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Climate Change Adaptation for Vulnerable Coastal Population of Bangladesh

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Abstract

The coastal zone of Bangladesh is the home of over 35 million people with 3 million extremely vulnerable and exposed to adverse effects of climate change. The coastal people lose working days due to cyclone, flood, and frequent maritime weather signals of number III and above in the Bay of Bengal. This study aimed to reduce collapsing of dwelling houses and the capsizing of fishing boats by identifying existing adaptation strategies and developing additional strategies in the design of boats, houses, and homesteads. The study was conducted in three coastal sites of Noakhali district during January 2010 to April 2012. Focus group discussions, participatory rural appraisal, and interviewing local elders were conducted. The professionals were engaged to design appropriate implementation strategies. Result showed that coastal people experienced increases in temperature, cyclones, rain, water logging, siltation, salinity, erosion, and flooding. Existing adaptations include making houses on high land and using radios, mobile phones, and strong boats at the time of fishing. Proposed adaptation strategies for coastal population are using boats of more than 30 feet in length, putting at least 3 longitudinal bar in the upper side of boats, using an adequate vertical side bars, and avoiding plank joints on boat front. The proposed housing measures include reducing house height, using cross braces on the wall frame, and tying an extra post to the roof with nylon ropes.

Keywords: Climate Change, Adaptation, Coastal People, Bangladesh

Introduction

Climate change impacts such as prolonged flooding, increased temperature and heat waves, drought, rising sea level, increased salinity, and greater rainfall variations are evident worldwide (Rahman *et al.*, 2008). Recent examples of events influenced by climate change include prolonged floods and severe droughts in South Asia and Africa, heat waves in Europe, devastating cyclones and tidal surges (e.g. *Hurricane Katrina, Sidr and Rita*) along the Atlantic coasts (Parry *et al., 2007*). Not only the developed countries but also

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the developing countries face adverse effects of climate change. The variability and extent of such adverse effects i.e. loss of lives and property are more prominent in developing countries than the developed countries (CCC, 2009).

Bangladesh lies on a deltaic plain with five major river systems: the Jamuna-Brahmaputra, the Padma-Ganges, the Surma-Meghna, the Padma-Meghna, and the Karnaphuli. Although altitudes up to 105 metre above sea level occur in the northern part of the plain, most elevations are less than 10 metre above sea level. The elevations decrease in the coastal south, where the landscape is generally at sea level. These geographical features make Bangladesh vulnerable to natural disasters, such as floods and cyclones, and the high levels of poverty increase the enormity of the challenges that the country is likely to face from climate change (ICDDRB, 2011 (cited in Mahmood, 2014)). According to Germanwatch's Global Climate Risk Index 2009 (Harmeling, 2008) Bangladesh is the most vulnerable country in the world. The manifestations of climate change are already being experienced in Bangladesh in the form of extreme temperature, erratic rainfall, increased number of intensified floods, cyclones, droughts, prevalence of rough weather in the Bay (Parry *et al., 2007*; Disaster Management Bureau, 2010; Haque *et al.,* 2012). Climate change has been affecting and will continue to adversely affect the country's agriculture, fisheries, and livestock as well as individuals' health and livelihood (Ministry of Environment and Forests, 2005). About 53 percent of the world's deaths from tropical cyclones killing more than 5,000 people occurred in Bangladesh and these disasters are still continuing (Ali, 1999). Flooding, storm surge levels, and the number of cyclones making landfall have increased substantially in Bangladesh over the last 10-12 years. For example, super cyclone *Sidr* hit Bangladesh on 15 November 2007 and the estimated damage was BDT 113 billion (US$ 1.6 billion). Moreover, Bangladesh had experienced the lowest temperature (5°C in the three northern districts) recorded in last 38 years during January 2007 (Parry *et al., 2007*).

Over 35 million people live in the coastal belt of Bangladesh, which is particularly vulnerable to climatic events (Disaster Management Bureau, 2010). The local fishermen are dependent on coastal fisheries and thus are one of the groups most at risk due to climate change (Bashar, 2000). In the coastal area, 72 offshore islands are the home of 2.7 million families whose primary income source is fishing. Again, over 1.6 million coastal fishermen and estimated 1.85 million shrimp collectors are involved in marine fisheries (Disaster Management Bureau, 2010). In addition to their existing impoverished socioeconomic conditions and livelihood insecurities, these people have to contest with annual extreme climatic events that result in the loss of lives, livestock, working days, fishing and household assets, and damage to their houses. But few literatures focused on fisher population's lifesaving resources i.e. their boat, house and homestead. Day-by-day the frequency of cyclones and the number of days with distant cautionary signal number III (the port is threatened by squally weather) or more have increased, reducing the number of fishing days for coastal fishermen (Disaster Management Bureau, 2010). In fact, climate change and climate variability have been adversely impacting the life and livelihoods of fishermen, pushing them to further worsening situations of life and livelihood, which is likely to increase in future. To make matters worse, the inland fisheries in coastal areas have greatly declined due to loss of land due to construction of embankment, rapid siltation, and the intrusion of saline water (Bashar, 2000). In many coastal areas, productive estuarine fishing grounds were lost or shifted further south and the poor fishermen cannot exploit the new fishing grounds without mechanized fishing boats. Studies in Noakahli coastal areas show that more than 60 percent of the fishermen exploiting inland fisheries became seasonally unemployed (Mollah, 2008).

Predictions for Noakhali have deemed the region as highly susceptible to the risks of extreme climatic events, which are exacerbated by poverty and livelihood insecurities. Adaptation is crucial in order to reduce harm and utilize opportunities. The government of Bangladesh has implemented structural interventions such as building polders, coastal embankments and shelter houses that can offset the effects of inundation (Parry *et al., 2007*). However, the areas inside and outside polders remain equally exposed to the risks of extreme climatic events such as cyclones. Outside of embankments and polders, the dearth of basic amenities such as cyclone shelters, hospitals, schools, roads and local government bodies adds to the burden of climate change and render the communities vulnerable and often unable to cope with disasters. A study in Noakhali district shows that fishermen's boats are often damaged due to the effects of strong winds and waves and in need of repair (Rahim, 2008). Mallick *et al.* (2008) studied the design and construction of rural housing in Noakhali and show that many houses are incapable of withstanding moderate level of cyclones and storm surges. Efforts are in place to deal with current extreme events such as heat waves and cyclones, but more extensive adaptation is required to reduce vulnerability to future climate.

Few studies were conducted in Bangladesh on the coastal fisher communities, especially in the areas of boat capsize and household damage. But promotion of appropriate technology-based boat and house design options among fisher communities could reduce the vulnerability of weather-related disasters in Bangladesh that claims a huge loss of life and property of fisher community. Fisher communities have some forms of coping strategies to encounter the effect of climate change and those strategies are mostly unknown and undocumented.

This study aims to reduce collapsing of dwelling houses and capsizing of fishing boats by identifying existing adaptation strategies and developing additional adaptation strategies by structural improvement in the design of boats, houses, and homesteads.

Data and Methods

Study area

The study was conducted in three specific locations having different ecological and disaster scenarios – an area protected by embankment, an area without an embankment and an isolated char land. All study areas were selected from Suborno Char Upazilla of Noahkhali district located in the Southern side of Bangladesh. From each site, 150 fisher households were selected randomly as target population. Because of the ecological and protection difference of these areas, fishers' livelihoods are entirely dependent on fishing whether they go to sea or bay channels for fishing or exploit inland fisheries.

Charbata: This site is protected by embankment and is less exposed to cyclones and storm surges, but the residents have experienced some problems due to embankment construction. A number of cyclone shelters are available here and the people in this area live in cluster villages.

Nongolia: Nongolia is an unprotected area that exposed to tidal bore and has no cyclone centre and homesteads are scattered throughout the area.

Noler Char: This is an isolated island (charland) that is unprotected and comparatively more exposed to cyclones, tidal flooding and storm surges than Charbata and Nongolia. The settlement in this island started 15 years before and homesteads are dispersed. Most fishers go to the Bay of Bengal for fishing. There are no cyclone shelters and the area lacks basic amenities like hospitals or schools.

Data collection methods

Both quantitative and qualitative methods were used for data collection. A household quantitative survey was conducted among the selected 450 fisher households using structured questionnaire. Qualitative data were collected through focus group discussions (FGD), participatory vulnerability assessment (PVA), participatory rural appraisal (PRA), and key informant (KI) interviews.

Documentation of coping strategies and development of adaptation strategies to climate change

Knowledge of coping strategies was developed organically within these communities as they experienced natural disasters. Thus, before developing any new adaptation strategies, existing coping strategies and adverse impacts of climate change were gathered. The coping strategies were documented by qualitative methods such as FGDs, workshops, and interviews and then assessed using PVA, PRA, KI interviews, consultative meetings, community meetings, and union and *upazila* level workshops. The PRA techniques included trend analysis, ranking, seasonal calendar, and cause and effect analysis. Eight FGDs were conducted with fisher community at different places with different topographical scenarios. In addition, three community level, three union level, and an *upazila* level consultative workshops were also organized.

Based on the information collected on local coping strategies and local level suggestions and the consideration of science-based knowledge and expert consultation, we developed adaptation strategies for the coastal fisher communities. Professional engineers were hired to develop adaptation strategies for cyclone resistant houses and for boats suitable to fishing in the mouth of the Bay of Bengal and in the sea. These professionals extensively consulted the local carpenters and community members to design the houses and boats.

Finally, information about 20 boat capsizing incidents was collected and some of the survivors were interviewed to gather information about their experiences.

Results

Background characteristics

Most people of the fishing communities belonged to age group 35-39 years, and their mean age was 37 years. About 80 percent of the fishermen's occupation was full time fishing and 76 percent of all fishermen were illiterate. About 21 percent of all fishermen used to fish in the sea, while most fishers (78 percent) exploit estuary areas in inland waters. However, some of the estuarine fishers move into the inland waters during monsoon (not shown in the Table). One-third of the fisher families earn less than 50,000 Taka per year with an average monthly family income of 5,634 Taka (Table 1).

Table-1: Background characteristics of the respondents (in percent)

Backgroundcharacteristics	Percentage
Age in years	
Up to 24	8.22
25-29	18.67
30-34	18.22
35 -39	19.78
40- 44	15.33
45 and above	19.78
Mean age in years	37.00
Education of respondents	
Never attended school	76.3
Incomplete primary	18.7
Completed primary and above	5.00
Mean years of schooling	1.15
Occupation	
Full-time fisherman	79.78
Part-time fisherman	20.22
Yearly family income (in Bangladeshi Taka)	
≤50,000	33.11
50,001-70,000	27.33
70,001 – 90,000	12.45
90,000 above	13.11
Can't say	14.00
Average monthly family income	5634.00
Number of family members	
Up to 3	10.00
4	19.11
5	20.22
6	28.89
7 and above	21.78
Average number of family member	**5.33**

Source: Household survey

Local perception about local level climate change

While there were conflicting statements in many areas of discussion, there was a strong consensus about the local climate. Invariably, the local people recognized that the climate was not behaving normal and that something went wrong. However, there are differences in the experiences between the people from polder/embankment areas and the people from unprotected areas, particularly those had risk-related experiences. Table 2 summarized the residents' perceptions of the local climate. Trend analysis of the local level perception about climate change indicates that all the physical parameters increased during the past 25 years.

Table-2: Trend analysis of some major climate change related physical parameters in study areas

Physical parameters	Charbata (protected)			Nongolia (unprotected)			Nolerchar (isolated char)		
	25 years ago	10 years ago	Present situation	25 years ago	10 years ago	Present situation	25 years ago	10 years ago	Present situation
Temperature	+++++	++++++	++++++++	++++	+++++	++++++	+	++	++++
Tidal flood				+++	++++	+++++	+	++	++++
Cyclone	++	+++	+++++	++	++++	+++++	+	++	+++
Salinity increase				++	+++	++++	+	+++	++++
Erosion				+++++	++++	++	+	+++	+++++
Rains	+++	+++	++++	+++++	++++	++	++++	+++	+
Water logging	++	+++	++++	+	+	++	+	++	+++
Siltation	+	++	++++	+	++	+++	++	+++	+++++

Note: Increase of '+' sign means increase of physical parameters of event

Data source: Qualitative surveys

Outcome of participatory planning for climate change adaptation measures

This study has identified a large number of adaptation interventions to reduce vulnerability and to help residents adapt to climate change. These planning schemes included changes to design of boats and houses. A brief description of the designs and interventions is given below:

Adaptation to fishing boats

In the coastal area of Noakhali, there are many incidents of boats capsizing resulting in the loss of life. Boats are capsizing due to faulty design. The poor structural components of the boats make them unable to withstand impact of winds and wave action. The main reasons that boats capsize are because the boats are too small, fishermen fail to heed weather forecasts, insufficient time for boats to reach a safe place, failure of engines due to poor maintenance, disproportionate engine power, mismatch of size and capacity of boat, and inexperienced boat drivers.

Existing coping strategies

- Fishermen use some communication links (mobile phones) between the people on the ground and boat crews.
- Most boats carry radio and try to comply with weather signals. However, in case of sudden localized cyclone/tornado type events, this precaution cannot help.
- Fishermen put efforts to build structurally strong boat, but not with much emphasis on quality building materials.
- Use some steel frame on *gosa* (vertical wooden bar for sides of boat) and *teraga* (longitudinal wooden bars along the upper side of the boat) for reinforcing structural strength of boat.

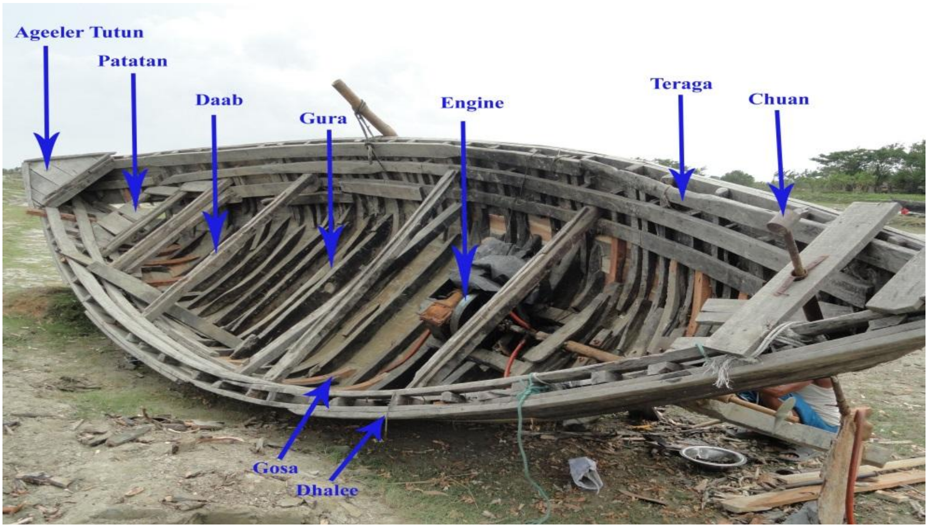
Proposed adaptations to boat

Considering the above facts and suggestions from fishermen, carpenters and other experts, the following adaptation strategies are recommended:

- There are many local boats that can withstand strong wind and wave action. Relevant experts also say that such local designs are suitable (Rahim, 2008). Local fishermen emphasized that the minimum size for fishing boats operating within the estuarine areas should be 30 feet in length. Boats less than 30 feet should not go for fishing in the Bay areas. Sea-going boats should be much larger (more than 30 feet in length).
- The boat should be reinforced by putting at least 3 longitudinal bars along the upper side of the boat, and having adequate number of *gosa* (vertical wooden bar for sides of boat), *gura* (bottom cross bars) and *daab* (upper cross bar on which platform is made). *Gura* and *gosa* should overlap by at least a foot and the *daab* should be thick and strong. Suggested structural elements of a boat are shown in Figure 1. Joints on the *teraga* and *gura* or the *gosa* may be reinforced by putting in a short steel frame.
- Local people use *koroi* and *tetuakoroi* timber for making fishing boats, which do not perform well in water. The timber of *Babla*, a local tree which is very hard and durable in water, is recommended to make fishing boats.
- There should not be any joints where waves strike most, particularly on the front part of the boat.
- Timber plank should not be small in size.

- The engine power should be compatible with the boat size
- An adequate number of nails, bolts, and screws should be used to get firm joining between various structural elements of the boat. The shell of the boat should be tightly affixed to the boat frame.
- Steel frames (small) could be fixed on *gosa* and *teraga* and could be used as shown in Figure 1.
- The design and structural strengths also largely depend on the workmanship of the carpenter. The skill of boat making is unfortunately disappearing.

Figure-1: A boat showing internal details for reinforcement



The following should be done to save lives in the case of a boat accident or capsize:

- When sailing each boat should carry life jackets for each of its crew members.
- There should be 1-3 life buoys in each boat depending on the number of crew members.
- There should be a few long bamboo stalks that can be tied together during a cyclone or during strong winds. A wood log and two plastic drums can also be used in these situations. The crew can tie themselves firmly to the logs or bamboo bundles so that they do not get separated from the floating devices during strong waves.
- Each boat should carry a radio and a mobile phone to listen to early weather warnings. A compass should be used to track direction.

- The crew should be given identity cards, which will help them if they get lost at sea and arrive in the territorial waters of another country.

Adaptation to Housing (Houses and Homesteads)

Existing housing conditions

Most fisher houses of the study area are vulnerable to natural disasters. The settlement pattern inside of the embankment areas is mostly linear, while that of outside of embankment area is highly dispersed. All fishers, either inside or outside the embankment areas, have a hovel. The structure of a typical fisher's house is made of un-split local timber posts or bamboo or from a split betel-nut tree roof frame with paddy straw roofing materials. The house wall is either made of bamboo mat, paddy straw, or from leaves. Some houses use sun-grass (*Imperata* sp.) or *chhon* as thatching material for roof. Use of a polythene sheet in the ceiling is common to prevent leaking of rainwater. Some fishers also have walls made of corrugated iron sheets, received as relief. In rare cases, some fishers have tin-shed houses.

The house of fishers are feebly built and not reinforced to withstand the strong wind action. Most houses are directly exposed to winds, making the houses more vulnerable to collapse or damage by moderately rated cyclone. These houses are particularly vulnerable to local tornadoes.

Existing coping strategies of the dwelling houses

- Reduce the height of the houses, which will reduce the wind action on the houses.
- Provide some supports to the houses, whenever possible, during cyclones so that these are not easily get inclined towards the direction of the winds.
- In rare cases, some people tie their houses and their roofs to outside trees or extra posts by using rope.

Proposed adaptations for dwelling houses

The present adaptation is based on the conceptual framework for improving fisher's dwelling houses to withstand frequent strong winds and storms, but not necessarily severe cyclonic storms.

- The house structure should be reinforced with cross braces of either timber or bamboo, so that wind cannot cause the house to collapse.
- The study has designed a low cost house for fishers, which will require only bamboo or small local tree logs as posts with a bamboo-made roof structure. However, in all cases crossbars are required to reinforce the structure (Figure 2). The roof-shed material could be the traditionally used

straw or sun-grass. The roof pitch should be 25^0 to 30^0 to minimize suction caused by negative pressure.

- The joining of these different elements must be good enough and frequent enough to stop the structure from breaking into separate and vulnerable elements.
- The house should be low in height as is currently practiced.
- A plantation of small trees, preferably banana trees, could be done around the house because these trees will protect the house from strong wind. Moreover, these will not be harmful for the house if fallen on it.
- Strengthening houses against wind action could be done by making alignment of the house with strong nylon rope tightly tied to deeply grounded outside posts at four corners.
- Some bamboo or logs could be used during cyclones to provide extra support against house collapse.
- The house should be built on a high floor base above the flood mark.

Figure-2: Suggested design of a *katcha* dwelling house

Adaptation to Homesteads

Homesteads are a defined area around a household purposively built mostly of raised land containing the house structure, a courtyard, gardens, some vegetation, and ponds among other things. In the study area, particularly in the unprotected areas, homesteads are on raised land to avoid tidal bores, local floods and storm surge waters. Because of their elevation from the ground, homesteads are small and constructed with soil obtained by digging an adjacent pond. Fishers grow plants, firewood, fruit trees and many more horticultural commodities of their daily needs on the homesteads.

Present condition of homesteads

In most cases homesteads are sufficiently raised but with a low slope that is almost vertical and has less vegetation on the homestead edge to prevent erosion. Most homesteads have few trees and other vegetation to reduce wind action on the houses. Therefore, a well-landscaped design (Figure 3 and 4) may reduce the cyclone impact as well as provide resources for household needs.

Figure-3: Landscaping of a homestead suited to withstand wind and tide (side view)

Proposed adaptation for Homesteads

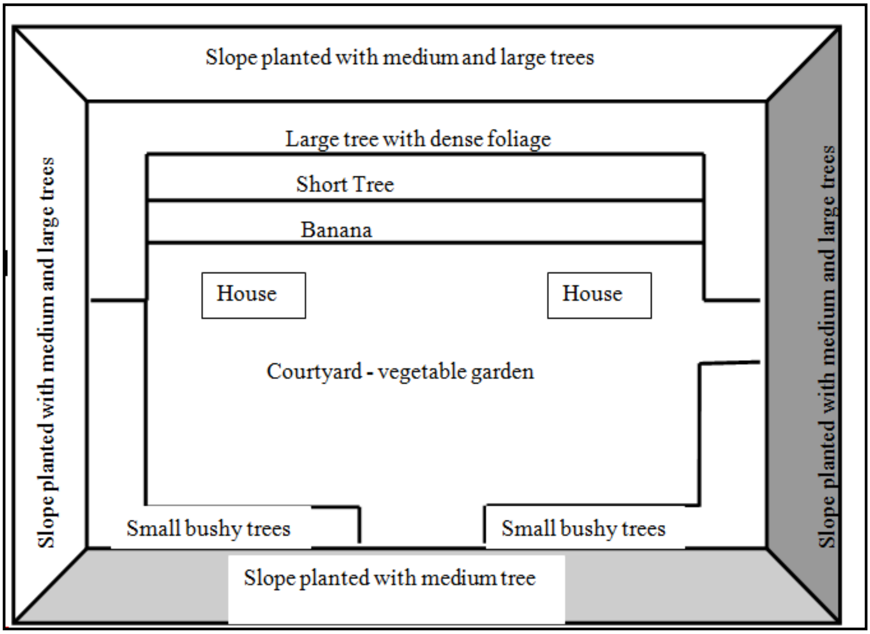
1. *Erosion proofing of the homestead slope*

   Lataghash (*Saccharum* spp.), a local variety of creeping vegetation, should be grown on the homestead slope and edges as erosion proofing vegetation. This grass can tolerate salinity to some extent and can withstand water logging for few days.

2. *Plantation plan/landscaping*

   a. **Homestead slope:** In addition to *lata*grass/*uri*grass (*Saccharum* spp.), the lower part of the homestead slope, which remains submerged for some period of the year, could also be planted with *kash* (*Saccharum* *spontaneum*), sun-grass (*Imperata* spp.) and some other local vegetation that grow in wet places. These plants could also be planted above the normal flood level. The advantage of *kash* and sun-grass is that they could be used as quality thatching material for roof, more durable than paddy straw. The wet part of the slope could be planted with some salt tolerant and deep rooted plant species like *natai* (*Pithcellobium dulce*), *nonajhau* (*Tamarix indica*), *gab* (*Diospyros pergrina*), *baul kata/babla* (*Acacia nilotica*), *keora* (*Sonneratia apetala*), or date palm (*Phoenix sylvestris*). These plants could also be planted on the upper part of the slope in order to reduce erosion. In addition, local trees with dense foliage that yield timber and fruit could be planted to create a barrier to strong winds.

Figure-4: Landscaping scheme for a homestead



b. Plantation on the homestead top

At the homestead edge some large timber and fruit trees that locally preferred – like *koroi* (*Albizia Lubbock*), mango (*Mangifera indica*), coconut (*Cocos nucifera*), and *jam* (*Syzygium cumini*), could be planted at a distance from the dwelling house so that it does not fall on to the dwelling house when uprooted by strong winds.

At the peripheral area of the homestead top, a strip plantation should be done with dense foliage low height trees. There could also be bamboo groves and canes and other lines and vines to form an effective barrier. Another strip plantation could be done with low height fruit bearing trees like *boroi* (*Ziziphus mauritiana*), guava (*Psidium guajava*), and improved mangoes, followed by a strip of banana (*Musa sapientum*) plantation. In the front courtyard, a provision for vegetable and flower gardens and other utility areas could be kept (Fig. 3 and 4).

Discussion and Conclusion

The respondents from all the three areas mentioned that over the last 10-25 years there has been an increased temperature and siltation in addition to an increased frequency of rains, cyclones, and water logging events. Only protected areas with embankments did not experience an increase in flooding, salinity, or erosion. Sarker and Hossain (2012) interviewed the local people of Ramgati coastal area of Bangladesh and found that the intensity of disasters/physical parameters such as tropical cyclone, tidal flood, rainfall, temperature is increasing with time. Especially the intensity of riverbank erosion and tidal surge has increased significantly. The coastal area of Noakhali district is a disaster-prone area and boat capsizing leading to loss of life is a common phenomenon (Rahim, 2008). The main reasons identified for boat capsizing were the use of poor construction materials, irregular maintenance, improper reinforcement, and inexperienced boat drivers. Rahim (2008) stated that out of 30 incidences of boat capsizing, only one was due to faulty design of the boat and recommended the construction of boats as per local designs. Based on our consultation with local boat makers, fishers and experts we find that the local boat designs are appropriate and suitable. While agreeing with the suggestions made by Rahim (2008), we further suggest the reinforcement of boats to withstand wave and wind action. In addition, we also suggest addressing other causes of boat capsizing and human casualties. We hope that if these suggestions can be implemented then it will contribute to the reduction in boat capsizing and the related losses of life and assets.

Mallick *et al.* (2008) worked on the design and construction of rural housing in Noakhali and made comprehensive suggestions for the construction of houses capable of withstanding moderate level cyclones and storm surges. We have reviewed their suggestions and found them to be useful. However, the suggested house designs would be costly and may not be affordable for poor fisher communities. In fact, the authors did not focus on the fishers; rather their design is for people from higher socioeconomic backgrounds (Mallick *et al.* 2008). Still, we used their suggestions to investigate further into the matter and addressed the root causes of house collapse. In this regard, we have emphasized the use of locally available building materials reinforcing the structure of houses in a cost effective way and blending other local techniques for strengthening of houses. Therefore, the suggestions made in this study are more appropriate and may be promoted among the fisher communities in coastal areas, particularly in charland areas.

While Mallick *et al.* (2008) provided some suggestions for landscaping for rural areas of Noakhali to reduce the impact of wind, those suggestions appeared too general. Therefore, we developed our recommendations through a process of consultation with the relevant local stakeholders and experts. Our landscaping scheme not only addresses the issue of cyclone proofing but also considers household needs. Therefore, it is hoped that this landscaping scheme will be popular among local people and can be promoted among fisher communities of coastal belt of Bangladesh.

Way forward

Local level adaptation strategies to climate change were developed in a participatory way blending local knowledge and expert opinion to suit the local socioeconomic and climatic conditions. In particular, the adaptation strategies were designed to reduce fisher boat capsize, loss of life and assets, house collapse and damages to houses, and loss of livestock.

Suggested adaptation interventions

- Construction of embankment in unprotected inhabited areas should be done on a priority basis, if feasible.
- Construction of adequate number of cyclone shelters, both in protected and unprotected areas should be undertaken.
- Ensuring compliance to carry life saving devices, compass and radio while fishing in the estuary and bay mouth and in the sea.
- The fitness of boats sailing for bay mouth and sea should be monitored and regulated by local authorities in consultation with fisher societies and boat owner societies. The fitness criteria should satisfy the suggestions set out in this study.
- The fishers should be encouraged to follow the guidelines proposed by various agencies when constructing new houses. We especially recommend following the design we proposed, as it was developed based on reviews of past studies and consultation with local people.

- The fishers should be encouraged to develop homesteads following the guidelines we proposed, which would not only protect houses from strong winds but also provide resources for household to use or consume.
- At different strategic places in protected and unprotected areas, *Killa* (earthen raised land) could be constructed to provide shelter for livestock and humans during destructive cyclones and storm surges.
- Special consideration should be given to the fisher communities in the case of relief and rehabilitation programmes as fisher communities are more vulnerable to natural disasters and are a comparatively poorer section of the society.
- Covering the fishermen in distant places under early warning system by establishing strong radio signal transmitting towers at different strategic places in the coastal belt.

To policy-makers

- Climate change issues should be mainstreamed in local level development planning, particularly when constructing embankments, roads, plantation, and drainage systems.
- In addition, awareness about climate change-related issues should be enhanced among policy-makers, planners, and local development agencies.
- There is also a need for institutionalization and local level capacity building for combating climate change issues.
- Emphasis should be given to bringing changes in national and sectoral policies and undertaking integrated sectoral actions on the climate change issues.

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References

ALI, A. (1999) Climate change impacts and adaptation assessment in Bangladesh. *Climate Research.* 12. p. 109–116.

BASHAR, M. A. (2010) Climate change: A threat for fishermen communities. [Online] Available from: http://en.bdfish.org/2010/12/climate-change-threat-fishermen-communities/. [Accessed: 15 November 2014].

CLIMATE CHANGE CELL (CCC). (2009) *Climate Change and Health Impacts in Bangladesh*. Dhaka: Climate Change Cell, Department of Environment, Ministry of Environment and Forests, and Comprehensive Disaster Management Programme, Ministry of food and Disaster Management, Government of the People's Republic of Bangladesh.

DISASTER MANAGEMENT BUREAU (2010) *National Plan for Disaster Management 2010-2015.* Dhaka: Disaster Management & Relief Division, Ministry of Food and Disaster Management, Government of the People's Republic of Bangladesh.

HARMELING, S. (2008) *Global Climate Risk Index 2009: Weather-Related Loss Events and Their Impacts on Countries in 2007 and in a Long-Term Comparison*. Bonn: Germanwatch.

HAQUE, M., YAMAMOTO, S., MALIK, A. & SAUERBORN, R. (2012) Households' perception of climate change and human health risks: A community perspective. *Environmental Health* 11(1).

ICDDR, B. (2011) Our Strategy. Cited in Mahmood, S. (2014) Impact of climate change in Bangladesh: Role of two governments. *Journal of Ecology and the natural environment.* 63(3). p. 119-125.

MALLICK, F., AHMED, K., KABIR, K., & KABIR, M. (2008) *Improved Design and Construction of Rural Housing in Noakhali.* Dhaka: IUCN, Bangladesh Country Office.

MOLLAH, A. (2008) *Climate Change and Fisheries.* Dhaka: IUCN Bangladesh Country Office.

MINISTRY OF ENVIRONMENT AND FORESTS. (2009) *National Adaptation Programme of Action*. Dhaka: Ministry of Environment and Forests, Government of the People's Republic of Bangladesh.

Parry, M., Canziani, O., Palutikof, J., van der Linden, P., and Hanson, C. (eds.) (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

RAHIM, A. (2008) *Study on Fishing Boats of Coastal Belt of Bangladesh: An investigation of accidents during cyclonic weather.* Dhaka: IUCN Bangladesh Country Office.

Rahman, A. A., Alam, M., Alam, S. S., Uzzaman, M. R., Rashid, M. & Rabbani, G. (2008) *Risks, Vulnerability and Adaptation in Bangladesh (Background Paper UNDP Human Development Report 2008).* Dhaka: UNDP

SARKER, S. and HOSSAIN, M. (2012) Climate Change Disaster and Community Based Mitigation Options at Ramgati Coast, Bangladesh. *Agricultural Science Research Journal.* 2(6). p. 346 -354.