

Indigenous Adaptation Practices for the Development of Climate Resilient Ecosystems in the Hail Haor, Bangladesh

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Abstract Human communities inhabiting remote and geomorphically fragile flood plain areas are particularly vulnerable to climate change-related hazards and hydrometeorological extremes. This study presents the community livelihood structure, perception of climate change, and indigenous coping strategies adopted by the local communities in the flood plain areas especially at the Hail haor. Field observations reveal that there have been several recent phenomena that are identified and reported on the manifestations of climate change by the respondent community members. These phenomena includes the following: loss of income (90 %), reduced fish availability (80 %), reduced fish diversity (70 %), reduced migratory bird's availability (70 %), decreased crop production (70 %), food crisis (70 %), reduced aquatic plants availability (60 %), sudden flood (60 %), increased storm (60 %), decreased water-retaining capacity of *beels* and *haor*

(60 %), increased drought (50 %), temperature rise (50 %), drying of water supply canal (50 %), scattered rainfall patterns (40 %), increased fish diseases during winter season (40 %), increased human viral diseases (20 %), and introduction of unknown paddy diseases (red coloration of plant, 20 %). The indigenous adaptation and coping strategies were identified. The correlations between coping strategies and physical, human, financial, natural, and social assets were significant. From the present field observation, it is evident that livestock rearing, homestead vegetable gardening, increased fishing time, and change in livelihood options found as most effective options to cope with the adverse effect of climate change. By identifying localized climate change disasters with intensity of impacts and analyzing indigenous coping mechanisms, this study attempts to address the community-based adaptation practices in climate change challenges.

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Keywords Climate change · Climate resilient ecosystems · Community livelihood · Indigenous adaptation practices · Hail haor

Introduction

The world's climate is changing and changing fast, bringing new threats and opportunities. Climate change is affecting significant changes in precipitation, temperature, frequency, and intensity of some extreme events. These changes affect natural and human systems independently or in combination with other determinants to alter the productivity, diversity, resources, functions of ecosystems, and livelihoods (FAO 2009; Hossain 2009, 2012). So the effect of climate change will therefore not only depend on the climatic changes themselves in that area but also on ecological, social, and economic factors (Adger and Kelly 1999; Mendelsohn et al. 2006; Byg and Salick 2009).

Bangladesh is a low-lying riverine country. Its topography, ecology, and human habitat are greatly influenced by the Ganges and Brahmaputra river systems originating from the Himalayas. Changing courses of the river systems and frequent flooding during the monsoon have created a large amount of diverse wetlands (4 million ha), such as rivers, baors (resulting from loss of river flows), beels and haors (natural depressions), and flood lands. These water resources contribute to a substantial proportion of the country's yearly supply of fish (72 %). The fishery subsector contributed 3.63 % to GDP and provides full-time employment to over 1.2 million people (DoF 2011). Another 11 million people earn their livelihoods indirectly from activities related to fisheries (Hossain et al. 2010; Hossain 2012).

The floodplains of Bangladesh are endowed with enormous inland fishery resources and vast inland waters that is one of the world's most important wetlands. The wetlands provide the habitat for over 289 indigenous fish species (13 orders, 61 families), 11 exotic fish species, 24 species of prawns (Rahman 1989; DoF 2012), and hundreds of thousands of migrating birds (BirdLife International 2004) and are an important source of income and nutrition for millions of households in rural Bangladesh, particularly the poor. As many as 80 % of rural households catch fish for food or to sell (FAP 1995) and about 60 % of animal protein consumption comes from fish (BBS 1999). In addition, poor and marginal households catch many small fish that are not included in official statistics or policies and use aquatic plants and animals for food or as feed for livestock. The wetlands also contribute to cleanse polluted waters (up to a certain capacity), recharge ground water aquifers; hence, these wetlands are known as the 'Kidneys of the Landscape' (Mitch 1993; Ferdousi 2013; Monwar 2013). The wetlands have also been termed 'Biological Supermarket' because they support an extensive food web and wide range of biodiversity (Mitch 1993).

Like most of the world fisheries, Bangladesh's inland capture fisheries have been declining in recent years, many species in decline and 54 species are threatened (IUCN Bangladesh 2000). Fishers and experts have identified potential causes for this decline including habitat degradation due to siltation and wetlands conversion to agriculture, climate change, increasing fishing pressure, destructive fishing practices, and an acute shortage of dry season wetland habitat, construction of roads, embankments, drainage, and pollution (Hughes et al. 1994; Ali 1997; Dev 2011). Despite growing recognition of building resilient communities and enhancing adaptation to climate change flood plain areas, fishing communities are not yet receiving adequate attention. Drought, reduced water-retaining capacity, and reduction of fish availability and diversity are having an increasing effect on the lives of people in the Hail haor areas and other flood plain areas of Bangladesh. These climate change disasters also affect their livelihoods, property, environmental quality, and future prosperity since climate change is expected to alter the frequency, severity, and complexity of climate change hazards (Majumder et al. 2013; Monwar 2013).

Climate change disasters and their impact on human are often considered as the regular social fabric. Disasters damage affect regions which are underdeveloped, overpopulated, uninformed, unprepared, and unplanned. Evidence of Centre for Research on Epidemiology of Disasters 2008 shows that the number of disasters sharply increased worldwide between the first and second half of the twentieth century. Occurrences of disaster make the human society vulnerable which is the susceptibility of a society to suffer from damages in the event of the occurrence of a given hazard. Victims of climate change disasters are marginalized geographically because they live in natural hazardous areas, socially because they are members of minority groups, economically because they are poor and marginalized, and politically because their voice is disregarded by those with political power (Gaillard et al. 2009). Marginalization of poor fishing community around the flood plain areas usually leads toward the high vulnerability and low capability to face natural disasters. There is a serious concern that the targets of Millennium Development Goals may not be effectively achieved if climate change disasters risk reduction is not prioritized in development planning (Monwar 2013).

Resilience refers to the ability to bend without breaking and to regain the original shape. Resilience is essentially about how systems (biophysical and socioeconomical) are able to respond to change or shocks while maintaining their key characteristics or identity. Resilience in terms of fishing communities refers how they are able to maintain livelihoods and desired ways of living, without outside assistance, following undesirable shocks (Hossain 2012). Resilience of any community makes strong connections among management and human ecology because it is directed at evaluating responses to disturbances. Responses may commonly refer to indigenous knowledge which is the cultural capital of a population in

association with the environment. Indigenous knowledge may include, for example, knowledge of local plants and animals, cultivation methods, local medicine, alternative economic activities, fishing craft and gear, etc. (Hossain et al. 2013).

In recent years, climate change has become an urgent issue for developing countries. Climate change will increase the poor's vulnerability and make pro-poor growth more difficult. Climate variability can divert the country's economic growth. According to Abramovitz (Abramovitz 2001), "While we cannot do away with natural hazards, we can eliminate those that we cause, minimize those we exacerbate, and reduce our vulnerability to most". Bangladesh is one of the countries most likely to suffer adverse impacts from anthropogenic climate change. So, research on climate change is important to assess the major climate change events, its impacts on community, and on their livelihood; to identify who are vulnerable to climatic extreme events and why; coping strategies; and to increase their ability to adapt against these catastrophes.

This study focuses on the Hail haor situated in the Sylhet basin, Moulvibazar, Bangladesh. The study covered several aspects of climate change, which include vulnerability, impact, and adaptation to climate change. The study also focused on the agroecosystems that are predominant in the region: upland and wetland ecologies as well as fishing communities. This focus was to address human, social, physical, financial, and natural assets which might influence adaptation to climate change. However, some limitations like access to information and cooperation of different organizations and fishermen community may affect this study.

This study was undertaken with the following objectives:

- Examine the current nature and status of community livelihood and associated assets in the study area;
- Explore the implications of climate change for the environment and community livelihood in the study area;
- Identify the indigenous adaptation and coping strategies and options deployed by the local communities in the study area.

Materials and Methods

Profile of Study Site

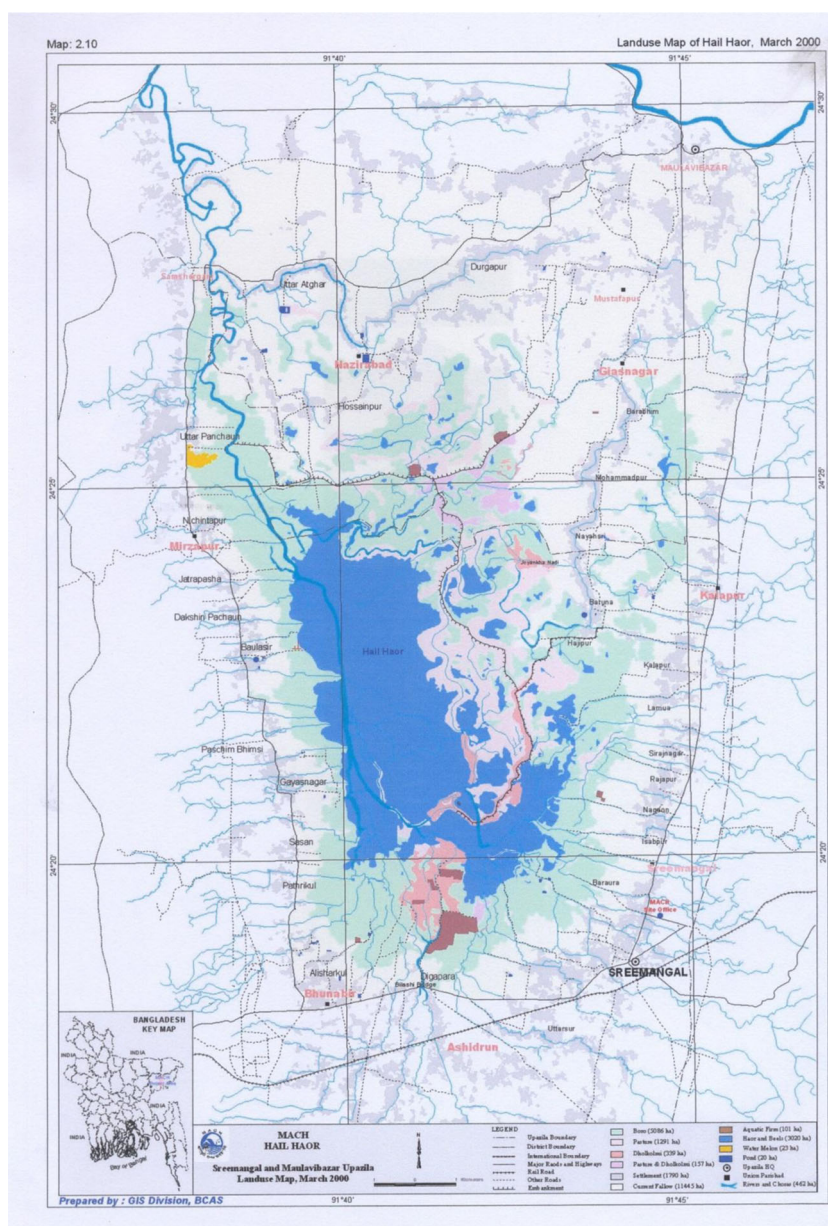
Hail haor is located in northeast Bangladesh and lies between the Balishara and Barshijura Hills to the east and the Satgaon Hills to the west (Fig. 1). Water from these hills flow through 59 streams (once 350 were reportedly active) into the haor (MACH 2007). The watershed of Hail haor covers about 600 km² (237 mi²). Hail haor was formerly connected by the Gopla River and Kamarkhali khal with the Kushiya and Manu Rivers. A series of flood control dikes along these rivers and a sluice gate restrict river flows and fish access to the haor.

The wet season area of Hail haor is approximately 14,000 ha, whereas the dry season area is typically just over 4,000 ha on an average (MACH 2007; Dev 2011; Majumder et al. 2013; Monwar 2013). The catchments area of the haor is about 60,000 ha, comprising a chain of tea gardens, pineapple fields, rubber plantations, and remnants of natural forest and plantations on the hills. More than 172,000 people in 30,000 households live in 60 villages around this haor (Dev 2011). The communities residing in this aquatic ecosystem rely heavily upon the procedure of the haor as their livelihood and basic substances revolves around these resources. Areas above flood level are intensively cropped (2–3 crops/year) with rice. Fishing occurs in the haor year-round. During the wet season, subsistence and gill net fishers predominate. Larger fishes are caught from the drying beels in the dry season. About 84 % of households are involved in fishing, and 53 % are full-time fishing households. Transportation to and from the haor area is always a challenge especially during the monsoon, and the communities living in these areas normally lack access to many basic facilities (Chakraborty et al. 2005; MACH 2007; Dev 2011, Fact Sheet of Hail haor, IPAC Project). The Baikka beel which is within the haor area has been a permanent fish sanctuary since 2003. The beel has the largest population of lotus flowers in northeast Bangladesh, and draws many tourists for its myriad attractions (MACH 2007; Monwar 2013).

Biodiversity Status of Study Site

The environment of the Hail haor supports a rich biodiversity in term of number and species. One hundred sixty-three species of wildlife are found and/or dependent on the Hail haor. Among them, 15 are amphibians, 21 reptiles, 13 mammals, and 98 local fish species as well as 160 bird species. Foli, *Notopterus notopterus*;; Ayre, *Mystus aor*; pabda, *Ompok pabo*;; and koi, *Anabas testudineus* are some of the local indigenous aquatic fish species. Among the water birds, more than 10 are recorded as being resident such as Lesser Whistling-duck, *Dendrocygna javainica*; Cotton Pygmy Goose, *Nettapus coromandelianus*; Pheasant-tailed Jacana, *Hydrophasianus chirurgus*; Bronze-winged Jacana, *Metopidius indicus*, etc.; while some Northern Pintail, *Anas acuta*; Garganey, *Anas querquedula*; globally near-threatened Oriental Darter, *Anhinga melanogaster*; Ferruginous Duck, *Aythya nyroca*, and Vulnerable raptor Pallas's Fish-eagle, *Haliaeetus leucoryphus* are migratory. In addition, many species of migratory passerine birds occur in the bushes of Hail haor. Hail haor also holds a significant population of the globally endangered fishing cat, *Prionailurus viverrinus*. Seven species of snails are found in the Hail haor of which two have commercial importance. Further, the haor is one of the 19 internationally important bird areas in Bangladesh, and one of the six existing freshwater ecosystem (MACH 2007; Kabeer 2013; Monwar 2013, Fact Sheet of Hail haor, IPAC Project).

Fig. 1 Location of the Hail haor, Sylhet, Bangladesh (MACH 2007)



Field Survey

The study relied on a series of questionnaire interview from households heads, key informants interview (KII), participatory observation and focus group discussion (FGDs), following the approach of Chambers (1992), Mettrick (1993), Mikkelsen (1995), Pido (1995), Pido et al. (1996), Townsley (1996), IIRR (1998), Hossain et al. (2004), Trap (2006), Sarker and Hossain (2012), and Hossain et al. (2013). Questionnaire interviews were conducted with Hail haor community households to collect data from July to December 2012. A total number of 50 people were selected randomly from the Baikka beel (declared fish sanctuary) and the Dumuria beel (fishers have open access for fishing) areas for interview to fulfill the objectives of the study. Out of the respondents, approximately 90 % were males

and 10 % were females. Questionnaire interviews are suitable for eliciting perceptions, motivations, and feelings (Ali 2005; Schrimshaw 1990). The questions focused on nature and status of community livelihood and associate assets, existing disaster pattern and its impacts on community livelihood, and indigenous adaptations and coping strategies and options against climate change disasters. A key informant is somebody with sufficient knowledge on a particular topic. They are expected to be able to answer questions about the knowledge and behavior of others and about the operations of the broader systems (Theis and Grady 1999). Participatory observation was conducted to get a comprehensive and authentic insight in existing situation of the evaluation topic including actions, conversations, and physical descriptions (Gittleston and Mookherji 1997). FGDs were conducted to identify the seasonal and daily activities of

the community as it has the advantage that a tendency of self-correction mechanism within the group because if one person put across an overfavorable picture of his/her own or group's behavior, a peer would give a more realistic observation (Das and Hossain 2005).

Data Analysis

Collected data from questionnaire interview were coded and entered into a data base system using Microsoft Excel Software (version 2007). A statistical method Statistical Package for Social Science (SPSS, version 11.5) was used to analyze the data, producing descriptive statistics. Spearman's rank correlation coefficients were determined to assess relationships among different variables (Ebdon 1985). Multiple responses were calculated to identify the climate change disasters. Mean and standard deviations were calculated to estimate the impact of climate change disasters on community. A regression analysis was done to understand the impact of climate change. For regression analysis, coding schemes were under taken. Different coping strategies were taken as dependent variables where assets were taken as independent variables. Coding scheme used is 1=yes and 0=no. Some weights were assigned for dependent variables (disaster damage) depending on the response of the interviewee. Community's livelihood assets and indigenous coping strategies were analyzed through multiple responses. Two correlation analyses were conducted to show the relationship between different types of climate change disasters and low income and five types of livelihood assets and coping strategies. Moreover, daily activities of the fishermen, seasonal calendar of that area, food consumption pattern

of local community, composition of stakeholders, and mobility pattern were explored from the collected data.

Results and Discussion

Nature and Status of Community Livelihood and Associated Assets

Livelihood Assets

Present study identified 25 types of components under human, natural, financial, physical, and social capital, following the DFID livelihood model (DFID 1999) on which livelihoods depend. Combination of 25 components is shown in Fig. 2. Livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Carney 1998). Livelihood assets are the means of production available to a given individual, household, or group that can be used in their livelihood activities and, in general, the greater and more varied the asset base the higher and more durable the level of sustainability and security of their livelihoods. The poorest people also require a set of resources upon which they depend for livings. These assets are the basis of livelihoods combinations of different assets work to cope against climate-induced disasters. They are the basis for the development of coping strategies.

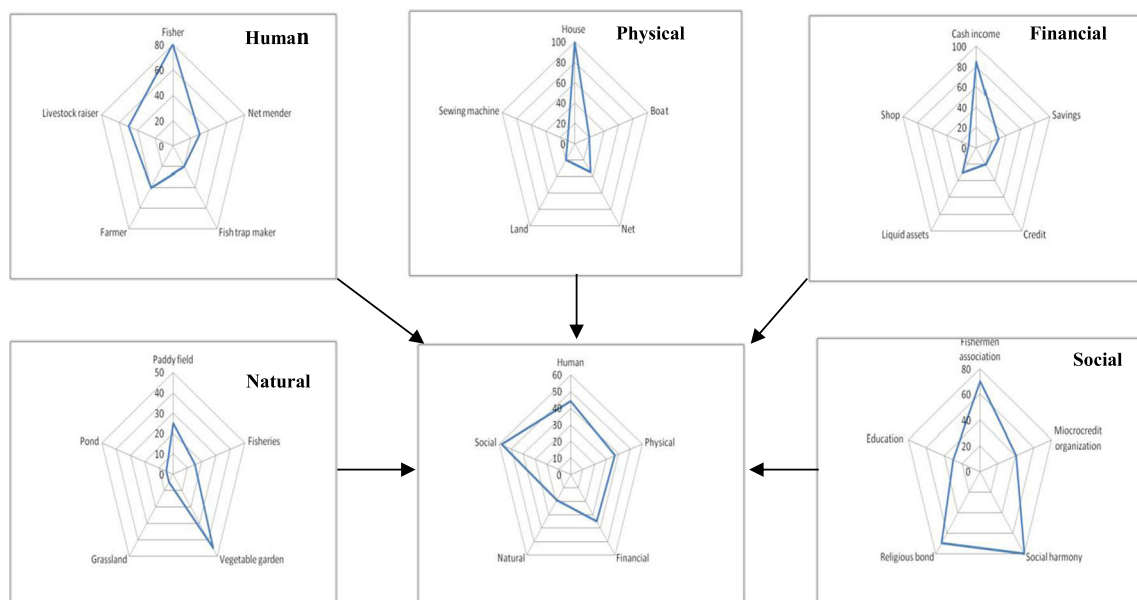


Fig. 2 The process of combining 25 components of human, physical, financial, natural, and social capital for the community of the Hail haor, Bangladesh. (The figure exceeds 100 % due to multiple responses)

Human Capital In this research, five types of components (Fig. 2) were identified under human capital. About 80 % engaged themselves with fishing activities, 30 % involved with net mending, 20 % make fish trap, 50 % with livestock rearing (cattle and poultry), and 40 % are farmers. Skills, knowledge, ability to labor, and good health are worked as an important factor to pursue livelihood activities. The skills, knowledge, ability to work, and good health that together enable people to pursue their livelihood strategies and achieve their livelihood objectives represent human capital (DFID 1999).

Physical Capital As per the field survey, 100 % respondents have houses, 20 % have boats, 35 % have nets, 20 % have lands, and only 10 % have sewing machines (Fig. 2). People who are engaged with fishing profession have nets and boats. Very few respondents especially women are involved with tailoring and have sewing machine. Physical capital represents transport, shelter, road, market, housing, water supply, health, and sanitary facilities that make people enable to pursue their livelihood strategies. Communities are often disadvantaged due to poor physical capital.

Financial Capital The present finding shows that about 85 % respondents have cash income, 30 % have savings, 30 % have liquid assets, 20 % have credit and only 10 % have shops (Fig. 2). Most of the people engage themselves in daily fishing, grocery, selling milk and vegetables, taxi driving, and other occupation for cash income. Few people have savings and liquid assets as they live hand to mouth in the lean periods. Only a very few people have credit and engage themselves with small business. Recently, Federation of Resource Users Group (FRUG), some NGOs, Dadondar (local money lender) and national banks have provided credit to the vulnerable community.

Social Capital About 70 % of the respondents are involved with fishermen association (resource management organization, RMO), 80 % with social harmony, 70 % with religious bonding, 40 % with microcredit organizations (FRUG and other NGOs), and 30 % have education (Fig. 2). Social capital is getting more prominence as an instrument in designing development policy (Mozumder 2005). Membership of groups and organizations, relationships of trust, and contact networks, those are taken to pursue a livelihood option that refers the social capital (Fine 1999). Coastal communities get advantage from social capital that has affected the livelihoods.

Natural Capital Natural resources like land, water, fisheries, etc. are considered as natural capital. The findings of this study show that 25 % have paddy fields, 15 % have fisheries, 45 % have homestead vegetable gardens, 5 % have grass land and 5 % have ponds (Fig. 2).

Seasonal Calendar

Year round activities are usually fishing, net mending, fish trap making, boat repairing, livestock raising, fish culture, tailoring, and shop keeping. Paddy (*Boro* and *Aush*) and vegetables were cultivated for 7–8 months. Natural aquatic fruits were collected from the haor area for 2 months only. In the months February–April, when water level goes down, local people face hardship for their livelihood. During the field investigation, both male and female respondents were asked questions regarding rainy and dry season duration, environmental condition, and their activities (IIRR 1998).

Daily Activities

The major daily activities performed by the local people are fishing, net mending, fish trap making, agriculture, and livestock and poultry rearing and businesses. One person may be engaged in two or more different occupations, i.e., fishing, net sewing, and livestock and poultry rearing. Daily activities of male members are intensively involved with income-generating options. During the day, most fishers have to stay at haor area for fishing. Some went for fishing at very early in the morning and return back in the afternoon, where as some went for fishing in the late afternoon, spent the whole night for fishing and return back in the early morning. Some of them are also engaged in repairing fishing boats, mending nets in alternate days when necessary. Some male worked in agricultural fields, fishing boats as labor, and some are owner.

Among the responders, only 30 % are female which indicates that only a few women were involved with income generation activities. Main tasks of the female are to look after their family. The daily activities of female members included child-care, livestock and poultry rearing, sewing clothes, making handicrafts, and occasional enterprises to increase family income, all of which are unrecognized and unpaid. Few women buy paddy from local market, boil and make rice, and sold it locally from their home.

Mobility

The local communities of the study area are mainly engaged for fishing. Tea stall, hotel and local hut (also known as Bazar) are the part and parcel of their daily life for gossiping, meet with friends as well as relatives, selling their fish, vegetables or cultivable products, buying their household requirements, and so on. The mosque, mobile center, and grocers' shop are adjacent to the Bazar. Some parents send their children to primary school, but the percentage decreases in high school while college-going students are scarcely available.

Family Food Analysis

Nutritional adequacy of the foods and beverages consumed by the family members were assessed. It provides an opportunity to gather information on food sources, allocation, diversity, and other security. The poor communities usually eat ruti (bread), muri (puffed rice), or chira (flattened rice) in the morning. Sometimes they take pitha (cakes), biscuits, and tea. Eating rice is common during lunch and dinner. They take fish or dry fish regularly with rice. Moreover, they take seasonal vegetable or dal (bean) or vorta (smashed vegetable) alternately during lunch. They tried to arrange beef or chicken weekly.

The Implications of Climate Change for the Environment and Community Livelihood

Impacts on Livelihoods

Impacts of climate change alter the function, diversity, and productivity of ecosystem and livelihood (Fig. 3). Climate change keeps the community in risk and makes them vulnerable. An impact study is most helpful when focusing on a single stressor, in this case climate change (Nkem et al. 2007). Vulnerability of climate change is not just a function of geography or dependence of natural resources; it also has social, economic, and political dimensions which influence how climate change affects different groups (AAI 2005).

Rapidly increased population in the coastal area and limited alternative employment opportunities has made the lives difficult (Ahmed et al. 2008).

Impacts of climate change on local community were assessed by questioner's survey during the study period (Fig. 3). Less income (90 %) was identified as major impact of climate change followed by reduced fish availability, 80 %. About 70 % respondents identified reduced fish diversity, reduced migratory bird's availability, decreased crop production, and food crisis as the impact of climate changes. On the other hand, reduced aquatic plants availability, sudden floods, increased storm, and decreased water-retaining capacity of beels and haor were identified as climate change impacts by 60 % of the respondents. Half of the total respondents (50 %) mentioned increased drought, temperature rise, and drying of water supply canal as the consequences of climate change, where rainfall patterns and increased fish disease scattered during winter season was identified by 40 %. Very few respondents (20 %) identified increased human viral diseases and introduction of unknown paddy diseases as climate induced impacts.

Adaptation and Coping Strategies and Options

Coping Strategies

Local community of Hail haor areas adapts many coping strategies to adopt with these disasters (Fig. 4). Most of the

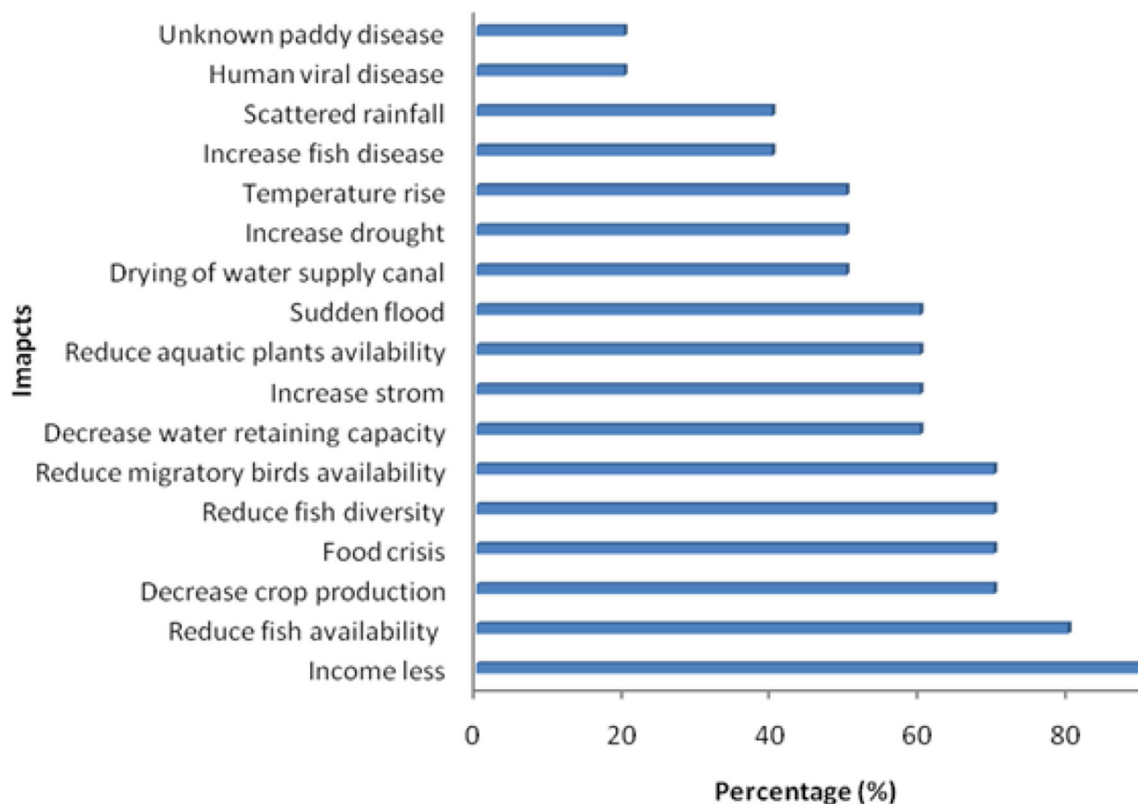


Fig. 3 Impact of climate change on Hail haor ecosystem and surrounding community

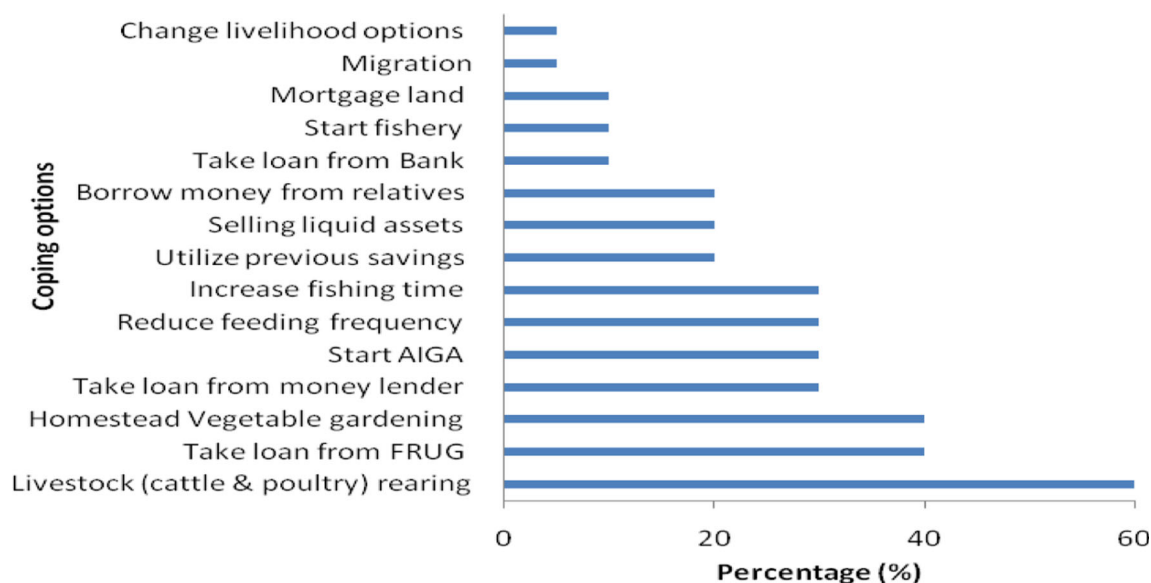


Fig. 4 Adopted coping options by respondents to cope with climate change

respondents (60 %) mentioned that livestock rearing as their coping options. Taking loan from FRUG (Federation of Resource Users Group) and homestead vegetable gardening was mentioned by 40 % respondents as their coping options. Taking loan from bank (10 %), taking loan from money lender (30 %), borrow money from relatives (20 %), selling liquid assets (20 %), utilize previous savings (20 %), mortgage land (10 %), increasing fishing time (30 %), start alternate income generating options (30 %), change livelihood options (5 %), reduce feeding frequency (30 %), start fishery (10 %), and migration (5 %) were mentioned by respondents as coping options.

Coping strategies is the manner in which people and organizations use existing resources to achieve various beneficial ends during unusual, abnormal, and adverse conditions of a disaster phenomenon or process (UNDP 2004). Disasters reduced the income and scope of income-generating activities. Poor communities are struggling to cope with the existing challenge of climate shocks but climate change could push many beyond their ability to cope. Many households in communities undertake a range of activities in order to cope financially and reduce the risks associated with high economic dependency on natural resources (Bailey and Pomeroy 1996; Allison and Ellis 2001). Strengthening coping capacities can enhance resilience of a community to withstand the effects of hazards (UN 2006). So, it is essential to know how community adjust themselves against climate change through indigenous methods.

The capacity to cope with crises largely depends on the strength and diversity of people's livelihoods (Gaillard et al. 2009). Individuals or families respond dynamically to resource fluctuations, shocks, and uncertainties by realizing a wider range of coping strategies (Islam 2008). Sustainable

livelihoods make people less vulnerable and equipped to cope in face environmental shocks. The people of Hail haor resort to a wide range technique to sustain daily life. Due to some limitations to get loan from different organization, as they are illiterate, people take loan from money lender at high interest rates, but functioning of FRUG is improving this scenario.

Capacity to purchase food depends on income and availability of assets. Disasters and adverse conditions like lean periods limit the income-generating options. The community has no other alternative rather than to sell their belongings which is indicated as an important coping strategy by households. Helpless people have to sell liquid assets such as jewelry, domestic animal, furniture, and kitchen material. But selling of assets ensures incomes for a particular period of time but not permanently, and continuous selling makes them more vulnerable to a disaster. Some utilize previous savings to cope with emergency condition where as some raise hand to borrow money from their rich relatives without any interest. Those who have no savings and income source but have land, they mortgage their land to the local money lender. The main problem of this strategy is that owner of the land have to pay the money with interest, as they got during mortgage land, from money lender; otherwise, the ownership of land goes under the control of money lender.

Required Adaptive Options

Required adaptive options by community to mitigate climate change impacts are shown in Fig. 5. Maximum respondents (80 %) mentioned that leasing beels to the RMOs instead of rich people or musclemen is their required adaptive options. Whereas 70 % respondents identified that availability of microcredit facility with flexible rate of payment, declare

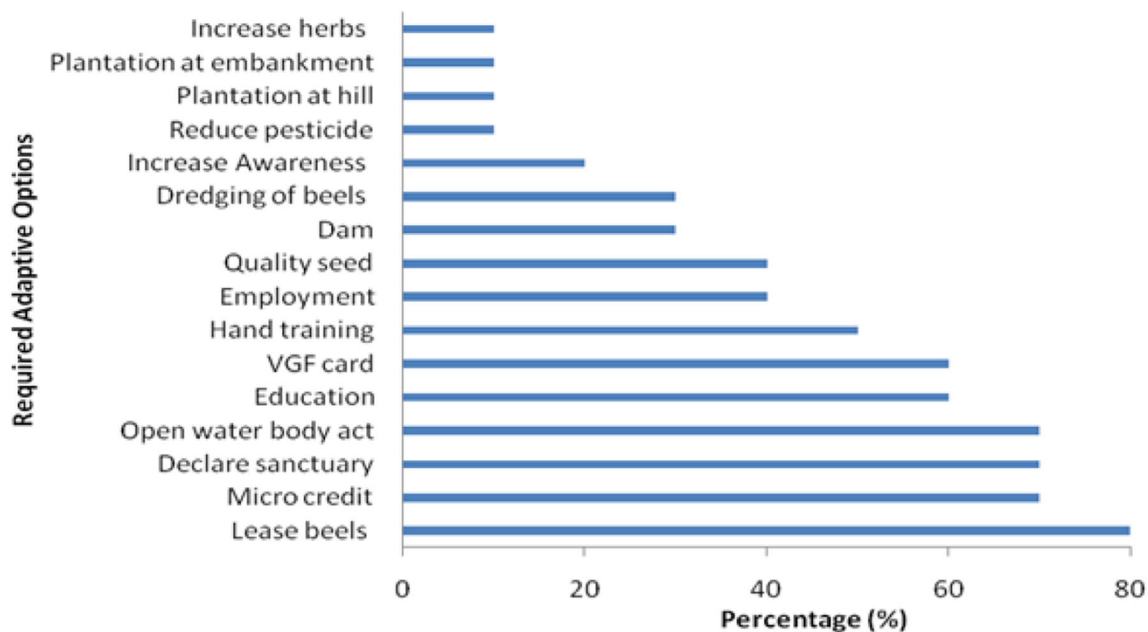


Fig. 5 Required adaptive options by respondents to cope with climate changes

more sanctuary around the hail haor and give all rights of the open water body to the Department of Fisheries instead to the Land Ministry, and 60 % respondents identified increased education facility, availability of vulnerable group feeding (VGF) card in lean period as their required adaptive options. Hand training was identified as required adaptive options by half of the respondents, and 40 % identified creation of other employment opportunities and available quality seed supply as their required adaptive options. Construction of dam to protect sudden flood/inundation of paddy fields (30 %), dredging of beels to increase water-retaining capacity (30 %), reduce or stop tea garden's pesticide contamination in the haor water (10 %), increase herbs at the side of the beels to support local birds (10 %), and increase awareness (20 %) are other required adaptive options mentioned by local respondents.

Community Resilience by Assets/Capital

By examining correlations between five types of assets and coping strategies, the study revealed that climate change disasters have created significant impact on the vulnerable poor and consequently changing and destroying their lifestyle. Different coping strategies were taken as dependent variables, and assets were taken as independent variables. The analysis shows significant positive correlations between coping strategies and physical, human, financial, natural, and social assets.

Under human capital, fisher family has high resilience, while farmer and livestock raisers have comparatively low resilience. Considering physical capital, a family with a house has high resilience than a family with boat, land, and sewing machine. Under financial capital, a family with cash income

has high resilience and those with savings, liquid assets, and shops have comparatively low resilience. In terms of natural and social capital, paddy field and pond holder and people taking loan from microcredit organization have medium resilience to climate change.

Physical, financial, and human assets are positively related with the coping strategies, valued at 0.21, 0.36, and 0.39 respectively, at the 0.001 significant levels. Natural assets moderately related with a correlation value of 0.37 at the 0.01 significance.

Effectiveness of Coping Strategies

Effectiveness of coping strategies to mitigate climate change risk was analyzed by correlation analysis. From the present field observation, it is evident that livestock rearing, home-stead vegetable gardening, increased fishing time, and change in livelihood options were found significantly ($P < 0.01$) effective options to cope with the adverse effect of climate change. However, money loan (from FRUG, money lender, bank), alternative income-generating activities (AIGAs), reduce feeding frequency, utilize previous savings, selling liquid assets, borrow money, start fishery, mortgage land, and migration were found not effective options to cope with the adverse of climate change.

Conclusion

The field observations reveal that there have been several recent phenomena that are identified and reported on the manifestations of the climate change by the respondent community

members. These phenomena includes the following: loss of income, reduced fish availability, reduced fish diversity, reduced migratory bird's availability, decreased crop production, food crisis, reduced aquatic plants availability, sudden flood, increased storm, decreased water-retaining capacity of beels and haor, increased drought, temperature rise, drying of water supply canal, scattered rainfall patterns, increased fish diseases during winter season, increased human viral diseases, and introduction of unknown paddy diseases (red coloration of plant). The indigenous adaptation and coping strategies were identified. The correlations between coping strategies and physical, human, financial, natural, and social assets were significant. From the present field observation, it is evident that livestock rearing, homestead vegetable gardening, increased fishing time, and change in livelihood options were found as the most effective options to cope with the adverse effect of climate change. By identifying localized climate change disasters with intensity of impacts and analyzing indigenous coping mechanisms, this study attempts to address the community-based adaptation practices in climate change challenges.

In-depth, long-term detail studies are needed to gain greater insights into the livelihood needs for fishers and ways to empower these traditional marginalized groups. Moreover, such study has a great importance on biodiversity conservation and natural resource management too. Furthermore, this kind of study is needed both for planning and awareness rising among policymakers, government agencies, NGOs, and research organizations. Well-informed natural resource and development planning will lead to increased protection of biodiversity and help people whose livelihoods depend on natural resources and find more sustainable livelihood approaches for the future.

Recommendations

In recent decades, Bangladesh's physical landscape has been transformed in many ways that have dramatically reduced the productivity of open-water floodplain fisheries and has a negative impact on the adjacent community. The following specific recommendations are made for developing and improving the existing scenario of the Hail haor and its resources in order to increase benefits to fishers around the haor:

- Declaring/create more sanctuary around the Hail haor which would increase recruitment, biodiversity, and safety place of fish during the dry season and spread out throughout the haor during the monsoon.
- Effective coordination between Fisheries and Land Ministry to the co-management system which would improve this scenario. Moreover, leasing the beels to the RMOs instead of local mussel men would ensure the right of the local fishers on the water body.

- Increase water-retaining capacity of the beels by capital dredging. Hill and plant cutting in the upstream areas accelerate the erosion and make this situation more vulnerable. Stop hill cutting and plantation in the exposed hills and beel bottom excavation may reduce the problem.
- Create provision of alternative income generation options with hands on training on AIGA, supply of raw materials, ensure marketing of finished product, interest-free loan facilities would improve the socioeconomic condition of the local people.

Furthermore, increase awareness, establish more educational institution in the adjacent areas, plantation at the embankments, create more herbs bush for indigenous birds nesting, less use of pesticide in the tea gardens, and availability of VGF card in the lean period may create a climate resilient ecosystem in the Hail haor areas.

Acknowledgments The study was carried out through the applied research fellowship program of the Integrated Protected Area Co-management (IPAC) Project and WorldFish Centre, Bangladesh with funding by the US Agency for International Development. I would like to acknowledge the IPAC–WorldFish Centre for providing me this research opportunity.

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