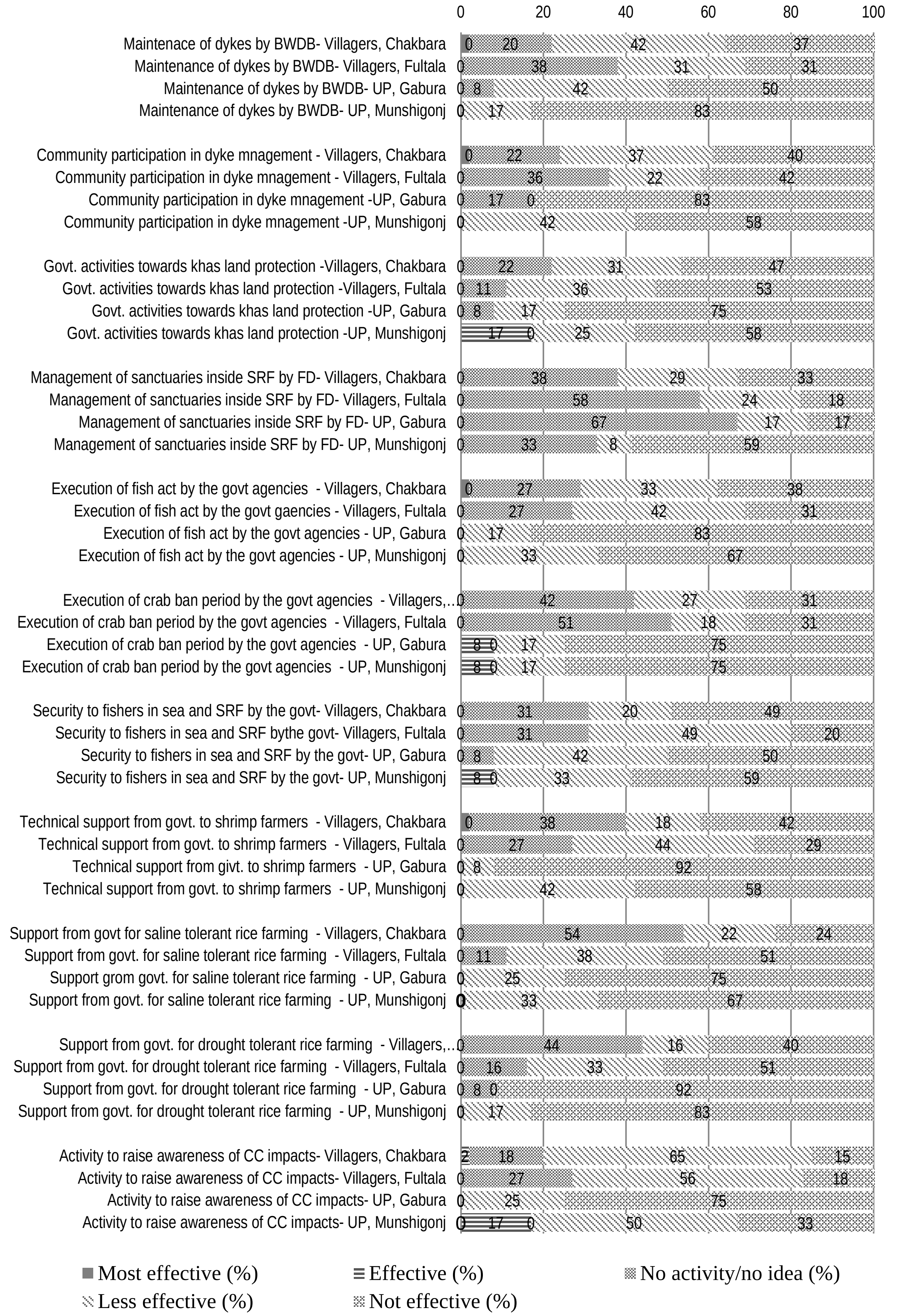
Ecosystems and biodiversity in the study area are already impacted due to various anthropogenic causes (over harvesting of fish, crabs, shrimp PL and habitat degradation and conversion coupled with low freshwater flows form upstream) affecting the livelihood of local communities. On the top of these, weather /climate change and variability have exacerbating depletion of natural resources. In this context, proper awareness and execution of related laws and acts (fisheries and environmental conservation laws) can protect ecosystems and biodiversity for environmental and social benefits. However, current policy operates in a punitive manner with the relevant government agencies (FD, DoF or BDWB) working with local police to apprehend people breaking laws. Less attention and interest is shown by these agencies in increasing local awareness of the laws and the reasons why they exist. A focus on deterrence ignores alternative strategies aimed at generating new income-generating opportunities so the poor can maintain their livelihoods and indirectly contribute to building their resilience.

Another component of effective adaptation is the extent to which relevant central government agencies actually deliver the services they are mandated to do and the views and reactions of local people to their activities. The next section discusses this.

Functions of development agencies – state of governance

The increasing importance given to mainstreaming climate change into development planning means that the activities, roles and responsibilities of public agencies charged with addressing local development issues are central to the climate adaptation process (Huq and Ayres, 2008). There is increasing interest in development planning to move away from seeing development and climate change adaptation as two separate institutional activities, to seeing how they can be integrated to serve a wider sustainable development agenda (Adger at al., 2007). In this section, I present my survey findings as to how the relevant government line agencies provided their mandated services to address local development issues in their relevant sectors (see Table 9.2). For example, how effective has the BWDB been in the operation and maintenance of coastal dykes, flood control and community participation in dyke management? How has the FD managed the fish sanctuaries inside the SRF and the ban on crab collection during breeding time? How effective has the DoF been in providing technical support to shrimp farmers and what has the DAE been able to do to support farming communities sustain crop production with the extension of saline or stress tolerant farming systems into local areas? How

Figure 9.2: Current management practices in line of climate change adaptation: perceptions of effectiveness by villagers (n =90) and UP members (n = 24), survey was done in 2012



effective have local campaigns and other activities been in raising community awareness at local level of climate change issues and impacts

The examples given below, which relate largely to a lack of good governance, largely predate current national concerns and actions over the potential impact of climate change on local resources both inside and outside the SRF. This strengthens the argument that any climate change policy must deal with the wider governance structures of the state within which local people operate.

The role of the BWDB in the proper operation and maintenance (O and M) of coastal dykes is central in safeguarding communities by reducing their exposure and related vulnerabilities to hazards. However, the evidence shows that local communities have limited trust in the BWDB to do its job. When asked to comment on the effectiveness of BWDB's current role in dyke management, 31% and 37% respondents of Fultala and Chakbara respectively stated it was "completely ineffective" and 31% (Fultala) and 42% (Chakbara) stated it was "less effective". None were of the opinion that the DWDB's work is effective (Figure 9.2). This indicates that current levels of BWDB's services are inadequate to protect coastal people from cyclones and tidal surges. Local UP members (50% from Gabura and 83% from Munshigonj) also expressed their negative attitude to the performance of BWDB in water management and flood control (dyke and sluice management) in the area.

With regard to community engagement in dyke management processes, over 40% of community members responded that their involvement was either ineffective or less effective and 58% and 83% of UP members in Gabura and Munshigonj were of the same opinion (Figure 9.2). This suggests that the dykes give local people a false sense of security as a result of ineffective O & M practices and the disconnectedness of local communities from dyke management activities. Recent events are testimony to this lack of trust as it took over 18 months for the BWDB to fix the cyclone-breached dyke in Gabura union. It also indicates a low readiness of the BWDB to support community level adaptation. Such weak capacity and non-responsiveness of the responsible public agency to their mandated responsibilities increases the exposure of communities to hazards and thus increases their vulnerability.

The problem of poor governance of natural resources in the SRF is illustrated by the government's sanctuary policy. The government declared three sanctuaries inside the SRF in places which are designated as World Heritage sites and banned the harvesting of any resource from these designated areas. The sanctuaries were chosen as they had high potential to rejuvenate the health and biodiversity of natural ecosystems both within and outside the spatial boundaries of sanctuaries. However, survey results revealed a gloomy picture on the management of the sanctuaries. No UP members had anything positive to say about sanctuary management. The data shows that 33% and 67% of the UP members of Gabura and Munshigonj respectively were not aware of any FD activity on sanctuary management and 17% and 59% respectively regarded current sanctuary management to be ineffective (Figure 9.2). At the village level, 38% and 58% of Chakbara and Fultala households also stated they had not seen any activity by the FD with the rest saying the management was ineffective. Some local fishers said that the sanctuaries were being heavily fished by fishers in collusion with the field level FD officials. One fisher of Chakbara said:

> Quite often the FD field staff asked us to bring more fishers to do fishing inside the sanctuary areas so that they could get more money from us. We regularly pay the FD field staff for allowing us to do illegal fishing inside the sanctuary. The FD field staffs not only allow us to do fishing inside the sanctuaries but also informed us to leave when the senior FD officials came to visit the sanctuaries.

The sanctuaries in SRF are thus acting as havens for fishers and foresters, rather for fish and wildlife. Fishers said that they got more fish in the sanctuary than other areas, which attracted more people to do fishing inside the sanctuary and the FD field staff took this opportunity to make money illegally. The size and remoteness of the SRF provides local FD staff with extra protection in their corrupt practices. Often, other relevant agencies, including the FD itself, do not have any firsthand information of how the sanctuaries are being managed. Besides technical management of SRF, the local poor who used to collect SRF resources are harassed in many ways by the foresters.

Some SRF users commented that they often found the foresters more dangerous than tigers and that they were next to God in terms of exercising power over people. Users pay “additional money” to the FD officials when collecting entry permits and once inside they continue to harassed by officials who ask for money as “duty fees” , meaning that while on duty to watch for illegal fishing, FD staff approach fishers for money even if they have legal entry permits. A local SRF resource user of Chakbara said:

> I tried to stop bribing the FD people but eventually I had to surrender. The FD officials have enough power, if they wish they could sue case against anybody at any time for hundreds of reasons. Therefore, I decided it is better to bribe, keep them happy and harvest resources as you like.

While fishers and other SRF resource users such as *bowalies* and *mowalies* can be said to share common interests in having fair and equitable access to SRF resources, this has not led to any organized cooperation among them to challenge the illegal use of power by foresters in the FD. The users have become used to a system of clientalism in which they seek entry permits through agents of the FD officials who operate in local villages. Such a practice works against cooperative action. Apart from the FD field officials, the poor resource users were harassed by the bandits inside the SRF.

The adaptive readiness of local people also depends on a secure 'law and order' environment in which people can go about their business without threat from thieves and other criminal elements. However, operating in the SRF and lower estuary has become riskier due to the actions of local bandits who steal fish, money and take people hostage for a ransom. While government had attempted to curb such activities, some villagers who were aware of government actions thought not enough was being done. Their growing personal insecurity has put greater pressure on local people to exploit further the resources of the SRF to offset the losses incurred by paying bandits. Thus, banditry can be seen as an indirect cause of the destruction of the SRF.

Historically, bandits have operated within the interstices of state power or in collusion with local power brokers. In the past they targeted wealthier people who invested in SFR resource collection. However, local people report that almost everybody, rich or poor, are open to attack by bandits. Shubash Mondal, a poor *bagdi* fisher from Kalbari village (adjacent to fish landing centre, Munshigonj), said:

> In the past, even before the cyclone Aila in 2009, they were not harassed by bandits as they are from the very poor and lower class of the society – *bagdi*. Bandits used to say "oh! You are the *bagdis,* just go away". Now, they do not care whether we are *bagdi* or what else, but demand money

> from us. Sometimes they detain one of our fishing members to ply their boat for a week or so and also ask for ransom.

Increased attacks have several causes. There are many more users in the SRF than in the past who are fair game for local bandits. Another factor is the growth of shrimp farming in the region. Fishers said that the bandit problem had increased over the last 20 years after the start of shrimp farming. Growing unemployment among labourers and sharecroppers who once worked the rice fields may also have attracted some to the bandit groups, which they see as a quick and easy source of money compared with collecting shrimp PL of fishing, which is laborious and risky. Sushanta Mondal, a fisher from Chandipur village said:

> A month back, bandits took me from the boat and asked for ransom of Tk. 50,000 (US $ 641) and contacted my family for the money. Then my family contacted a local *mohajan* and borrowed Tk. 10,000 (US $ 128.21) which was then handed over to bandits and I got released after a week. This not only caused a loss of money but also I lost the fishing opportunity and associated income for seven days. My family and I had to suffer a lot from mental anxiety plus increased debt burden…

The fear of kidnap and ransom makes fishers and other SRF resource collectors more dependent on local *mohajans*, which increases further their social vulnerability. Currently, all types of fishers, whether sea going or local, have become potential targets of bandits. They now include the estimated cost of paying bandits as part of their operational costs. For example, on each fishing trip, each *goisha jal* operator requires some Tk 8,300 (US $ 106.41) as operational costs which they borrow from *mohajons*. Usually three people in one boat operate six *goisha jals*. Estimated costs of operating a fishing trip in the Bay are given in Table 9.2.

Table 9.2: Operating cost of one trip of fishers operating *goisha jal* (Interview with a fish trader in Kolbari Fish Landing Centre)

Items required	**Costs**		**% of costs**	**Remarks**
	BDT	**US $**		
Ice 10 blocks	1,300	17	15.66	Each block cost 130 taka
Food items and other costs	2,000	26	24.09	For the group
FD entry permit costs	1,000	13	12.05	FD also take additional money
Paying two bandit groups	2,000	26	24.09	Illegal/ Coercively collected

FD office inside SRF (3 locations)	1,500	19	18.07	Illegal collection /bribes
Fish marketing cost	500	6	6.03	Handling, weighing
Total:	**8,300**	**106**	**100**	

Source: An elderly fisher from Chakbara, Gabura union

It is seen (Table 9.2) that a quarter (24%) of the operating cost was paid to the bandits and another 20% to FD officials, which is close to a half of the operational cost. This exploitation of fishers encourages them to fish illegally and to overfish. They also cut trees in the forest while fishing, which further increases pressure on forest resources. In summary, banditry combined with corrupt forestry practices hinder people's readiness for adaptation and increases their social and physical vulnerability. Villagers pointed out that the amount of ransom and the release of hostages was negotiated at different levels. With poor fishers, a small ransom is demanded and negotiated locally while for more substantial amounts negotiations escalated to district and even higher levels. The banditry issue is well known to political leaders and administrators but their effort to control it does not seem to have been effective.

Another area of government policy is the conservation of fisheries. However, no local fishers or UP members knew of any steps taken by government to apply the Fish Conservation Act related to regulations regarding gear and mesh size, taking of juvenile hilsha fish (*jatka*), and the ban on poison fishing in canals of the SRF. Local people made similar observations with regard to the execution of the crab harvesting ban period in the SRF. A good numbers of villagers (42% - Chakbara 51% - Fultala) said they had never seen any government action to carry out the crab bans while one-third said the FD's effort in this regard were ineffective. The majority (75%) of UP members said that the application of the FD's crab ban was "completely ineffective" (Figure 9.2).

The DoF has a mandate to assist shrimp farmers to reduce their impact on local social and ecological environments, particularly rice farming. Shrimp farming is generally more profitable than rice farming but has led to the introduction of two major problems: viral diseases that can lead to a collapse of shrimp farming and poor cultivation technologies with low yields. However, local villagers and UP members people expressed serious doubts about the DoF's capacity and willingness to act. Their doubts can be grouped into three categories. Between 27% and 38% of villagers stated that DoF took no action to assist. Between 18 and 44% considered DoF support to be of limited effectiveness while 29 to 42% stated DoF was ineffective. No respondents considered DoF support for shrimp farmers was effective. The majority of UP members (Gabura- 58% and Munshigonj-92%) said that local farmers did not get technical and material support from local DoF officials in solving their day to day problems and rated their services as ineffective (Figure 9.2). In fact, over the last 5 years the DoF had virtually no fisheries or aquaculture development activities in Gabura and Munshigonj unions except attending some training programmes organized by NGOs.

Another main government agency is the DAE (Department of Agriculture Extension), which assists agricultural production in the area. The communities reflected their frustration with the work of the DAE with 37% and 40% rating its activity as ineffective, 22% and 53% as less effective and 5% and 40% as completely ineffective. Figure 9.2 shows that 50% and 75% of UP members in the two unions stated that the DAE's support to rice farmers was ineffective. Part of the DAE's brief is to assist farmers with new salt tolerant strains of rice. Demonstration of saline tolerant rice varieties (BRRI dhan 47 in winter) at farmers' plots in Chakbara (Gabura union) was shown to produce good yields (over 6.5 tonnes per hectare), which is above the national average (CNRS, 2012). The Bangladesh Rice Research Institute (BRRI) invented saline tolerant rice varieties suitable for coastal areas but the evidence shows that the agricultural extension department of the government (DAE – Department of Agriculture Extension) did not systematically disseminate the varieties to farmers in high saline affected coastal areas. Over 11% and 54% of the villagers of Fultala and Chakbara respectively said DAE had done nothing for them while 24% and 51% said what had been done proved to be ineffective (Figure 9.2). The majority of UP members (Munshigonj-67% and Gabura-75%) also considered the DAE work with salt tolerant rice crops was ineffective. Similar experiences were shared by villagers and UP members in the case of DAE's support to farmers with drought tolerant technology on rice farming.

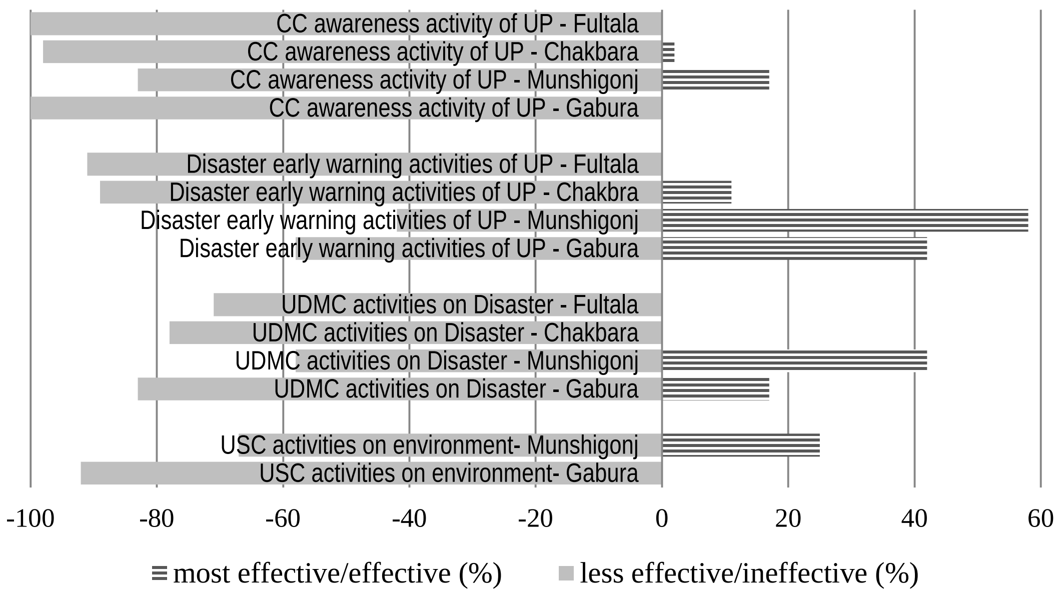
These data show that the extraction and production systems in the area are seriously neglected and suffering from various technical, managerial and policy related problems. This means that the local communities are faced with a major challenge in planning and implementing adaptation programmes.

Capacity of Local government in disaster management

While there are weaknesses in the capacity and delivery of services in a range of areas, it might be thought that the local Union Disaster Management Committees (UDMCs) could take a lead role in building resilience at the local level. However, the evidence points to a history of neglect. Over 22% and 29% of villagers in the two villages said they were unaware that such a committee existed and had no idea what they did. Over one third of villagers stated that while such a committee was operational, its activities were ineffective as they had not seen them take any action at the grass roots level. By contrast, 17% and 41% of UP members in the two unions defended the work of the UDMC by claiming that it had worked effectively, although they were unable to provide any examples of what it had done. Figure 9.3 shows that the majority of UP members supported the views of villagers by saying that the UDMC's activities were either ineffective (8% and 16%) or less effective (43% and 75%).

In addition to the UDMC, 13 other committees operate at the UP level under the name of UP Standing Committees (USCs) several of which have functions relevant

Figure 9.3: Adpatation enabling activities of Gabura and Munshigonj UPs: a survey of villagers' (n = 90) and UP members' (n=24) resonses in 2012

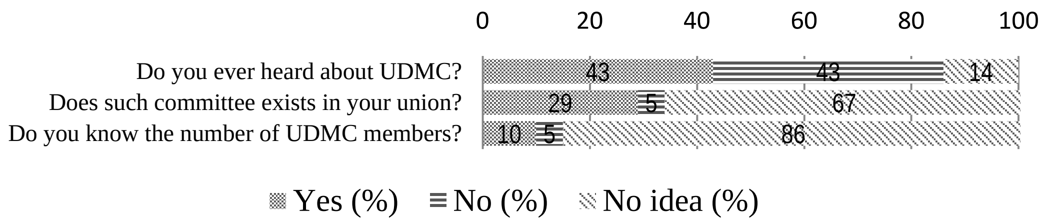


to development planning and adaptation. The USCs are comprised of elected members as well as representatives from within the local communities. The main environmental task of the USC is to engage with local communities within the UP jurisdiction in various activities, including environmental conservation activities. Since the project area has serious environmental problems, the activities of USC-environment are crucial in managing the environmental health of the area. However, the feedback received from the UP members on the activities of these committees was that they were virtually ineffective.

The invisibility of UDMCs as local disaster management institutions is also reflected in the responses of primary school teachers in the area. Data shows that the majority of school teachers had never heard of the committee in their respective unions or seen it functioning. Some 43% and 29% teachers in the two unions knew of the existence of such a committee but 90% did not know how many members were on the committee and who the members were (Figure 9.4).

This general lack of UP activity is of concern as disasters and environment are key issues of concern to local people. Such lack of activity and connection with local

Figure 9.4: Primary school teachers' knowledge on UDMC (n = 21) : a survey was conducted in 2012



people is likely to create barriers to climate change adaptation initiatives.

Community views and priorities in relation to weather issues and adaptation

In the face of major governance concerns at the local level, it is important to understand the views and priorities of local people towards managing weather related issues as they are important in shaping people's responsiveness to community based adaptation planning.

I began by putting to local people the following statement and asked for their responses: "God controls all the natural things like sun, rains, temperature, seas and the like thus humans cannot make any change in this domain of God". The majority of villagers and UP members agreed with this statement. There are several ways of interpreting this response. The most obvious is that it indicates a fatalism about human's capacity to intervene in the natural world, which could restrain some from taking up proactive measures for adaptation (planned adaptation). It also suggests that local people lack an understanding of how extensive human intervention has been in altering climatic conditions. This suggestion received some support from the next statement when I asked about priority actions to be taken in the area. Local people were asked which problems should be given greater priority, non-climate related problems or climate-related ones such as adaptation. Some 73% of Fultala respondents and 74% of those in Chakbara stated that non-climate concerns should take priority over climate change adaptation (Figure 9.5). However, most members of Munshigonj UP disagreed, with 75% stating that climate change programs should be given priority. Surprisingly, two thirds of the UP members of Gabura union, which is highly vulnerable to climate change impacts, disagreed with their Munshigonj counterparts and agreed with the communities that non-climate issues should be given priority. These responses provide some support for what has been called the Giddens paradox (Giddens, 2009: 2), which states that because climate change does not appear obvious or recognizable within the experience and understandings of local people, they are less likely to support rapid action to deal with it. Giddens extends this idea when he refers to the idea of 'future discounting', by which he means:

> People find it hard to give the same level of reality to the future as they do to the present (Giddens, 2009: 2).

It suggests that even where local people have an abstract awareness that something called the climate is changing, the issue is still not experienced or understood enough within the local context to warrant urgent action through a mobilization of local resources.

The villagers were asked if there was anything they could do to reduce climate change impacts. There were mixed responses but the majority agreed that they could play little role in reducing the impacts of climate change. However, some villagers (4% in Chakbara and 18% in Fultala) appeared confused by the question and did not respond. More importantly, 31% and 42% of Fultala and Chakbara villagers disagreed that there was little they could do and that they did have a role to play in responding to climate change impacts. In addition, a majority of UP members (58% in Gabura and 75% in Munshigonj) did not agree that they could not do anything and were positive about the importance of local people becoming more engaged with climate change concerns. This suggests a degree of institutional and popular support for action on climate change adaptation.

However, the evidence also shows that tension existed between the UP leadership and local people over UP's capacity to deal with climate change adaptation. To this end, UP members were asked whether their current capacity was adequate to tackle climate related problems in the area. Figure 9.5 shows that out of a total of 24 UP members surveyed, the majority (75% and 84% in Gabura and Munshigonj) considered their current capacity to be inadequate to deal with climate change problems. They stated there was a need to enhance local capacity to effectively plan, design and implement climate change adaptation projects in the area. It is also important to understand how their local constituents judged the capacity of their elected representatives to assist them in meeting the various hazards that threatened their well-being. They were asked to respond to the following statement: "I have trust in UPs that they can tackle climate related problems". The majority of community members (69% in Chakbara and 80% in Fultala) disagreed while 11% and 13% remained non responsive. Interestingly, 75% and 84% of UP members in Gabura and Munshigonj respectively also agreed about their poor capacity.

The villagers and UP members were then asked how they thought the central government could contribute to dealing with climate change problems in their locality. Here again a majority of villagers (64% in Chakbara and 75% in Fultala) said they did not trust the central government agencies working in the area to help solve climate related problems. The UP members expressed similar views, with 50% and 33% from Gabura and Munshigonj respectively agreeing that they did not trust central government agencies. This indicates that the local people had lost their trust in and were dissatisfied with the performances of both the local and central government agencies which affected planning and implementation of effective adaptation interventions.

Figure 9.5: Community views on dealing with weather/climate probelms: a survey was conducted of villagers (n = 90) and UP members (n = 24) in 2012

The focus of attention then changed to community views on current management practices of SRF by the FD. Local people have a high reliance on SRF resources for their livelihoods, and their future was of great concern to them in terms of underpinning their livelihoods and providing protection from cyclones and storm surges. To this end, I assessed community views of expert opinions that a major part of the SRF is likely to be damaged by climate induced sea level rise (SLR) in the future (UNESCO, 2007). The majority of the communities (80%) and UP members (66-83%) agreed with this statement. I then asked villagers to respond to the following: The SRF is a vast resource system and climate change cannot affect its integrity. Here again the majority of the local communities (60-71%) and UP members (58-66%) disagreed with the statement, meaning they thought that climate induced SLR will affect the SRF. It should be remembered that these responses were given with the impact of cyclone Aila fresh in people's memories and the on-going and largely negative impacts of natural and human-induced changes on the SRF.

From the resources point of view, the SRF has three dimensions. First, it is a vast mangrove forest located in the inter-tidal zone of the coast, and a forest resource base. Second, it is a large fisheries resource base and many varieties of freshwater, brackish and marine fin fish and shell fish species use this mangrove as their breeding, nursery and feeding grounds. Third, it is a large wildlife habitat that provides home for a wide range of wildlife species including migratory birds, sea turtle nesting sites and one of the largest habitats in the world for the endangered Bengal tiger. The SRF is thus a multiple resource system upon which multiple stakeholders are dependent in terms of access and use of various resources and they often compete among themselves for such access and use.

However, this vast and multiple resource system is being managed by the FD alone, which is institutionally a department of well-trained foresters with a small wildlife wing, it is dominated by the foresters with regard to policy, strategy and activities relevant to SRF management. There is no fisheries wing in the FD and thus virtually no management of the fisheries of the SRF, except for the issuing of entry permits and record keeping of fish landings with intermittent checking of fishing boats.

The Government of Bangladesh declared three wildlife sanctuaries within the SRF with clear boundaries in order to create a haven for fish and other wildlife. However, during my fieldwork, I was informed by the local fishers that the sanctuaries were not managed properly and were being heavily fished in collusion with the field level forest officials.

With regard to the community views on improved management of SRF, a majority of villagers (82% and 84%) and UP members (92%) agreed that the FD alone was unable to effectively manage the resource. They all favoured multi-stakeholder based management of SRF rather than the FD-alone system. Currently there is no role for UPs in the management of SRF and 75% to 83% of UP members expressed the view that they had no role in its management (Figure 9.5).

The evidence presented suggests that local villagers and UP members have limited knowledge of weather change issues and impacts. I then asked them to respond to the following statement: Before planning for adaptation, I need to know more about weather/ climate change issues. Nearly 100% villagers and UP members emphasized the necessity of enhancing their knowledge on climate change, suggesting that this lack of understanding could hamper the implementation of practical adaptation interventions. Given the fact that the local communities have unclear understanding and mixed opinions of weather issues in prioritizing local development, I looked at the status of common pool resource (CPR) systems and their current management practices which have high potential to support the poor communities in adapting to environmental shocks.

Common Pool Resources (CPRs) management

CPRs have the capacity to absorb various shocks and stresses associated with environmental change affecting local livelihoods. For example, wetland and forests CPRs contribute to ensuring a balance between human needs for food security and livelihoods and environmental sustainability. The restoration, protection and management of available CPR bases provide social and ecological benefits (MEA, 2005). Since most CPR bases include ecosystems, there exists high potential for the adoption of ecosystem-based adaptation approaches that can provide cross-household benefits and support community-based adaptation initiatives rather than focusing singularly on individual or household level adaptation schemes (CBD, 2009).

All these CPR bases are owned by the state (*khas* land). Constitutionally, it is the responsibility of the concerned government agencies, including local government, to protect and maintain the CPR bases for the benefit of local ecosystems and their biodiversity which, in turn, provide community livelihoods. However, the current management of CPR is contrary to the state policy aimed at benefitting the poor and conserving biodiversity. I asked Fultala villagers to respond to the following statement: Government is effectively protecting and managing CPR bases in your area. In response, 75% did not agree with the statement and indicated that government efforts to protect the CPR bases were ineffective (Figure 9.6).

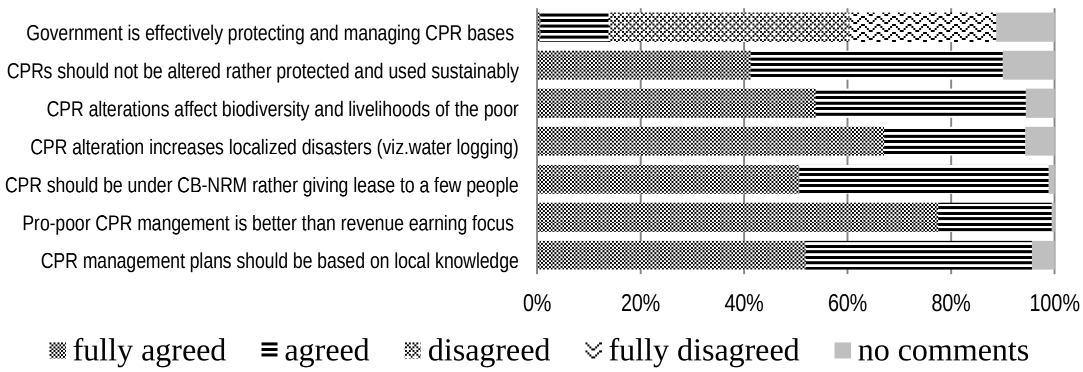
Physical alteration is one of the main causes of the loss of CPR bases. For example, wetland are filled or converted to cropland, settlements, roads and infrastructure and for other uses. With such alternations, CPRs lose their ecosystem functions and quality and are no longer able to provide ecosystem services and products to local communities. For the most part, the beneficiaries of altered CPRs are a limited proportion of the general population. As an example, a major section of the Kultali Khal (shared between Fultala and Kultali villages) of around 3 km is leased to only 18 people and most of them converted the leased canal to cropland, fish ponds, settlements. Hundreds of households in three villages were unable to use the khal for fishing, irrigation, collection of aquatic weeds, and other activities related to the provision of food, fuel and fodder. Around 80 hectares of crop land that had once been irrigated with canal water to produce winter rice was denied water once leasing of the canal began. The majority of Fultala villagers agreed that the quality and types of CPR should not be altered but be protected and used sustainably for the benefit of the wider community as they experienced such changes negatively affect the livelihoods of the poor (Figure 9.6).

Often physical alterations to CPR bases affecting local villagers were localized disasters that created flooding and drainage congestion. Fultala and Kultali villages experienced drainage congestion and consequent flooding after physical alterations to Kultali Khal and their amon rice crops were damaged during monsoon rains (Figure 9.6).

Another major issue of concern to local people and other rural communities in Bangladesh was the use of CPRs for fishing. Bangladesh has a long history of local struggles over control of fishing grounds and there is much evidence that the current leasing system has failed to provide access to local poor, including fishers, to wetland and has further entrenched asset and income inequalities in rural areas. One of the key struggles has been over attempts to introduce community based management of wetland and other CPRs to help the poor make a living. There was strong support expressed by people in Fultala for the community-based management of CPR resources. Over 98% of respondents expressed support for the community management of CPR bases for the greater benefit of the poor (Figure 9.6). Over 95% also agreed that the planning and management of CPRs should be based on the opinion and experience of local user communities. Although there is high risk of elite capture, this problem can be contained if not fully overcome if the overall multiparty governance structure and system was made functional. There are examples in Bangladesh where community based organizations (CBOs) formed under co-management projects were able to establish rights and access to wetland replacing local elites with the support of DoF, local government agencies and project teams (Halder and Thompson, 2006).

These sorts of natural resource bases under CPR regimes have a high potential to help poor communities absorb shocks from climate and non-climate stressors and a shift to a pro-poor sustainable management of these CPR bases can contribute to providing a basis for better adaptation options for coastal areas. However, local readiness for effective adaptation in places such as Fultala is seriously impaired when CPRs are lost or degraded.

Figure 9.6: Community responses on current management of CPRs in Fultala (N = 45): a survey was done in 2013

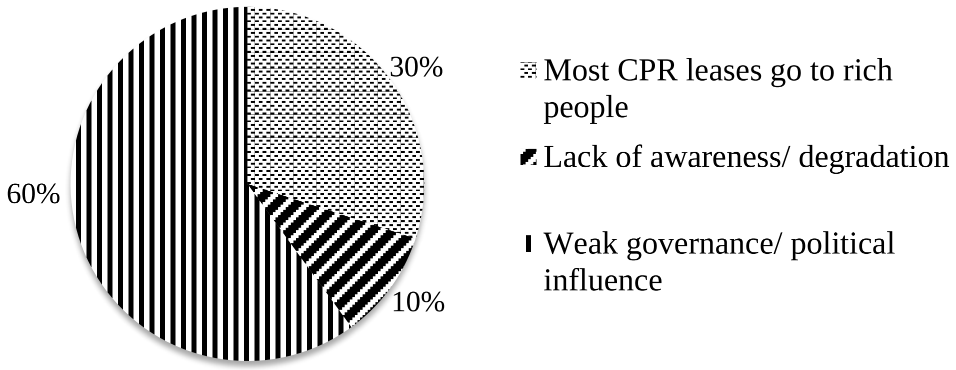


Overall, many local people thought that most fishing leases had gone to rich and influential people either directly or through informal channels (30%) and that even where fishers were in nominal control of a lease, it was wealthier non-fishers who financed the fishers and were able to use the papers and documents of fisher cooperatives to obtain leases of wetland. Figure 9.7 shows that 60% of local people blamed weak governance and political influence as the main barriers to a sustainable and pro-poor management of CPRs in the area. This problem of elite capture led me to examine in more detail the workings of local government in the two village areas.

State of safety net and disaster risk reduction activities at local level

The Government of Bangladesh has launched several social safety net programmes aimed at helping the poor and marginalized households to maintain their livelihoods

Figure 9.7: Percived barriers to pro-poor management of CPRs in Fultala (n = 45) : a survey was done in 2013



during the lean period, when work is scarce, and to protect households with elderly and disabled people and widows. These programmes include old age allowances, a VGD programme (vulnerable group development), a VGF or vulnerable group feeding programme, allowances for widows and a 100-day work programme during seasonal lean periods. All these initiatives target extreme poor and vulnerable households and aim to assist them strengthen their capacity to absorb the various pressures they face. They are implemented through the UPs at village level.

Although designed to help vulnerable households, villagers commented that it was often very hard for them to access these services because of corruption, inadequate facilities and nepotism. The household survey data collected from the two study villages shows that poor people had encountered similar corrupt practices in accessing these services from their respective UPs. The data shows that none of the eligible households got their full entitlements. Chakbara households had access to all five types of packages in varying degrees but most Fultala households were excluded from having access to these benefits (Table 9.3). They mentioned several reasons for their exclusion.

Table 9.3: Extent to which safety net services reached the households: a survey of villagers done in 2012 (n = 90).

Safety net packages	Eligible HHs (Nos.)		Benefits actually received (%)	
	Chakbara	Fultala	Chakbara	Fultala
Old age benefits	6	4	50%	0%
VGD benefits	21	7	14%	0%
VGF benefits	36	4	86%	0%
Widow allowances	4	6	25%	0%
100-day works package	26	18	4%	6%

The top ranked reason for lack of access to all the packages was that villagers were unable to offer sufficient bribes to local officials and UP elected bodies (Table 9.4). Some stated that even after paying money for entry on the eligibility list, their names were excluded to benefit others. They found it difficult to contest such corrupt practices as they were not organized to take collective action. People also alleged that the UP Chairman and members failed to provide them with the correct information on who was eligible and how to seek assistance such that many people were excluded from benefits. Such exclusion was in some instances a result of people working away from home. For example, Chakbara has many fishers who spend two to four weeks at a-time fishing in the sea or lower estuaries. They claimed that if they had been informed ahead of time about the safety net packages, they could have re-scheduled their fishing trips to ensure they were enlisted. However, as they had not been informed many were unable to claim any benefits.

Table 9.4: Governments safety net benefits and governance: a 2012 survey of villagers (n = 90).

Reasons given by householders why they failed to receive safety net benefits	Percentage distribution of households by reasons for failure to receive different safety net benefits from UPs

	Old age allowance	VGD Benefits	VGF Benefits	Widow benefits	100-day works
Failed to offer a bribe and thus not included on the eligibility list	71%	68%	55%	100%	71%
Paid BDT 2,000 (US $ 26) in bribes but still excluded	14%	0%	0%	0%	0%
UPs did not inform in time for benefit packages	14%	16%	0%	0%	0%
No assistance provided in obtaining benefits	14%	16%	22%		14%
Did not know about the safety net programme	0%	12%	0%	0%	7%
Was fishing in the sea during enlistment of names	0%	0%	22%	0%	0%
Being supporters of opposition parties (Political reasons)	0%	0%	0%	0%	0%
People lost motivation after repeated harassment	0%	4%	0%	0%	0%

While table 9.4 reports that being a member of an opposition party was not an important factor in benefit receipt, in more informal conversations somepeople said they were excluded because of having a political affiliation different from that of the UP chairman. Such political discrimination is highly institutionalised in Bangladesh politics from the national to local levels. Local people were also required to pay bribes in accessing disaster response benefits and recovery support.

Immediately after cyclone Aila made landfall on 28 May 2009, massive relief and rehabilitation operations were carried out with support from government and donor countries. Major relief work was managed by government agencies, local government (UP), and international and local NGOs. Response to the cyclone was managed in three phases: emergency response and relief supply to the victims (food, water and other daily essentials for survival); early recovery (assistance to return to work); and rehabilitation in the form of reconstruction of physical and social infrastructures. The Emergency Response and Recovery effort was highly successful in that there were no deaths after the cyclone. However, corrupt practices were reported to have occurred at various stages of the response.

Obtaining information on this highly sensitive subject proved to be very difficult for myself as chief researcher. Villagers were unwilling to talk to me directly about the corrupt practices they had either heard of or experienced themselves. However, my research assistants were able to gradually collect some information on corrupt practices, which confirmed that corruption had indeed taken place. One key obstacle to people's willingness to talk about corruption was fear of the local UP Chairman who was a rich and politically powerful person who had been involved in corrupt practices. Government agencies and NGO officials also had to follow his guidelines in implementing relief-rehabilitation activities due to his extensive political connections with the governing party. One particular way in which the Chairman was able to act corruptly was by not allowing local people to fix immediately the cyclone induced breaching points of embankments. Rather, he managed to delay such action with the intent of letting the breaching points widen in order to claim that more money was needed from central government, of which he would receive a larger share. The BWDB did little to fix the embankment immediately after breaching, silently supporting the intention of the chairman. This deliberate negligence meant local people suffered prolonged saline water inundation for 18 months and experienced a considerable loss of assets and livelihood opportunities (See chapter 4 for further discussion of this issue)

Other corrupt practices commented on in relief distribution activities were as follows. There was corruption in the ways in which relief recipients were selected. Agents of the UP chairman took bribes from people so they could receive relief materials. The amount of money paid varied from Tk. 500 to Tk. 7,000 per person according to the relief packages. The higher the value of the relief package, the more they paid. The staff of some NGOs, including international NGOs, took bribe money in enlisting the recipients, saying they had been forced to do so by the UP chairman. However, several local people claimed that the money went into the pockets of NGO staff. Second, in some cases, the intended relief materials were not given to the recipients. Rather, the allocated money was shared between the recipients, NGO staff and chairman's agents. Third, money was appropriated by submitting false bills. For example, if 100 labourers were employed as earth cutters, the official documents showed that 150 people had been employed, with the extra payments taken by the agents of the Chairman. Fourth, in some instances payments for earth cutting works were provided in kind. For example, where a labourer was to receive 5kg rice per day, they actually received less and the remaining amount was sold in the market.

These examples of corrupt practices not only point to a failure of elected local officials and their allies to carry out their legally required duties. They also highlight how local people became implicated in the continuation of such practices against their will. Although there is no evidence to support it, it is likely that some of them became agents of official distributors of relief materials as a means of enhancing their livelihood status. The villagers confirmed that corrupt practices were extensive across a range of officially sanctioned relief agencies and that the local UP Chairman was directly or indirectly involved in all sorts of misappropriation of assets and money.

Effective adaptation to weather impacts in a given setting requires an enabling environment that should facilitate execution of adaptation interventions a good deal of which are new and additional to conventional development planning depending on the types and extents of weather induced threats. Apart from the communities' views and experience that affect adaptation and adaptation readiness, local staff of several NGOs recounted their experiences in regard to local planning and provision of support that have implications for future adaptation planning and implementation.

Views of local NGO staff on barriers to local adaptation readiness

Moser and Ekstrom (2010) have argued that adaptation planning and the implementation of appropriate strategies are often obstructed, delayed or made ineffective because of a range of obstacles associated with policy and practice and multiple scales. However, they suggest that such '…obstacles can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, and institutions (Moser and Ekstrom, 2010:22027). They distinguish between limits and barriers to change, referring to limits as '…obstacles that tend to be absolute in a real sense (Moser and Ekstrom, 2010: 22026): they constitute thresholds beyond which existing activities, land uses, ecosystems, species sustenance , or system states cannot be maintained, not even in a modified fashion (Gaston, 2009; IPCC, 2007). However, some physical and ecological limits can be overcome through technological interventions (Moser and Ekstrom, 2010) while Adger et al. (2009) argued that many social limits can be overcome with the right mix of political and social support, resources and development efforts. With this in mind, I investigated local barriers to adaptation in which I discussed with local NGO staff and UPs what they regarded as the main barriers to adaptation at grassroots level in my study areas.

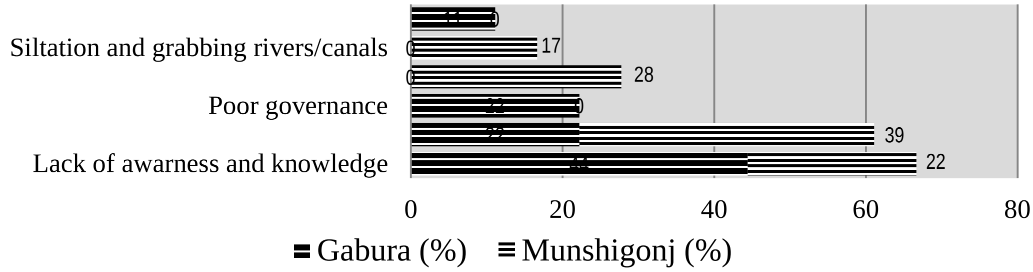
The field staff of several NGOs working in the area were asked to note the issues that affected local adaptation and to prioritize them on a five-point scale as a major problem, a problem, minor problem, not a problem and no idea. Based on this prioritization, they ranked siltation and grabbing and conversions of rivers and canals as the top most barriers to adaptation as these led to scarcity of water, drainage congestion, loss of freshwater fisheries, and loss of agriculture production due to shortage of water for irrigation (Figure 9.8). In this respect, their experiences mirrored those of the communities as discussed in the section on CPR. NGO staff emphasized that without proper water management for the production and extraction sectors, local level adaptation was difficult. For example, Fultala, being a rice farming dominated village, needs water management to provide water storage for the dry season crop and effective drainage of excess water during the monsoon to avoid flooding and crop loss. The leasing of the canal and subsequent conversions permanently damaged the water management system that existed in the past. NGO staff also mentioned increased banditry in the SRF as a barrier to adaptation. Other than these common areas, they also noted several other barriers to successful adaptation. These were lack of local awareness on weather issues, knowledge and skills on adaptation methods and approaches (see also Chapter 5, Chapter 8), poor prices for farm products, high prices of farm inputs, and the non-availability of quality crop seeds and fish fingerlings /shrimp PL. Other barriers were lack of coordination among relevant government agencies, lack of information on weather or climate change at the local level, and poor coordination among the relevant institutional actors.

More generally, NGO workers pointed out that development agencies and local actors had yet to fully grasp the importance of linking weather/ climate change concerns to development planning. The local UP members also identified barriers to adaptation from their own perspectives (Figure 9.9). They emphasized lack of knowledge, understanding and skills to tackle weather change issues as the highest ranked barrier among others, which is consistent with the perspectives of NGO staff.

They ranked lack of funding as the second main barrier. The UP members of Gabura union mentioned poor governance as a major barrier to successful development and adaptation and referred to the corrupt practices in embankment rehabilitation works done in 2009-2011 and in relief distribution systems in the area. Similar to NGO staff, they talked about siltation and grabbing of rivers and canals in the area as one of the barriers for effective adaptation. Being local government representatives, the UP members in Gabura Union identified the gap in understanding and coordination between local and central government as one of the main barriers. UP members in Munshigonj considered local environmental issues such as high salinity as a major barrier to successful adaptation. This was based particularly on their experiences of the impact of cyclone Aila in 2009 and it’s after effects.

In summary, the barriers to adaptation mentioned by NGOs and UP members included the following. First was the need to provide enabling legal, policy, institutional and good governance processes, which were lacking for planning and implementing of effective adaptation at all levels. Second, there was a lack of awareness, knowledge and information on weather, climate and technologies related to adaptation methods, processes and tools. Third, they identified poor institutional coordination and readiness among relevant public and private actors to adapt to weather/ climate hazards. Finally, there was a lack of funds for adaptation actions and the low priority given to weather /climate issues at all levels. The new Bangladesh Climate Change Trust Fund was established by the Government of Bangladesh to demonstrate adaptation actions but it did not sanction any projects for the high salinity prone cyclone affected Shyamnagar area.

Figure 9.9: UP members understanding of barriers to adaptation: a survey of UP members was conducted in 2012 (n=24)



Using Moser and Ekstrom's framework (Moser and Ekstrom, 2010), most of these barriers were related to the actions of local actors such as sub-district level government officials, UP representatives and NGOs who managed development and adaptation planning and who brought to their task particular understandings, priorities, attitudes and practices of adaptation. Some barriers were related to the wider governance context within which adaptation activities took place. These were poor compliance with state laws and acts, increased banditry, and the authoritarian management of SRF by the FD, which excluded other relevant government agencies and local actors in the governance process. Another set of barriers were related to the wider socio-ecological context in which adaptation will take place. This context has been heavily impacted by various exogenous and endogenous interventions described in detail earlier that have, for the most part, had negative impacts on local social-ecological systems and compromised future adaptation planning. These include the widespread conversion of rice paddies to shrimp farms, water diversions from upstream rivers, land and water grabbing and conversion of rivers, canals and wetland to new uses (see Chapter 4).

Based on the multiplicity of problems and barriers discussed below is provided an index to depict the picture on local "adaptation readiness" status for the project area.

Local Adaptation Readiness index

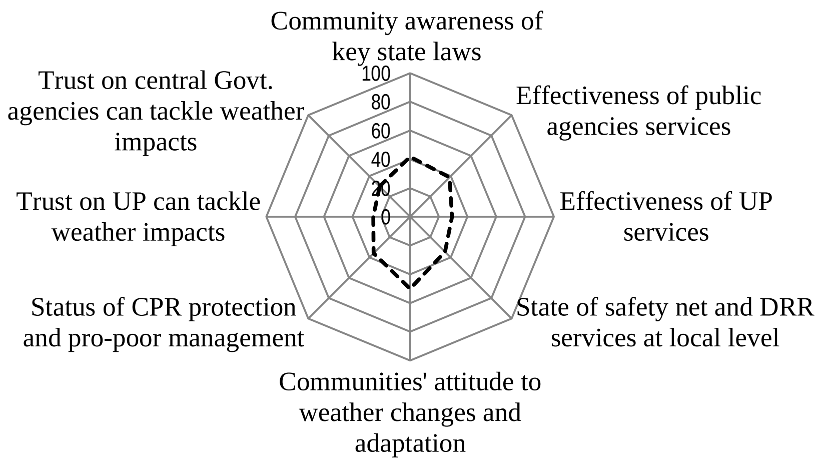
These findings support the argument that the local communities are not ready to take effective adaptation to changing weather induced environmental changes and that new approaches are required. To visualize the current status of adaptation readiness, I developed a readiness index to help judge the status of each of the six local readiness factors in comparison to others. The index was based on scores given to sub-factors under each braod factor and expressed as a percentage against the maximum possible 'score' one factor could get (Appendix 2). The scores for each factor ranged from 0 to 4 where 0 represented the worst status and 4 the best status. After cumulating the sub-factor scores under each factor, an aggregated score was obtained which was then expressed as the percentage of the total maximum possible score one factor could obtain. For example, appendix 2.a shows that the total aggregated score obtained on the broad factor on "awareness of laws and acts by the local communities" that influence their livelihoods is 10 which is 41.67% of the maximum total score of 24 that could be obtained if all six sub-factors under this broad factor received the maximum score of 4 on each. A sub-factor scored 4 when over 60% of people stated they were aware of the laws and acts. Through this method I calculated the aggregated scores of each of the 8 broad factors (see Appendix 2).

Figure 9.10 shows that the current adaptation readiness of the local communities is very poor. This makes it more likely that adaptation planning will be difficult to implement and may even be maladaptive.

For many local people, it was the structure of local governance and government that constituted the greatest barrier to effective change in the local area. In particular, they considered that official collusion in corrupt practices during cyclone-related relief distribution and recovery activities had undermined their confidence in the capacity of government to work effectively with them.

Summary

Figure 9.10: Local adaptation Readiness scores based on community responses (n=90): a villagers survey was conducted in 2012



This chapter has shown that communities and local government representatives have limited awareness of various state laws and acts that govern local development issues. Local communities underscored poor governance and low performance of different public-private agencies, including local government bodies, in delivering their mandated services such as safety net and disaster risk reduction benefits and supports to the local communities. This resulted in increasing vulnerability as opposed to building adaptive capacity. Banditry and bribery inside the SRF increased fisher and resource collector vulnerabilities and led to continuing destruction of the fragile SRF resources, which, in turn, negatively affecting local social-ecological resilience.

Local communities did not see tackling the challenges of changing weather patterns as their main priority, stressing instead the need for action on more pressing non-climate related local concerns. The local CPR bases had been seriously impacted due to private leasing, land grabbing and conversions that excluded the poor communities. They were deprived of access to various ecosystems services and lost the opportunity of adapting to climate impacts through ecosystem based approaches to adaptation. Local people stated they had lost their trust in local and central government agencies and regarded them as corrupt and inefficient.

Community experiences of local barriers to adaptation were similar to those of local NGO staff and UPs. The majority of NGO staff identified land leasing policy, canal grabbing, privatisation and conversions as key barriers to adaptation as these excluded poor people from productive use of these resources, caused a scarcity of freshwater, increased salinity and drainage congestion, affecting land productivity. They also mentioned increased banditry inside the SRF as a barrier to ecosystem based adaptation and which pressured the poor to overharvest SRF resources and further degrade the forest. Some stated that other barriers to successful adaptation were the lack of coordination and sense of common purpose among various government agencies and NGOs,a lack of information on climate change, the non-availability and high price of production inputs, and a lack of funds. Overall, the findings support the view that local communities' lacked "readiness" to adapt to weather adversities, which impeded prioritization, planning and implementation of effective adaptation at local level.

The next chapter summarises the study's main research findings and discusses their implications for future research and adaptation policy.

Chapter 10:
Summary and Conclusion

The research examined local understanding and responses to weather/climate induced threats on local environments and livelihoods in the coastal zone of Bangladesh. It was argued that such research is important in the light of the difficulties of identifying the precise effects of weather induced threats in the short term, and the subsequent importance of prioritizing local adaptation actions under conditions of climatic uncertainty. It was also argued that weather and weather-related changes are two factors among many that have shaped the lives and livelihoods of local people and that such changes have entered their everyday life-worlds. Attention was also given to the impacts of past development interventions upon the two villages current socio-ecological conditions. It was shown that local people's understanding of weather is grounded largely in their local experiences and that such experiences consist of a complex interaction between weather- and non-weather-related events and processes. This fact makes it difficult for both local people and the researcher to attribute any local changes specifically or precisely to particular weather events and processes. In addition, weather and non-weather events and processes have variable impact across and within the two study villages such that generic adaptation prescriptions may not be realistic to tackle weather induced threats.

Context Specificity and Local Priorities in an Age of Climate Change

It was argued that when researching the impacts of weather and weather-related events and processes on the two study villages, it is important to recognize that the villages have their own socio-ecological histories stretching back over decades and centuries. Of particular importance in these histories is the impact of post-1950 development interventions on village society and economy, which occurred prior to official and expert attention being given to the question of climate change adaptation (elaborated in Chapter 4). These impacts include the construction of roads, polders and water control structures, the conversion of wetland to other uses, changes in land and waterscapes and water flow regimes. The impacts of these changes have been uneven, affecting some groups more than others in both positive and negative ways.

In particular, the livelihoods of the poorer members of both villages were shown to have been negatively affected by reduced freshwater flows, salinity intrusion, land use change associated with the shift to shrimp farming, and also the appropriation of land by wealthier and more powerful community members, loss of river navigation, and reduced biodiversity. These changes have been occurring for decades and even centuries and the origins of some of them lie outside the present-day borders of the country.

A particularly serious problem faced by members of the two villages was high salinity. The causes of high salinity in the southwestern coast were shown to be the result of a combination of weather (sea level rise, drought) and non-weather (upstream water diversions, grabbing and conversion of coastal rivers/canals, shrimp farming, failure of coastal polders) related factors. The introduction and spread of shrimp farming reduced the share cropping and wage laboring opportunities that landless workers and marginal farmers had enjoyed under an earlier rice farming regime. The reduction in such opportunities had a knock-on effect as many became fishers and scavenged in the SRF, which created extra pressures on fish and forest resources. The excluded poor who had once been the allies of landed farmers gradually turn into rivals of shrimp farmers, which manifested itself in various ways, including the growth of individual and organized opposition to the shrimp farming regime. Capture fisheries saw a decline in catches and the private leasing and conversions of *khas* wetland (rivers, canals and beels) to individuals reduced the amount of common pool resources available and changed the agro-ecological character of the region. The permanent loss of wetland (rivers, canals, roadside borrow pits) resulted in a scarcity of freshwater for fisheries, agriculture, biodiversity and other community uses in the dry season and caused localized drainage congestion. For example, in the case of agriculture, land grabbing,conversion and privatization of canals and road side borrow pits in Fultala village restricted farmers' use of freshwater for irrigation and thus reduced the dry season farming areas and yields. This affected food security and livelihoods which, in turn, reduced adaptive capacity. The study findings confirm that all these changes, which can be linked directly and indirectly to past exogenous and endogenous development interventions, collectively disrupted local environments and the social and economic lives of local people, with negative implications for their local adaptive capacity.

Recent changes in weather patterns have further affected local environments and livelihoods, which were discussed in Chapter 5 and 6. The combined effects of development interventions and weather-related changes have become part of the everyday practical consciousness of local people, which is expressed in various ways. For example, when local people talked about the causes of embankment breaching, they complained about the weak performance and corrupt practices of the official agencies tasked to deal with such concerns (a non-weather factor),which made local people more susceptible to strong waves and storm surges. In addition, they drew attention to the growing frequency and intensity of cyclones along with storm surges and abnormal tidal heights of high tides (weather-related factors), which seriously weakened and destroyed embankments, homes and property. This example illustrates the more general point that weather changes and their impact are mediated by the socio-political structure of local communities and their variable capacity and readiness to respond to such changes and impacts. In this instance, the risk of embankment breaching was increased in recent times as a result of changes in the weather interacting with local non-weather factors. A clear lesson to be drawn from this example is that attempts to mitigate such weather events and processes require a multi-factorial policy approach that includes non-weather stressors.

The study also revealed that while climate change is a major topic of discussion and debate among national and international policy makers, its full implications have yet to filter down to the everyday lives of the people of the two study villages. One reason for the lack of local awareness is the abstract nature of the issue, its remoteness from their everyday lives and their preoccupation with the everyday problems of ensuring livelihoods for themselves and their families. While there have been NGO orientation sessions and occasional visits of government officials to create greater awareness of the issue, these have been limited and those making presentations were not always well-versed in the complexities of climate change and its impacts.

However, local people understood better the localized impacts of weather as knowledge of weather factors were embedded in their livelihood activities such as farming, aquaculture, and fishing operations. They spoke of changes in local weather patterns in recent years but offered a diversity of views as to causes. They were particularly knowledgeable of how changing weather patterns impacted on their livelihood activities, providing their own interpretations, concerns and options to respond and make adjustments to such changes (see Chapters 5, 6 and 8). The inadequate knowledge of UP members, local NGO staff and primary school teachers on climate change issues poses a particular challenge for local communities as these groups are often considered to be local change agents who provide a link between the national and international levels and grass roots activities.

An important finding of the study relates to the differential knowledge of local changes in weather among different occupational groups. All groups regarded weather as becoming more unpredictable, but the ways in which that unpredictability impacted upon them varied. While reporting weather stressors, different occupational groups had different priorities and concerns based on the sensitivity of their livelihood options to specific weather stressors. For example, drought was of greater concern to rice farmers than fishers in the same village. Frequent rough sea conditions were of much greater concern to sea going fishers while a temperature rise linked to post-monsoon drought affected honey collectors more. Two conclusions can be drawn from these observations.

First, before assessing climate change impacts and planning for adaptation there is a need to carry out a thorough contextual analysis of a given geographical setting taking into account the effects of past and ongoing development interventions, policy directives and institutional responses on local social-ecological systems. Such an analysis should include the extent to which such effects influence weather induced perturbations and the ways in which local people's world views shape their responses to such coupled weather and non-weather related issues. Second, robust efforts are necessary to educate the many border or mediating organisations and groups such as NGOs and government officials and local government bodies on the issue of climate change and the ways to tackle weather or climate induced impacts at the local level.For example, weather/ climate change information centres could be established to assist local communities learn more about weather/ climate change issues, impacts and adaptation strategies.

The research revealed that the impact of changing weather on people's livelihoods even where communities were located geographically and climatically close to each other. The livelihood vulnerability indices showed that the people of Chakbara were more vulnerable to specific weather stressors, had more sensitive livelihood options and weaker adaptive capacity compared to the people of Fultala. Weather impacts also varied between occupational groups living within the same place-based communities in a given geospatial context. This finding suggests three directions for climate /weather vulnerability research and adaptation planning.

First, planners must recognize that place based communities contain diverse livelihood and occupational practices and community members relate to their socio-ecological environments in different ways. Second, communities that appear to occupy the same 'ecological space' in fact vary widely due to differences in land use patterns, production systems,resource endowments, effectsof past development interventions, institutional and policy responses, levels of knowledge, skills and awareness and disaster exposure. Third, as a result of these previous comments, adaptation options, preferences and priorities will vary within and between place-based communities in a given area as a result of varied levels of vulnerability as well as varied occupational patterns even if they share common geographical, administrative and hazardous landscapes in a coastal sub-zone. However, this is not to deny that there may be scope across and within communities for some generic application of adaptation options such as capacity building, education, awareness generation, and disaster warning systems.

Making adaptation happen on the ground: from coping to adaptation readiness

Local communities in the two project villages had tried to make adjustments to weather related stressors and extremes in various ways using their own initiative as well as with the support of outsiders. Following the cyclone Aila in May 2009, the people of Chakbara left their homes and moved to make-shift shelters on embankments where they remained for up to 18 months or as long as the village was inundated with saline water. We can refer to this as an autonomous, partly individual and collective response to weather extremes.This immediate response was followed up with other actions designed to provide longer term protection (see Chapter 8). These actions included the renovation of cyclone induced saline contaminated ponds for freshwater, fish culture and other household uses; the de-contamination of shrimp *ghers* by removing bottom soil and organic debris carried in by the cyclone and storm surges; the construction of house plinths to avoid flooding from tidal surges and rain-based flooding; changes to fishing gear and fishing locations to avoid increased tiger attacks inside the SRF resulting from a decline in tiger prey; changes in fishing locations as the cyclone degraded old fishing grounds through siltation; the regular monitoring of water salinity of shrimp *ghers* and the cooling of water using aquatic vegetation to counter increased water temperatures and salinity levels, which killed shrimp and fish; and the cultivation of salinity and flood tolerant rice varieties to adjust to increasing soil salinity and rain based flooding.

These adaptation actions formed part of what can referred to as resilience building exercises. The adoption of new varieties of rice seeds, improved technologies in rice farming and shrimp aquaculture such assalinity monitoring, maintenance of higher water levels in shallow *ghers* and contacts with government agriculture extension officials are good examples of what Pelling (2011) calls adaptation as resilience and what Kates et al. (2012) refers to as incremental adaptation.

The research suggests that while the adaptation measures taken provide some assistance to local communities in the short term, they lie at the coping end of the adaptation continuum and are unlikely to provide longer term adaptation benefits. For example, the renovation of shrimp *ghers* and ponds will likely be offset if another cyclone visits the area or the embankment is breached due to high tides. The poor and sometimes corrupt governance system, as seen in failures to apply national laws and acts and the uncoordinated performance of different relevant government agencies, hinder or even subvert effective adaptation on the ground. Currently there is no programme in place to achieve greater local readiness to facilitate improved adaptation planning and implementation.

Future adaptation planning for the study area requires consideration of the following two factors. First, without proper embankment strengthening, the provision of regular operational and maintenance systems, the funding to underpin such efforts and greater community engagement, there will be much greater risk of embankment breaching and consequent flooding, which would outweigh any adaptation benefits. Likewise the saline and inundation tolerant late varieties of rice alone cannot guarantee a safe harvest and longer lasting adaptation benefits without the availability of freshwater, pest management, drainage improvement, access to quality seeds, agricultural inputs and technologies and enabling markets.

Second, the heavy dependence of local people on ecosystem goods and services means that akey principle of adaptation should be to improve, protect and maintain such goods and services through the adoption of a more ecosystem-based approach to adaptation (CBD, 2009; MEA, 2005). As weather stressors affect ecosystems directly and via the livelihood practices of local people, adaptation planning should encompass a physical ecosystem or inter-connected ecosystems (cropland-wetland-mangrove-seascape or a wider landscape) with clearly defined social and ecological boundaries. Specific adaptation actions need to be designed based on comprehensive weather vulnerability assessments with the active participation of local communities.

The study also drew attention (see Chapter 9) to the need to assess the local level ‘adaptation readiness’ that would help facilitate adaptation to take place on the ground (Ford and King, 2013). The effective planning and success of adaptation actions depend upon certain institutions and processes being in place. These include relevant and implementable policies and legal mechanisms, local and national actors able to deliver their mandated services, and community awareness and willingness to prioritise adaptation. Adaptation readiness also refers to more than being prepared for weather/climate related hazards and stressors. It means taking an integrated development-climate approach to encompass both weather and non-weather-related events and processes.

However, the study showed that most villagers were unaware of, ignored or felt powerless in the face of the legal framework that governed aspects of land and water use and the management of coastal natural resources, ecosystem services, sustainable livelihoods and disaster risk reduction. They expressed considerable frustration with the activities of some of the relevant government agencies such as BDWB, FD, DoF, DAE, and the local *khas* land management authority responsible for overall management of coastal resourcesand disaster risk reduction. For example, it was shown that due to the BWDB’s negligence and venality in performing its mandated duties, local influential shrimp farmers were able to flout the law and act in ways that subverted local actions aimed at protecting local people from floods and salinity. The field level land department officials, working with UPs and the local administration, illegally leased out *khas* canals to individuals on a long term basis. Such actions affected local production systems, local food security and reduced people’s confidence and trust in government.

What these comments suggest is that single purpose actions such as introducing salt tolerant rice varieties, repairing an embankment or building a home on plinths are not simply technical exercises but are embedded within a political and economic system that in its current form is not capable of delivering good governance, greater equity and enhanced local engagement in the task of building resilient communities.

Contributions of the research to theory

In chapter 1 I reviewed relevant theories around multiple aspects of vulnerability and dimensions of adaptation to moderate climate induced risks. From the theoretical perspective vulnerability is viewed as ‘susceptibility of a system to harm when exposed to hazard events’ (UNDRO, 1980; Wisner, 2002; Cutter et al., 2003; UNISDR, 2004), as ‘potential for change or transformation’ when confronted with a perturbation rather than the outcome of a perturbation (Gallopin, 2006) and as ‘capacity to be wounded and react adversely’ (Kates, 1985) when exposed to hazards. Anthropogenic climate variability and change as a new generation of threatshas influenced theories of vulnerability and given rise to more diverse foci of analysis in the understanding of the scale and extent of vulnerability in order to moderate harm. One major shift in vulnerability thinking is broadening of its scope and scale to accommodate socio-economic aspects of vulnerability in addition to biophysical ones (Blaikie et al., 1994; Cutter, 1996; Wu et al., 2002;Adger, 2003; Pelling, 2011).

My research in two place-based communities in remote areas in the southwestern coastal zone of Bangladesh drew upon the change in ways of assessing livelihood vulnerability of local communities to weather induced stressors and found them useful in understanding the core determinants of vulnerability.It also contributed to a widening of the scope of inquiry to see vulnerability as the product of place-based and temporal factors as proposed by Cutter (1996). For example, cyclone Aila hit in the project site in May 2009 and caused severe losses to shrimp farmers as at that time the shrimp *ghers* of Chakbara were fully stocked and destroyed by surge water. While in Fultala the rice farmers were not so severely affected as the cyclone struck before the rice farming cycle. Thus, temporal and spatial dimensions of hazard impacts are important phenomena that determine the degree of vulnerability differently for different occupational groups in different time scales even if they live within the same geographical location. Based on the context of my research area and hazard-vulnerability-impact nexus, it is necessary to add two more dimensions in the assessment of vulnerability to weather related stressors, in addition to hazards of place. These are the time of the hazard, which means when a hazard strikes, and the corresponding land use of a place at the time of the hazard strike. I have shown these linkages in Figure 10.1.

On the first issue, the study showed that the temporal dimensions of hazard impacts need to be refined to capture the processual nature of weather and climate impacts. Field observations revealed that the level of exposure and sensitivity of a system to hazard events are not limited to the immediate and direct effect at the time of a hazardbut can last for years, making people vulnerable on a continuing basis. For example, after cyclone Aila, rice farmers of Fultala village experienced losses of rice production due to salinity infestation of soil and water resulting from the residual effects of saline water inundation from surge water. This lasted for another two years from the time of the cyclone's first impact. In the case of Chakbara, the increased salinity of soil and water post cyclone did not have such harmful effects as over 95% of land wwas under salt water due to shrimp farming. These findings have implications for widening the theoretical dimensions of climate vulnerability as well as climate-induced loss and damage research landscapes.

Another new conceptual dimension relevant to future research and planning is the concept of local level "adaptation readiness". A recent pioneering work of Ford and King (2013) sheds light on the theoretical perspective of "adaptation readiness" at

Figure 10.1: Relationship between hazard of place, time of hazards , land use of place and extent of damage (source: based on my study findings)

the national level that provides a starting point for future research. During the field work several observations I made prompted me to apply the idea of adaptation readiness to the field sites.

First, local understanding and execution of various state laws and acts that support local development were observed to be inadequate and weakened local adaptation readiness. For example, the embankment protection act was routinely violated by shrimp farmers who breached embankments to obtain water for shrimp *ghers*, which increased salinity of adjacent rice fields as well as weakened the protective function of embankments. Another example is that of the *khas* land distribution act, again violated through illegal allocation to local influential[29]. The government ban on crab harvesting from SRF in January and February to allow natural breeding was seldom respected.

Second, the activities of mainstream development agencies were inadequate. Farmers in coastal saline affected areas continued to use traditional rice varieties that do not perform well in saline environment but the DAE had provided little support in the form of saline tolerant varieties that were available in the country.

Third, it was observed that local community attitude to climate change adaptation was not a priority issue over other traditional development schemes. This meant that people were discouraged from taking longer-term actions necessary in the light of projected weather changes in the area linked to climate change. Fourth, widespread corruption by the local government-central government agencies and NGOs (including international NGOs) deprived cyclone affected peoples and delayed the recovery processes. This is an urgent area of research as without proper leadership based on a reform of governance practices at all levels, there is likely to be little in the way of a systematic and widespread approach to climate change adaptation (Mahmud and Prowse, 2012).

Policy implications

The research findings have several implications for climate and development policies in Bangladesh. The study has shown that past development policies and practices led

[29] Under existing *khas* land related act, flowing canals cannot be permanently leased to individuals – only cultivable *khas* land can be given to landless households for agricultural purposes.

to increases in the vulnerability of the communities studied and indirectly made it more difficult for climate adaptation policies to be implemented. An effective climate adaptation policy requires a reconsideration of past development practices to make them more compatible with future adaptation strategies. The study findings on community awareness and understanding of climate change issues, capacity for planning and implementation of adaptation actions provide empirical grounding for a more reflexive approach to policy making. For example, the assessment tools used in the research to assess the climate induced livelihood vulnerabilities of the two communities have high potential to be used in local, sub-national and national level climate vulnerability assessments through the design of site specific climate impact based adaptation strategies and actions. The findings on the lived experiences of local people in dealing with weather and non-weather stressors can be of value to mainstream adaptation planners and managers in shaping broader adaptation assessment methods, strategies and action plans. However, the capacity to adapt and the means available to do so were more than technical capabilities. They were embedded within wider social, economic, political and ecological structures and processes that both set limits upon and provided opportunities to their capacity to act.

Adaptation Readiness

The study sought to assess the ‘adaptation readiness’ at the local level to determine the degree and type of preparedness of local people, NGOs and government agencies to take adaptive actions. It argued that adaptive capacity needs to be complemented by adaptation readiness as a tool for determining to what extent local people and local development actors are actually ready to take adaptive actions. Such an approach has the potential to reduce the risk of mal-adaptation.

Common Property Resources, Environmental Spaces and Ecosystems-based Adaptation

Over the last thirty years most of the Common Property Resources such as *khas* wetland, roadside borrow pits, char land and cultivable land have been lost or privatized, which has deprived poor people of access to basic subsistence resources. The privatization, conversion and degradation of wetland CPRs and the ecosystems that underpin them were facilitated by state and local government officials working directly or indirectly with local politicians and local elites. While many of these

CPRs have been lost, there is a need for government to re-think its land and water tenure policies to help revitalize the remaining CPRs and make available environmental spaces for community uses and public easementin disaster situations or other crises. In the coastal region, the availability of freshwater for drinking, aquaculture, bathing, irrigation, and other household uses has been greatly affected by increasing salinity such thatthe only usable sources left are canals and private ponds where access is restricted. Under such circumstances, policy priority should be given to bringing back wetland CPRs and restoringthem for direct and indirect community multipurpose uses. The study findings suggest that there have been opportunities for implementing ecosystems-based adaptation (EbA) to climate change for wider community benefits in the coastal areas through restoration of wetland and mangroves involving local communities (Caritas, 2011). The UK DfID has sought to demonstrate the importance of community access to natural resources through its climate resilient farming systems programme that facilitates access to *khas* land for the extreme poor in the coastal and northeastern haor[30] areas of Bangladesh (Shiree, 2012). Coastal areas have high potential for *khas* land-based adaptation programmes to build resilience of the extreme poor if such land are restored, protected and access arrangements made.

Future Research Directions

Based on the findings of this study, four areas for future research are of particular importance.

Adaptation governance– political economy of DRR and CCA

While conducting my research several governance issues surfaced related to planning, operation and management of disaster risk reduction and climate change adaptation activities at the field level. Of critical importance for future examination are the institutional coordination among multiple actors, the quality of services linked to their mandated responsibilities towards the needs of affected communities, and equitable and pro-poor approaches in responding to disaster vulnerability and climate change adaptation. The outcomes of this research have potential to inform

[30] Vast low lying basins in the northeastern Bangladesh remain under water for 5/6 months of the year during monsoon and a single cropped area (farmers can grown on winter rice in the dry season).

and influence policy stakeholders to formulate policy documents and create effective environments that facilitate greater attention to pro-poor sustainable adaptation programmes for countries such as Bangladesh where the overall standards of governance are questionable.

Environment induced migration/displacement

While the research did not examine in detail the role of migration as an adaptation strategy, it is clear Bangladeshis have historically migrated to domestic and international locations to meet livelihood needs. In the two villages, people migrated seasonally when local jobs opportunities were limited. The drivers of migration includedthe damage to shrimp *ghers* and rice farms due to cyclone Aila, the decline in job opportunities in rice farming as a result of shrimp farming, and wider regular and abnormal flooding events that undermined the capacity of many farmers to sustain their livelihoods. People also mentioned recent increases in tiger attacks and bandits inside the SRF, which contributed to pressures to find alternative income sources outside the local area. In the light of growing international concerns about future climate-induced migration, more detailed empirical work needs to be done on the link between climate change, environmental degradation and migrations in highly vulnerable areas such as the coastal and deltaic parts of Bangladesh. Such work has the potential to inform policies that seek to establish a balance between planned migration and the local retention of people in their original homes.

Estimation of loss and damage due to climate change impacts

I witnessed the massive loss and damage to assets and resources as well as disruption of employment opportunities due to cyclone Aila in two project villages. The loss and damage was very high in Chakbara where every household was affected and experienced adverse impacts of cyclone which were manifested as damages to homestead land, houses, fish ponds, shrimp *ghers*, crops and vegetables. In addition, common facilities and resources such as embankments, roads, canals, freshwater fish, and water sources were severely impacted. In contrast, Fultala, though located only 11km away from Chakbara, experienced far less damage due to its geographical location and exposure to hazard events. Local people reported both instant loss and damage as well as residual effects of disaster that continue to damage crops and income of people even two to three years after the cyclone.

Besides climate extremes such as cyclones and storm surges, local people experienced loss and damage due to the slow onset of impacts of weather induced perturbations and stressors such as prolonged drought or *lamba khora* (loss of crops and aquaculture), intense rain based flooding or *akash bonnaya* (crop damage and loss of fish and shrimp from aquaculture), rough sea conditions or *shagor kharap* (loss of fishing efforts in lower estuary and sea) and salinity of new areas (loss of crops and grazing land).

There remains a lack of comprehensive methodologies for assessing risk of loss and damage due to both rapid and slow onset weather/ climate induced threats to local social-ecological systems that impair effective adaptation planning. Such assessments need to cover various sub-sectors such as settlements, infrastructures, water resources, agriculture, fisheries aquaculture, natural assets, and biodiversity, health and income opportunities as well as across organizational geographical, temporal and other scales

Ecosystems vulnerability to climate change impacts

My research focused on social aspects of climate change and conducted a livelihood vulnerability assessment for two project communities that revealed the extent to which the two place-based communities were disproportionately exposed and sensitive to weather and weather-related impacts and what local capacities they possessed to deal with them. A high proportion of local people were directly dependent on the ecosystem services and products of the SRF which is highly vulnerable to sea level rise as well as to other land-based changes in land and waterscapes in Bangladesh and in surrounding countries, particularly India. To protect local ecological systems and the people who depend on them requires a multi-scalar approach that recognizes that climate change knows no borders and that the ability of local people to thrive depends as much on actions taken nationally and internationally as those taken at the local level.

There is an urgent need to reframe current climate change and development research paradigms in terms of the mutually constitutive nature of social and ecological systems and to recognize that these relationalities transcend the local. There is only so much local communities can do to improve their chances of thriving in the face of globally induced climate change. The research has shown how unprepared local people are for the slow-working and slow-acting impacts of climate change and that a key reason for this is the slow-working and slow-acting nature of governments, aid agencies and NGOs.

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Appendices

Appendix 1: Calculating the LVI: composite index approach

Several indicators under each of the seven major vulnerability components are considered to calculate the LVI of two study villages. The major components are Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water and Natural Disasters & Climate Variability of the area. These were developed based on local situations. Table 1 shows the major components, indicators and explanation of how each sub-component were quantified, the survey question used to collect the data. The LVI uses a balanced weighted average approach (Hahn, et al, 2009; Sullivan et al., 2002) where each sub-component contributes equally to the overall index under each major component that comprises multiple sub-components as such the LVI formula uses the simple approach of applying equal weights to all major components. Since each sub-component is measured on a different scale, standardization was done by using equation adapted from the one used in the Human Development Index to calculate the life expectancy, which is the ratio of the difference of the actual life expectancy and a pre-selected minimum, and the range of predetermined maximum and minimum life expectancy (UNDP, 2007):

$$Index_{s_v} = \frac{s_v - s_{min}}{s_{max} - s_{min}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where s_v is the original sub-component for village v, and s_{min} and$s_{max}$are the minimum and maximum values respectively for each sub-component determined using data from both villages. For example, the ‘average time taken to collect drinking water’ sub component ranged from 5 to 180 minutes in the two study villages. These minimum and maximum values were used to transform this indicator into a standardized index to be integrated into the water component of the LVI. For variables that measure frequencies such as the ‘% of households drink water from open ponds (unsafe),’ the minimum value was set at 0 and the maximum at 100. Some sub-components viz. ‘average agricultural livelihood diversity index’ were created because an increase in the crude indicator, the number of livelihood activities undertaken by a HH, was assumed to decrease vulnerability assuming that a HH who grow rice and do aquaculture is less vulnerable than a household who only grow rice.

Table 1: Major components and sub-components of Livelihood Vulnerability Index (LVI) for two villages in project area

Major components	Sub-components	Explanation	Interpretation for LVI	Source of Data
Socio-demographic profile	Dependency ratio	Dependent population : aged below 14 and over 60 years	Lower the dependent population greater the adaptive capacity	Household census
	Percent of female-headed households/ female member maintain and take care of the family	Women-led HHs (husband either ill, died or left)	Lower % of such HHs, higher adaptive capacity	Household census
	Average age of female head of household	Young women generally have less HH management capacity	Lower % of such, higher adaptive capacity	Household census
	Percent HHs where head of HHs did not attend school	No literacy and numeracy skills of heads of HHs	Lower % of such HH, higher the adaptive capacity	Household census
	Percent HHs have members with no functional education	None of the HH member has minimum education level	Lower % of such HHs, higher the adaptive capacity	Household census
	Percent HHs have female with no functional education	None of the female HH member has minimum education level	Lower % of such HHs, greater the adaptive capacity	Household census
	Percent HHs have girl child aged 10-19 years	This age of girl child is generally more susceptible to abuse	Lower % HHs have girls of this age have higher adaptive capacity	Household census
	Percent HHs have members need help from other to move	Physically challenged members are more exposed to disaster	Lower % HHs have physically challenged members have higher adaptive capacity	Household survey
Livelihood strategies and assets	Percent households with family member do not working in a different community	HH where any member go outside their locality for work /livelihoods	Higher % of such HHs, increases adaptive capacity	Household Survey
	Percent HHs dependent solely on agriculture as a source of income	HH income & livelihood security comes from only agriculture	Lower % of such HHs considered higher adaptive capacity	Household Survey
	Average agricultural livelihood diversification index (LDI)	The inverse of (the number of agricultural livelihood activities + 1) viz. A HH that grow rice, raise cattle, do aquaculture will have a LDI = 1/(3+1) = 0.25	Number of HHs with higher the LDI, higher the adaptive capacity	Household Survey
	Average profession of diversity index	The inverse of (the number of professions of a HH +1)	HHs with higher diversity, greater the adaptive capacity	Household Survey
	Average occupational diversity index	The inverse of (the number of earning members of HH +1)	HHs with higher no. of earning members, increases adaptive capacity	Household census
	Percent HHs have member did not receive any skill training	Skills training in different trades enhance capacity of HHs	Higher % of such HHs enhances adaptive capacity	Household census
	Percent HHs had to loss/ change previous occupation due to cyclone Aila	Cyclone Aila (2009) disrupted various local employment	Higher the no. of HHs lost previous employment after the cyclone lower the	Household Survey

Major components	Sub-components	Explanation	Interpretation for LVI	Source of Data
		opportunities	adaptive capacity	
	% of HH ad to borrow loan last year	HHs borrow loan from non-formal or formal sources in last one year	Higher no. of HH borrowed loans, lower the adaptive capacity	Household census
	% of HH Received *dadon* last year	HHs received *dadons* from mohajons in last one year	Higher no. of HH received dadon, lower the adaptive capacity	Household census
	% of HHs have no homestead land of their own	HHs have no land of their own for making dwelling house	Higher no. of HHs of this category, means lower adaptive capacity	Household census
	Percentage of HHs have no cultivable land of their own	HHs have no land of their own for farming	Higher no. of HHs of this category, means lower adaptive capacity	Household census
	% of HHs that do not have chicken/ducks	Women can supplement HHs with income from selling eggs, meats	Higher no. of HHs of this category, means lower adaptive capacity	Household census
	% of HHs that do not have goats	Women can earn extra by selling goats	Higher no. of HHs of this category, means lower adaptive capacity	Household census
	% of HHs that do not have cattle/cow	Having cattle, can have milk, cow dung to earn extra livelihoods	Higher no. of HHs of this category, means lower adaptive capacity	Household census
	% of HHs that do not have fish ponds	Having own or leased-in fish ponds ensure extra income	Higher no. of HHs of this category, means lower adaptive capacity	Household census
	Percent HHs do not have mobile phone	Having cell phone increase access to information, social contacts	Higher no. of HHs of this category, means lower adaptive capacity	Household survey
	Percent HHs do not have Radio and TV	Having radio and TV increase access to information	Higher no. of HHs of this category, means lower adaptive capacity	Household survey
Social networks/ safety net programmes	Average help receive: provide ratio	Ratio of (the no. of types of help received by a HH last year +1) to (the no. of types of help given by a HH to someone else last +1)	A measure of social bonding which helps HHs in crises and help build adaptive capacity	Household survey
	Percent HHs have not gone to local institutions for assistance in last one year	Local institutions include union and sub-district level public-private service providers	The lower the better signifies interactions between villagers and service providers	Household survey
	Percent HHs did not receive old allowances	Government provides cash money to old people from poor HHs	Increased access to this allowance is sign of good governance and increases adaptive capacity	Household survey
	Percent HHs did not receive VGD (vulnerable group development) allowances	Govt. support to poor through VGD schemes administered by UP	Increased access to VGD indicates good governance, adaptive capacity	Household survey
	Percent HHs did not receive VGF (vulnerable group feeding) allowance	Govt. support to poor through VGF schemes administered by UP	Increased access to VGD indicates good governance, adaptive capacity	Household survey
	Percent HHs did not work for ‘100days activity’	Govt. creates “100 days” jobs for poor during the lean period	Increased access activity indicates good governance, higher adaptive capacity	Household survey

Major components	Sub-components	Explanation	Interpretation for LVI	Source of Data
	Percent farming HHs did not seek farming assistance to others	Local public and private entities to seek farming supports	Higher social capital enabled HHs to share problems and seek assistances	Household survey
	Percent farming HHs had problems did not seek assistance from govt. extension agents	Contact fisheries and agriculture department for advice	Frequent contacts help getting more supports- higher adaptive capacity	Household survey
Health services	Percent HHs with family member suffer from chronic illness	Chronic Illness in HHs members suffered in last year	Higher % of such HHs indicates higher sensitivity to risks	Household survey
	Percent households where a family member had to miss school due to illness	Illness affected attending school in last one year	Higher % of such HHs indicates higher sensitivity to risk	Household survey
	Percent HHs have no water sealed/Ring Slab latrine	Water sealed latrine is safer – cause less health problems	Lower % of HH have water sealed latrine are more sensitive to risk	Household census
	Percent HHs have no latrine of their own	Ownership of latrines	Higher % of such HHs indicates higher sensitivity to risk	Household census
	Percent HHs have members suffered from diseases due to cyclone Aila	During after cyclone Aila people got sick and lost income	Higher % of such HHs indicates higher sensitivity to risk	Household survey
	Average distance to get health facilities at sub-district level	Distance from HH to health facilities	The greater the average distance higher the sensitivity to risks	Household survey
	Average time to reach health facilities at sub-district level	Time taken to reach health facilities	Higher the time taken grater the sensitivity to risk	Household survey
	Average cost of reaching health facilities	Average cost of reaching the health facilities from HHs	Higher cost of reaching health facilities greater the sensitivity	Household survey
	Percent HHs did not receive training on primary health care	Any sort of training on health and hygiene management	Higher the no. of HH received heath training lower the sensitivity to risks	Household survey
	Percent HHs did not immunize their children	Immunization can save children from some deadly diseases	Higher % of HHs immunized their children lower the sensitivity to risk	Household survey
	Percent of HHs have no member can prepare or-saline	Oral saline (or-saline) can save lives from diarrheal diseases	Higher % of HH able to prepare or-saline lower the sensitivity to risks	Household survey
	Percent HHs have member cannot work due to sickness on a regular basis	Due to idleness members of HHs cannot work and loss income	Higher % of HH have such member increased sensitivity to risks	Household survey
	Percent HHs have members suffered from diarrhea in last 1year	Diarrhea affect people to work and loss income, even could be fatal	Higher % of HH with such members increased sensitivity to risks	Household census
Food security	Percent HHs do not have access food grown on their own land	Dependent on market for food, lack access to farm land /farming	Higher % of such HHs increased sensitivity to risks	Household survey
	Average number of months HHs struggle to find food	No. of months HHs face difficulty to arrange food for the family	Higher no. of months HHs struggle for food increased sensitivity	Household survey
	Percent households that do not save crops	HHs save crops for lean period or crisis time	Higher % of HH do not save crops for lean period increased sensitivity	Household survey
	Percent households that do not save seeds	HHs save seeds for next cropping	Higher % of HHs do not save seeds	Household

Major components	Sub-components	Explanation	Interpretation for LVI	Source of Data
		seasons	increased sensitivity	survey
	Percent HHs faced scarcity of food	HHs face crisis times when unable to arrange food for the family	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not afford 3 meals a day during crisis period	HHs face crises may not be able to eat 3 meals a day	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not afford fish in their diet for more than 16 days per month	HHs that failed arrange fish for a single meal in 2 weeks	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not afford chicken/meat in their diet for more than 6 days per month	HHs that failed arrange chicken for a single meal in 1 week	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not eat chicken that raised in their own farm	HHs always buy chicken – do not raise chicken at home	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not afford egg for more than 6-10 days per month	HHs that failed to arrange eggs in their diet at every second day	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not eat eggs from chicken raised in own farm	HHs always buy eggs– do not raise chicken at home that lay eggs	Higher % of such HHs increased sensitivity to risk	Household survey
	Percent HHs could not afford milk in their diet in a month	HHs that failed to arrange milk in their diet in a month	Higher % of such HHs increased sensitivity to risk	Household survey
Water security	Average time taken to collect drinking water	Average time for HHs to reach drinking water sources	More time taken indicates higher sensitivity	Household survey
	Percent HHs do not have access to PSF (pond sand filter/safe water)	PSF provides safe drinking water in the coastal area	Higher % of HHs have access to PSF lower the sensitivity	Household survey
	Percent HHs drink water from open ponds (unsafe water)	Where people are to drink water directly from ponds - unsafe	Higher % of HH drink water from open ponds increases sensitivity	Household survey
	Percent HHs that do not have consistent drinking water sources - due to cyclone Aila	Cyclone Aila disrupted drinking water sources for varying time	Higher % of lost consistent supply from sources, increases sensitivity	Household survey
	Percent HHs could not collect drinking water from previous sources after cyclone Aila	Cyclone water collection from previous sources	Higher % of HH of such category increases sensitivity	Household survey
	Percent HHs do not have access to safe cooking water	Safe cooking water is also not readily available in coastal area	Higher % of HHs with poor access, increases sensitivity	Household survey
	Average time taken to collect cooking water	Average time for HHs to reach safe coking water sources	More time taken to fetch safe cooking indicates higher sensitivity	Household survey
Natural disasters and climate variability	Average number of flood, drought, cyclone events in last 6 years	All types bio-physical hazards communities experience	Higher the hazard events greater the exposure	Household survey
	Percent HHs did not receive warning messages on cyclone Sidr	Early warning messages to people to take preparedness measures	Higher % of HHs received warning messages, reduce the exposure	Household census
	Percent HHs did not receive warning messages on cyclone Aila	Early warning messages to people to take preparedness measures	Higher % of HHs received warning messages, reduce the exposure	Household census

Major components	Sub-components	Explanation	Interpretation for LVI	Source of Data
	Percent HHs had to leave their house due to cyclone Aila	HHs displaced due to cyclone Aila induced saline water inundation	Higher % of HHs had to leave houses, increases the exposure	Household survey
	Percent HHs had their homes inundated in last cyclone (Aila)	Houses got inundated due to the cyclone	Higher % of HHs had their houses inundated, increases the exposure	Household survey
	Percent HHs had their fish ponds inundated in cyclone Aila	Fish ponds got inundated with saline water due to cyclone	Higher % of HHs had their ponds inundated, increases the exposure	Household survey
	Av. months homesteads remained inundated due to cyclone Aila	Extent of inundation of homesteads	Higher % of HHs with homesteads inundated, increases the exposure	Household survey
	Percent HHs had lost previous occupation due to cyclone Aila	Cyclones disrupted livelihood options for people	Higher % of HHs had lost previous occupation, increases the exposure	Household survey
	Average diversity of damaged assets index during cyclone Aila	Average number of assets damaged during cyclone Aila (in 2009)	Higher the damaged assts, greater the exposure	Household survey
	Average diversity of damaged assets index after cyclone Aila	Average number of assets damaged after the cyclone Aila (in 2009)	Higher the damaged assts, greater the exposure	Household survey
	Percent HHs with disable or died due to Aila	Loss of life or disability due to cyclone	Higher % of HH experience dead or disability, greater the exposure	Household survey
	Average diversity of conflict index due to Aila	Any social conflicts during and after cyclone	More conflicting events increases exposure to disaster risks	Household survey
	Percent HHs did not store drinking water after receiving cyclone warning messages	Store drinking water for disaster period	Higher % of HHs store drinking water lessen the exposure	Household survey
	Percent HHs could not re-start vegetables production after 1 year of cyclone Aila	Cyclone borne salinity affected vegetables cultivation	Longer the salinity affected period greater the exposure	Household survey
	Percent HHs have members did not receive training in disaster management	Training on disaster provide skills of HHs to reduce exposure	Higher % of HHs received reduces exposure to hazards	Household survey
	Mean standard deviation of monthly average of average maximum daily temperature (years: 1950–2010)	60 years data of Satkhira (nearest station) was used (Bangladesh Met Department - BMD)	The higher the variability, greater the exposure to climate risk	Meteorological office data
	Mean standard deviation of monthly average of average minimum daily temperature (years: 1950–2010)	60 years data of Satkhira was used (collected from BMD)	The higher the variability, greater the exposure to climate risk	Meteorological office data
	Mean standard deviation of monthly average precipitation (years: 1950–2010)	60 years data of Satkhira was used (collected BMD)	The higher the variability, greater the exposure to climate risk	Meteorological office data

By taking the inverse of the crude indicator, a number is created that assigns higher values to households with a lower number of livelihood activities. The maximum and minimum values were also transformed following this logic and Equation (1) used to standardize these sub-components. After each was standardized, the sub-components were averaged using Equation (2) to calculate the value of each major component:

$$M_v = \frac{\sum_{n=1}^{n} Index_{s_v i}}{n} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

Where M_v = one of the seven major components for village v [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W), or Natural Disasters and Climate Variability (NDCV)], $Index_{s_v i}$ represents the sub-components, indexed by i, that make up each major component, and n is the number of sub-components under each major component. Once values for each of the seven major components for a village were calculated, they were averaged using Equation (3) to obtain the village-level LVI:

$$LVI_v = \frac{\sum_{n=1}^{7} W_{M_i} M_{\text{vi}}}{\sum_{n=1}^{7} W_{M_i}} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3)$$

which can also be expressed as

$$LVI_v = \frac{W_{\text{SDP}} SDP_{\text{v}} + W_{\text{LS}} LS_{\text{v}} + W_{\text{SN}} SN_{\text{v}} + W_{\text{H}} H_{\text{v}} + W_{\text{F}} F_{\text{v}} + W_{\text{W}} W_{\text{v}} + W_{\text{NDCV}} NDCV_{\text{v}}}{W_{\text{SDP}} + W_{\text{LS}} + W_{\text{H}} + W_{\text{SN}} + W_{\text{F}} + W_{\text{W}} + W_{\text{NDCV}}} \quad \ldots \ldots \ldots (4)$$

Where, LVI_v, the Livelihood Vulnerability Index for village v, equals the weighted average of the seven major components. The weights of each major component, W_{M_i}, are determined by the number of sub-components that constitute each major component and are included to ensure that all sub-components contribute equally to the overall LVI (Sullivan et al., 2002). The LVI is scaled from 0 (least vulnerable) and 1 (most vulnerable) and for clarification, the detailed calculation of water major component for the LVI for Chakbara village is presented in Table 2.

Table 2: Calculating the water major component for the LVI for Chakbara

	Sub-component values for Chakbara	Max sub-component values	Min sub-component values	Index value for Chakbara	Water major component values for Chakbara
Average time taken to collect drinking water	75.4	180	5	0.40	
Percent HHs do not have access to PSF (safe)	82.2	100	0	0.82	
Percent HHs drink water from open ponds (unsafe)	42.2	100	0	0.42	
Percent HHs that do not have consistent drinking water sources	28.9	100	0	0.29	
Percent HHs could not collect drinking water from previous sources after cyclone Aila	95.6	100	0	0.96	
Percent HHs do not have access to safe cooking water	86.7	100	0	0.87	0.594
Average time taken to collect cooking water	72.8	180	2	0.40	

Step 1 (repeat for all sub-component indicators):

$$Index_{Water1_{Chakbara}}(W1_{Chakbara}) = \frac{75.4-5}{180-5}=0.40$$

Step 2 (repeat for all major components)

$$\text{Water}_{\text{Chakbara}} = \frac{\sum_{n=1}^{n} Index_{s_v i}}{n}$$
$$= \frac{W1_{Chakbara} + W2_{Chakbara} + W3_{Chakbara} + W4_{Chakbara} + W5_{Chakbara} + W6_{Chakbara} + W7_{Chakbara}}{7}$$
$$= \frac{0.40 + 0.82 + 0.42 + 0.29 + 0.96 + 0.87 + 0.40}{7} = 0.594$$

Step 3 (repeat for all study areas):

$$LVI_{Chakbara} = \frac{\sum_{n=1}^{7} W_{M_i} M_{\text{vi}}}{\sum_{n=1}^{7} W_{M_i}} = \frac{8*0.285+20*0.586+10*0.528+13*0.478+12*0.701+7*0.594+17*0.521}{8+20+10+13+12+7+17} = 0.539$$

2.2. Calculating the LVI–IPCC: IPCC framework approach

Hahn et al (2009) developed an alternative method for calculating the LVI that incorporates the IPCC vulnerability definition. Table 7.2 (main text) shows seven major components in the LVI–IPCC framework. Exposure of the study population is measured by the number of natural disasters that have occurred in the past 6 years, while climate variability is measured by the average standard deviation of the maximum and minimum monthly temperatures and monthly precipitation over a 60-year period. Adaptive capacity is quantified by the demographic profile of a village (viz. percent of female-headed households), the types of livelihood strategies employed (viz. predominately agriculture based, or natural resources dependence), and the strength of social networks (viz. percent of households assisting neighbors). Sensitivity is measured by assessing the current state of a village's food and water security and health status. The same subcomponents as presented in Table 1 as well as Equations (1)–(3) were used to calculate the LVI–IPCC. The LVI–IPCC diverges from the LVI when the major components are combined. Rather than merge the major components into the LVI in one step, they are first combined according to the categorization scheme in Table 7.2 using the following equation:

$$CF_v = \frac{\sum_{n=1}^{n} W_{M_i} M_{\mathrm{vi}}}{\sum_{n=1}^{n} W_{M_i}} \qquad (5)$$

where $\mathrm{CF_v}$ is an IPCC-defined contributing factor (exposure,sensitivity, adaptive capacity) for village v, M_{vi} are the major components for village v indexed by i, W_{M_i} is the weight of each major component, and n is the number of major components in each contributing factor. Once exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

$$LVI - IPCC_v = (e_v - a_{v)} * \ s_v$$

where $LVI - IPCC_v$ is the LVI for village v expressed using the IPCC vulnerability framework, e is the calculated exposure score for village v (equivalent to the Natural Disaster and Climate Variability major component), a_v is the calculated adaptive capacity score for village v (weighted average of the Socio-Demographic, Livelihood Strategies, and Social Networks major components),and s_v is the calculated sensitivity score for village v (weighted average of the Heath, Food, and Water major components). The LVI–IPCC scaled from -1 (least vulnerable) to 1 (most vulnerable). Detailed example of calculating the contributing factors of the LVI–IPCC for one of the two villages is presented in Table 3.

Table 3: Calculating LVI- IPCC for Chakbara village

Contributing factors	Major components for Chakbara Village	Major component values for Chakbara	No of sub components per major component	Contributing factor values	LVI-IPCC value for Chakbara
Adaptive capacity	Socio-demographic profile	0.656	8	0.441	
	Livelihood strategies and assets	0.367	20		0.047
	Social networks/safety nets	0.418	10		
Sensitivity	Health	0.478	13	0.587	
	Food	0.701	12		
	Water	0.594	7		
Exposure	Natural disasters and climate variability	0.521	17	0.521	

Step 1 (calculate indexed sub-component indicators and major components as shown in table 2, taking the inverse of the adaptive capacity sub-component indicators: Socio-demographic Profile, Livelihood Strategies, and Social Networks).

Step 2 (repeat for all contributing factors: exposure, sensitivity, and adaptive capacity):

$$AdaptiveCapacity_{Chakbara} = \frac{\sum_{n=1}^{7} W_{M_i} M_{\mathrm{vi}}}{\sum_{n=1}^{7} W_{M_i}} = \frac{8*0.656+20*0.367+10*0.418}{8+20+10} = 0.441$$

Step 3 (repeat for all study areas):

$$LVI - IPCC_{Chakbara} = (\mathrm{Exposure}_{Chakbara} - Adaptive\ Capacity_{Chakbara}) * \mathrm{Sensitivity}_{Chakbara} = (0.521 - 0.441) * 0.587 = 0.047$$

Appendix 2.a: Awareness of some key national laws and acts by the people of study villages and adaptation readiness score

National laws and acts that govern local areas development and management	Community responses on agencies performance					
	Over 60% aware (4)[31]	40-60% aware (3)	20-39% aware (2)	10-19% aware (1)	Less than 10% aware (0)	Score obtained
Embankment Protection Act			26.7			2
Environment Conservation Act				13.3		1
Khas land distribution Policy		50.0				3
Fish Conservation Act				14.4		1
Crab conservation policy				16.7		1
Shrimp PL catching policy			21.1			2
Aggregated score and (in %)	Maximum (24)					10 (41.67**%)**

Appendix 2.b: Effectiveness of some key central government agencies in the area and readiness score as judged by villagers

Statement	Community responses on agencies performance					
Statement related to performance of some key central government agencies in the area	Less than 25% said not effective (4)	25-49% said not effective (3)	50-75% said not effective (2)	Over 75-90% said not effective (1)	Over 90% said not effcetive (0)	Score obtained
Maintenance of embankment by BWDB			70.0			2
Protection of *khas* land local administration/MoL				83.3		1
Management of sanctuaries inside SRF by FD				83.3		1
Execution of Fish act by DoF and FD			72.2			2
Execution on crab catching ban by FD			53.3			2
Security of people inside SRF by the Government[32]			68.8			2
Technical support to shrimp farmers by DoF			67.7			2
Technical support to crop farmers by DAE				75.6		1
Raising awareness on CC issues by the Govt.				75.6		1
Aggregated score and (in %)	Maximum (36)					14 (38.89%)

Appendix 2.c: Effectiveness of Local Government (UP) activities in the area and readiness score as judged by the villagers

	Community responses on UPs performance related to CC issues	

[31] Figures in parentheses are scores against level of awareness/ effectiveness

[32] Government means multi-agency responsible for maintaining law and order situation viz. police, boarder guard, local administration, elected bodies, etc.

	Less than 25% said not effective (4)	25-49% said not effective (3)	50-75% said not effective (2)	75-90%% said not effective (1)	Over 90% said not effective (0)	Score obtained
Raising awareness on CC issues by UPs				75.6		1
Disaster early warning by UPs				90.0		1
Activities of UDMC			74.5			2
Activities of union standing committee on env.				79.5		1
UP's activity on environment in Fultala			67.0			2
UP's activity on environment in Chakbara					92.0	0
Aggregated score and (in %)	Maximum (24)					7 (29.17%)

Appendix-2.d: Community attitude to CC and responses to tackle impacts in the area and readiness score as judged by the villagers

	Community responses to CC issues					
	Over 75% believe (4)	50-75% believe (3)	25-49% believe (2)	10- 25% believe (1)	Less than 10% believe (0)	Score obtained
CC is not due to natural causes only			40.0			2
Believe that CC will affect SRF		65.5				3
Can plan adaptation based our current knowledge on CC					4.4	0
Important to know more about CC issues	95.6					4
Villagers also have role to tackle CC impacts			36.6			2
Priority should be given on CC impacts over other issues				22.2		1
Aggregated score and (in %)	Maximum (24)					12 (50%)

Appendix-2.e: Current state of protection and management of CPRs (Common Pool Resources) and readiness score as judged by the villagers

	Community responses to CC issues					
	Very good condition (4)	Fair/good condition (3)	Poor/ not too bad (2)	Poor and bad (1)	Very poor/worst (0)	Score obtained
State of protection and management of CPRs			X			2
Conversions and degradation of CPRs					X	0
Access by the poor to available CPRs			X			2
Trend of CPRs and their resources				X		1
Any restoration of CPR implemented			X			2
State of any CPR under common use				X		1
Incident of major conflicts on CPR use			X			2
Aggregated score and (in %)	Maximum (28)					10 (35.72%)

Appendix-2.f: Current state of safety net and DRR activities in the area and readiness score as judged by the villagers

	Community responses to CC issues					
	Very transparent/ no corruption (4)	Transparent /minor corruption (3)	somewhat transparent/ corruption (2)	Poorly transparent/major corruption (1)	Not transparent/ highly corrupt (0)	Score obtained
Transparency in managing sanctuaries in SRF					X	0
Harassment of people collect SRF resources			X			2
Intention of Bandit control in SRF			X			2
Social safety net support to communities			X			2
Disaster relief and recovery activities			X			2
Community participation in dyke management				X		1
Protection of illegal structure in dykes by BWDB			X			2
Transparency in Alia affected dyke repairing					X	0
Aggregated score and (in %)	Maximum (32)					11(34.38%)