Assessment of Vulnerability to Climate Change & Adaptation Options for The Coastal People of Bangladesh

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FOREWORD

Following the recent publications of IPCC on climate change, the issue has emerged as a major challenge for the mankind. It is threatening social and economic progress across the globe, especially the recent strides to address issues such as poverty, malnutrition and hunger, and overall objectives of human development. Least developing countries in general, and Bangladesh in particular, will be the worst victim of adverse consequences of climate change in foreseeable future. Published literature shed light on overall vulnerability of the country. However, there exists little analysis on regional differences in vulnerability which will be triggered by impacts of climate change.

In an attempt to provide an analysis of region-specific vulnerability, Practical Action Bangladesh has decided to carry out an assessment for the coastal zone and its population. Coastal zone of the country is faced with a plethora of hydro-geophysical constraints, coupled with unsustainable land use practices, precarious conditions dealing with resource management, etc. Such complexities have been giving rise to high incidence of poverty, loss of livelihoods amongst the poor and wide scale out migration. This study connects these prevailing realities with climate related hazards, which will aggravate prevailing contexts of vulnerability for millions of coastal people. In the assessment, human dimensions are given higher priorities over physical causes of vulnerability. We believe that, outputs from such an analysis could analyze the contexts of vulnerability in the coastal zone, which in turn could identify the needs and priorities of adaptation to address such vulnerability to climate driven phenomena.

We are pleased that Practical Action Bangladesh sponsored the research, which came up with a number of potential adaptation options. A number of such options may be given field trials on a pilot scale. Practical Action is willing to try a few identified adaptation modalities in near future and invites other development partners to promote suitable adaptation options. With a concerted effort involving both Local as well as National Government Institutions and the development partners, Practical Action Bangladesh expects that the hardship faced by the coastal population can be reduced significantly.

We also believe that the current development strides in the country can be made climate resilient, where suitable and carefully chosen adaptation measures will help people to defy anticipated adverse effects of climate change.

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Country Director
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Acronyms

AAI	Action Aid International
ADB	Asian Development Bank
BARC	Bangladesh Agriculture Research Council
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BFRI	Bangladesh Forest Research Institute
BIRD	Bangladesh Institute for Rural Development
BRM	Bangladesh Resident Mission
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CC	Climate Change
CCC	Climate Change Cell
CEGIS	Centre for Environmental Geographic Information Services
CEP	Coastal Embankment Project
CGC	Centre for Global Change
CPP	Cyclone Preparedness Programme
CZMP	Coastal Zone Management Programme
DA	Development Alternatives
DAE	Department of Agricultural Extension
DC	District Commissioner
DDC	Design and Development Company Limited
DFID	Department for International Development
DND	Dhaka-Narayanganj-Demra
DOE	Department of Environment
DPHE	Department of Public Health Engineering
DTW	Deep Tube Well
EGIS	Environmental Geographic Information Services
EPIP	Environmental Policy and Implementation Program
FAO	United Nations Food and Agricultural Organization
FAP	Flood Action Plan
FFWC	Flood Forecasting and Warning Centre
FFWP	Food for Works Programme
FGD	Focus Group Discussion
GBM	The Ganges, the Brahmaputra, and the Meghna (region)
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Ground Water
HYV	High Yielding Variety
IEC	Important Environmental Concerns
IPCC	Inter-Governmental Panel on Climate Change

KII	Key Informants' Interviews
KJDRP	Khulna-Jessore Drainage Rehabilitation Project
LDC	Least Developed Countries
LFA	Livelihood Framework Analysis
LGED	Local Government Engineering Department
MDG	Millennium Development Goals
MODM	Ministry of Disaster Management (currently called MOFDM)
MOEF	Ministry of Environment and Forest
MOFDM	Ministry of Food and Disaster Management
MOWR	Ministry of Water Resources
NAPA	National Adaptation Programme on Action
NC	North Central (region)
NGO	Non-Government Organizations
NIPA	National Institute for Public Administration
NWMP	National Water Management Plan
OB	Old Brahmaputra (River)
PC	Planning Commission
PRSP	Poverty Reduction Strategy Paper
PSF	Pond Sand Filter
PVA	Participatory Vulnerability Analysis
RA	Resource Analysis
RAJUK	Rajdhani Unnayan Kotripakkha
RMG	Ready Made Garment
RVCC	Reducing Vulnerability to Climate Change (Project)
SC	South-central (region)
SD	Sustainable Development
SE	South-eastern (region)
SSP	Single Super Phosphate
SST	Sea Surface Temperature
SW	South-west (region)
TERI	The Energy Research Institute
TRM	Tidal River Management
TSP	Triple Super Phosphate
UDMC	Union Disaster Management Committee
UN	United Nations
UNDP	United Nation Development Program
UNESCAP	United Nations Education, Social and Cultural Organization (Asia-Pacific)
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
VGF	Vulnerable Group Feeding
WARPO	Water Resources Planning Organization
WB	World Bank
WEF	World Environment Fund

EXECUTIVE SUMMARY

Geographically, Bangladesh is situated in a natural hazard prone area. Compared to the rest of the areas, the coastal sub-districts (*Thanas*) are more vulnerable to climate variability and change. However, the hydro-geophysical reality of the sub-districts predominantly determines their contexts of vulnerability and its nature differs accordingly. Intriguingly enough, the poorest of the areas appear to be the most cornered among the different vulnerable sects. Among these deprived segments, however, the women, the persons with disability and the minorities are generally more vulnerable and they face a high risk of being marginalized.

The most threatening hydro-geophysical vulnerability have been created by prolonged water-logging, as observed at Manirampur in Jessore and its adjoining sub-districts named Keshabpur, Abhaynagar, Dumuria and Tala. The absence of land-based production and employment in the areas has led to severe food insecurity. As a result, a large number of males are forced to migrate to other parts of the country in search of livelihood. The rest including women and children have got to live there, being fated to suffer the hazardous consequences. It is likely that the water-logging will be exacerbated under climate change.

Besides water-logging, salinity ingress is endangering safe drinking water sources and putting small holders out of agriculture based livelihoods in the sub-districts of Satkhira and Khulna districts. A sizeable fraction of small holders are still trying to hold on to their small-scale shrimp productions, despite being under pressure to sell off their cultivating lands to the influential shrimp merchants. While their desperate efforts to take advantage of the increasing salinity has been somewhat successful, their families still face a greater risk of health hazards owing to the lack of safe drinking water. Unless the issues of salinity in drinking water cannot be redressed, the state of the affected people will be in great jeopardy.

The rising Sea Surface Temperature (SST) during monsoon and post monsoon seasons affects the livelihood of fishermen throughout the entire coastal area. Under the same geophysical influences, however, the south-western, south-central, and south-eastern fishermen face separate vulnerabilities. While the mere presence of the Sundarbans mangrove ecosystem reduces the hazard of fishers in the SW region, the fishers in the south-central zone (from Patharghata to Subarna Char sub-district) face moderate risk of 'rough sea events' created by high SSTs. Since the south-central fishermen are mostly estuarine i.e. shallow water fishermen, they require less time for fishing trips and do not necessarily have to give up their trips often, as the deep sea fishermen do. In addition, the close proximity to the sea-shore allows them to save their lives during high tidal waves and cyclones.

On the other hand, the deep sea fishers of Chakaria, Maheshkhali, and Cox's Bazar sub-districts in the SE region struggle hard to maintain their livelihoods, due to frequent rough sea events induced by high SST. They are in the most vulnerable position as these deep sea ventures mean that they need to retreat from a long way on the sea and are often caught by storms and whirlwinds where they lose their fishing equipments and even lives. Even if they save their lives by frequently abandoning the fishing trips, they fail to recover from financial losses or repay credits and then gradually become unemployed. The situation of the 'Jaladas' i.e. 'slaves of the sea', who solely depend on fishing, has become highly vulnerable and many have been considering migration from their ancestral homes.

Poverty is a major predicament that intensifies the vulnerability caused by hydro-geophysical conditions. Severe erosion has occurred in different areas, for example, in Char Patila of Char-Fassion and Haim-Char sub-districts. A large number is being added to the destitute and homeless community every year due to coastal erosion.

The government attempts to relocate a small fraction of the erosion victims onto mid-river chars as in case of Tazumuddin, Char-Fassion, Haimchar, Laximpur Sadar and newly accreted offshore islands. This program may not be successful in the long run because of the increasing vulnerability of the *chars* (strips of land that rise out of rivers) to higher wind-wave interaction under climate change. Since most of these *chars* or islands are unprotected, they are under continuous threat of inundation caused by cyclonic storm surges. The loss of productive lands due to erosion aggravates poverty as a result of climate change.

It is a recurring experience of the coastal inhabitants to desperately look for shelters after issuance of cyclone warning and leaving their huts. It is also a common phenomenon that a large number of women stay back fearing the loss of their belongings and they die as a consequence. This may be attributed to the high death rate of women and children during disasters, as it has been observed once again during the aftermath of Sidr. Resources to rebuild houses are often beyond the reach of the affected people in the absence of employment, investment or proper aid.

Water-logging along the Kobadak and Betna basin has increased food impoverishment and given rise to matri-linear households (not as a choice) amongst the affected people. Drastic measures are needed to drain off all the stagnant water from the area and to improve the blocked drainage system as early as possible. The latter may require macro as well as micro level planning and large-scale financing for the excavation of choked rivers and rivulets. Investment on TRM can also be considered. However, one needs to be aware of the difficulty regarding the governance and compensation process. Removal of water is surely the primary measure for reducing vulnerability from water-logging. However, a few arrangements for overall adaptation might be considered, such as a) increasing the coverage of primary health-care b) ensuring the supply of pure drinking water c) building adequate number of community toilets for women above the highest water levels d) providing a safety-net support for the water- logged periods e) and maintaining solar power operated vessels to work as ambulances etc. These measures will help to build up local resilience and lessen the hazards but they will be limited to reduce the overall vulnerable situation caused by climate change to a considerable extent.

It is generally believed that a stronger infrastructure of the houses built with low cost housing materials, adequate storage system for the entire community, suitable shelters in time of disaster will benefit the affected people across the coastal area. In order to safeguard lives, livestock and belongings of the affected people, the Cyclone Preparedness Programme is a globally accredited and successful one. But its effectiveness is eroding away as the shelters built after the devastating cyclone in 1991 fall short to accommodate the present population. Besides, especially women find it difficult to take shelter in such cramped, crowded places for days without the least privacy. Most of the cyclone shelters are dilapidated due to lack of maintenance. Unless a large number of cyclone shelters are built based on population density and with provision for separate facilities for women, the high death toll caused by high tidal waves and cyclones may not be avoided.

A large population of Shaymnagar, Kalaroa, Assasuni sub-districts is afflicted by a chronic high salinity in ground water aquifers. This problem has also been detected in Laximpur and Noakhali districts. Since the rising sea level increases the risk of further contamination of other aquifers, steps are needed to find alternative source of non-saline drinking water.

The fisher folks who are often out of a steady income need timely credit on soft terms. The easy to access credits on soft terms disbursed on due time and the techno-economical potential livelihoods insurance may help the coastal fisher folks, especially those who are living in Chakaria and Maheshkhali sub-districts.

1. INTRODUCTION

1.1 Background of the Study

In recent times, the global climate change is one of the most discussed issues among the environmentalists, scientists and concerned people. The scientific community around the globe is fully convinced that climate change is a reality and the adverse impacts of climate change will be both irreversible and disproportionate on the poor (Parry *et al.*, 2007).There are scientific evidences to suggest that concentrations of certain 'heat trapping' gases in the atmosphere, popularly known as the greenhouse gases (GHGs), are on the rise (Solomon *et al.*, 2007). GHGs are emitted primarily when fossil fuels are burnt for industrial activities, electricity generation and transportation.

Scientists fear that gradual accumulation of such gases would eventually cause a rise in atmospheric temperature and there by, the global surface temperature. Based on atmosphere-ocean-terrestrial heat exchange mechanism, it is postulated that a general rise in surface temperature would also cause swelling of ocean water, an increase in melting of snow-caps at the peaks and ice-sheets and an overall rise in mean sea level (Cruz et al., 2007). A combination of such events will have discernible impacts primarily on natural system and also on ecosystems. Such an adverse effect is generally known as the 'greenhouse effect'.

The global scientific community has already forecast that the impacts of greenhouse effect will be devastating in many parts of the world, especially in the low-lying coastal areas (Nicholls *et al.*, 2007). Coastal agriculture will be devastated due to tidal inundation and salinity; low-lying lands and wetlands will be submerged with saline waters; human settlements and physical infrastructure will be destroyed due to prolonged inundation and tidal surges; economic activities will be adversely affected; and recreational and tourism facilities will have to be abandoned permanently - all such effects will be observed in the coastal areas (Nicholls *et al.*, 2007).

To assess the possible impacts of climate change on Bangladesh, several studies have been undertaken in the recent past (Huq *et al.*, 1996; ADB, 1994; Warrick and Ahmad, 1996; Huq *et al.*, 1998; World Bank, 2000; and Agrawala *et al.*, 2003). The Ministry of Environment and Forests, on behalf of the government, prepared the first Initial National Communication for the United Nations Framework Convention on Climate Change (UNFCCC), where an updated emission inventory up to the year 1998 is provided along with a compilation on impacts of climate change on various sectors (MOEF-DOE-DDC, 2002).

Recently, the National Adaptation Programme of Action (NAPA) has been prepared and submitted to the UNFCCC (MOEF-UNDP, 2006). Despite having a wealth of information on climate change issues, very little is known on people's understanding regarding possible adaptation measures to fight back such adversities. For Bangladesh, the adverse impacts will perhaps negate most of the outcome of continued development strides of the country, causing severe and far-reaching problems to its poor people living along its coasts (RVCC, 2003; Thomalla *et al.*, 2005).

On one hand, coastal areas of Bangladesh usually create great opportunities for its people to prosper day by day. On the other hand, coastal areas put them at high risks as these areas are susceptible to a number of natural hazards: cyclones and tidal surges, salinity intrusion, riverbank erosion, shoreline recession, tsunami etc. It has been observed time and again that the low-lying coastal areas suffer the most due to occurrence of such natural events (Haider *et al.*, 1992; UNESCAP, 1987).

The coastal area of Bangladesh, with its near-flat topography and its location at the tip of 'funnel-shaped' Bay of Bengal, often experiences such natural hazards. In recent past, a super cyclone called Sidr (having intensity equivalent to a hurricane category 5) devastated the south-central parts of the country, took a heavy toll of about 4000 human

BOX-1: The Myth Related to Inundation of Coastal Zone in Bangladesh

It widely believed that the low-lying areas of coastal Bangladesh, having elevation within meters from the mean sea level, will be completely submerged in sea water under sea level rise. The general characteristics of flat flood plains often guided people to postulate catastrophic consequences of coastal areas of Bangladesh. However, the existence of coastal embankments leaves little scientific room to believe such a consequence.

The coastal embankments were built over the past three and a half decade. A network of about 5000 km of earthen defense infrastructure is found along the coastal zone of Bangladesh, built and maintained under the aegis of the Bangladesh Water Development Board. The initial idea was to protect coastal floodplains from being inundated by saline water during diurnal tidal cycle. This allowed cultivation of rice in slight to moderately saline coastal lands. While the lands inside the embankments were made virtually free from salinity, there still exists narrow strips of mudflats and foreshore areas outside the embankment systems which are subject to diurnal inundation.

During daily tidal activity, the water levels outside each of these embankments generally rise as well as fall by several feet. The maximum rise occurs during the neap tide, especially during peak monsoon. The crest height of the embankments generally does not allow saline water to enter into the 'protected paddy fields and homestead areas' inside the embankment.

Intriguingly, the water level outside the embankment systems is expected to rise under sea-level rise. Available sea-level rise scenarios for Bangladesh suggest about 60 to 90 cm rise in sea level by the year 2100 (Ahmed, 2006; MOEF-UNDP, 2006; Agrawala *et al.*, 2003).

The tidal influence will perhaps make the coastal embankments vulnerable to increased erosion. However, a few tens of centimeters of rise in water level would not be able to overtop the crest height of such embankments. Therefore, complete inundation of vast coastal lands appears to be incorrect. It would occur only if the embankments are dismantled (improbable) or breached simultaneously (low confidence).

It is interesting to note that, with rising sea levels the unprotected coastal mudflats will be inundated. The extent of such inundation outside the embankments would be much smaller compared to the landmass under the coastal zone. People generally do not live in exposed mudflats. Therefore, the risk of drowning appears to be another exaggeration.

The coastal areas of Bangladesh are already faced with so many hydro-geophysical risks, which will be exacerbated by climate change and subsequent sea-level rise. However, given the realities along the coastal zone, there is no substantial risk of permanent inundation of a large area due to a rise in sea level.

lives, mauled standing crops, destroyed hundreds of thousands of dwelling units and wrecked different parts of the best productive mangrove forest vegetation. Under usual conditions the struggle for survival is already way too hard in the coastal areas of Bangladesh. It is, therefore, easy to realise how difficult it would be if climate change exacerbates such natural events in terms of both frequency and intensity.

From previous research activities it is known that climate change induced effects will increase shoreline recession and thereby disrupt agricultural activities along the shore (Islam *et al.*, 1998). Such adverse effects will be observed mainly along the south-eastern shoreline spreading from Kumira to Teknaf. Due to the presence of polders in the south and south-western areas, shoreline recession will not be as fatal as in the case of the south-eastern coast lines. However, the estuarine islands in the south-central areas may experience increased rate of land erosion, if not otherwise protected in the meanwhile. In order to address both shoreline erosion and tidal surge, the Ministry of Environment and Forest has recently

implemented Coastal Greenbelt Programme and facilitated regeneration of mangrove forestry along the shorelines of these islands. It is most likely that without adequate natural regeneration or implementation plan of actions the estuarine morphology will be changed in the unprotected coastal areas (Ahmed *et al.*, 2007a).

Coastal areas are generally located where the land meets the sea (Islam, 2005). In a deltaic coastal area, the mixing zone of brackish water significantly influences coastal ecology. The south-western coastal areas of Bangladesh have already experienced the prelude of rapid change in surface water salinity following the commissioning of the Farakka barrage in India, which allowed the upper riparian India to unilaterally divert the major share of lean season flow of the Ganges since 1975 (Mirza, 2004). This unfortunate event has not only reduced the lean season flow of the Ganges dramatically, it also triggered a rapid transformation of agricultural lands of the area into shrimp-beds (Rahman, 1995). Such a rapid salinization dramatically changed the millennia old surface water systems along the south-western areas, depriving over 6 million people from fetching saline free drinking water in the dry season. Since the lean season flow along the Ganges and its distributaries is most likely to decrease further under a warmed up world scenario, the surface water salinity will also increase throughout the region. Moreover, lacking in adequate surface flows; salinity will penetrate further north wide, resulting in a gradual change in saline affected areas throughout the south-western region (CEGIS, 2006).

As a result of frequent inundation of the riparian lands, soil salinity will increase. Salinity intrusion will increase further due to substantial increase in evapo-transpiration, induced by increasing temperature. Since top-soil salinity reduces potential yield of C3, C4 and many other crops, agricultural activities will be severely affected. At present the coastal lands are unsuitable for *Boro*, economically the most suitable crop of the country, and only slightly suitable for wheat. Chronic salinity intrusion will further reduce cropping potential of the coastal lands (Habibullah *et al.*, 1998). Furthermore, high temperature and evapo-transpiration will cause demands for additional irrigation that might be beyond the means of the poor farmers. It is found that the areas suitable for Aman crop in the South-western (SW) region will gradually shrink, due to increase in sea-level rise induced salinity (CEGIS, 2006).

Tidal inundation in the apparently protected coastal areas will not only increase soil salinity but also the salinization of the ponds and kuas (depressions) and will reduce potential freshwater hatchery and fisheries. However, it may open avenues for brackish water fish cultivation, especially shrimp-cum-paddy cultivation in those areas (CEGIS, 2006). The economically lucrative alternative will be viable only if the upper limit of the water temperature remains within 34°C. Any temperature beyond the limit will cause high rate of mortality for shrimps (World Bank, 2000).

Storm surges, as it has been observed in the recent past, cause devastation in every aspects of life in the coastal areas. Increasing intensity of storm surges will cause havoc on the immobile infrastructure. Any breach in the coastal polders will result into loss of lives and assets; destruction of settlements, markets, destruction of schools and administrative infrastructure, disrupting normal life of the local people. The destruction of houses and schools will render the inhabitants homeless and deprive the students of their education for a considerably long period. Cyclonic storm surges are often found to have severe negative impacts on cultured fisheries including shrimp culture — one of Bangladesh's main export interests. The high water columns easily overtop the small muddy barriers and completely destroy the shrimp beds. Cyclones also take away the lives of the deep-sea fishermen, along with their boats and other valuable belongings on board (Ahmed *et al.*, 2007b).

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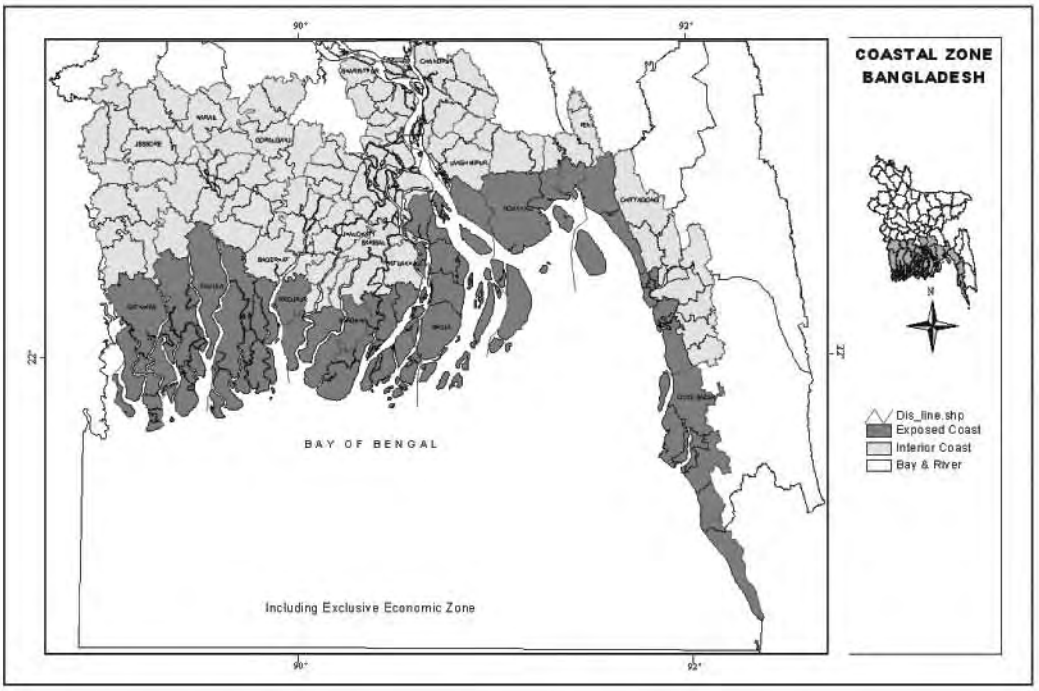

Figure-1: The Coastal Zone of Bangladesh is Shown in a Map

normal life of the local people. The destruction of houses and schools will render the inhabitants homeless and deprive the students of their education for a considerably long period. Cyclonic storm surges are often found to have severe negative impacts on cultured fisheries including shrimp culture — one of Bangladesh's main export interests. The high water columns easily overtop the small muddy barriers and completely destroy the shrimp beds. Cyclones also take away the lives of the deep-sea fishermen, along with their boats and other valuable belongings on board (Ahmed *et al.*, 2007b).

The entire salt production in the country takes place in Cox's Bazar region, at the prolonged south-eastern tip of the country. Increased evapo-transpiration will assist the salt-farmers, but a single cyclonic storm surge in late April or early-May may wash away all the salt in one evening. Since salt beds are located in the remote areas, relatively, the vulnerability of the salt growers is very high. Destruction of roads and culverts will have adverse impacts on transportation sector. Trade and business will be disturbed due to disruption of transportation and will create an impact on the local markets. Prolonged saline water logging in the polder areas may reduce availability of potable water and cause other adverse health and sanitation problems.

Responding to the growing concerns regarding climate change and sea level rise along the coastal zone of Bangladesh, Practical Action, Bangladesh has launched a scoping study on particular aspects of vulnerability along various coastal areas of the country and to figure out how adaptation may be facilitated in a bid to build resilience and reduce the overall impacts of climate change. The study has been completed in co-operation with the Centre for Global Change (CGC).

1.2 Objectives of the Study

The overarching goal of the research is to build an information source on specific aspects of vulnerability of coastal communities to climate change. Towards meeting the goal, the followings are considered as the specific objectives of the study.

- To identify a few adaptation options, based on field realities of coastal people, so that target oriented adaptation activities may be carried out by concerned organizations;
- To analyze whether people's adaptation needs are satisfied by the known adaptation measures;
- To identify barriers of implementing perceived adaptation measures and to recommend ways and means to overcome the barriers.

2. METHODS EMPLOYED

2.1 Approach: Vulnerability in the Eyes of the Vulnerable People

The generic approach of the study is to define the contexts of vulnerability of coastal population, taking into consideration their own perceived risk factors and specific circumstances. The participatory methods and tools employed for such a generic approach have been successfully utilized in a number of countries, perhaps pioneered by Bangladesh through the implementation of RVCC project (RVCC, 2003; Ahmed and Schaerer, 2004). Such approach has again been successfully applied towards defining vulnerability of women within a gender relation framework under the aegis of the Climate Change Cell (Ahmed *et al.*, 2007a). This study benefits from the generic approach by applying it to a number of coastal areas, chosen for this study.

2.2 LFA and PVA as Analytical Tools

In past, the initial attempts to study vulnerability used to focus on the vulnerability of a contiguous area or a country. Over the years, the focus has been shifted gradually on the assessment of the vulnerability of people from different perspectives (Dercon, 2001; Kenward, 1999). It is often argued that the vulnerability assessment procedures often tend to miss the real vulnerable people of a country or a region. Primarily it happens due to their marginal presence in existing social structure that stops them from being heard and from partaking in the decision making processes. The needs for incorporating perceptions and views of the vulnerable groups in the assessment mechanisms are highlighted repeatedly (Kelly and Adger, 2000; Heijmans, 2001; Ahmed, 2004; Smit and Wandel, 2006). Kelly and Adger (2000) developed an analytical framework to cover climate change related vulnerability, which has been further developed to cover more generic global scale environmental issues by Clark *et al.*, (2000).

One of the means to incorporate concerns of the vulnerable people and analyze their contexts of vulnerability is to employ the Livelihood Framework Analysis (LFA) technique. It not only allows to integrate geophysical risks of the vulnerable people in question but also considers all forms of assets. Without this integration the vulnerability accelerates and negates their empowerment process and their resilience (Cannon *et al.*, 2003). In the recent past, Action Aid International adopted LFA and introduced its Participatory Vulnerability Analysis (PVA) technique to justify their approach to assess 'socially inclusive' vulnerability on a group of people instead of a generic vulnerability assessment framework (AAI, 2002). The latter has been further adopted in Bangladesh to successfully assess vulnerability of local people in the south western region of the country under the RVCC project (RVCC, 2003; Schaerer and Ahmed, 2004). This methodology has again been adopted with modification in Bangladesh and a few other countries to analyze the vulnerability of collective people under a given context of climate related adversities (Alam and Mqadi, 2006).

An attempt has initially been made to collate relevant information on all of the above mentioned research methods and objectives to the extent possible from available literature. As a generic approach to the research, a close interaction between the vulnerable groups including women and other disadvantaged group members and the Research Team is established. A number of such close interactions, by applying Participatory Vulnerability Assessment (PVA) technique, have been arranged. At the outset, it is envisaged that the research would cover all major geo-physically vulnerable coastal regions in order to identify a wide range of vulnerable people. The study sites, as identified in the next section, are carefully chosen so that diverse geo-physical realities and their interactions with the future climate system are adequately represented.

Efforts are made to have PVA sessions with economically challenged groups (i.e. farmers and fishers) and with women in each of these study sites. These efforts have been supplemented by organizing Key Informants' Interviews (KII), to ensure representation of other groups such as minority communities, people with special needs and others. Each of the PVAs begins with general observation of the area, approached by a transact walk. These physical observations are made on

the basis of people's vulnerability contexts analysis. 'Close interactions' with people provide information on types of vulnerability, perception regarding physical aspects of vulnerability, ranking of vulnerability, seasonality mapping of livelihood aspects, cropping system, employment, food security, etc. The entire analysis in each of the study sites has been informal, without any written or prescribed format to guide the processes. The researcher has been involved as a mere facilitator of the discussions, not as resource person. This is how, the collective voice of the participants is heard, which formed the basis of identifying the specific issues relating to their specific vulnerability to climate variability and change.

2.3 Identification of Study Locations

The first question is to determine the criteria for identifying the study locations. The major issue is to ascertain generic coastal risk elements analyzed and found in the literature as well as observed. Following the super cyclone Sidr, which wrecked the coastal zone of Bangladesh as mentioned in the course of the current study, reaffirm the obvious that cyclonic storm surge will always remain as the major hydro-geophysical threat in the coastal zone, only its fury will be aggravated under climate change.

According to Coastal Zone Management Programme (CZMP), the typology of coastal zone is determined according to the proximity of a coastal sub-district relative to the sea front: the 'Open Coastal Sub-Districts' are those which are facing directly the sea front and being affected by tidal surges. There are, of course, 'Interior Coastal Sub-Districts', where the effects are not so pronounced as in the former cases. In a bid to identify FGD locations, emphasis has been placed on 'Open Coastal Sub-Districts' due to the fact that under climate change these sub-districts will face greater risk of cyclone and storm surge related inundations.

While regional variations exposed to certain geo-physical hazards are taken into consideration, it is found that increased coastal erosion would pose increasing risks in both south-central (SC) and south-western (SW) regions (Neelormi, 2005; Ahmed *et al.*, 2007a). Increasing risks associated

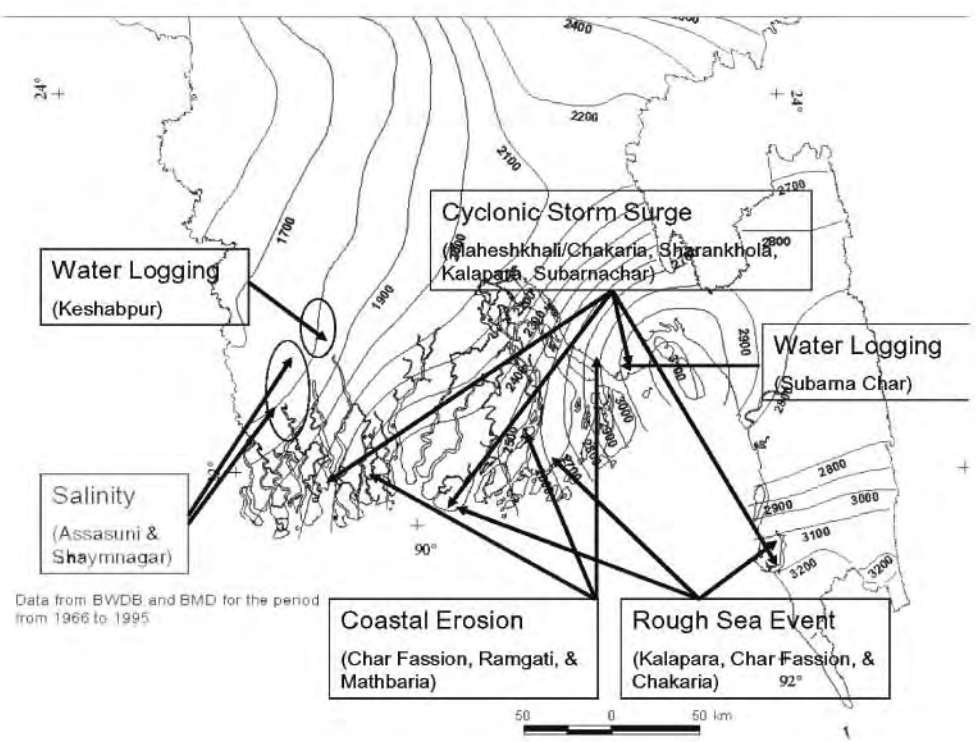

Figure-2: Coastal areas of Bangladesh where the field activities have been taken place

with salinity intrusion under climate change in the south western region has already been reported in a number of articles and publications (RVCC, 2003; Ahmed, 2004; Ahmed *et al.*, 2007a; CEGIS, 2006). Similarly, south western region would likely to face increasing risks from water logging (Ahmed *et al.*, 2007a; Ahmed *et al.*, 2007c). Meanwhile, recent publications suggest that 'rough sea events' would likely to be exacerbated under climate change, as the latter would influence a rise in sea surface temperature (Ahmed *et al.*, 2007b). In this case, the effect would be pronounced in terms of loss of livelihoods of a particular group of people, the fisher folks throughout the coastal zone.

It has been reported earlier that scanty, untimely or excessive rainfall of a highly varied range is a regular phenomenon in some parts of the coastal zone, as experienced by the local people (Neelormi, 2005; Ahmed *et al.*, 2007a). All these issues have been highlighted by people in SC and SW regions. Since such extreme rainfall events have impacts on food production, these require further investigation to identify places where people are already facing them as elements of risks under climate change.

Based on the analyses above, the following ten (10) sub-districts have been identified in order to carry out field based FGDs.

Region: South-east (SE)			
Sub-District:	Chakaria and Cox' Bazar	District: Cox's Bazar	Type: Open/Open
Region: South-central (SC)			
Sub-District:	Subarna Char	District: Noakhali	Open
Sub-District:	Ramgati	District: Laxmipur	Open
Sub-District:	Char Fassion	District: Bhola	Open
Sub-District:	Kalapara	District: Patuakhali	Open
Sub-District:	Mathbaria	District: Pirojpur	Open
Region: South-west (SW)			
Sub-District:	Sharankhola	District: Bagerhat	Open
Sub-District:	Shaymnagar	District: Satkhira	Open
Sub-District:	Assasuni	District: Satkhira	Open
Sub-District:	Keshabpur/Abhaynagar	District: Jessore	Internal

3. CYCLONE, STORM SURGE AND PEOPLE'S VULNERABILITY

The entire coastal belt of the country is vulnerable to cyclone and storm surge, especially the small islands along the coast are widely exposed to such events (Islam, 2005). Owing to the successful disaster management through the issuance of early warning and building hundreds of cyclone shelters, people in the coast now face comparatively less casualty during cyclones. However, their tremendous economic hardship in post cyclone periods, let not mention the extraordinary event like Sidr, must be properly addressed.

Most of the people in a small island like Dholghata in Moheshkhali are found living below the poverty line. Employment opportunities are very limited. There are two types of land based production systems- cultivation of *Aman* in *Kharif* season and salt cultivation on the same land in dry season. Due to close proximity to the sea, salinity ingress is a pressing concern in the coastal areas. Salinity has detrimental effect on land based production system (Karim *et al.*, 1990). People can not get high yield from *Aman* cultivation because of salinity. The only significant employment (almost 60 per cent) comes from salt cultivation during November to early May. About 10 per cent of the population is self employed in marine fisheries. Some 15 per cent of employment is generated through project related activities such as the Food for Work Programme (FFWP).

Winter, the relatively dry season, is more suitable for employment in these islands. Being detached from the mainland, it is expensive for the people to commute to mainland by engine boats (locally known as trawler) in search of alternative livelihood. The inhabitants of these islands do not have any choice, but to accept the harsh reality of employment insecurity for about six months including peak monsoon period (i.e., June to October). In winter, employment is generated both by salt cultivation and FFWP. The fishermen and the salt cultivators find a favourable weather for their livelihood in winter. Even then erratic rainfall behavior often causes devastation to salt cultivation.

The credit services in these areas are generally governed by absentee rich landlords (locally called *mahajans*) who often sponsor the local musclemen (i.e., *Mastans*). During peak monsoon when people face difficulty to find employment, they eventually suffer from hunger and malnutrition. People go to the local money lenders just to survive during this lean season, hoping that they can repay the loan (with high interest rate, as high as 100 per cent interest rate in fishing community in Chakaria) when they get back to employment in winter. If the employment opportunities in winter are disrupted by any reason, this loan takes heavy toll on them, perpetuating their poverty. Often they are forced to become cheap 'bonded labor' in *mahajans'* salt- pans in the process of repaying outstanding loans. Thus the frequent natural disasters in the coastal belt almost regularly cause severe devastation to these areas and destroy the potentiality to *bounce back* from a crisis.

In absence of adequate land based productions, these islands are dependent on the mainland for food supply. This is manifested in the high prices of the essential commodities. The poor can hardly afford the proper nutrition; food impoverishment is a persisting concern here. Any kind of health care facilities other than traditional ones, both for men and women seem to be absent. People find it expensive and beyond their means to visit any doctor even in case of emergencies. As a result of a prolonged exposure to corrosive working environments in salt-pans, workers often suffer from skin legions. There are some NGO health care interventions to their great relief but in a limited extent in comparison to their requirements.

The community of coastal fishermen is in peril. The estuarine fishermen are extremely poor. If they miss fishing trips because of rough sea events and issuance of no 3 or higher signals, they face extreme difficulty to maintain their mere subsistence. Since global warming is a reality (IPCC, 2007) and sea level are expected to rise, the sea surface temperature (SST) is also likely to rise causing increased number of depressions and

Figure-3: Track of Cyclone Sidr which has Devastated the Coastal Zone

Source: NOAA website

low pressure system in the Bay of Bengal. Increased number of depressions and low pressure mean increased number of risky days for sailing. Poor fishermen therefore, will have lesser number of active days, lesser catch in the sea, and eventually lesser income. Often they defy the signals and risk their lives in rough sea. This desperate effort causes capsi-zing of their boats in storms and loss of lives.

Extreme poverty and victimization by local influential deliver another clear context of vulnerability of the coastal inhabitants, especially of those who live in small islands. This misery is compounded by cyclonic hits coupled with storm surges. Under climate change, these events are expected to strike more frequently with greater strength increasing the vulnerability of the poor to a higher degree. Unemployment, reconstruction of houses, shortage of drinking water, poor health services and above all abject poverty are the predominant challenges to fight with in these cyclone prone areas.

The case of Bhola Island is somewhat different from that of Dholghata. Bhola is a much bigger island and its population is higher than the over all population of small islands in Bangladesh. People in Bhola find their employment in agriculture, livestock rearing, even in a few small scale industries, estuarine fishing etc. Despite of diversified employment opportunities compared to small islands, a sizeable portion of the population are living under poverty line in Bhola. The southern part of the island is susceptible to salinity ingression which has detrimental effect on crop cultivation. In dry season, the *boro* production is greatly affected by salinity. Input into the intensive high yielding *boro* requires larger investment which poor people often cannot afford. Due to absence of adequate institutional financing and patronization, they often take loans from local money lenders with high interest rates. Both *aman* and early Rabi season vegetable cultivations are at stake due to cyclonic adverse effects during October-November. Considering the erratic nature of rainfall and increasing salinity under climate change, crop cultivation might face increased difficulties. In the backdrop of cyclonic events, the devastation of crop fields does not allow them to overcome the crisis period. The poor are relatively burdened with greater loss than the comparatively richer section of population. The poor agro based community depending on year-round land based production system will face extreme difficulties under climate change.

The people in cyclone prone coastal areas know how to survive during cyclones. Bangladesh has demonstrated notable improvement in disseminating early warning information in case of cyclones. Hundreds of cyclone shelters are built all over the cyclone prone areas and people are aware that they have to seek shelters to save lives. In spite of all life saving measures, many people become victims of cyclone and associated storm surges every year. Finally, the super cyclone like Sidr compels us to reconsider the preparations to fight against cyclone.

The people in coastal belt are in general vulnerable to cyclone and storm surges, as we have mentioned before. Among them poor women are invariably vulnerable and constitute the most deprived segment of population. According to the women in Dholghata, the tidal surge associated with high speed wind due to cyclone has the most destructive effects among all other hazards. Salinity intrusion, especially contamination of drinking water sources and other pathogens following a high intensity cyclonic event has appeared to be a pressing concern for the women in this belt. The hydro-geophysical vulnerability in cyclone prone areas is also followed by saline water logging followed by high neap tide. Death and destruction of dwellings and food insecurity, health and sanitation problem and outbreak of water-borne diseases have been identified by women as the common reasons of vulnerability in these areas.

Women of cyclone prone coastal belts are well aware about the issuance of 'signals'. In Bangladesh women have very restricted access to public places and therefore their mobility is largely hampered due to social taboos. As their participation in public sphere is very limited, women get the message of warning later than their male counterparts. Issuance of signals is generally disseminated through radio bulletins. Warnings are further disseminated repeatedly in remote

communities by use of mikes in public places like bazaars, mosques etc. As soon as their male counterparts let the women informed about the warning, they need to take some measures on a short notice. Because of gender based roles determined in a patriarchal society, women have to perform certain distinct role and responsibility in the family. Women shoulder the major responsibility of managing the whole household and taking precautionary measures to safeguard all the assets including livestock before leaving for cyclone shelters.

Women have reported incidents of sexual harassments on the way to cyclone shelters. Adolescents and young girls do not feel safe unless they are accompanied by other male or aged female members. The environment of the shelters is also a discouraging factor for them for not going to the shelters. The number of existing shelters is quite inadequate in terms of current population density. In some areas people have to walk for 2/3 kilometers in the windy and muddy condition to be able to reach to a shelter. Especially for elders, ailing persons, pregnant women and children it is too difficult to accomplish this hurdle. As most of the cyclone shelters do not have ramps, physically challenged persons find themselves entirely dependent on the others.

In the shelters, it has been reported that in cases people have to keep standing during the whole episode lasting from 2/3 hours to 2/3 days. Because of high density population and inadequate number of shelters, these places become so crowded that pregnant women might not withstand this pressure so long and in some cases face miscarriage.

There is no provision for emergency medical facilities in the shelters. No trained midwives or any first-aid arrangements are in offer in the shelters. It is unimaginable to manage a separate room or even a small space with some privacy for lactating mothers. Young women, having menstruation find extreme difficulty to maintain their hygiene. There is no separate designated toilet for women in the shelters. Actually in most of the shelters, there are provisions of 1 or 2 toilets which are built in the ground floor, and because of tidal surges these toilets are of no use during cyclone. Often people have to defecate at places they find a bit suitable. For women, privacy is a major issue, and one can readily understand why women in many cases prefer to stay back even in time of danger. Moreover, often people take shelter in near by schools, embankments etc. in case the shelter is inaccessible or too far away. Women on the embankments, living under open sky are often subject to insecurity in different ways,

In Sharankhola (Bagerhat), Mathbaria (Pirojpur), Kalapara (Patuakhali), the most affected areas by Sidr, people were reluctant to go to shelters. Even on that very night most of the people did not leave their houses. They admitted that in past they got warned for cyclone but no casualty took place there. This time, during Sidr, they could not take the warning system seriously. Besides, inadequate number of cyclone shelters and long distances of the camps are also identified as causes for not going to shelters. People in Southkhali, Bagerhat, described that after Sidr the dead bodies were scattered all over like 'Hyacinths'. One mother was found dead holding her two kids with her two hands. She could not survive, yet did not let go her kids swept away in the storm surge.

The relief workers in these areas found the women and children in the worst conditions than the others. Availability of safe drinking water becomes acute after any such disaster. Pond Sand Filter (PSF) and Rain Water Harvesting are popular in Sharankhola, though a large number of population drink water directly from ponds and canals. In Mathbaria, Kalapara, majority of the population collect drinking water from ponds and canals, drink them directly without any treatment. Diarrheal diseases are already acute in these areas and any such disaster like Sidr accentuates the problem in million times. Especially, the dead bodies, debris are found in the wet lands and the situation becomes unmanageable. After Sidr a few NGOs have come forward to install plants for safe drinking water, though the number in terms of population density is quite few.

People make their livestock free before cyclone as they cannot accommodate their valuable

livestock in shelters because of inadequate space. They cannot be left in the houses either, because of risk of injury. The aftereffect of cyclone is catastrophic. People have to rebuild almost everything. Their employment opportunity appears to be gone, all the belongings are lost and devastated houses and crop fields need to be restored. There is hardly any aid or credit facility, especially for reconstruction of the households. Poverty is the driving factor to intensify the vulnerability of poor people during post disaster struggle.

Storm surge and high tidal waves are common in association with cyclones in Bangladesh. People suffer from ensuing effects of saline water along with extra pressure due to cyclonic destruction. This grows worse as the houses becomes dilapidated in a faster rate and availability of drinking water become uncertain. Women have to walk longer distance to collect drinking water in this situation. Fetching water from long distance, defecating in nearby forest as the sanitation system breaks down in cyclones lead women towards a vulnerable living condition in post disaster days. Surviving a cyclone easily turns into a nightmare, especially for the women along the coastal areas.

3.1 Coping With Cyclone by the Distressed

Following the issuance of cyclone warning, people evacuate their houses and go to cyclone shelters in a bid to save their lives — a practice which is common in the coastal belt of Cox's Bazar and Maheshkhali. But in Bagerhat, Pirojpur, Barishal areas, people are quite reluctant to go to shelters. In consequence of the disastrous cyclone in 1991, initiatives had been taken to raise the awareness about following the warnings. Hundreds of cyclone shelters were built. People had received training about their roles during disaster through Union Parishad Disaster Management Committees (UMDCs) and some local NGOs. Currently because of inadequate number of shelters in terms of population density, people often feel reluctant to evacuate their houses.

Often they tend to save their valuables, in pots made of mud or steel by digging earth inside their houses. They try to secure and make their houses durable within their limited resources before the tempests begin, for example in the months of April-May and October-November. They usually tie up their houses in a strong manner so that these can withstand the pressure of the cyclone.

Coping with cyclone needs to be backed up by capacity building training such as quick evacuation training, management training of household resources as well as children and livestock during disaster etc. Generally, women monitor the flag warning and take necessary steps. They put safe water in a plastic canister and bury it along with polythene-wrapped dry-food, match sticks, candles, and life saving medicines in a designated place so that following the storm they can reclaim those important things quickly. It is important to mention that, people act with great preparatory skills in Chittagong, Cox's Bazar, Maheshkhali, Chakaria coastal belt.

During post disaster period, people give efforts to rebuild their houses and boats, prepare their cultivable lands, and explore new employment opportunities through temporary migration. Erosion of assets in a bid to gather cash for the purchase of rebuilding materials is a common practice, where women do participate by voluntarily selling out ornaments, etc. Often the cultivable lands become saline and farmers find extreme difficulties in cultivation. In some areas, for example, Sharankhola, people are trying some High Yielding Variety of paddy which they identify as Chinese technology, in a very limited experimental extent.

It is a common practice for poor people to take loans from local money lenders with high interest rates (in some cases, as high as 100 per cent) just for mere survival after disaster.

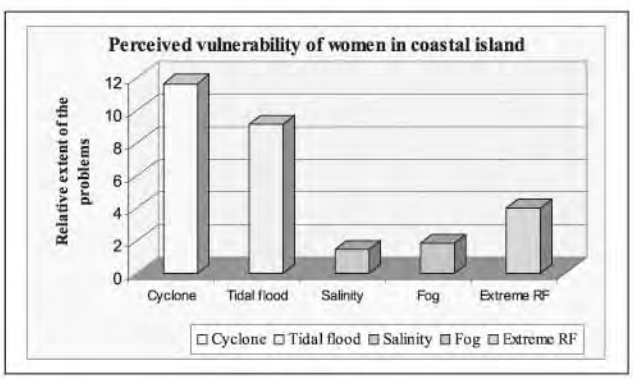

Figure-4:
Cyclone is a major risk in coastal islands

4. WATER LOGGING: THE MAKING OF A CATASTROPHE

4.1 The Hydro-geophysical Characteristics of the Issue

The vulnerable state of Bangladesh created by recurring natural calamities is known all over the world. However, a lesser known new phenomenon—water logging—has been added to disrupt livelihoods of about one million people during the past two decades (Rahman, 1995; Ahmed *et al.*, 2007). The phenomenon involves deterioration of drainage condition in a number of southern coastal rivers leading to temporary to permanent inundation of floodplains along those rivers, causing enormous difficulties towards maintaining livelihoods and disrupting land-based productive system including crop agriculture (CEGIS, 1998; Rahman, 1995). The problem has become severe in the South-western parts of Bangladesh, especially along the Kobadak river system covering parts of Jessore, Khulna and Satkhira districts (pls. see Map in Figure-5).

Water logging is also becoming an issue in central southern Noakhali district, where gradual choking of the Noakhali rivulet (i.e., *khal*) has given rise to temporary water logging every year (Neelormi, 2005). Since a large majority of the rural population is dependent on agriculture for life, the unavailability of land round the year or for a considerable period in season due to clogged water put agriculture based communities in extreme hardship. Unfortunately, as it happens in other cases in Bangladesh, rural women are the worst victims of water logging condition (Ahmed *et al.*, 2007d). Sea-level rise and climate change induced increased monsoon flow would aggravate water logging condition in both the areas (Ahmed *et al.*, 2007b).

The South-western (SW) Coastal Region of Bangladesh has been subjected to a number of hydro-geomorphological hazards which include poor drainage network through its river system, high rates of sedimentation on river beds, acute low flow conditions during the dry season, salinity ingress along the rivers, cyclonic storm surge, moisture stress in the dry season, rise in sea level, and to a lesser extent, flood (Halcrow-WARPO, 2001; RVCC, 2003). The region is located in the coastal zone, and is significantly influenced by tidal effects. The entire region is monotonously flat, having very low elevation. According to available statistics on coastal zone, the major portion of the land is within one meter from mean sea level, a significant proportion of which again falls below high-tide level (Islam, 2005).

The problem of water logging appears to be highly visible along the coastal rivers in the south-western region, where the adjoining lands are mostly empoldered. The Gorai River has been the major distributary of the Ganges, passing through the region, providing the majority of the dry season flow (DHV-WARPO, 2000). Main River systems of this region consist of the Gorai-

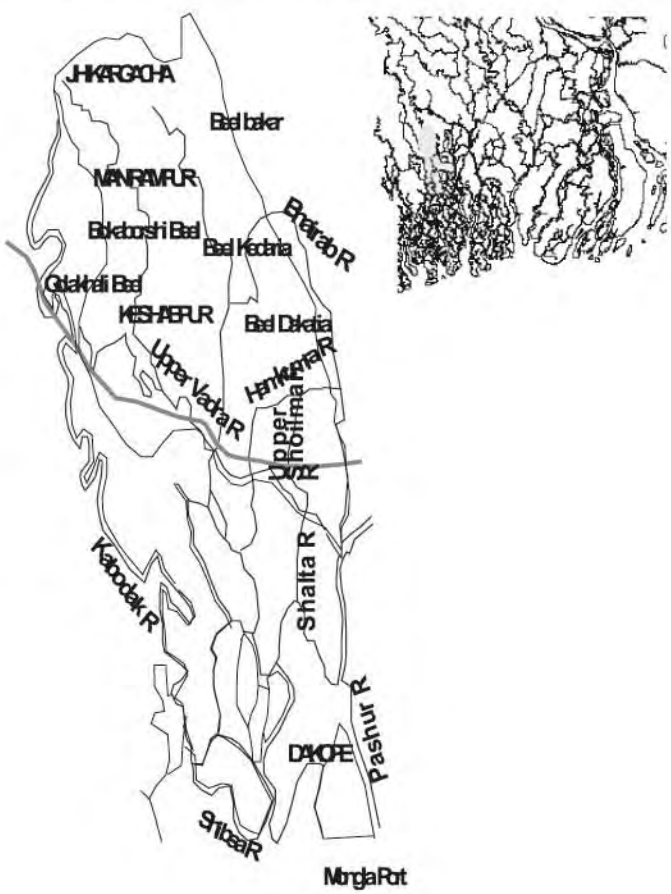

Figure-5:
Map Showing River Networks in Water Logged Areas

Source: Ahmed et al., 2007b

Madhumati-Baleswar river system, the Gorai-Bhairab-Pusur river system, the Bhadra-Gengrail river system, the Hari-Teka-Mukteswari river system, Sibsa river system, the Kobadak-Betna-Kholpetua river system and the Mathabhanga-Ichamati-Kalindi river system. These river systems criss-cross the region through a complex network of smaller rivers and rivulets. Through a natural process of gradual east-ward migration of the Ganges—the primary source of freshwater for all these river systems, many smaller rivers lost their drainage capacity over the past two centuries (Williams, 1919; Sarker, 2004).

The construction of polders along the coastal reaches through the implementation of the Coastal Embankment Project also had a severe negative effect, which has been demonstrated by enhanced sedimentation on the riverbeds. The latter eventually blocked the rivers (Sarker, 2004; Islam *et al.*, 2004). The polders ceased apportionment of available sediments on the floodplains along the coastal (embanked) rivers. The processes have been rather slow, however the results have been incremental and cascading. Not only the morphological processes have been altered severely with adverse effect in terms of narrowing down of width of rivers and estuary, it also reduced the height differential between the crest height of embankment and the peak water level mostly during neap tides in peak monsoon. Following a few iterations of such cascading effects, the drainage capacity of the affected rivers has been shrunk significantly.

Perhaps the most dramatic hydrological effect has been observed in the region ever since the Ganges flows have been withdrawn by the upstream neighbour India by building and commissioning of the Farakka barrage in 1975 (Mirza, 2004; Halcrow-WARPO, 2001). The adverse impacts reached their height during the period between 1990 and 1996, when the Gorai River has been found completely disconnected from its tributary, the Ganges (DHV-WARPO, 2000).

Moreover, heavy siltation at the Gorai off take deteriorated the flow condition of the river. Consequently, most of the smaller rivers in the region choked during every dry season, allowing salinity to penetrate inland towards north. Accordingly, the mixing zone between freshwater and brackish water has been shifted towards the North. During the dry season, a combination of

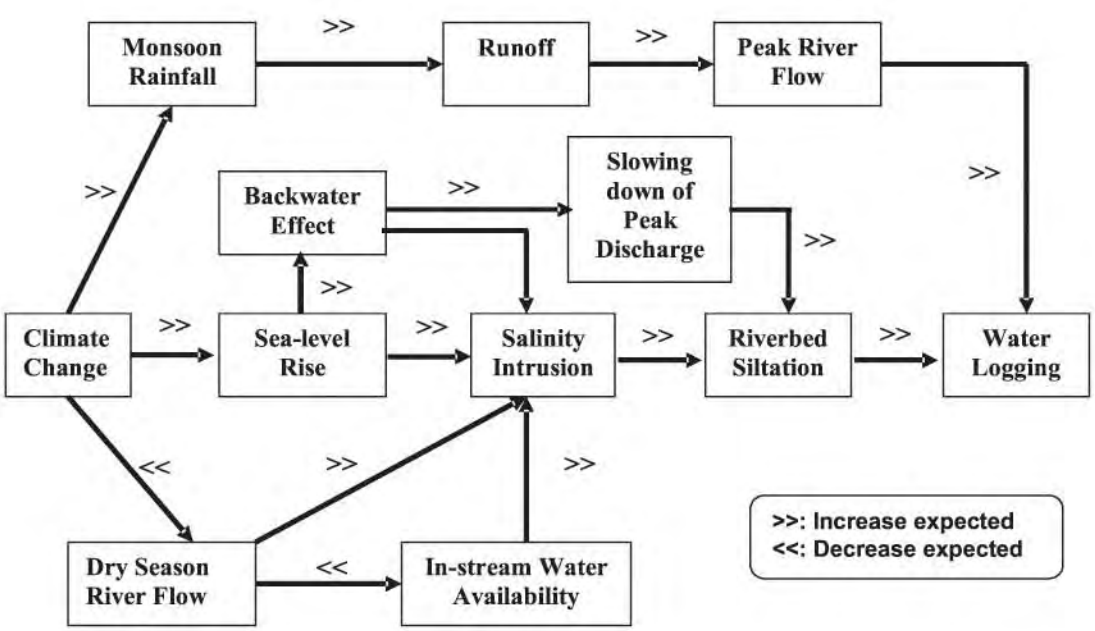

Figure-6:
Schematic representation of various cause-effect relationships towards increasing Water Logging under Climate Change

Source: Ahmed et al., 2007b

extreme low flow and increased salinity accelerates the processes of sedimentation in the riverbed, which eventually block the river and drastically reduce its drainage capacity. This is how drainage congestion becomes a regular phenomenon in that river, resulting into over bank spillage during each peak monsoon. Consequently, the entire basin becomes water logged for a certain period of the year.

It is suggested that the above processes will be aggravated under climate change induced increasing salinity along the coastal rivers. This in turn will further complicate the current state of water logging. The process of developing susceptibility to water logging due to climate change is schematically represented in Figure-6. It is inferred that water logging will be spread over a larger area, involving many other smaller river basins within the Ganges Dependent Areas.

Often it is found that the drainage infrastructure such as sluice gates also become inoperable due to heavy sedimentation and aggravated drainage congestion. Ill-planning on the part of the custodian of the water structures, The Bangladesh Water Development Board (BWDB), especially on wrong placement of such sluices has also contributed to the blockage of the infrastructure. Once spillage takes place over an existing embankment, water does not find ways to recede, inundates both agricultural lands and homesteads. Water logging within an embankment system becomes a perennial problem. The infamous water logging in Polder No. 24 of the BWDB had become a major concern in the 1990s (Rahman, 1995).

Currently, vast areas in Manirampur, Keshabpur, and Abhaynagar thanas of Jessore district, Dumuria thana of Khulna district, and Tala thana of Satkhira district are commonly water logged. In case of Manirampur and Keshabpur thanas, over 85 per cent land has been remained water logged for over seven years. It has been observed that during the flood in year 2007, Kobadak River had been flowing continuously above danger level in Jhikargachcha over 80 days (FFWC, 2007). However, in the other flooded river basins towards the northern reaches, continuous inundation lasted up to 20 days in each of the two flood spells. The *beel* areas along the Kobadak River were all inundated between June and November in 2007.

In the South-central Bangladesh, however, water logging has been observed in Noakhali as a localized phenomenon due to choking of the Noakhali *Khal* (rivulet). To many local people, for the combination of Land Reclamation Project that helped to reclaim almost 0.55 M acres of land through coastal cross-dam in the 1970s and the Char Development Project that influenced the hydrology of the region significantly, the overall drainage capacity of the river-canal network has declined. The Noakhali Khal, a major discharge canal in Noakhali District, has been gradually choked, resulting into drainage blockades. In peak monsoon, following the torrential rainfall, the accumulated water cannot be receded. Consequently, the relatively smaller pocket area becomes inundated for at least several months.

The problem has been causing sufferings to small and marginal farmers of Subarna Char and Noakhali Sadar Thanas. Interestingly, many people have actually been enjoying benefits of land reclamation and extensively utilizing the lands for agriculture. However, in a small pocket, the problem appears to be risky towards maintaining livelihoods of a relatively smaller number of households. Since climate change will induce increased rainfall in peak monsoon, it may be anticipated that in future more areas will be temporarily inundated in every peak rainy season, thereby affecting crop lands and agriculture.

4.2 Implications of Water logging on Farming and Low Income Communities

When a land is inundated, permanently or seasonally, it becomes difficult to maintain livelihoods that are dependent on land based production system. Waterlogged situation, depending on the duration of water logging, can potentially destroy land based production system, as has been observed in Keshabpur and Manirampur upazilas of Jessore District, Abhaynagar Upazila of Khulna District and Tala and Assasuni Upazilas of Satkhira District. To a large number of people living in water logged region in the SW, the phenomenon has given rise

to unbearable malnutrition and hunger in the affected areas, destroyed the social fabric as well as human dignity, and influenced perpetuation of poverty, especially among those who depend on small land holding for their sustenance.

From the field-level FGDs and informal and formal courtyard consultation sessions involving poor and marginal farmer representatives of Keshabpur, Tala, and Assasuni upazilas, it appears that most of the lands in the affected area are inundated year round. However, the intensity of water logging varies seasonally: All the lands undergo deep water during peak monsoon, while in the dry season the water column on the lands are generally knee high and the roads and other notable infrastructure become inundation-free. The seasonality map of water logging intensity (in relative scale) has been provided in Figure-7.

The absence of land-based productive system causes tremendous food scarcity of the affected people. Only in those areas where inundation lasts for six to seven months, people can take advantage of the remainder time and try to produce crops. However, in most of the lands cereals cannot be grown due to miss-match in timings between land availability and cropping season. In relatively deeply water logged lands, water does not recede before *Magh-Falgun* (late February till the end of March). As a consequence, the owners of those lands cannot transplant *Boro* variety of paddy and thereby cannot avail either of the growing seasons for paddies. Food system for the poor, therefore, is found to be dependent completely on income outside the land based productive system. Of course, due to improvement in transportation sector and better food distribution system in recent years, wealthy people manage to get supplies from neighbouring urban sales centres. Unfortunately, the poor people find it out of their reach, since they do not have any savings and they lack income diversification in a bid to cope with changed hydro-geophysical realities. Commodity prices are found to be higher than those are in non-waterlogged areas, mostly due to higher carrying cost through disrupted road networks.

However, in Noakhali District (Sadar and Subarna Char Upazilas) the condition of water logging appears to be somewhat different compared to that in Jessore. In Noakhali, productive lands become water logged only seasonally, during the period July-October. When the peak period for HYV *Aman* transplantation approaches (usually in early August), the lands are mostly water logged and a significant proportion of the lands are thus left fallow. The forfeiture of *Aman* crops robs the farmers' food security, taking the state of malnutrition to a further level. Similarly, those who seek employment as agricultural labours, face food insecurity as well due to loss of employment.

The farmers face the second blow when their opportunity for *Boro* production is significantly diminished due to salinity ingression in groundwater aquifers. At present, *Boro* crop provides the best yield compared to other breeds. When *Boro* potential is diminished, poor and marginal farmers find it extremely difficult to maintain food security. Likewise, agricultural labours also face the similar fate, though to a much greater extent.

In addition to food and employment insecurity, poor households experience many other forms of vulnerability due to water logging condition. Poor people's houses are naturally built with fragile

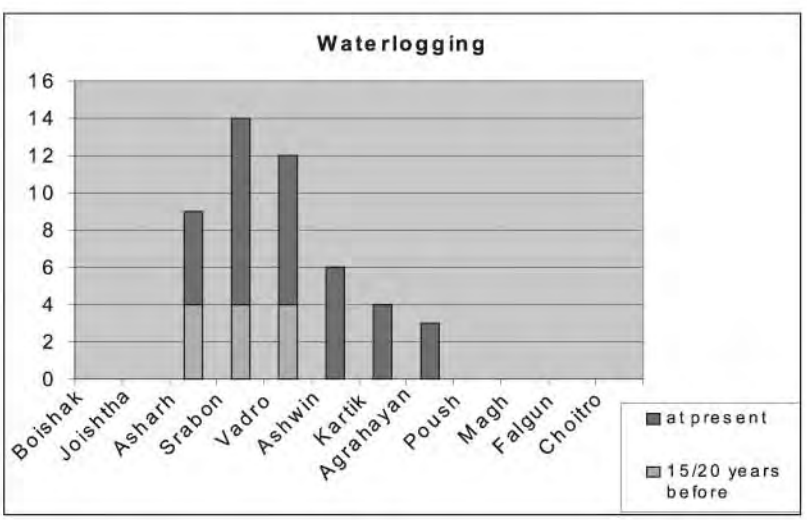

Figure-7: Seasonality of Water Logging

materials which gradually get rotten during prolonged water logging. Inundated roads and other physical infrastructures are severely damaged in water logged conditions. Biomass based walls and earthen walls are completely destroyed even in one water logging event and the family members readily become homeless. Financially insolvent and marginal people find it difficult to reconstruct their houses, clearly knowing that their efforts will be proved futile in the next summer.

In permanent water logging condition, most of the latrines are found out of order. The poor are forced to defecate in open water that surrounds them, while the women in the family wait till dusk to avoid social harassment. Open defecation spread water borne diseases and skin ailments, especially when people need to bath in the same water. A village doctor is used to treat a large number of skin patients in Keshabpur by prescribing cheap ointments, fully knowing that a large number of his patients would not be cured without antibiotic medicines. Since antibiotic medicines are costly, he finds the cheaper alternative (!) as a compromise.

Under water logged condition, the only mode of communication is navigation. However, frequent boat ride can be quite costly. As an alternative, one has to purchase a boat to maintain uninterrupted communication with the neighbourhood. For a poor and marginal household, such an alternative is not viable either. People commonly use rafts, often made of bamboo stems. Lack of transportation often adds to their problems. Indeed, the rapidly urbanized growth centre, Noapara along the Khulna-Jessore corridor, offers employment opportunities for a large number of day-labours. Though the urban centre is only within 10 kilometers from Manirampur, water logged people find it difficult to commute and maintain livelihood, while staying at their respective ancestral homes. Just to avoid hazardous commuting (and perhaps to avoid the water logging problem altogether), males generally migrate to Noapara, leaving their respective family members entrapped in the unhealthy water world.

Under water logged conditions, poor households lose their assets quite quickly. Erosion of family assets is a common set back for coping mechanism, especially in a pre-existing crucial condition. For example,trees are regarded as assets for the poor people in rural Bangladesh. Palm tree trunks are generally used for making rafts there. Most of the common species cannot withstand year-long water logged condition and perish easily. It is ironical that while Jessore happens to be the most successful district in terms of increasing vegetation, the water logged parts of Jessore is gradually getting devoid of trees.

It becomes a major problem to raise livestock, another source of living, in water logged condition. Providing feed, fodder and safe drinking water becomes an indescribable hazard for most of the population. Due to lack of agricultural activities, agricultural residue based fodder has become much costlier which a poor farmer can hardly afford. If one chooses to bear the expense of 'imported fodder,' the year round cost of keeping cattle heads appear to be almost 80 per cent of the current market price of the animal itself! Those who tend to keep cattle heads as draught animals, as they lose their agricultural land, gradually they sell out their cattle. By losing assets such as livestock and trees, financial vulnerability of poor households only aggravates to further extent.

In terms of fisheries, water logging is helpful to the poor in Jessore while it brings new problems in Noakhali region. Common people benefit from open water fishing in Jessore. However, the wealthy ones can no longer use their ponds for aquaculture. If a *beel* (water body) is taken on a lease, then fishing often generates social tension between the underprivileged and wealthy landlords. In most cases, local authority stand by the wealthy and powerful people and the fishing right of the poor gets severely violated. In contrast, the possibility for aquaculture in Noakhali has been totally shattered by seasonal water logging. Although the fish grow well in standing water, it becomes a nightmare for the investors once the fish escapes from captivity.

The energy deficiency is an addition to the vulnerability to the water logged poor community. Those who depend largely on

biomass, due to lack of agricultural work in the locality require cash (of which they are always short of) to purchase biomass energy and to transport it to their households. This is an added difficulty to their financial situation.

Since the educational institutes are often closed or inaccessible during peak monsoon children are compelled to stop attending schools and academic activities as it is expensive to pay for raft rides to school. schools are often used as shelters. In these areas, children do not have any opportunity for recreations. Male children can at least play in filthy water which is also forbidden for the female ones. Having no other means, the young girls manage themselves to the unacceptable living condition in water logged areas.

4.3 Implications of Water Logging for Women

In Keshabpur upazila, the female participants in the FGD have broadly detected the following five natural adversities due to climate change in their locality: (a) water logging, (b) excessive rainfall (c) salinity intrusion, (d) tornado, and (e) hail storms. Women held excessive rainfall responsible for the aggravated water logging in the peak monsoon. And they determined water logging as the chief cause of their vulnerability in Keshabpur.

In Noakhali Sadar upazila, women have detected the following five climate-induced concerns according to ascending order of priority: (a) water logging, (b) drought, (c) Cyclone, (d) changes in temperature regime, and (e) salinity intrusion. From the view of the women of Subarna char upazila, the saline water logging is the major climate induced concern, which practically gives rise to increased soil salinity and affects food security in the long run.

In Jessore and Noakhali districts, the water logging appears to be a periodical problem. However, in Keshabpur, water logged condition prevails during the entire course of monsoon, while people report that the duration has been increasing gradually. On the other hand, water logging condition in Noakhali has been triggered by excessive rainfall with inadequate drainage system, which finds its route to the implementation of coastal embankment project. In the latter case, therefore, it is predominantly a man made hazard, only aggravated by climate induced effects.

Water logging compels women to struggle against great adversities for several months in a year. Women of the waterlogged areas face dissimilar problems than other women of the society. In rural areas in Bangladesh, most of the mud-built houses are destroyed in water logged condition. This leads to social vulnerability of women who have to take shelters on embankments. Often families take shelter on the roof top of the house. In a bid to avoid sudden slipping of young children into flood water, women take every precautionary measure and often curtail the slightest opportunity to rest during the day. Collection of fuel and potable water become extremely hazardous. Preservation of firewood or kerosene, food, and safeguarding educational equipments for the children become difficult. Women cannot send their children to school during prolonged water logging.

In the rural areas of Bangladesh, most of the kitchens as well as latrines are situated outside the main dwelling unit. Therefore, in waterlogged condition it becomes difficult to reach to the kitchens and in cases even to the latrines. All family members especially women cross the waterlogged courtyard several times a day in 3 to 4 feet high water level for cooking purposes. If one wants to avoid such troubles, she accepts cooking inside the house and inhales the unhygienic smoky air along with the children.

Waterlogged situation often increases diarrhea, dysentery and skin diseases. Pregnant women cannot travel to receive the health care, so they stay back inside the house and ultimately fall victim to unhygienic reproductive health conditions. In many cases, it has been observed that people discourage marital relationship with the women in the waterlogged areas because those women generally suffer from skin diseases.

Loss of livelihood due to submerged land areas often forces males to travel long distances leaving their homes for weeks in search of employments.

In their absence, their females become the easy targets of local vices. They are often teased and sexually abused by other males in the neighborhood. While women are forced to go out in search of fuel, often they leave their children unattended or tied with ropes to a pole in order to save them from drowning. Such behavior, according to these women, is believed to be inhuman. However, they find little alternative other than requesting other women to accept the responsibility to look after the children in their absence.

Water logging has remote effects on the social and economic status of women. Homestead vegetable production becomes difficult in waterlogged condition and therefore, women cannot plan to upgrade their financial position. Due to lack of fodder, livestock rearing cannot be sustained which is often the means of livelihood of many women at rural areas. Financial activities are greatly hampered in a waterlogged situation. As a result, increasing number of distressed people fail to meet their basic needs. Unfortunately, reflecting the reality of Bangladesh, the womenfolk become the scapegoats of social norms everywhere. If one tries to catch fish in a bid to avoid hunger, she can only do it after dusk to avoid social harassment. Women's work outside their homestead has been perceived derogatory for the family and such families pay the price when no respectable bridegroom wants to take his bride from that family. Water logging halts all forms of social activities: weddings, ceremonies, social interactions - everything seem to be postponed (even cancelled) during water logging condition. Nobody wants to engage herself in such activities especially when one is encircled by the standing water.

4.4 Peoples' Coping with Water Logging[1]

In the south-central water logged areas, farmers cannot make use of *Aman* cropping season. Only in the elevated sides of *beel* areas (locally called *Kanda*), few lucky farmers can grow *Boro* paddy, especially if water recedes early from those lands. In the case of agricultural production in Noakhali, late varieties of '*Aman*' rice viz. '*kazal-shail*', '*raje-shail*'(both black and golden), '*chapraish*', '*kartik-shail*', '*dholamota*', '*leiccha*', '*nazir-shail*' are sown to survive the water-logging. During the water-logging period, the farmers raise the floor of the cattle shed (locally known as *Bathan*) and stockpile the water hyacinth to protect and feed the herd.

Seed-beds, in elevated lands, are often prepared by raising a piece of land with additional soil and mud. Purchasing imported seeds is also a common practice. In that case, farmers pay dearly for healthy seedlings. In some places agricultural land is raised to some extent, often in *Kandas*, for cultivating winter crops ('*rabi*' crops). In many areas, as a safety measure the levees (sides) of the fishing ponds are raised up to a certain level so that fish cannot escape the ponds with flood water. However, the latter precaution is not applicable in the south-western water logged areas.

Sometimes, males leave their families behind in search of alternative livelihood, often as labours in neighbouring areas where economic activities are going on. Their family depends on the remittance they send for food items available in local markets. Otherwise, starvation appears to be their only option. Indeed, almost 90 per cent of families within the affected areas have been suffering from chronic malnutrition.

To cope with water logging, people generally build houses with fences made of bamboo ('*muli*' bamboo) and wood. The foundations of the houses are raised so that water does not cross the threshold very easily. They build a sort of false ceiling with bamboo slips locally known as "darma", to keep important documents or deeds of lands, dry food e.g. fried swollen rice ('*Cheera*', '*Muri*' etc.), rice and pulses, salt, sugar ('*gur*'), matches, candle, kerosene, quilt, '*kantha*' etc. safe and stored for emergencies during the water-logged period. Rainwater is collected and stored in some areas of the country to be used as drinking water since almost all tube-wells go under water during the waterlogged period. Besides this measure, branches and twigs of trees are stored on the false ceiling to be used as firewood for boiling pond-water. During the flood, water is purified by

[1] In addition to FGDs and KIIs conducted in Keshabpur and Subarna Char areas, a number of coping modalities highlighted in this sub-section have been drawn from Ahmed *et al.*, (2007a).

some families either by boiling or by using alum ('*fitkiri*'). But the rest do not pay much attention to purified drinking water. Ovens made of mud, tin or cement are stored to use during waterlogged period or flood. Cooking is done on top of beds using those ovens as learnt from the demonstration in mass communication campaign by local NGOs/CBOs.

Due to absence of hygienic sanitation, males defecate in open water, knowing well that this conduct is frowned upon. Women, however, do the same only after sunset to make sure nobody sees them. They accept the physical adverse consequences by refusing to defecate in public in open day light. If people become sick, especially in the south western areas, they can hardly afford any medical facilities. Males, if working and commuting to workplace, often go to village doctors and seek medical support. They often do not have means to purchase medicines. Skin diseases are quite common, often due to prolonged exposure to stagnant water. However, females suffer more as they do not have the opportunity for even to see a doctor.

Adaptation to the water logged life is the one and only choice for women in these areas. Females have no choice but to cope with permanent water logging throughout the period. In this patriarchal society, women share the gender based responsibilities. The rural women of Bangladesh are responsible for looking after their family, keeping the household safe and secure, nursing the sick, preparing food and everything else to preserve the harmony in the house. In Jessore, where water logging is being continued for years, they are forced to live in a hopeless situation, even when their male counterparts migrate for a living avoiding the water world during the peak water logged condition.

In contrast, owing to the temporary/seasonal water logging in Noakhali, the conditions are slightly better than that in Jessore-Khulna-Satkhira. They build a sort of false ceiling (of 'darma', a local term) in the houses inside the embankment which offers safe storage for most of their valuables, other important documents, dry food e.g. fried swollen rice ('*Cheera*', '*Muri*' etc.), rice and pulses, salt, sugar ('*gur*'), matches, candle, kerosene, quilt, '*kantha*', etc. Women climb up the bamboo made stairs and fetch anything needed as many times as required.

Since the problem is temporary, women continue to rear up poultry and livestock. Feeding these animals require extra bit of effort on the part of the women. Cooking becomes a hazard; especially if biomass based cooking stoves are being used. Women suffer from subsequent bronchial diseases as they regularly inhale the unhealthy smoke. Fetching safe drinking water becomes another major difficulty. If the personal tube well is inundated or contaminated or both, women carry safe water from the neighbourhood. Social capital often creates access to some certain services which would have been otherwise unattainable.

5. SALINITY INGRESS: THREAT TO FOOD AND DRINKING WATER SECURITY

5.1 The Hydro-geophysical Realities under Climate Change and Salinity Ingress

Primarily the coastal zones experience the tidal effects to the full extent. Tidal front penetrates inland twice daily and interacts with freshwater along the river systems. In the same river stretch flowing southward (i.e., seaward), there is a salinity gradient towards the sea. As the river runs close to the sea, the surface water salinity is observed to be increasing. Besides, as the south-western rivers discharge to the Bay of Bengal, the gradient of salinity is spreading along the south-western corner of the region. As a consequence of increasing salinity, the vegetation in the south-western corner of the Sundarbans is found to be of inferior quality than that of the north-eastern corner of the forest (CEGIS, 2006).

Since a healthy flow along the river systems push the saline front towards the sea front, the surface water salinity is found to be decreasing during the discharge in the monsoon. With the advent of dry season following post-monsoon period, salinity again starts to spread out in the land and water. Thus, the surface water salinity along the coastal zone is an outcome of riverine discharge which has a cyclic order. As a thumb rule, salinity

increases with decreasing flow volume in coastal rivers and the salinity in the dry season is generally higher than that in the rainy season.

According to available model results, the dry season rainfall will be decreasing and the monsoon rainfall will be increasing under climate change (Agrawala *et al.*, 2003). Since the flow volume of rivers in the South central region (i.e., the Lower Meghna up to Payra River) will still be adequate under climate change regime, the effect of salinity ingress will be higher along the south western river systems (i.e., from Baleswar up to Raimangal rivers). The salinity regime along the Passur River system, the major drainage channel in the south western region, will be dependent on the dry season flow of the Gorai River, being the major distributary of the Ganges. Salinity in all the other rivers and rivulets along the south west reaches of the country – all parts of the Ganges Dependent Areas (GDA) – would depend on dry season flow regime of the Ganges and its distributaries.

The salinity front will also be pushed northward (towards inland) when sea-level rise induced backwater effect would interact with inward flows (CEGIS, 2006). Considering lower level salinity threshold (i.e., say, 5 ppt), the effect would be more pronounced along the South-central Rivers, as shown in Figure-8. However, considering the over all salinity ingress, the south west would be more severely affected coastal area than the rest. Satkhira, Khulna and Bagerhat districts – which are already moderately saline affected – will face the brunt of increasing salinity ingress, while parts of Jessore and Narail districts will also be adversely affected due to increasing salinity. Under climate change, the surface water salinity in Barguna, Patuakhali, Bhola, Laxmipur and Noakhali districts will also be increased slightly to moderately.

Interestingly, soil salinity does not follow the similar dynamics as the surface water salinity. Salinity generally builds up with increased dryness (index of aridity) on the surface area as well as increasing capillary action throughout the pores of the soil texture (Karim et al, 1990; Habibullah *et al.*, 1998). If salinity is built up on top soil, agricultural potential gets severely constrained. The adverse effect of soil salinity is dramatic if one considers the potential loss of yield from the expected yield (Karim *et al.*, 1990). The production of rice, the staple food for 145 million Bangladeshis, is at high risk due to salinity build up on the top soil. Habibullah *et al.* (1998) have estimated the potential loss of crops under moderate to severe climate change scenarios. Intriguingly, while only 0.83 Mha of coastal land has been subject to various degrees of soil salinity in late 1980s, by 2002 the total coastal land under various degrees of soil salinity has increased to 3.05 Mha (Karim and Iqbal, 2003).

The above reality is a caveat for the changes caused by the climate effects. Firstly, the dry season will continue to become drier (Ahmed and Alam, 1998) and the index of aridity will continue to rise. The evapo-transpiration from barren soils and surface vegetations will continue to increase as available rainfall in the dry season will further decrease (Karim *et al.*, 1998). This will give rise to increased capillary action. The latter will culminate in increased soil salinity damage across the coastal zone.

Salinity adversely affects crop production as the coastal farmers experience in many areas. Therefore, they are not eager to grow dry season paddy. Under climate change induced effects, the potential for Boro rice along the coastal region

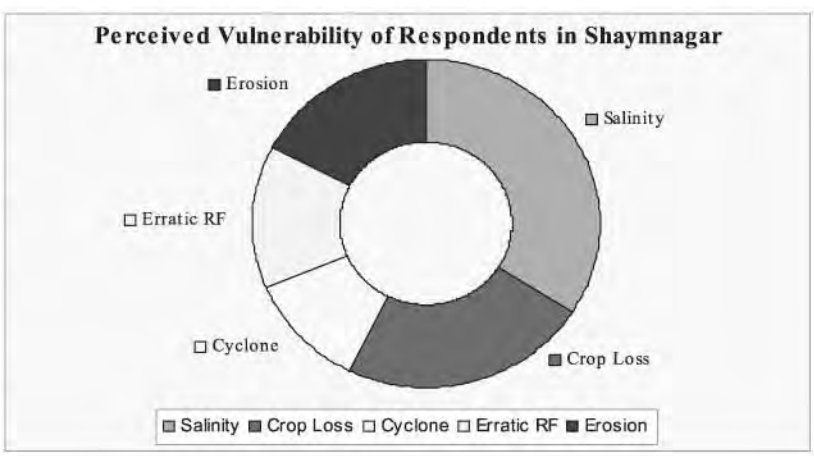

Figure-8:
Salinity is a Major Risk Element in Shaymnagar

will likely to decrease, as it has been found from modeling exercises for the three southern most districts in the SW (CEGIS, 2006). With decreasing potential for *Boro,* food security of marginal farmers in saline affected coastal regions will become a major concern in future.

The problem of drinking water has been a trouble already for the coastal population. In the SW region, about 6 million people are deprived of safe non-saline drinking water. The surface water is not only saline, it also contains dirt and pathogen. Therefore, people cannot simply use surface water sources for drinking purpose. Occasional inundation of water storages like ponds and artisan wells often turn saline if the area is hit by tidal surge or embankment failure. The only other source of drinking water is the ground water aquifers. In the coastal zone, people make use of such aquifer system and draw potable water by drilling a well (generally tube wells). Unfortunately, in many coastal areas (reported in Shaymnagar, Assasuni, Sharankhola, Char Alexander, Char Bata, Subarna Char, etc.) the shallow aquifers have either become inoperable (perhaps exhausted!), or it provides slight to moderate saline water. A large number of people are now suffering due to inaccessibility of non-saline drinking water.

It is postulated that the dependence on the remaining aquifer system will increase for drawing non-saline drinking water in near future. Since the rise of sea level might interfere with the recharge of such aquifers and salinize the aquifer system, non-saline water supply throughout the coastal zone of Bangladesh is going to be a crucial problem. However, there exists almost no information in this regard to warrant immediate actions to develop an alternate water supply system for future considering climate change reality.

5.2 Salinity Ingress: Implications on Farming and Low Income Households

Salinity affects the crop production in extended levels. Thereby, the vulnerability of the poor and marginal farmers is directly linked with salinity ingress. Soil salinity above a threshold would reduce potential for the production of *Boro,* the most popular crop in *Rabi* season. There are areas which remains less saline at the initial cropping stages, but gradually becomes saline as *Boro* reaches reproductive stages in April. In such cases, adequate irrigation can still ensure a considerable harvest. However, due to climate change and mean sea level rise effects, slightly saline areas will become moderate to highly saline and surface water based irrigation will not be possible. A combination of salinity and lack of adequate irrigation might result in a drastic reduction of crop production in the south-western region of the country.

Figure-9: FGD in Satkhira

For the marginal community reduced crop production will result in food insecurity. Poor farmers do believe that under changing climate condition *monga*-affected areas will be extended to many other parts of the country.

Salinity ingress causes major problems in the south-western region of Bangladesh as in Satkhira, Khulna, and Bagerhat districts and comparatively less complicated ones in the coastal reaches of Borguna, Pirojpur, Barisal, Bhola, Laxmipur, Noakhali, Chittagong and Cox's Bazar districts. During the dry season, the problem becomes intense in agriculture and lack of saline-free water becomes an acute problem for the households. This is especially true in Satkhira and Khulna districts. Two FGDs have been organized in Tala and Shaymnagar Upazilas of Satkhira District to understand women's perception regarding salinity-related vulnerability to climate change. Women participants have identified a large number of

vulnerability contexts in relation to climate variability and change, which include the followings: (a) increased salinity, (b) untimely rainfall, (c) inadequate rainfall, (d) high temperature, (e) frequent droughts (f) delayed winter, (g) short duration of cold spell, (h) reduced availability of sweet water, (i) excessive silting of canals and riverbeds with high tides, (j) increased water logging situation, and (k) untimely occurrence of monsoon.

Women are also asked to prioritize a few problems that require immediate attention. The following appears to be the three most important climate induced vulnerability concerns: (i) increased salinity, (ii) increased water logged situation and (iii) increased drought stress.

Being the homemakers, women find it necessary to provide saline-free drinking water. Since in some areas water sources in the neighborhood are all affected by high salinity, the women need to cover long distances on foot every day in search of drinking water. This is almost the compulsory duty of women in the South-western Bangladesh irrespective of their physical condition. Recent observation and field study reveals that a significant proportion of women, who travel long distance to fetch drinking water, are pregnant or mothers of new born. People who can afford to buy filtered sweet water are an insignificant part of the population. Most of the people, especially the poor faces acute salinity problem in drinking water (RVCC, 2003).

Usually women and adolescent girls carry out the task of collecting drinking water from distant sources. This may take three to four hours a day. As a result, they do not have enough time or energy to carry on other household duties like cooking, cleaning, washing clothes, taking care of elders including themselves. In saline prone region, therefore, women have to curtail extra hours from their household works to combat with salinity problem. The consequent effects are having difficulty in time management for other household activities. Moreover, womenfolk after their daily chores ordinarily do not get either physical or mental rest or recreation.

On their way to the distant water sources, women and adolescent girls are sometimes being harassed by men or boys. The women and girls therefore feel uneasy and threatened to collect water from distant sources. The skin, a sensitive issue of adolescent girls, gets rough and unattractive due to the regular use of saline water. Men from outer areas express reluctance in marrying these young girls. Even within the area, girls from poor families are ignored by the rich families for a matrimonial relationship.

Nevertheless, such women suffer from various diseases in the long run for excessive hard work and hasten their old age. Women and adolescent girls are affected by gynecological problems from using saline water during menstruation. Women, while explaining their bitter experiences about menstrual hygiene management, reported that saline water creates pain during menstruation. The used clothes become hard after drying (due to the water salinity), which creates discomfort when next used. Further use of the same hard clothes can create genital injury, including bleeding, infection and other complications.

Some women, who do not feel safe to leave their children alone at home, bring their children with them while travelling for drinking water. Obviously, it affects the health of the accompanying children as well. When a poor family cannot afford to collect water due to sickness or for not having any family member capable of doing the job, they have to buy water from water vendors at Taka 10 per pitcher. It is very inconvenient for them to spend at least Taka 300 per month for drinking purposes as their monthly income is typically Taka 500 -Taka 1500. Therefore, sometimes they have no choice but to use saline water for drinking purposes. Furthermore, females are the prime consumers of saline water in their family. There are examples of families where old parents can not afford to spare their daughter to get married as the daughter appears to be the key person to collect water for the family.

5.3 Coping with Salinity Ingress

The rural people of saline prone region previously used drinking water from shallow tube-wells. But

now-a-days, with the growing awareness, they have started to drink water from deep tube-wells since the chance of salinity is much lower in the latter source. In past, when they did not have any specific knowledge about salinity, they used to drink water from ponds as well. Now even when people drink water from shallow tube-wells, some of them do purify it using alum (*'fitkiri'*). As a noticeable effect of salinity, the complexion of the local people has grown dark. But locals have got used to this phenomenon through living in this neighbourhood for a long time. For cultivation, farmers use fertilizers viz. gypsum, TSP[2], potash, etc. to reduce salinity in land. The extent of salinity varies in different sections of an uneven land. Hence to make the extent of salinity equal all over the land the farmers first make the land even and then use various types of fertilizers mentioned above.

In saline prone regions of Bangladesh, unavailability of suitable drinking water is the major problem. Traditionally women shoulder the responsibility to fetch non-saline drinking water, even if the source is located far away from her household. It might sound so simple, yet it can be quite hazardous. The onus one woman has to take under specific circumstances can be quite dramatic. For example, a pregnant woman at advanced stage has to continue the duty unless other women in the community relieve her by sharing her responsibility. Kinship plays a major role here. However, the primary responsibility remains on the part of women.

Ironically, one of the respondent in the FGD held in Tala informed that she had to fetch water the next day following the birth of her first child when she was in her teens. It affected her reproductive health severely and she had been suffering from various related diseases ever since. Another anecdotal story was told of a woman who left one of her toddlers at home and carried the other to fetch non-saline water from a few kilometres adrift. On her return, she found the child dead due to snake bite. Woman, in their daily struggle to collect potable water, face difficult circumstances, including sexual harassment and assault.

Women are aware of the fact that a certain species grow well in saline conditions. They plant palm, betel nut, *sofeda* (a local fruit), etc. saplings which provide little cash for the family. In doing so, they actually utilize the condition which otherwise poses threat to their betterment of life.

In Satkhira, due to close proximity of *gher* fisheries, women find it easier to raise ducks. This helps them to avoid dearth of animal protein. Women also engage themselves in handicrafts, based on individual skills. Mainly for lack of time, many women cannot simply make the best use of their acquired skills.

6. EROSION AND EMBANKMENT BREACH RISKING LIVELIHOOD SECURITY

Coastal erosion is a century old problem in a dynamic deltaic sea front. The shoreline has been experiencing both erosion and accretion since ages. Although the available records are scanty, maps drawn by Rennel and satellite images clearly depict the changes that have been taking place in recent past along the shoreline.

Since the late 1960s, the morphological dynamics along the coastal areas has changed completely due to two structural alterations:

(a) Coastal embankments have been built to safeguard agricultural lands from saline tidal effect, however that triggered into irreversible hydro-morphological and environmental changes, and

(b) Cross-dams have been built in the southern reaches of greater Noakhali region, which have helped accretion of new char lands and settlement of people, however affecting local level drainage due to constriction and choking of rivers and rivulets (*khals*).

[2] Triple Super Phosphate (TSP), a phosphorous containing fertilizer. Single Super Phosphatre (SSP) fertilizer was also observed in stores, bearing evidence that SSP was also being used as fertilizer.

Despite the fact that some of the weak coastal embankments have been refurbished through a number of projects in the recent past, in many cases the earthen structures have become structurally vulnerable. With the growth of Sea Surface Temperature (SST) in the Bay of Bengal, the waves are damaging the structures exerting increased energy, which is leading to frequent embankment failures and breaches. In 2007, one of such breaches in embankment was detected in Shaymnagar thana in Satkhira, It has been subsequently mended twice, yet the structure could not secure the land from being inundated by saline water. The sense of security of people living inside the embankment has been shattered completely, with huge toll on standing crops, dwelling units and people's livelihoods.

In September 2, 2006 the high tide eroded parts of embankments in Patuakhali, Barguna, Bagerhat, and Satkhira districts and a total of 168 villages have been reported to be under water for weeks following the incidence. It has been reported in Mathbaria upazila that the local embankment along the Baleswar River has been overtopped by high tides during *Choitra* and *Boishakh* (late March till Early May) during the past four years. The problem of embankment breach has reached its peak following the super cyclone Sidr, which occurred in mid-November 2007.

Over 10 kilometers embankment has reportedly been eroded away in southern Barguna area (including areas under Mathbaria Upazila) and over three hundred sluice gates have become inoperable as a consequence of cyclone Sidr. Local people fear that tidal saline water will certainly penetrate into their crop lands, having detrimental effect on crop agriculture. Official statistics released following the event suggest that over 1,875 kilometers of embankment were damaged due to Sidr. The same event also caused damage to 1,687 bridges and culverts, over 16,000 educational institutions, and over 8,000 kilometers of road networks (MOFDM, 2007).

With every breach in embankment, the sense of security among the local people of these areas gets shaky in apprehension of extreme odds. Moreover, the sudden onrush of water inundates the croplands, destroys standing crops (if any), and washes away valuable livestock for any lacking in protective measures. The worst effect is observed in terms of destruction of dwelling units, especially the little biomass-based huts generally owned by poor people. A few days of submergence in saline water easily brings down the biomass based structures (basic bamboo structure, with thatched walls and *Golpata* roof) and make people homeless. A high intensity cyclone can destroy even better structures, as it has been demonstrated by Sidr.

Under climate change scenario, it is postulated that the wind-wave interaction of this level will continue to destroy infrastructures and weaken the embankments, with eventual loss and failures. The rate of failures of such structures has been on the rise in recent years; however the attribution to climate change cannot yet be made decisively. In 2007 alone, embankment failure occurred in twelve such cases throughout the country, which brought immense miseries to affected population.

It is difficult to identify one particular area where such embankment failure has been more prominent than in other areas. However, coastal erosion has been exhibiting pronounced effects along the major drainage channels, especially along the coastal chars on Lower Meghna River. Allison and Kepple (2001) estimated the erosion accretion balance in Bangladesh and inferred that the balance has been tilted towards net erosion. It has been found from field visits that the char lands within the administrative boundary of Bhola Island has been undergoing net erosion over the past 15 years. Mr. Yunus (57), an early settler in Char Patila Island is facing the eventual catastrophe, as the Lower Meghna has been devouring lands through continued erosion. He fears, within a year or so, he will have to move from here if his lands and dwelling unit are eroded by the river.

In addition to Bhola Island, the char lands of Noakhali and Laxmipur (especially Haimchar Upazila) have been facing coastal erosion in recent years. Hatiya has become a much smaller island than it was a few decades ago. Although many people have settled in the newly accreted lands, a large number of households have lost their belongings and become destitute due to erosion.

6.1 Implications of Coastal Erosion and Embankment Failure

Erosion generally occurs quickly and the results are often devastating. The poorest are the worst victims, since they are incapable to relocate themselves following such an event. Erosion takes away crop lands, the major source of living for the poor and marginal farmers. Moreover, erosion makes people uprooted and forces them to migrate. Unless they are properly rehabilitated, which seldom happens, they cannot escape hardship, physical and emotional sufferings, social injustice, etc. Even they cannot escape the lengthy legal processes to establish claims of their non-existing land.

It is ironic that an erosion event can descend a rich and a poor family on the same plane. However, the rich family, owing to their better financial stature and much improved social resilience compared to that of the poor family, can bounce back. If one carefully does a life cycle analysis of two such families, one can reach an inference that the social and economic vulnerability of erosion is eventually disproportionate on the part of the poor family.

Coastal erosion appears to be the most important climate related vulnerability concerns in Bhola district, as revealed through the FGD which has been conducted in Char Fassion. Of course, women in Char Fassion are almost equally concerned about cyclone storm surge. However, they express the view that the southern embankments created by Bangladesh Water Development Board and the coastal green belt of vegetation created by Bangladesh Forest Department have reduced their state of vulnerability and sense of insecurity to a great extent. As it has been described by people in Char Fassion, erosion reaches its peak during Bhadro to Ashwin. They have informed that a large part of north-eastern Bhola Island has now been totally eroded and the island is gradually shifting to south-west direction. The cataclysmic currents of the rivers swallow up the lands during peak monsoon.

Erosion leaves profound physical marks on the landscape, which can rather easily be studied later by means of satellite imagery. A comparison of Rennell's Map and recent images reveal that Bhola has undergone tremendous morphologic changes over the past two hundred years. When large areas are eroded, as frequently experienced by the locals, settlements, infrastructure, and community places, service centres in large scale get destroyed within days. People cannot withstand the fury of nature; neither can they slow down the eventual destruction.

Loss of land due to erosion causes scarcity of food in the family. Men often tend to go far away places in search of employment. They leave behind their families, resting the responsibility upon the senior woman in the family. Women find it disgraceful to live in the open, since they are the primary victims of any mishappenings. Without having the husband around, the woman suffers from social oppressions to physical and sexual harassments. Moreover, she has to provide food for the rest of the family members, especially for young children. Sometimes, the man abandons the family and settles down in urban areas. In such cases, the woman faces greater hardship than ever. In desperate attempts for survival, sometimes she gets involved with anti-social activities. Many other erosion victims take up the same sort of activities or join the floating population and the youth often go astray.

When the dwelling unit gets ruined in a storm, the women become extremely helpless. It is not easy to resettle in someone else's land and it often creates social chaos and conflicts. The homeless people live in the open, without having the slightest privacy even for the women. It becomes a nightmare for the women to take care of their family without resources. Fetching water becomes a major task. It takes an extra effort to ensure safe drinking water. As in the case of water logging (section 4), lack of sanitation facility becomes a major problem on the part of the woman as she cannot defecate along the river in open. She often has to wait till dark and consequently bear with unhygienic and unhealthy conditions. Unlike their male counterparts, a woman cannot escape social condemnation if she has to accept the life of a destitute woman following erosion. Besides, people find it difficult to arrange marriage for their adolescent daughters once they become homeless.

6.2 Coping with Erosion and Embankment Failure

Erosion often does not spare any personal resources to start over with. In most cases, the affected community become homeless and is forced to accept socially derogatory consequences. Male members often try their luck elsewhere, offer daily labour and eke out a living. However, it comes along with sacrificing family life. On the other hand, the women take the onus of maintaining the family affairs all by herself, while offering solace and comfort to other members of the family. A rootless family often becomes disjointed, demoralized and eventually fragmented. Sooner or later, members of the disjointed family out migrate to urban areas in search of employment and livelihood. Erosion often turns well off farmers into urban destitute.

Once local people realize that the land is subject to erosion, they stop investing in their dwelling units. In most of the erosion-prone unions, "*kacha*" houses made of bamboo ('*muli*' bamboo) and tin roof are very common; even jute sticks are also used as the walls and jute fabrics as ceiling. People who are very poor use mud as housing material. These types of houses are more vulnerable to sudden shocks in natural disasters than brick-built houses, owned by comparatively wealthier families.

Every section of the society tries to strengthen their houses prior to the monsoon and cyclonic storms. They reinforce their houses according to their financial capability. Usually the foundations of all the houses are raised high so that the rain water cannot enter into the house. Usually people raise the platform at a height which can protect the houses from average flood and rain water. The families who have some savings to spend on this reinforcement, they usually raise the platform of houses above the anticipated water level as a safety measure for survival in case of water logging condition due to excessive rainfall. The kitchens are also placed on raised platforms.

Raised platforms are made of bamboo in order to keep provision for urination and defecation purposes during the flood. Houses outside the embankments are usually raised on even a higher platform, allowing the regular tidal surges to flow without any protection. This platform is about 4-5 feet high. Then on this raised platform people again raise another platform (say about 1-2 feet high) and build houses on this secondary raised platform. This secondary raised platform helps to protect the houses from unusual tidal surges (Ahmed *et al.*, 2007). They use to do post harvesting activities on the primarily raised platform. Other than this Two-staged raised platform, the internal arrangements of the houses outside the embankments are almost the same as the houses inside the embankments.

People make some arrangements before the season of embankment overtopping gets started. Again, the arrangements depend on individual household's capability to invest. Usually they use to tie the corners of their houses with strong ropes or steal wires. To protect themselves from rain they use to repair their ceiling almost every year. Before the rainy season or cyclone season people take special care of those houses, where walls are made of mud and ceiling is made of jute sticks or leaves. People who are very poor and do not even have the minimal means to reinforce the house; they use to take shelters in the next door, adjacent schools and in madrasas. During the long water logging period due to excessive rainfall cattle, poultry, pets all get shelter under the same roof where the family lives. Very few families have that luxury to keep a separate cow shed which is locally called "*Goal Ghar*".

In a desperate effort to safeguard inundation of standing crops, farmers employ daily labours and try for early harvest. They try to compete with the onrush of water. If the cultured fish (in ponds) somehow escapes within the embankment, young children go out in groups and catch as much as possible. However, if the embankment is completely over flown, fishes slip over. In both the above cases, investors face major losses.

7. ROUGH SEA EVENTS: LOSS OF LIVELIHOODS OF FISHERFOLKS

In recent decades, along the northern Indian Ocean which covers the Bay of Bengal region, there has been a gradual rise in Sea Surface Temperature (SST). Figure-10 provides the

decadal increase in Mean SST for two seasons: (a) monsoon season, and (b) post-monsoon season. This may be attributed to, among other physical phenomena, global warming.

The IPCC in its Fourth Assessment Report has indeed confirmed a net rise of about 0.6 to 0.7 degrees Celsius over Asia during the past five decades (Cruz *et al.*, 2007). The rate of change of SST during 1961-2001 also shows a similar trend (Singh and Sarker, 2003). Singh and Sarker (2003) observed that, during the period 1985-98, the SST in the coastal region of north Indian Ocean (i.e., in the vicinity of Bay of Bengal) shows an increasing trend in all the seasons.

The linkage between global warming and recent gradual increase in monsoon and post-monsoon SST Anomaly (SSTA) has further been established by Khote (2005), who revealed a paradigm shift in seasonal SSTA after 1975 i.e., during the post-global warming period. The increasing Sea Surface Temperature (SST) fulfills one of the major preconditions of the formation of an increased number of depressions and low pressure systems in the Bay of Bengal.

The rise in SST has been translated into a rise in 'rough sea events' along the Bay of Bengal, as reported by fisherfolks along the coastal zone. The Jaladas community in Chakaria, the fishermen in Char Patila, Kalapara, Mathbaria, and Sharankhola – all suggested unanimously that they could sense a warming up of the sea temperature. They obviously link the rise in temperature with frequent rough sea event – an incidence that incur the direct loss of their livelihoods due to their inability to continue fishing in that weather.

In the coastal areas of Bangladesh, the estimated number of households depending on fisheries one way or the other ranges between 140,000 to 160,000. The coastal fishermen are poor; however their economic hardship is most likely to be aggravated under climate change. Increasing numbers of low pressure system means that for an increasing number of days per annum the sea will be rough and stormy (accompanied with high tides) along the shore – a change in the coastal environment which will prevent fishermen to sail for fishing. In simple terms, poor fishermen will have lesser number of active days, lesser amount of catch per annum and perhaps lesser income (in terms of both income opportunities and lesser catch). Those who would try to minimize the 'apparent loss' by defying signals, might have to frequently put their lives at stakes.

A successful fishing trip generally requires about 14 days, particularly for the fishermen living in the SE parts of the country. Each group of fishers generally borrows[3] cash from money-lenders (locally known as *Mahajans*) at very high interest rates and purchases fuel and other commodities to cover the entire fishing trip. According to the Standing Orders on Disasters prevailing in Bangladesh, people must come back to shore and take shelter if signal number three (3) or above is issued (MODM, 1998). Issuance of signal number 3 or above in a seaport is therefore considered as 'dangerous' and signifies highly rough sea conditions.

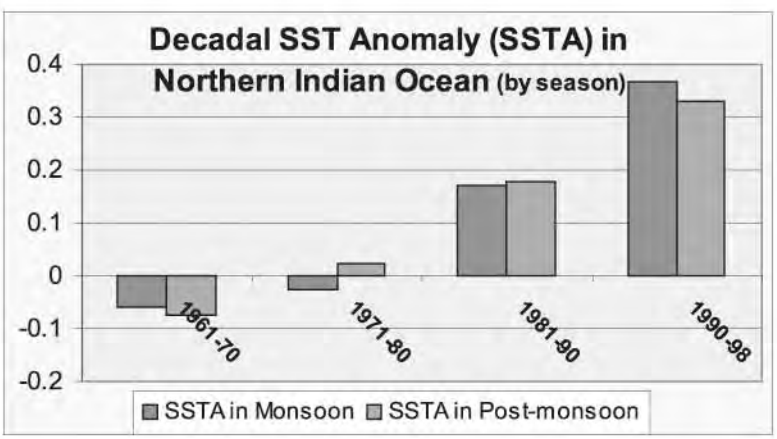

Figure-10: Increase in SSTA During 1961-1998

[3] In SC coastal areas, the minimum number of days appears to be about 7. It generally depends on type of fish being caught and the fishing grounds in the vicinity.

Following the issuance of such warnings, fishermen along the coastal region had to come back to the shore frequently during the monsoon of 2007 abandoning their 'fishing trips'. During July 22 and November 13-14, there had been eleven such warnings for rough sea conditions, issued by the concerned authority. During the same time frame, there were ten brief periods where sea-going fishermen either made their fishing trips or remained along the shore to safeguard their potential investment. Figure-11 provides a graphical record of the fate of fishing trips for the SE fishermen of Chakoria Island during the specified period.

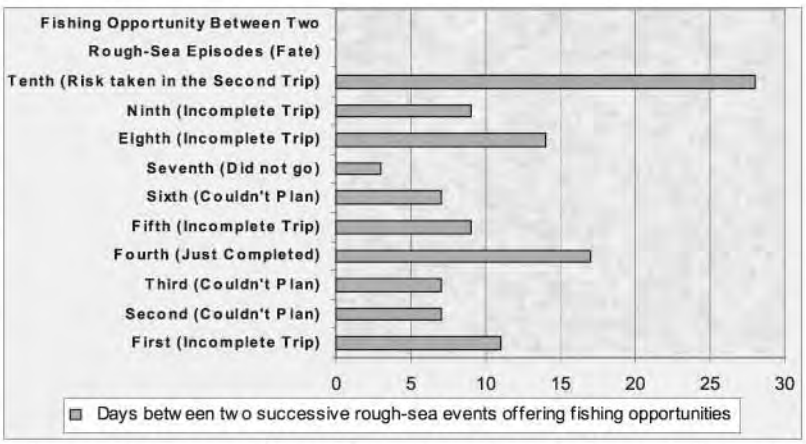

Figure-11: Loss of Livelihoods by Fisherfolks in Chakaria

As the fishermen along the SE region (viz. Chakoria) chose not to risk lives and refrained from fishing trips, they had to accept loss of income potentials. If they went for fishing, following the issuance of a warning they had to come back abandoning the fishing trip. The unfinished trips would cause a significant loss of their livelihoods, especially in the peak fishing period. The fisher folk communities in Chakoria claimed that they had actually faced twelve warnings throughout the monsoon in 2007, which matched with the official number of warnings being issued. By the time they could come back to safety, their investments for the purchase of food, fuel and other commodities might have all been consumed, while the catch volume would be lesser than expected. Many lost their boats and fishing gears when the weather had become stormy. Since it all started with the increase in Sea Surface Temperature (SST), one cannot ignore the fact that it had been essentially caused by global warming. Perhaps, such an extreme event provides the primary evidence that climate change is a fact and its consequences are actually affecting people's lives and livelihoods in Bangladesh.

The super (Category 5 Hurricane equivalent) cyclone Sidr actually provided a major evidence that many of the fishermen, who safeguarded their lives repeatedly during the peak monsoon months and accepted certain loss of their livelihoods by abandoning their fishing trips, were actually forced to defy the signal issued by the authority. They remained in the sea with a 'hope' that the warning would be proven false. Taking such a chance resulted in fatality. In one way or the other they were being constrained within two choices: either a slower death by accepting loss of livelihoods once again or a quicker death by accepting the eventual fate.

8. ADAPTATION TO CLIMATE CHANGE IN THE COASTAL ZONE

8.1 Cyclone and Storm Surge Related Adaptation

The disaster management capabilities of Bangladesh regarding cyclone and storm surges along the coastal areas have been globally acclaimed so far. However, the super cyclone Sidr posted a harsh message to the policy makers about the drawbacks at policy level. A combination of model-based highly advanced warning system, social mobilization of a large number of volunteers to reach out the warning to the millions of coastal poor people, building of over 2200 coastal cyclone shelters to safeguard lives and many other earthen *killas* to save lives of livestock have clearly demonstrated that Bangladesh can effectively reduce otherwise staggering death tolls due to cyclone and storm surges. The idea of getting more and more people involved in the process of which they will take pride certainly deserves credit. Still the south-western part of the coastal belt is lagging behind to achieve this level of skill in a large scale to safeguard lives from disastrous cyclones.

However, such mechanism has otherwise been proved to be gender blind, as it also happens in many other hazard management particles in the country. Contexts of women's vulnerability in an event of cyclone and storm surge have only slightly been changed due to the innovative approach of 'Cyclone Preparedness Program'. For obvious reasons, an opportunity to survive the onslaught alone can be considered as a great achievement. However, women seek more cooperation from the society, as they deserve to be treated with honor and dignity. Mere survival and subsequent social maltreatment can no longer fulfill the needs of coastal women in quest of adapting to climate change.

Women require to be informed adequately and well ahead of time of occurrences of the events. They require training on translating the flag signs, preparatory measures etc. Moreover, they want their respective male counterpart to be responsible enough to share equal responsibilities in the preparatory processes before running to the shelters. It is understood that training should be designed and imparted to equip coastal women for cyclone combat. However, changing patriarchic norms and behavior would certainly require social and economical mobilization and awareness which cannot be achieved only with rhetoric of the policymakers. The designs of the shelters must be women friendly. Carefully responding to the needs of women can facilitate gender-sensitive adaptation in the wake of climate change induced cyclones and storm surges.

Number of cyclone shelters must be increased according to population density. The access roads to shelters must be built with bricks or concrete. Housing loan with low interest rate and easy installments must be made available for the affected people. People, especially women must have easy access to institutional financing in order to make their dwelling units sturdier.

The destruction of standing crops caused by a storm surge can have a significant bearing on the economic status of poor and marginalized farmers to middle income earning farmers. Saline water can potentially destroy crops even within an embankment if trapped inside. Following Sidr, destruction of standing crops becomes a pressing concern in those affected areas. There is hardly any preparation throughout the embankment system to quickly remove saline water logging following a tidal storm surge. Investments in this regard and making improved embankment design and enhancing management system are extremely crucial. Bangladesh Water Development Board (BWDB) could greatly contribute in facilitating poor people's adaptation to cyclonic storm surges.

The provision of safety net program, as highlighted in the Poverty Reduction Strategy Paper (PRSP), is not so specific to tackle food insecurity following a cyclonic event. Local level needs assessment is absolutely vital here for a quick and better response after cyclonic devastation. Creating employment opportunities for the affected people can be considered a great challenge altogether.

Positively the coastal green belt program has indeed created a safety barrier to decelerate the onrushing storm surge in many coastal areas. This greatly facilitates the adaptation along the coastal belt. It is also noticed that the tree density in many of those areas are being reduced due to poaching and illegal felling. The Sundarbans has greatly been affected during Sidr. We must take strong initiatives to replenish these losses through intense plantation. Efforts must be made to keep uprising green belt intact. It would not only require strengthening the current surveillance and monitoring of the Department of Forest, it would also require active support from local administration, local communities and the Bangladesh Coast Guard Authorities. It would also turn into an example of adaptation co-benefit of an otherwise mitigation program.

8.2 Adapting to Water Logging

The most difficult challenge posed by persisting water logging relates to non-availability of crop land for cultivation. Since most of the rural communities in the affected regions used to be farmers, their main concern is to restore land-based productive system, thereby maintaining farming-based livelihoods. It is therefore of utmost importance to identify 'the removal of standing water from crop lands' and 'to restore

land-based production system' as the overarching development as well as adaptation objectives for the water logging affected areas.

Restoration of land-based production system requires facilitating drainage of water from the inundated areas. However, such a great potential adaptation is far beyond the capacity of individual person or a small water logged community. Only the authority can plan and execute an integrated emergency water drainage programme, much to the benefit of the helpless people. However, little has actually been done so far. An effort has been made to remove sediments from the Gorai River under the Gorai River Restoration Plan (GRRP), which could be of little help towards removing silts from the river bed. The project concluded by indicating that the river bed must be brought under regular maintenance dredging in a bid to enhance its drainage efficiency (CEGIS, 2002).

Based on such inference, the National Water Management Plan has created provision for resuscitating major rivers including the Gorai River, with a further provision of maintaining a sustained flow regime throughout the dry season, by virtue of building a barrage on the Ganges and by linking distributaries of the Ganges flowing through the SW region. However, due to lack of political commitment, no significant stride has so far been taken to implement these programmes.

As a sharp alternative, local people in Manirampur has raised some money through contributions and employed a number of pumps to drive off the standing water just prior to the Rabi season of 2008. The local self-help activity successfully has driven off the water from one *Beel* and rescued land over 900 *bighas* (approximately 370 acres) and transplanted *Boro* seedlings after seven long years. NGOs can facilitate such local initiatives, organize people to come forward and try to make the best utilization of resources to maintain their livelihoods.

In the absence of a land-based production system, food-relief during lean employment season generally helps maintain nutrition and contain hunger. NGOs have been generously providing the food assistance. At any rate, compared to the scale of requirement, too little has so far been offered by the NGOs, unfortunately. The regular safety net programs of the government (e.g., the Food for Works program, the Vulnerable Group Feeding program etc.) could not be initiated in a major way in the affected areas as yet.

The local people and their representatives, the *Pani Committee* i.e. Water Committee and the People's Forum on Water Logging, have been requesting the Government to declare the affected region as a 'Vulnerable Zone' (*Durgato Elaka*) so that these people can be brought under the safety net programs. However, their requests have so far been ignored. Meanwhile, more and more new areas are being inundated every year, especially in the SW region. Reliance on food-relief, therefore, cannot be useful towards sustaining food security.

In the recent past, another alternative management system has drawn attention to policy makers and the local communities. The experience of development and management of the tidal basin for the rehabilitation of the choked drainage system[4] is a positive example of how to approach adaptation in low lying areas that are subjected to tidal inundation and water logging – the anticipated geophysical effects of sea level rise along the coastal zones. The Tidal River Management (TRM) approach appears to be highly acceptable among the key stakeholders. Trials are now being carried out in a number of water-logged lakes such as *Beel Kedaria* and *Beel Khukshia*. It will be worthwhile to promote such adaptation only if early experiences yield satisfactory results towards solving the emerging problems in the coastal zones of the country.

Providing safe drinking water is a major objective for adaptation in water-logged areas, especially if one considers a gender-friendly adaptation. It is praiseworthy to note that the proactive approach of the NGOs as well as the Department of Public Health Engineering (DPHE) led to the installation of a number of tube wells in high lands of most of the Unions of the affected region. These tube wells escape contamination even during the peak water-logging season. As a consequence, during

4 By means of implementing the Khulna-Jessore Drainage Rehabilitation Project (KJDRP) in Khulna-Jessore region.

the flood of 2007, most of these newly-established tube wells served as a trusted source of safe drinking water to the local people.

Adaptation to address health care system is also necessary in the affected areas. People want to have health care services. The KII involving local NGOs clearly suggests that there has been a dearth of qualified health care practitioners in the locality. The government's effort to keep doctors posted in their respective stations in the affected areas has so far been failed. The local health practitioners i.e. mostly village doctors (*Palli Chikitshaks*) cannot treat the ailing people properly. Also considering the destitution of the people, they tend to refrain from prescribing costly but effective drugs. As a result, the poor continue to suffer from disease. Public health care facilities have to be increased with special attention to adolescent girls and young women for allowing them to receive improved reproductive health-care. In order to keep the qualified health practitioners in the locality, proper incentive packages need to be provided. NGO activities in this regard have been inadequate. Their collective efforts need to be strengthened in a bid to offer better health care facilities to the affected communities, especially the women.

If the marooned women receive reproductive as well as neo-natal health care on time, it will drastically reduce neo-natal death rates. A number of low-cost Glass Fibre coated boats with engines can be provided to each of the LGIs, solely to facilitate the rapid hospitalization of women in labor in order to ensure safe motherhood. Women living in the area however feel that their vulnerability could be further reduced if (a) similar community based solutions to public toilets could be implemented and (b) the passage to tube wells and toilets for women are made to remain above standing water. NGOs should address these issues, since these can be implemented with little technological knowledge as well as finance.

At the household level, plinth height of houses and toilets needs to be raised. However, it is easier said than done, under the prevailing dire poverty of the households. NGOs can come up with credit facilities coupled with skills enhancement training, linked with marketing channels. To improve cooking conditions, promoting coal in the affected areas can be considered. To further help these communities, coal from Barapukuria mine could be provided at subsidized rate under the supervision of local government institutions (LGIs) in the locality.

In an attempt to make children utilize the entire academic year, schools need to be rebuilt on higher grounds or to be raised adequately (applicable only for shanty structures). Otherwise the academic activities have to be curtailed during the peak water-logging season. In wretched dwellings, however, studying often seems a bizarre option to those who are barely surviving the water-logging and despair. Many of the school buildings have been dilapidated. Special arrangements must be made by the Facilities Department of Ministry of Education and Local Government Engineering Department (LGED) to reconstruct the school buildings and raise the approach-roads to the schools.

Regular health awareness related NGO activities can continue as normal. Special safety net programs must be initiated for this community through the Ministry of Women and Social Welfare. However, water-related health hazards can be reduced significantly if community representatives are trained to prepare and use low cost water purifying techniques. To train community people, Department of Public Health Engineering (DPHE) and local NGOs can come forward and initiate training programs.

The state can also consider implementation of short-term adaptation measures. For example, when rural roads rise above the water-level during dry seasons, a few designated roads could be reconstructed in order to facilitate people's movement. This could also be done by implementing Food for Works Program, which generates local employment. Though these are known survival strategies[5] adopted after every major disaster in the country, it is not yet designed for the regions prone to water-logging.

5 The PRSP for Bangladesh categorically endorsed such strategies (MOP, 2004).

Furthermore, adequate numbers of community centers should be built, especially for adolescent girls and young women. Since their recreational opportunities are severely limited, compared to their male counterparts, the proposed community centers should be equipped with facilities for indoor games, information services, etc. The road network connecting such facilities should stand high enough to avoid seasonal inundation. Otherwise, the purpose of building such facilities will be nullified.

8.3 Adaptation to Salinity Intrusion

For the coastal people of Bangladesh, there are two major dimensions of salinity intrusion: (a) the productivity of saline affected lands reduces drastically, which in turn affects people's food-security and livelihood (b) salinity intrusion has been causing significant problems of safe drinking water, which then affects people's health, especially that of women. In view of these realities, the major objective of adapting to increased salinity caused by climate change will be to improve flow regime throughout the dry season, thereby pushing the salinity front towards the southern coastal reaches. This entails technical measures, which the government can contemplate on micro as well as macro scales. At the same time, people can try to protect the gradual build-up of salinity in their crop-lands and homesteads and find alternatives to tackle salinization of drinking water sources.

The National Water Management Plan has given emphasis on arresting in-stream salinity through scientific interventions. If planned and implemented early, the southward push of the isohaline line above threshold levels will not only help reduce in-stream salinity, it will also facilitate lowering of soil salinity by increasing chances of flushing of crop lands with river water. In doing so, the population forced to accept saline affected water can be immensely benefited, with or without climate change.

Given the increasing pressure on surface water systems during the dry season, arresting soil salinity as a consequence of salinity ingress along the coastal river systems may not be totally successful. However, soil salinity may effectively be reduced below threshold limits through rational interventions. A number of methods have been highlighted by Habibullah *et al.* (1998), which should be popularized by the Department of Agriculture Extension in saline affected areas. Meanwhile, the Bangladesh Agriculture Research Council, in cooperation with its National Agriculture Research System (NARS) Institutions, can consider undertaking a joint saline-tolerant varietal development research project.

Agriculture production is greatly hampered by salinity in the coastal region in general and in the south-west (SW) and south-central (SC) regions in particular. Since a large tract of coastal land becomes saline much above the threshold concentration in late March and April, it becomes very difficult to gainfully cultivate *Boro*-rice in those affected lands. An attempt has been made to cultivate alternative cash crops such as chili and water melon during the spring-harvest season, just to compensate for *Boro*-crops (CEGIS, 2007). The lessons from such trials, with assistance from Bangladesh Agriculture Research Institute (BARI), can be utilized for further extension of such alternative crops which can sustain salinity regime which is otherwise detrimental to *Boro*-crops.

During the past few years, two cultivars (BRRI 40 and BRRI 41) have been developed by Bangladesh Rice Research Institute (BRRI), which can sustain up to 10 ppt of soil salinity. The new discovery in terms of salinity-tolerant cultivars can potentially facilitate adaptation in agriculture to a significant extent. Even such limited options are not being explored by most of the saline affected farming houses, because of lack of proper extension services. Wide scale extensions of BR 41 (a variety that can tolerate up to 10 ppt of salinity) and 'on-farm water management technologies' that efficiently manages irrigation have to be immediately taken up as 'institution-led' adaptations. More research must be done to invent saline tolerant crop varieties. Bangladesh Rice Research Institute (BRRI) and Bangladesh Agriculture research Council (BARC) can essentially lead the process. Extensive extension services are needed in field level to disseminate the saline tolerant varieties.

Current forms of agriculture in areas that are highly vulnerable to climate change might not be possible in many parts of the country. Millions of existing households, particularly those in the SW are already vulnerable to climate variability (RVCC, 2003). Due to climate change related complexities, the vulnerability to salinity will be exacerbated and therefore, agriculture may no longer remain a viable livelihood option in saline affected areas.

Often in many statements, the promotion of shrimp culture in saline affected areas attains much attention. But large farmers (*gher* owners) will be benefited out of this shrimp farming at the expense of impoverishment of thousands of poor and marginal farmers. If shrimp appears to be the only viable option for maintaining production in the highly saline affected areas, then a planned shrimp production needs to be considered. It is to be noted that, with the advent of new 'phyto-sanitary standards', small holders may not be able to produce export quality shrimps without proper training, despite having suitable salinity regime on their lands. These small holders need to be provided with adequate training and perhaps technical know-how so that they can be competitive in the growing export market.

Livestock rearing can be a viable alternative livelihood option in these areas. Saline tolerant grass varieties, such as "Nipa" can be promoted as fodder in this region. Associated service(s) like, vaccination, veterinary health facilities, credit facilities must be made available to the affected community.

Salinity severely affects the well being of the community. Especially for the women of the affected area, it is the most pressing concern (Ahmed *et al.*, 2007d). Most of the tube wells, even dug up to 700 feet, cannot ensure non-saline safe water for drinking purposes. Living in a society where gender biased activities force women to shoulder most of the household activities, salinity in drinking water adds up enormous hardship to them. There are some places (south of the south west) where women have to fetch water from long distance, even walking 5 kilometers all the way. This naturally results in health hazards.

Coastal Zone Policy clearly mentions that women suffer a lot to collect water due to poor availability of 'safe water'. This is also regarded as a barrier for the development of women. Unfortunately, while the policy theme is divided in a number of policy issues, the issue of poor availability of safe drinking water is dropped. The policy must address this issue, with due emphasis, and provide solutions to the long lasting problems. A mere identification of a problem is not enough to solve the problem.

The Environmental Policy and Implementation Program (EPIP) for Bangladesh were pronounced by the Ministry of Environment and Forest (MOEF) in 1992 (MOEF, 1992). In its proposition and scope, the EPIP states *"... natural disasters such as frequent flooding, drought, cyclone and storm surge; preliminary symptoms of desertification in the northern zone; salinity ingress along the river systems; land erosion; rapid reduction of forested areas; variability of climate and/ or weather and other environmental problems are observed in the country"*. The statement certainly sets the tone and correctly points out major environmental concerns, with the exception of high salinity in drinking water. It is to be noted here that the policy directives haven't been translated yet into firm action in most parts of the coastal zone. People have still been suffering from non-availability of safe water. The problems are particularly acute in Satkhira and Khulna Districts (RVCC, 2003).

Although tube wells throughout the country have been causing health disorders due to drawing up of arsenic laden drinking water, the primary modality to address saline drinking water lies in creating provisions for deep (hand) tube wells. Tube wells, sunk below 700~800 feet and subject to availability of adequate aquifer system, must be installed to face the problem of salinity in drinking water. If the number of deep (hand) tube wells are made adequate in the community, then women need to travel less or even they do not have to travel at all to collect water for drinking.

DPHE (Department of Public Health Engineering) must take necessary initiatives to meet the necessary steps. For obvious reasons, deep tube wells cannot be sunk in many areas due

to not having defined aquifers. To overcome this physical constraint, a combination of pond sand filter and rain water harvesting in ponds can be an alternative to avoid the salinity problem in drinking water to some extent. Extensive research should be taken place in this issue and training on rain water harvesting and pond sand filter can be given to the affected people. Local NGOs coupled with other government offices can take initiatives to this technology transfer.

The National Water Policy under the policy theme titled Water Supply and Sanitation, clearly states "*salinity intrusions from sea water deep into the land in the southwest are rendering groundwater unfit for consumption*". It is anticipated that, due to reduced dry season flows under climate change, surface water salinity will be on the rise along the coastal rivers and the salinity front is likely to ingress further north. Unfortunately, in the following statements (i.e., paragraph 4.6 a through e), no policy item was prescribed as such to tackle the issue. Salinity affects both agriculture production and human well-being adversely. The policy needs to be amended in order to address the issue of salinity in drinking water. A policy adaptation is therefore vital towards accommodating long term perspective.

In many coastal areas, there are local ponds which can be utilized as community ponds with a view to supplying surface water for drinking. However, the ponds are generally contaminated by pathogens and micro-organisms, which spread water borne diseases. People therefore do not find these ponds as potential source for drinking water. Incidentally, there are commercial chemicals, such as halotabs, which can purify such contaminated but 'non-saline' water and make it pathogen free (i.e., risk free). The high price of such chemicals often defeats the willingness of the poor, which is a limiting factor for the chemicals being used extensively in acute saline prone regions (Ahmed et al., 2007e). The state can wave all forms of taxes and even offer subsidy in a bid to popularize the alternative so that people can drink non-saline water. The civil society can launch an advocacy program to draw the government's attention to take steps in this regard.

8.4 Adaptation to Erosion of Riverine Charlands and Coastal Embankments

In order for the government to facilitate adaptation to coastal erosion, the primary objective should be to maintain safety of charlands as well as embankments, thereby ensuring safety of lives and livelihoods of people living within such embankments. In addition, the government must be prepared to respond to humanitarian call, especially when large landmass is either eroded and/or a stretch of an embankment breaks down. In this case, it would be necessary to adapt through the relocation and resettlement of the climate displaced people.

In an attempt to achieve the overarching adaptation objective to maintain safety, a number of adaptation modalities can be envisaged, which are elaborated below.

Along the coastal zone, there are a large number of embankments which have been built and maintained since late 1960s. Many of such embankments have already been weakened and/or completed their respective economic lives. A good number of embankments have been refurbished between the 1980s and present time. In view enhanced wind-wave interaction as a consequence of climate change driven higher SST, it is necessary to monitor the status of the embankment system on a regular basis and improve maintenance of the valuable infrastructure. If, on the other hand, it appears increasingly costly to maintain any of these embankments, it might be necessary to dismantle a few identified ones which become inoperable and/or economically non-feasible. To this end, updating the knowledge-base on currently available embankments is an extremely necessary step towards efficient adaptation programs involving the infrastructure.

It would also help if specific stretches of coastal embankments are identified as 'weak points' being at the risk of breaching. Since coastal failure inflicts upon too high a cost to recuperate, frequent assessments and monitoring could help reduce the loss burden in this regard. Moreover, identification of a 'weak point' might help increase local awareness, enabling people to

safeguard their assets and belongings well ahead of the coastal embankment failure. Such an institutional adaptation, likely to be implemented by Bangladesh Water Development Board (BWDB) in cooperation with local government institutions, would also embark on frequent monitoring, analyses of vulnerable structures leading to a rehabilitation plan to strengthen particular vulnerable spots/points/stretches. Moreover, if the government decides to improve its safety criterion from being 'one in a twenty year overtopping' to an enhanced frequency hazard event, the BWDB can improve the design criteria and increase the coverage of safety net in engineering terms.

Obviously, such a series of institutional adaptation regarding design criteria and rehabilitation of existing embankment system would not be possible without adequate finance. The state must commit to provide the notion of safety for an indefinite period, even if climate change occurs. The requirement for safety can be overwhelming, especially if one considers the economic ability of the state. However, continued safety has to be ensured for low lying coastal plains, even if the cost appears to be high.

These activities, on principle, have been endorsed by the National Water Policy (MoWR, 1999). However, an effort must be made to check whether similar provisions have been made in the National Water Management Plan (WARPO, 2004). If the long-term action plan has not yet envisaged the necessity of such adaptation actions, it would be of great importance to incorporate such ideas in the plan, as the latter has already created provisions for periodic reviews[6] and updates.

It is also necessary to develop human skills in charge of coastal infrastructure. The understanding on climate change hasn't yet been mainstreamed in the regular business planning and implementation of the custodian of the infrastructure – the BWDB. It would be necessary to provide training on climate change to both BWDB and WARPO Officials[7]. The Climate Change Cell has been trying to develop capacity of national focal points at various key national institutions, including BWDB and WARPO. However, the novel approach hasn't been successful towards mainstreaming adaptation in regular business of the two respective national agencies. A more dynamic mechanism towards mainstreaming adaptation would be of great help in this regard.

The track record for water governance has not been satisfactory in Bangladesh. Poor performance of the embankment system is generally attributed to poor quality engineering works/earthworks, which has roots in (a) political interferences during the implementation of the works, (b) inadequate monitoring and supervision, (c) poor quality materials being used while implementation, etc. If the government decides to invest towards strengthening such embankment system and/or further securing the erosion-prone charlands by engineering means, the governance practices must be strengthened and made transparent. A poor quality earthen structure may not necessarily ensure safety of coastal communities and may crumble earlier than expected. It would eventually increase vulnerability of the local people.

Although CBOs, NGOs and individuals generally come forward to help erosion victims, the potential role of the government towards facilitating relocation of climate victims and their resettlement cannot be overemphasized. To begin with relocation/rehabilitation, it would be necessary to identify costal areas and charlands those are at high risk of erosion. The methodology for monitoring erosion-prone riverine chars (CEGIS, 2007) may be extended along the coastal areas to monitor coastal morphological dynamics. Once probable erosion-affected areas are

6 WARPO is supposed to review and amend the 'live document' periodically, while the earliest review is supposed to be held before March-2009.

7 The needs for increased understanding through training have been highlighted by Officials of both the agencies during consultation meetings.

identified, it would be necessary to plan early for resettlement of victims elsewhere.

There are, of course, problems associated with resettlement of erosion victims. The sheer human density leaves little room for relocation and resettlement. Forced resettlement, therefore, might not be socially acceptable (Ahmad and Ahmed, 2002). It would be better if resettlement processes involve state owned (*khas)* lands. The successful future resettlement demands planned approach towards the distribution of the remainder state owned (*khas)* lands.

It has been observed earlier that, people have a tendency to resettle in newly accreted coastal lands (i.e., in open islands). In advent of climate change, resettlement arrangements in newly accreted coastal islands would not perhaps result in proper adaptation. The coastal islands would also be vulnerable to erosion and cyclonic storm surges. Therefore, without having enough protection, the new settlers might find it equally vulnerable after settling in such islands. The other problem might involve limited employment opportunity in the newly accreted lands. This might render additional burden on the erosion victims.

To address the issue of resettlement for the coastal erosion victims (along with potential erosion victims along the main rivers), the government should identify new areas where the risks from hydro-geophysical vulnerability are perhaps amongst the least, even under climate change. It would require proper analysis and thorough research. A collaboration among national government institutions, research bodies and centres of excellence would be of great help in this regard.

Parts of the coastal zone, having potential of becoming growth centers, should be identified and facilitated to become safe homes for new settlements, industries, business centers, educational and recreational centers, etc. These new breeds of urban centers need to be planned early, with adequate financing for the SMEs to prosper and invite settlers to offer new opportunities (Ahmed *et al.*, 2008). The urbanization processes along the coastal zone, therefore, needs to be guided through proper planning and careful implementation. Large-scale financing would be necessary in order to facilitate development of 'guided urban townships' along the coastal zone. This therefore falls under the domain of institutional adaptation.

NGOs and CBOs can help organize skill enhancement trainings so that erosion-prone people may find viable alternative employment. Efforts needs to be made to arrange feasible credits for fishermen community to invest in modernizing the fishing trawlers and gears so that they not only can become increasingly competitive, they can also avail opportunity to save their lives following issuance of warnings.

The facilitation provided by the state must be complemented by social adaptation, from individual to community levels. Nevertheless, it would be difficult to engineer social adaptation, especially where a major part of the population is poor. Thinking about a second home in safer places is already a luxury to many! One may however try to develop skills, especially for economic diversification. Apparently there is no alternative other than switching livelihoods options, especially when traditional coastal livelihoods have become extremely risky. Coastal people must make the best out of educational facilitation, offered by the government.

People also need to respond to planned relocation processes. Being sentimental regarding ancestral homes would not probably provide viable alternatives apart from a cruel consequence of climate change. Besides, when opportunities are created, people should try to avail them to relocate themselves to safer places rather than being fatalistic. A combination of planned relocation and economic diversification – by means of investment and acquiring new skills, might help many to find better employment and livelihoods opportunities in urban areas. However, over dependence on one or two urban centres to find employment for every body might create other problems. Urban planning should be considered a part of institutional adaptation in order to guide a balanced urban development along the coastal zone.

8.5 Adaptation to Rough Sea Events: Safeguarding Livelihoods of Coastal Fisherfolks

The roughness in sea, especially during the monsoon and post-monsoon seasons, will continue to increase under a warmer world. Unless the global community decides to curb emissions of GHGs significantly, especially in the post-2012 negotiated regime, there is no way one can change the fate of the poor coastal fisherfolk of Bangladesh. The question remains whether one should try to help these traditional fisherfolk to find alternative 'relatively safer' livelihoods, or allow them to accept the inevitable fate.

Given that the poor fisherman can meagerly invest and do not have the means, both technical and financial, to suddenly adopt modern fishing technologies which can withstand increased sea roughness, it would not be a prudent idea to keep them in their ancestral business. Socio-culturally, it would be extremely difficult for them to switch to alternative livelihoods. However, the pain of switching to alternative livelihoods would be surpassed if repeated rough sea events start to devastate their very basis of livelihoods. Therefore, a planned

approach towards economic diversification of these coastal fisher folks needs to be considered.

Economic diversification, however, demands skills development, technological know-how, and the most important of all, education. All these cannot be achieved overnight. The state must assume its responsibility to offer training packages to the lackluster fisherfolks. A significant proportion of the fisherfolks could be employed, if converted into trained labours, in safe urban centres, as proposed in earlier sub-section. It however requires a holistic planned approach, which needs to be facilitated and financed by the state. Financing, in this case, would be highly challenging for a least developed country such as Bangladesh. If the government can draw international support, even as compensation against its climate induced vulnerability, only then such safe coastal townships could be put into place.

As an alternative, the government also can engage in 'migration diplomacy', through which it can demand for a preferential status of these primary victims of climate change to be given emigration in a number of Annex-1 countries, especially in those countries where labour migration is allowed. If these fisherfolks are allowed to settle in economically advanced countries, they will find alternative livelihoods. They can even send remittances, which have the potential to assist the economy further. Since these fisherfolks are direct victims of climate change induced phenomenon, they have rights to ask for compensation.

Meanwhile, to assist the fisherfolk in the short run, they may be provided with long term soft loans from financial institutions in a bid to maintain their livelihoods. They can also be given low-cost communication equipments such as radios so that they can receive warnings while fishing in the sea. A number of floating telecommunication routers and transmitters can be placed, which would increase the coverage of telecommunication networks, allowing the fishermen to receive real-time forecasts and warnings.

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