

Adapting to Climate Variability and Change in Bangladesh

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Introduction

Background

The coastline of Bangladesh is particularly vulnerable to the sea level rise in the Bay of Bengal on account of the low-lying deltaic environment. The tropical cyclones, which strike the coastal areas periodically, create misery and loss of life, property and damage to the ecosystems. The total area of the coastal belt is about 39,300km² (27% of the country's total area) and more than 29 million people (22% of the national population) live in this fragile and vulnerable area. Climate change may influence erosion, accretion, floods, waterlogging, cyclones and tidal surges in the coastal region. Against this backdrop, the people who live in the coastal areas are dependent on its resources for their livelihood sustenance and already belong to a vulnerable category. The livelihood of the people has been affected through the impacts of climate change on agriculture, fisheries, livestock, shrimp farming, off-farm activities and even the locations of human settlements. These situations have led the people to devise unique coping strategies for their survival. The future of their livelihood and for that matter, the human settlements in this region will depend on viable adaptation measures to cope with the future extent and consequences of global warming.

Approach and Methodology

The activities of the Netherlands Climate Change Assistance Program (NCAP) have been designed in order to explain the three common questions: what are the demands of stakeholders? What is available to them? And how can their needs can be communicated to policy makers to steer necessary action?

A combination of the participatory approach and scientific tools and data was adopted in this project, to attain maximum input and ensure the interaction of stakeholders. Sustainable livelihood framework was used extensively to understand the local vulnerability issues. These approaches were based on the premise that there was a need to acquire an in-depth understanding of the local issues in terms of people's perception and understanding of climate change and institutional capacities to respond to the perceived changes.

Description of the Study Area

Noakhali is one of the coastal districts of the country. The district has an area of 3600.99km² and is bordered by Comilla district to the north, the Meghna estuary and the Bay of Bengal to the south, Feni and Chittagong districts to the east and Lakshmipur and Bhola district to the west (see figure 1). The absolute location of the district is 2200⁰ N to 23010⁰ N latitude and 89050⁰ E to 91030⁰ E longitude.

Noakhali district consists of six *upazilas* (sub-districts) namely Noakhali Sadar, Begumganj, Sonaimuri, Chatkhil, Senbagh, Companiganj and Hatiya. The study area, Noakhali Sadar *upazila* is located between 22038' and 22059' N and 90054' and 91015' E. The *upazila* occupies an area of 1071.66km², including 220.34km² of rivers and 103.71 km² of forested land. The *upazila* is bordered to the north by Begumganj and Senbag *upazilas*, to the east by Compaiganj, to the southeast by Hatiya *upazila* of Noakhali district and to the west by Ramgati and Laksmipur *upazila* of Laksmipur district. The southwestern part of the *upazila* faces the sea and forms part of the Meghna estuary. Noakhali Sadar *upazila* is now split into two *upazilas*, namely Noakhali Sadar (or Sudharam) *upazila* and Subarna Char *upazila*.

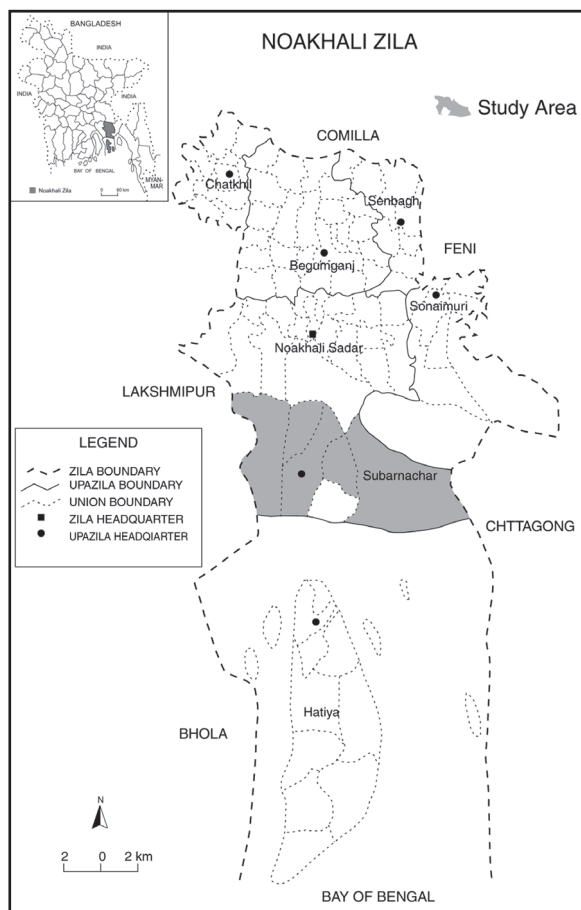


Figure 1: Location of the Study Area

Physiographic condition

The area represents an extensive flat, coastal and deltaic land, located on the tidal floodplain of the Meghna River delta, characterized by flat land and low relief.

The area is influenced by diurnal tidal cycles and the tidal fluctuations vary depending on seasons, being pronounced during the monsoon season.

The population of Noakhali Sadar and Subarna Char *upazila* in 2001 was 766,722 with the male and female population divided almost equally. The population growth rate is 1.65% and density is 715/km². Urban population is 14.52%. Literacy rate for males is 51.43% and for females is 45.04%.

Natural Hazards

Noakhali, being exposed to the Bay of Bengal is prone to multiple hazards. Cyclones are frequently occurring disasters, which hit the coastal villages every year. Sometimes, cyclones accompanied by tidal surge inundate the very remote coastal areas of the district and cause massive destruction. Along with these, annual flooding due to excessive rainfall and poor drainage systems has recently been devastating. Waterlogging is common in and around the Sadar area. Rapid population growth and intensification of human activities are the main contributors to an increase in risk, especially in the remote areas adjacent to the sea. Very recently, there has been an additional (Tsunami hazard) hazard which is also threatening the vulnerable coastal populations.

Vulnerability

Research on the vulnerabilities of coastal inhabitants indicates that the vulnerability of the people of Noakhali is exacerbated by the natural disasters and their socio-economic status. The challenges posed by waterlogging, floods, lack of employment opportunities, ownership of *khas* land, cyclones, low prices of cultivated crops etc. increase the vulnerability of the small and landless farmers. In the case of the fishermen, cyclones, depletion of fisheries resources, dearth of capital or seed money, deteriorating law and order situation, weak communication facilities etc. make them extremely vulnerable. Laborers also fall prey to the vulnerabilities arising out of the lack of employment opportunities in both urban and rural areas, cyclones, ownership and claims over *khas* land, lack of safe drinking water and poor communication networks.

Life and Livelihood

Climate change may affect the coastal region through salinity, erosion, accretion, floods, waterlogging, cyclones or tidal surges. Considering this, the people living in the coastal area and depending on its resources for their livelihoods belong to a vulnerable category. Livelihoods of people have been affected through the impacts of climate change on agriculture, fisheries, livestock, shrimp farming, off-farm activities and even the locations of human settlements. Over the centuries, climate variability and extreme weather events have caused deaths and destruction of assets, resources and livelihood practices, which eventually have led people to devise indigenous coping strategies for survival. The practiced coping mechanisms within the communities and their traditional knowledge-base enable them to organize at the community level and manage disasters. Even their wealth of knowledge regarding the management of their livelihoods in different changed climatic scenarios is substantial.

Perceived Changes in the Observed Climate

The changing scenarios of climatic events that have been perceived and mentioned by the participants of focus group discussions (FGDs) carried out at the study area are as follows:

- *Excessive rainfall in a few successive days:* Torrential/huge rainfall within a short period (in days) is becoming more common, rather than constant rainfall over a wider span of days as in the past.
- *Change in the rainfall calendar:* Time/season of rainfall has changed over the years, what the participants termed as 'untimely rainfall' that poses much difficulty in the cultivation of crops. The highest annual rainfall still occurs in the months of Ashar and Srabon. However the past 5 or 6 years' rainfall in Ashwin and Kartik has been increasing significantly causing severe devastation to *Aman* crops and to culture fisheries.
- *Increase in Temperature:* Temperature, as perceived by the participants in general, has increased recently compared to the past.

- *Routine occurrence of drought:* Drought is being experienced every year in a routine manner. Both the time-span and intensity of drought have increased over the years. Excessive heat is felt during drought-time.
- *Colder winter:* The span of winter has become shorter but the intensity seems to be higher.
- *Excessive fog during winter:* Fog/mist being experienced is erratic as far as timing of occurrence is concerned but the intensity and volume are higher/greater than the past.
- *Salinity in soil:* According to the participants, salinity is noticeably present in the soil of the whole area covering both Subarna Char and Noakhali Shadar but not up to that extent in water. Due to this salinity in soil, bricks made of soil remain saline affected and this causes brick-made house to be less durable. But to their relief, the extent of salinity has declined these days after the construction of embankments.
- *Salinity in drinking water:* Although salinity in surface water has remarkably declined, it continues to affect drinking water extracted from shallow tubewells.
- *Waterlogging:* Waterlogging has become a major climatic concern for all the inhabitants of the area. In the past, lands used to become temporarily waterlogged due to inundation fueled by an unusually high-tide. After the construction of *veri-bandh*¹ in 1974 (in some areas, i.e. in Charclerk, an embankment was constructed about 4 or 5 years ago), sea water no longer enters the area, but following excessive rainfall during the rainy season water remains stagnant and turns the whole area into a 'seasonally waterlogged' area (for at least 5 to 6 months) causing great misery to the people. The extent of waterlogging, according to them, is increasing day by day.
- *Occurrence of tidal surge:* Tidal surge no longer affects the people of the area inside the embankments. Although in the past water used to enter and inundate the area with unusually high-tides in the time of full-moon. During those days there was no well-built, designated cyclone shelter in the coastal areas. Modern multipurpose cyclone shelters were built after 1991. Tidal surge now no longer occurs due to the existence of embankments. However, it still torments the life of people residing outside the embankments, especially when cyclone-led surge routinely occurs once or twice every year.
- *Occurrence of flood:* Inundation is very common, caused mainly by excessive rainfall during the rainy season. But this type of inundation can not be termed as a 'flood' defined in the usual way which is caused by the overflow of water from rivers. The construction of embankments is obstructing the inflow of water from the overflow of the river Meghna as used to be seen in the form of flooding in the past. Flood still occurs these days but it is not as severe and as frequent as it had been in the past due to structural changes.
- *Frequency of Occurrence of Cyclones:* According to the participants, the frequency of cyclone has lessened over the years. In the past, cyclones coupled with tidal surges used to devastate the whole area.

Problems due to climate change

Participants were asked in all the discussions to outline the problems and sufferings, personal, social and economic, that they confront in their day-to-day lives afflicted by the occurrence and variability of the major climatic events.

Waterlogging

- Low-lying houses usually go under water or are, at least, greatly damaged by water.
- Severe damage takes place in the case of crop-agriculture, especially when it is inundated.
- The very process of cultivation is hampered, in particular timely cultivation.
- Both the *Aus* and *Aman* crops are potentially at high risk of being damaged due to waterlogging, especially when the lands start to be inundated at the time of harvesting of *Aus* crops causing immediate damage to that crop as well as stalling the process of sowing for *Aman* crops.
- The untimely excessive rainfall in Ashwin and Kartik causes devastation to *Aman* paddy; just before harvesting this rainfall creates the problem of waterlogging which leads to a huge loss in *Aman* production.
- Waterlogging causes severe damage to vegetable cultivation.

¹ Embankment to protect the area from tidal surge.

- Even if serious loss does not occur in the case of crop-cultivation in the waterlogged areas, the yield declines mainly due to the damage to saplings.
- Saplings in waterlogged areas become infected with pests/insects. It is impossible to use pesticides or insecticides as they are merely washed away.
- The cultivation of potatoes, peppers, soybeans, nuts, etc. is not possible during the period of waterlogging.
- Trees are severely affected by any prolonged standing of water. Jackfruit trees, neem trees, papaya trees, etc. die, in their thousands, because of waterlogging.
- Waterlogging causes enormous losses to fisheries in the area, especially when it becomes impossible to keep the fishes inside the ponds/water reservoirs with the rise of water level that causes an overflow of water. The extreme rainfall in October 2004 caused almost total devastation to culture fisheries as the banks of the ponds overflowed and the fishermen were not prepared.
- Houses, especially low-cost houses made of mud and bamboo become dilapidated due to stagnant water and eventually collapse.
- During prolonged periods of waterlogging, a number of people die from snake-bites. Loss of domestic livestock such as cattle, chickens, ducks, etc. also occurs from snake bites.
- Since it becomes difficult for people to go outside during these periods, people incur huge losses from unemployment and lack of income/earnings.
- Communication becomes disrupted since most of the roads and paths are damaged causing difficulties for people, especially the elderly, young and disabled. Access to health facilities becomes a great worry for families.
- People now use shallow tubewells for drinking water; whereas previously they used to drink surface water, pond-water in particular. There are threats involved in using this water however, as there is often a threat of arsenic contamination.
- During the period of waterlogging, the problem of sanitation becomes acute. Cases of diarrhea and other waterborne diseases increase.
- People face energy insecurity during periods of waterlogging.
- Waterlogging ultimately leads to a situation of environmental degradation. The polluted standing water causes severe environmental hazards.
- It can be summed up that waterlogging increases people's vulnerability; especially poor people who have a lower shock absorbing capacity.

Drought

- During the winter/dry seasons the southern part of Noakhali Sadar and most parts of Subarno Char face the problem of salinity. This leads to a substantial part of these lands remaining abandoned during this dry winter season.
- A substantial part of Noakhali Sadar and Subarno Char does not have an electricity supply and therefore cannot have deep tubewell irrigation. These people cannot use *Boro* cultivation methods which need intense irrigation. Besides this problem, the salinity increase during the dry season does not allow people to cultivate their crops.
- The problem of drinking water becomes evident in drought conditions. In many areas tubewells are of no help as the water level is drastically lowered.
- Fishermen who own culture fisheries face tremendous problems. The ponds become dry and for most fishermen, droughts lead to a lack of work.
- As a result, fishermen face unemployment and food insecurity during dry winters.
- People try to grow vegetables in the winter, which is greatly hampered by severe drought conditions.
- There are outbreaks of various diseases.

Cyclones

- Cyclones not only cause loss of human lives but loss of livestock such as cattle etc.
- The physical effect of cyclones is evident. They destroy houses, especially weakly-built ones.
- People face loss of physical assets (houses, gardens, household utilities, boats, tubewells, latrines, poultry, cattle, roads, embankment etc.).

Salinity

• Salinity severely affects the potential to cultivate *Boro* crops. Prevalence of salinity in drought conditions limits farmers' options for cultivation, which causes income loss and insecurity.

Changes in Temperature

- Due to heat stress during hot summers, people, especially those working as farmers and day laborers, face serious physical stress that tends to affect their capacity to work.
- The day laborers cannot work at a stretch due to scorching heat in summer and in the month of Bhadro, which causes income loss and insecurity.
- It is very difficult for the fishermen to catch fish at any point other than during the day in winter due to the extreme cold.
- It is usually women and children who are responsible for fetching water from distant tube-wells. It is more difficult to do this in the extreme heat of the summer.

Coping Measures: Inherent Resilience

Coping practices are often spontaneous and an immediate response of vulnerable people to different shocks. People use the means that are available to them in order to cope. The livelihood conditions of the people largely depend on the ownership of or access to capital by households which broadly determines their capacity, scope and survival strategy. The asset base is categorized by human, social, natural, physical and financial assets.

Table 1: Typology of Assets which are used for Coping

Group	Assets
Human	Household members, health, education, training
Social	NGO/cooperative groups, network/connection
Natural	Land, water, homestead, wetland, pond
Physical	House, tube well, latrine, electricity, cattle, poultry, tools and utilities, boat, net
Financial	Savings, credit, food/cash assistance (safety nets)

Coping Starts with Strengthening Houses

At the very outset of the study the team made a reconnaissance visit to selected areas. Other than the *Pouroshova*², in most of the unions *kacha* houses are made of bamboo (*muli* bamboo) and tin roofs are very common; jute sticks are used as walls and jute fabrics as ceilings. People who are very poor use mud as a house building material. These types of houses are more vulnerable to natural disasters than the brick-built houses of comparatively wealthier families.

Everyone tries to strengthen their houses before the seasons of rainfall and cyclones start. They do this in a manner which is within their means. Usually the foundations of all the houses of Noakhali Sadar and Subarno Char *upazila* are raised so that the rain water cannot enter the house. Usually they raise the platform to a height which will protect the houses from regular/average flooding from rain water. The families who have some extra money to invest in their houses, raise the platform of their houses above the average height of anticipated rainfall which causes devastating waterlogging conditions. The kitchens are also placed on raised platforms.

² An urban centre, where an elected body takes care of local level development and management issues.

When the living conditions deteriorate due to excessive rainfall, people move all their household utilities on to a bed where all the family members not only live but also cook. The internal structure of a house has a space in a false ceiling called a *darma*. These ceiling-like raised/high platforms are built inside the houses to keep ownership documents/deeds of lands, other important papers/documents, dry food, rice, pulses, salt, sugar (*gur*), matches, candles, kerosene, quilts, kantha etc. safe and stored in the case of an emergency during the waterlogged period. A staircase made of bamboo usually connects people to the *darma*.

Ovens are made using mud, tin, and cement and kept on *darma* in order to use during waterlogged periods/times of flooding. Cooking is done on top of beds using those ovens, which the participants have learned to use via demonstrations/publically performed mass communication campaigns. Raised platforms for urination and defecation purposes are also constructed from bamboo.

Houses outside the embankments are usually raised on even higher platforms, allowing the regular tidal surges to flow without any interruption. This platform is about 4 to 5ft high. Then on this raised platform people again raise another platform, about 1 to 2ft high, building the house on this secondary raised platform. This secondary raised platform helps to protect the house from abnormal tidal surges. People do post-harvesting activities on the primary raised platform. Other than this two-stage raised platform, the internal arrangements of the houses outside the embankments are almost the same as the houses inside. The financial conditions of the households outside the embankments are the worst. Most of the houses here are built of mud. There are latrines in some houses, but the overall sanitation conditions are not at all satisfactory.

People carry out preparations before the cyclone season starts. Preparations depend on their capacity to invest. Usually they tie the corners of their house with strong ropes or wires to the ground. To protect from rain they repair the ceiling almost every year. Walls made of mud and ceilings made of jute sticks or leaves are especially taken care of before the rain comes or cyclones strike. People who are very poor and do not have the means to repair their houses with minimal effort, take shelter in a neighbor's house, adjacent school or *madrassa*. During the waterlogging, livestock shelters in the same room as the family lives. Very few families can afford the luxury of keeping a separate shed for cattle which is locally called a *Goal Ghar*.

Coping Strategies for Agriculture

As agriculture is the main sector of economy in Noakhali Sadar and Subarno Char *upazila*, a detail edeffort has been initiated to study the corrolation of changes in cropping patterns with different climatic events. Different cropping patterns are followed in different unions of the same *upazila*. The pattern depends on land type, salinity, land quality, availability of irrigation facilities etc. The practiced cropping behaviors of the selected sample sites of Nokhali Sadar and Subarno Char *upazila* are summarized later. Details of agricultural coping practices are also described later.

Coping Strategies Taken by the Fishing Community

For the past 15 to 20 years culture fisheries have been kept by the inhabitants of Noakhali Sadar *upazila*. In some areas of Subarno Char, which are in the southern part of the *upazila* and close to the Meghna River, some people prefer to catch fish in open water.

Employment Pattern of Fishermen

- Culture fish in ponds and sell them to local markets;
- Catch fish in open water/rivers/*khals* and sell them to local retail/wholesale markets;
- Trade in fish – do not culture or catch fish themselves but buy fish from local wholesale markets and sell to local retail markets;
- Trade in fish along with other small-scale businesses in local markets.

Problems Encountered by the Fishermen

The fishermen reported through a consensus that:

- The availability of fish has declined significantly;
- Not only has the availability gone down, but the number of species of fish in open water has dramatically decreased. About 75% of the species previously available are not seen or caught anymore.
- To catch fish, fishermen now have to go to deeper water.

It is understandable that the problems of culture fisheries and the fishermen who fish on open water are not the same. The fishermen who only depend on fishing and do not have any other trade or business also have unique problems. Fish traders have business throughout the year, but fishermen in culture fisheries face employment insecurity in dry seasons, especially in the months of Falgun and Chaitro due to the drying up of the ponds. They then employ “crisis coping” strategies which will be discussed later on. Fishermen who fish in the rivers/sea must have equipment to pre-warn them of cyclones. They have radios in their trawlers and head into shore following the alarm signal. However, they are not alerted before the danger signal reaches 8, they have reported.

Ownership pattern

- Fisherman owns his own pond, cultures fish by himself, collects fish from the pond with his own net and own effort, sells in the local market by himself;
- The owner of the pond is not directly involved in the culture fishery. Rather the owner hires somebody to run the ponds and catch the fish. Sometimes the net can be owner’s and sometimes the net can be hired labor’s. The hired labor can earn Tk.100-125 in the peak seasons.
- Sometimes fishermen arrange leased ponds and culture fish there. They have to pay a certain amount for the lease to the pond owner; this payment is made usually on an annual basis.
- Usually the fishermen who catch fish in open water have their own/collective nets. These collective nets are owned by the fishermen who fish together in the same trawler; often they themselves make the nets. They do not have trawlers of their own. They go to sea for at least 15 days at a stretch. They store food in their trawlers for these days. The cost of their food is partly borne by the trawler owners. The rest of the cost of fishing apart from the fuel for the trawler must be borne by the fishermen. They have to pay half of their earnings to the trawler owner. These fishermen suffer from serious insecurities due to dangers such as pirates.

For the fishermen involved in culture fisheries, excessive rainfall and waterlogging cause severe devastation to their livelihoods. During the waterlogging in October 2004, every fisherman suffered serious losses as their fish spilled over the banks of the ponds. Consequently they have raised the banks of their ponds to a height which can cope with a regular waterlogged conditions as well as an extreme height of water. Another coping method is to net the whole surface of the pond to prevent the fish from escaping. People who can afford this netting can try this coping strategy. However, fishermen, who are very poor and cannot afford these methods, have to accept the reality that they do not have any control over the situation. They seek alternative livelihoods like day labor, rickshaw pulling, small trade etc.

Coping with Food Insecurity

As mentioned earlier, people face seasonal food insecurity. Food ‘security’, means the availability of food three times a day. Here, the question of food quality is not relevant. Focus group members agree on the changes in their food intake both in terms of quantity and quality. As shown in figures 2 a) and 2 b), their protein intake has drastically decreased in recent years, although it shows improvement for the families of fishermen, who can regularly eat fish. Pulses have always

been a major source of protein for poor people. The preferred variety was mung, however people could easily afford mosuri. Now mosuri is too expensive for the majority of people. They now eat cow-peas (buter dal) which used to be used as cow fodder. This fall in protein intake causes serious nutritional problems, especially in children and pregnant women. In the months of food insecurity, mentioned earlier, the families often exist in famine-like conditions (locally known as monga). During monga they do not have their usual three meals a day. For fishing households, the dry season of Falgun-Chaitro brings food insecurity, Ashwin-Kartik for farmers, and Ashar-Srabon for day laborers. Often they cope with extreme food insecurity by consuming smaller amounts of food, and most often by forfeiting one or two meals a day. In addition, they avoid unnecessary movement, thereby conserving energy and pass most of their time sleeping. Carbohydrates form the major part of their food intake during these times of food insecurity.

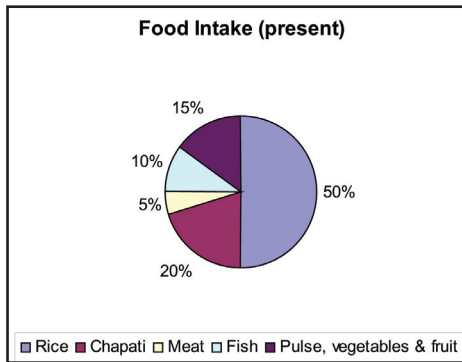


Figure 2 a): Present Food Intake

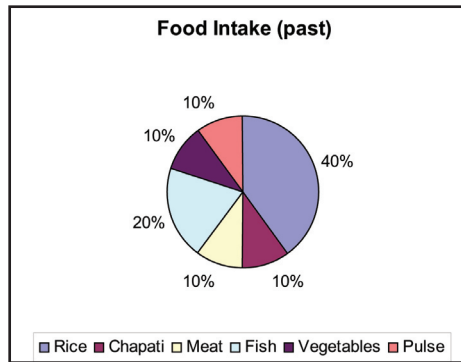


Figure 2 b): Past Food Intake

Women were specifically asked how they manage this lack of food security. Often women collect vegetables from common property resources (*tokano*). In most cases food priority is given to the male member of the household. Then the remaining food is distributed among the old and children. Women come last. If something is left over they can have that.

To face natural disasters women often store dried food within polythene packs and store it on *darma* in their house as a coping mechanism.

Availability of Safe Drinking Water

Both in Noakhali Sadar and Subarno Char, people take water from tubewells for drinking. They are aware of the problem of arsenic. Not every household possesses a tubewell. Those who do not have a tubewell in their house have to go to a neighbor's house, school or *madrasa* to fetch drinking water. Usually the women or children in the family are responsible for this job.

When there is excessive rainfall and waterlogged conditions, sometimes polluted water reaches the water level of tubewells, and then it is extremely difficult to obtain safe drinking water. During waterlogging or flooding, water is purified either by boiling or by using alum (*fitkari*). However, as electricity is not readily available during flooding it is difficult to boil water for drinking. Rain-water is collected to use as drinking water when all the tubewells become flooded. On top of this, wood is stored on *darma* to be used as firewood for boiling pondwater.

The inhabitants of the Subarno Char in particular, had previously been used to drinking water from shallow tubewells. But now-a-days, with the dissemination of knowledge, they usually drink water from deep tubewells since the chance of water being contaminated is much lower. In the past, when they did not have any specific knowledge of contamination, they used to drink surface water as well.

Coping with Energy Insecurity

As shown in figures 3a) and 3b), biomass is still the most important source of energy. But as the common property resources decrease over time and agriculture tends to depend on technology rather than animal power, the availability of cow dung has decreased. In farmers' families agricultural residues are an important source of energy, while the families of fishermen are largely dependent on fuels bought from the markets. Dried-up maize plants, paddy straw, roots and branches/creepers (*lata*) of bean plants etc. are used as firewood for cooking. During waterlogged periods this fuel is stored on *darma*.

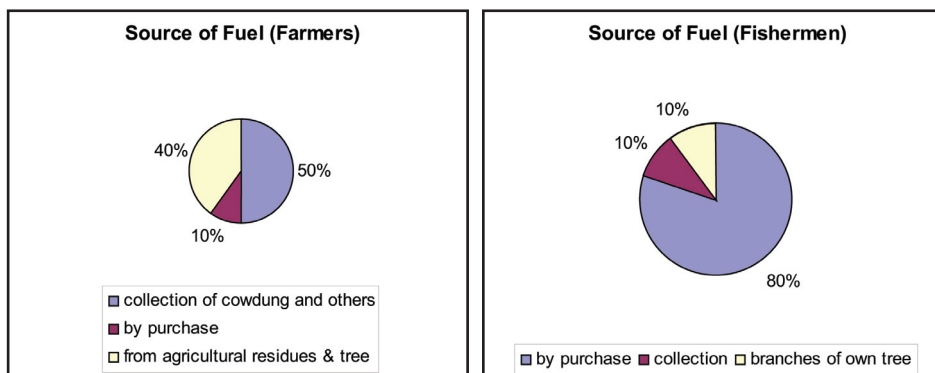


Figure 3 a): Source of Fuel (Farmers)

Figure 3 b): Source of Fuel (Fishermen)

Coping with Crisis

Households adopt a wide range of strategies to cope with crisis. Sometimes, immediately after or during the crisis, people take out loans from local *Mahajans* (wealthy people) with high interest rates (usually 100 tk. interest per month for 1000 tk. of loan) to deal with their emergency needs. If, during or just after waterlogging or drought, diarrhea and other diseases breakout they often resort to informal loans. Often in this situation they sell their assets. Of course, selling land is the last resort for them.

Seasonal migration is very common, especially during the dry season when farmers cannot cultivate land due to salinity or lack of irrigation facilities. People often leave their houses and go to nearby cities in search of job opportunities.

Hazard Specific Coping Strategies:

Waterlogging

- To cope with waterlogging, some houses are being built with fences made of bamboo (*muli* bamboo) and wood. Yet most of the houses are made of mud and bamboo fences.
- The foundation floors of the houses are raised so that water does not enter, until it reaches a certain level.
- In the case of crop-agriculture, late varieties of *Aman* rice such as *kazal-shail*, *raje-shail* (both black and golden), *chaprash*, *kartik-shail*, *dholamota*, *leiccha*, *nazir-shail* are sown as they are more resilient to waterlogging.
- During the waterlogged period cattle are kept on raised floors. Seedbeds are also prepared by raising the land with soil/mud. In some places crop-land is raised quite considerably for cultivating winter crops (*rabi* crops).
- As a precautionary and safety measure, the sides of the fish ponds are raised up to a certain level so that the fish are not washed out of the ponds.

- Fishermen catch fish in ponds, reservoirs and sometimes in waterlogged land since almost all the canals are filled up with silt and the Meghna River changes its course due to flooding.
- Ceiling-like raised/high platforms (*darma*) are built inside the house to keep important documents, dry food such as cheera, muri, rice, pulses, salt, sugar (*gur*), matches, candles, kerosene, quilts and kantha, etc. safe and stored during the waterlogged period.
- Those who live from hand to mouth become compelled to borrow money. If they fail to borrow any money or food, they have to go hungry.
- Rainwater is collected to use as drinking water since tubewells are unusable during the waterlogged period. As well as this, wood/branches of trees are stored on *darma* to be used as firewood for boiling pondwater.
- During waterlogging/flooding, water is purified either by boiling or by using alum (*fitkari*).
- Dried-up maize, paddy straw, roots, branches and creepers (*lata*) of bean (*seem*) plants, are used as firewood for cooking.
- Cow-dung collected either from own cattle or from other sources is another source of energy for cooking.
- Ovens are made using mud, tin, and cement and kept on *darma* for use during waterlogging/flooding. Cooking is done on top of beds using those ovens, which the participants have learned to use through demonstrations performed in mass communication campaigns.
- Raised platforms are made of bamboo in order to use for urination and defecation purposes during waterlogging/flooding.

Salinity

- The inhabitants of the Subarna Char Thana in particular previously used drinking water from shallow tubewells. But now-a-days, with the dissemination of knowledge, they usually drink water from deep tubewells since the chance of water being saline is much lower. In the 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 tubewells, they do purify it using alum (*fitkari*).
- An effect of salinity is that the complexion of people's skin becomes darker. But people adjusted to this phenomenon over time.
- Farmers use fertilizers such as gypsum, potash, etc. to reduce salinity of the land.
- The extent of salinity is different for different sections of uneven land. Therefore, to make the extent of salinity equal the farmers first make the land even and then use the various types of fertilizers mentioned above.

Drought

- With the onset of drought, land becomes covered with a thin layer of salt. Farmers thoroughly plough their land in order to reduce concentrated salinity.
- Since water becomes scarce and less available farmers bring water from ponds to use on their land for cultivation.
- Farmers usually use pitchers for fetching water from nearby ponds. Relatively well-off farmers use shallow tubewells and machines to channel water from ponds.
- Throughout the drought period there is a shortage of drinking water availability since water cannot be withdrawn from shallow tubewells. People have to look for deep tubewells nearby.

Cyclones

- In a bid to reduce the extent of loss of lives and resources, The Red Crescent Society alert people against danger and motivate them to adopt safety measures with the warning of cyclones.
- Upon hearing these announcements by the government through the radio, people take refuge in cyclone shelters.
- In addition to cyclone shelters, people take shelter in strongly built houses.
- After 1991, another practice of taking shelter during cyclones has emerged with people and their cattle taking refuge on higher ground.
- People usually secure their houses so that they can withstand the severity of the storms.
- They keep food in mud pots and bury them in the ground.
- People keep seeds in polythene bags and bury these in the ground too.

Floods

Due to the erection of the embankments, no drastic flooding has occurred since 1970. After the building of the embankments the only flooding has been in the form of severe waterlogging. Therefore, peoples' coping practices for flooding are similar to those for waterlogging and cyclones.

Women's Vulnerability to Natural Disasters in Noakhali

In Noakhali, society supports a rigid gender division of labor that perceives men and women's roles differently and distinctly defines women's mobility, duties and responsibilities. The traditional family model and gender roles in Noakhali are changing very slowly. However, due to extreme poverty and the increased inability of families to provide protection for their women, there is an increased mobility of rural women in economic activities when previously women would have stayed at home. Other than the *Pourashava* areas and some urban areas, the gender roles imposed by society are usually considered 'natural'.

Gender Division of Labor:

In Noakhali, women's positions are rooted in their social traits, patriarchy and gender division of labor. Men's activities are considered as income generating, while women's activities are mostly limited to the domestic domain. The table depicts the gender division of labor in Noakhali as revealed during focus group discussions with both men and women.

Table 2: Gender Division of Labor in Noakhali District

	Women	Men	Both
Private Domain	<ul style="list-style-type: none"> • Child care • Domestic tasks • Livestock and poultry rearing • Homestead gardening • Post-harvest tasks • Seed preservation • Subsistence agricultural tasks • Collection of biomass within homestead 	<ul style="list-style-type: none"> • Building the house • Preparation for strengthening the house before the potential rain/ cyclone periods • Fishing in adjacent ponds 	<ul style="list-style-type: none"> • Water fetching • Weaving • Fish processing • Domestic management during disasters
Public Domain	<ul style="list-style-type: none"> • Collecting cow dung and other biomass • Domestic maids • School teaching • Egg selling by children 	<ul style="list-style-type: none"> • Farming • Fishing • Trading • Day labor • Rickshaw pulling 	<ul style="list-style-type: none"> • Day labor • Industrial labor • Agricultural labor • Small trading • Fish selling at market • Commercial vegetable production • Milk selling services

Wage Rate:

Today, though not comparable with their male counterparts, women are participating in the labor market, but there exists high wage rate disparities between men and women. Wage rates are different over different seasons, depending upon the demand for labor. In rural areas the wages reach their peaks during the transplantation and harvesting periods of main crops (such as *T. Aman*). In *char* areas the wage differences are even greater.

Access to Resources:

Women's access to resources in Nakhali is mostly confined to the domestic domain (domestic utilities, cattle, homestead and adjacent ponds), it is often only when they go to fetch drinking water from a distant tubewell that they leave the domestic domain. Some women have inherited landholdings (either from their father, or in case of widows from their husband), but in most cases the women do not have the right to make decisions on the usage of these resources, whether to retain them and how to use them, or to sell them. Social expectations, family values and laws all affect women's access to common property resources, infrastructure and formal and non-formal institutions. Women's claim on household resources is also secondary to men's which undermines their contributions to sustainable livelihoods.

In terms of access to financial resources, hardly any women in Noakhali go to the Krishi Bank or other banks and apply for loans. Only non-governmental organisations (NGOs) sometimes support them with micro-credit, although this is still uncommon. It is the norm that the male member of the household (father, husband, brother) has the control over this money anyway, so it is difficult to assess whether the increased access to borrowing from NGOs alone can improve women's access to financial resources or enhance their participation in private/family decision making processes. The question of who controls the resources is vital.

Access to Health Care, Safe Water, and Sanitation:

It is mainly women who take the responsibility for collecting water. Those households that do not possess tubewells have to fetch water from distant households, adjacent schools, madrasas, the district board office etc. Women and childrens face tremendous problems collecting drinking water all year round. It is often dangerous when women have to go outside for water at night. There is also a risk of arsenic poisoning and people do not use those tubewells on which the Department of Public Health Engineering (DPHE) has put red marks.

The health of women, especially those who live in *char* areas, is in a poor state. Many women never visit a doctor in their lives and their attitude towards medication is negative. Most of the women in *char* areas would not consult a doctor unless there was a severe emergency. In the case of childbirth, almost every family prefers delivery at home with the help of their female relatives. The sanitation situation is very poor; almost every house in *char* areas uses a *kutchra* latrine which is unsanitary. According to these people, sanitation is the most neglected area for them.

Social Insecurities in *Char* Areas

The construction of embankments (*beribadh*) is a symbol of both environmental and social security for the people of *char* areas although people living on and outside *beribadh* are less secure than the people living within them. People outside the embankments are often attacked by local terrorists. When women have to go outside for various purposes like fetching water etc. they feel unsafe. People outside the embankments tend to be poorer as they are more vulnerable to disasters without the protection that those living inside the embankments have.

Conclusions and Recommendations

Climatic Trends

The analysis of local temperature data shows an increasing trend of annual average temperature of the study area. It has been noted that 7 out of the 10 hottest years on record have occurred since 1990. Rainfall during monsoon season shows no apparent trend, however it appears that variability of rainfall in recent years has increased. Also, the wettest and driest monsoons are increasingly on record in recent times.

Life and livelihood

Climate change may affect the coastal region through salinity, erosion, accretion, floods, waterlogging, cyclones and tidal surges. Livelihoods of people have been affected through the impacts of climate change on agriculture, fishing, livestock, shrimp farming, off-farm activities and even the locations of human settlements. Over the centuries, climate variability and extreme weather events have caused damage to people's lives, assets, resources and livelihood practices, which eventually have led people to devise indigenous coping strategies for survival. The practiced coping mechanisms within the communities and their traditional knowledge-base enable them to organize at the community level and manage disasters. Even their wealth of knowledge regarding the management of their livelihoods in different changed climatic scenarios is found to be substantial.

The study area suffers tremendously from waterlogging which is expected to be aggravated with the change of climatic patterns. Arguably, the best coping potential lies in moderation of the physical risk factors. For the prevention of waterlogging, proper drainage systems and housing planning must be ensured. For this, local government can initiate different measures to drain out the water due to excessive rainfall and to structure a planned township.

Other than waterlogging, droughts, cyclones and salinity are the most devastating phenomena in Noakhali district. To cope with cyclones, adequate multipurpose cyclone centers can be built. To renovate or rebuild the dwellings as a protection from cyclones, soft-term loans can be disbursed to local people. To cope with drought and salinity, research must be carried out in the agricultural sector to develop crop varieties (especially rice varieties) which can tolerate these conditions.

Agriculture

Simulation studies have shown that the climate change impacts could result in significant reductions in crop yields, in most cases, and therefore production. The effect of the changes would vary because of the differences in the crop varieties and local differences in growing seasons, crop management etc.

As the incidence of floods and droughts is likely to increase in frequency, effort should be made to develop crop varieties tolerant to these conditions. On the other hand, agronomic manipulations such as shifting the planting dates, using short duration crop varieties could be other options. During the dry months of March and April, salinity problems, resulting from seawater intrusion, are more acute and lands are commonly left fallow as crop production is restricted by the presence of salt. Cash crops such as tomatoes and chilies can be grown with proper management of soil and water. Use of raised beds and irrigation through drip irrigation systems permit proper leaching of salt from the root zone. This system of crop cultivation produces high economic benefits compared to traditional methods.

Improvement in the crop-based weather and flood forecasting systems is one of the adaptation measures that is urgently required. Early warning systems should be strengthened to inform the farmers about their roles in an adverse weather condition on the basis of specific information analysis. The Department of Agricultural Extension (DAE) provides "extension messages" on the basis of agro-meteorology and agro-climatic data, and forecasts the sowing/transplanting time and possible yields of crops to the farmers.

Fisheries

The potential impacts on coastal fisheries may include: (i) loss of coastal inland fisheries; (ii) further changes in species composition, particularly due to inundation of coastal areas; (iii) loss of

fresh water culture fisheries due to storm surge-related tidal bores and salt water inundation; (iv) changes in fishing methods and gear; (v) declined *hilsa* fishery due to changes in migratory routes; and (vi) loss of shrimp farms, etc. However, there could be increased fish production from marine fisheries.

The present coping strategies practiced by the community and supportive activities undertaken by various agencies for combating the adverse impacts of climate induced disasters are probably not adequate to address the full range of present and potential impacts in the future and therefore would require some additional adaptation in future. With the participation of local people, a range of future adaptation needs are identified, which are as follows: (i) improvement of fish habitats; (ii) promotion of mechanization of boats for fishing in the sea; (iii) further promotion of scientific pond aquaculture; (iv) introduction and promotion of community-based *doghi* culture; (v) development and promotion of culture of salt tolerant fish species; (vi) strengthening of evacuation system and awareness building; (vii) increasing of embankment heights; and (viii) construction of cyclone centers in newly formed char lands.

Fishing boats

It has been found that poor structural strength of the boats is the principal reason for the accidents involving fishing boats. The poor strength is caused by the use of poor quality timber, poor construction and improper maintenance. The second but far less important reason is the poor condition of the engine and equally poor maintenance and operation. However, all these are the direct result of lack of availability of market finance for the sector and it hardly needs mentioning that most of the boat owners, especially in the study area, are poor. There are other factors such as inadequate life savings and communication equipment, absence of navigation aid etc. Improvement in these matter would either contribute to reduction of human casualties in such accidents or avoid the hostile situation altogether.

Housing

Instead of designing a proto-typical model house to be indiscriminately replicated without paying heed to context, it was conceived wise to recommend “Building-for-Safety (BFS) Options”. These are modest technological innovations that would contribute towards improving the performance of existing housing types by strengthening or improving parts of the house, which are particularly weak and vulnerable in the local climate.

Because of the coastal location, houses need to be built to withstand strong wind. Perhaps the nature of rural housing would not permit it to withstand a severe cyclone, but strengthening the house structure would at least provide resistance to the frequent strong winds and storms. The roof is particularly exposed to damage by wind and this building aspect requires careful attention by incorporating strengthening techniques within local means. There is a need for trained, village-level house building specialists – “para-architects” or “barefoot engineers” – for replicating, disseminating and sustaining within the community new construction methods that are introduced. Key people at the community level should be trained for this purpose.

Institution

The local level institutes need to be equipped with climate change knowledge so that they can help the local people in adapting to the change. Engineering related local level institutes have technical people and are capable of incorporating climate change into their design provided there is higher level decision making and funds are available. It is also important to note that changes in infrastructural design need local level data and information of climate change impacts on different infrastructures. Awareness raising and targeted capacity building for different groups is necessary

to promote rural development and livelihoods of the local community. Incorporation of climate change issues in the sectoral policies and institutional mandate for awareness raising at senior level (decision makers) is equally important.

Glossary

- *Aus* rice: This is a periodically fixed maturing, photoperiod-insensitive group of rice. In Bangladesh this crop is mainly rainfed and dry-seeded but when sufficient rainfall or irrigation water is available the crop is also transplanted. Seeding of this crop is done during March to April with the beginning of pre-monsoon showers, and harvesting is done during July to August, in mid-monsoon. Transplanting is generally done a little later than the dry-seeded crop.
- *Boro* rice: Photoperiod insensitive winter season irrigated rice transplanted in December to January and harvested in April to May.
- *Kharif* season/crops: Monsoon season, i.e. from April to September in Bangladesh which is known as the kharif season. Crops grown during this time are known as kharif crops. Examples are *Aus* rice, *Aman* rice, and jute.
- *Mudflats*: Newly formed land, mainly silty to clayey in texture.
- *Sorjan*: A system of cropping in the wet land or waterlogged area on artificially made alternate raised beds and ditches.
- *Upazila*: An administrative unit in Bangladesh comprising several 'unions' which, in turn, are composed of several villages.
- *Transplant (T.) Aman*: A group of traditional photoperiod-sensitive rice varieties transplanted in July to August and harvested in November to December. In Bangladesh today, photoperiod-insensitive varieties are also available and farmers are also growing these during T. *Aman* season.
- *Khas* land: Government owned land
- *Char* land: Newly formed island

Bangladeshi and English Year and Seasons

GRISHHO		BORSHA		SHOROT		HEMONTA		SHEET		BOSHONTA	
Boishak	Joshtho	Ashar	Srabon	Bhadro	Ashwin	Kartik	Agrahan	Poush	Magh	Falgun	Chaitro
April-May	May-June	June-July	July-August	August-September	September-October	October-November	November-December	December-January	January-February	February-March	March-April
SUMMER			AUTUMN			WINTER			SPRING		

