



Environmental Jeopardy and Coping Strategies of the Small-Scale Fishers in the Bangladesh Sundarbans: The Precedent of the World's Largest Mangrove

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ARTICLE INFO

Article History:

Received: Sept.9, 2023

Accepted: Dec. 4, 2023

Online: Dec. 12, 2023

Keywords:

Sundarbans,
Environment,
Livelihood,
Climate change,
Coping,
Fishers

ABSTRACT

The Sundarbans Mangrove Forest (SMF) is the world's largest tidal halophytic mangrove forest block. This forest and the livelihoods it depends on are extremely susceptible to anticipated climate change. The lives and vulnerabilities of small-scale fisheries are still poorly known despite the Sundarbans being frequently used as a test case by scientists to examine climate variability and change. Based on research on six fishing villages in the Sundarbans, this study analyzed the environmental and livelihood risks of small-scale fisheries and how they responded to climate change-related events. A range of qualitative techniques, such as focus groups, oral histories, and interviews, were used to gather empirical data. The study found that environmental changes have a significant impact on how well-off the Sundarbans community is, having an impact on things, including housing, income, savings, literacy, health, agriculture, and daily living. The most at risk from these negative effects are residents of nearby areas. The study's conclusions, which were based on the perspectives of the fishers, are important for the co-management of mangroves, biodiversity preservation, planning, and the improvement of livelihoods.

INTRODUCTION

The Sundarbans are the largest mangrove forests in the world, constituting a unique ecosystem shared by Bangladesh (62%) and India (**Chakma et al., 2022**). It is a world heritage site with tremendous ecological and economic value. The 4143km² of total land is surrounded by 1874km² of water, which is made up of rivers, small streams, and canals (**FAO, 2007, Islam et al., 2018a**). The Sundarbans are a model mangrove ecosystem that sustains abundant fish, shrimp, and edible crab stocks that represent a source of food and money for coastal residents (**Alexandar, 2014; Sunny, 2017**). The Sundarbans are the primary source of income for more than 3.5 million people in the surrounding districts. Furthermore, another 2 million human individuals are indirectly employed, with 69% of them working with aquatic resources, 22% collecting wood, 5% producing non-timber forest products, and 4% working for other purposes (**Hossain & Dearing, 2015; Mondal, 2015**).

For both domestic and foreign tourists, the Sunderbans offers a fantastic aesthetic attraction. The vegetated tidal lands of the Sundarbans constitute a vital environment that generates nutrients and cleanses water (Allison, 2005; Chowdhury *et al.*, 2007; Haq, 2009). Additionally, the forest traps sediment and nutrients, providing a storm barrier, shore stabilization, and energy storage (Chowdhury *et al.*, 2014). Hedges of mangroves operate as a barrier against natural climates, prevent coastal erosion, and serve as a nursery for a variety of fish, prawns, and crabs that are crucial to the food industry. Among these, the production of the fisheries in the mangrove wetlands is significantly increased by the neritic waters nearby, exporting organic and inorganic nutrients (Agrawala *et al.*, 2003; Barua *et al.*, 2010; Islam *et al.*, 2018a; Bari *et al.*, 2023).

The Sundarbans, which is classified as "Reserved Forest," is significant since it provides fish and forestry goods that boost the local and national economies (Alongi *et al.*, 2004; Rahman & Asaduzzaman, 2010). Furthermore, it serves as a buffer against the severe ravages of storms and tidal surges that come from the sea (Islam *et al.*, 2017; Sunny *et al.*, 2020). The natural floral and faunal diversity of the Sundarbans mangrove forest is abundant including 334 species of plants. Additionally, the region is a home to 425 species of wildlife, comprising 40 species of mammals, 300 species of birds, 35 species of reptiles, 177 species of fish, 24 species of shrimp, and 7 species of crabs, among others (DoF, 2010; Swapan & Gavin, 2011; Sunny, 2017). A large number of people also depend on small-scale fisheries of the Sundarbans as sources of nourishment, income, and well-being. In the Sundarbans, fishing is a common activity on various scales, supporting 15% of the population's subsistence (Blasco *et al.*, 1996; Islam *et al.*, 2016). While small-scale fishing is practiced in the delta region (about half of which is illegal). In contrast, organized large-scale fishing operations take place in the sea and deep water. Eminently, agribusiness is the primary source of income for almost 65% of the population.

The poorest of the poor, small-scale fisheries (SSFs) are acknowledged as one of the most climate-vulnerable professional groups (Milton, 2010; Rana *et al.*, 2018; Sunny *et al.*, 2021a). According to Rana *et al.* (2018), the small-scale fishermen yearly per capita income (BDT 2,442) is nearly 70% less than the national per capita income. The primary anthropogenic factors that make life miserable for fishers include dependence on a single profession, lack of alternative employment possibilities, inadequate income, debt cycle, and stakeholder conflict (Mohammed & Wahab, 2013; Islam *et al.*, 2016; Sunny *et al.*, 2021b). The daily lives of fishermen are plagued by several natural disasters, variations in temperature and rainfall, tidal flooding, fishing prohibition periods, and seasonality.

The climate in Bangladesh has altered over the past few decades and has had significant negative effects along the shore. Bangladesh is expected to see an annual temperature increase of 0.4 degrees Celsius, and the sea level is expected to rise by 4 millimeters due to climate change (Ahmed *et al.*, 2012; Sunny *et al.*, 2023). These events will deplete the Sundarbans' key forest resources by raising salinity and reducing the flow of sweet water (Ahmed & Neelormi, 2008; Rahman & Asaduzzaman, 2010; Alam & Laurel, 2016). Moreover, there is an increase in migration as a result of resource shortages and unstable employment markets brought on by climate change, where small-scale fishers are particularly susceptible to the utmost negative effects (Mizan & Bijoy, 2009; Barua *et al.*, 2010; Faruk *et al.*, 2023; Tufael *et al.*, 2023). Therefore, it is critical to pinpoint the climate change-related shocks and pressures that put fishers at risk (Lönnqvist, 2010; Giri, 2014; Payo *et al.*, 2016; Sunny *et al.*, 2021c). It is possible to see signs of climate change and variability in Bangladesh, including an increase in extreme weather events like cyclones and floods, tidal inundation, irregular or excessive rainfall, temperature volatility, drought, and

sea level rise that harm coastal ecosystems. A measure of exposure to shocks, stress, poverty, dangers, and food security is called climate vulnerability.

Sundarbans Mangrove Forest has been the subject of numerous studies, but little research has been done on how the small-scale fishers may be impacted by climate change. Adequate information on sustainable livelihoods and forest management is crucial for decision-making, yet the main barrier to the development of unprivileged small-scale fishermen's livelihoods is the lack of necessary information regarding their coping strategies.

This study aimed to examine several livelihood and climate change-related risks that make small-scale fishers vulnerable. The study also determined coping strategies implemented by Sundarbans fishers in order to determine the sustainability of their means of subsistence.

MATERIALS AND METHODS

1. Study sites

The research was carried out in three districts of the Khulna division and six fishing settlements in the Sundarbans (Fig. 1). The areas included Shyamnagar and Munshigonj in the Shatkhira district, Dacope and Koilashgonj in the Khulna district, and Chila and Joymonigul in the Bagerhat district. These communities were chosen since they all have easy access to, share the same fishing grounds, are close to all of the zoned regions, as well as having a variety of livelihoods, populations, linkages to the Sundarbans, and climate change vulnerability.

2. Data collection strategies

Both the qualitative methodology and the quantitative data were used to inform the empirical portion of this study. The qualitative approach was used to gather the main data. In order to gather primary data, fieldwork was conducted across three 12-month periods, from October 2021 to October 2022, utilizing interviews as the major data collection technique. However, this study's qualitative methodology included observation and other types of data gathering. Secondary data was gathered from government papers, policies, and news articles. Through online searches, scholarly publications and pertinent grey literature were extracted.

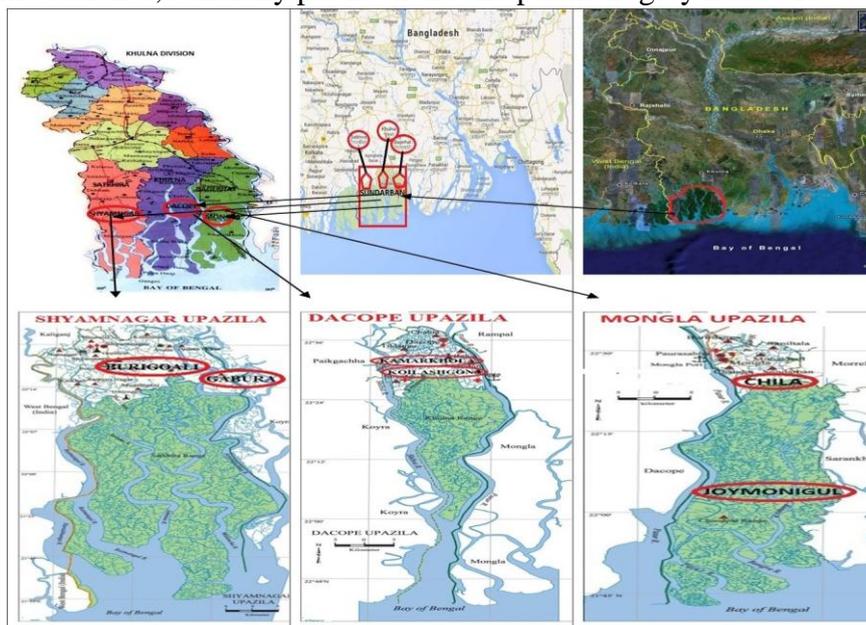


Fig. (1). Map of the study area

3. Data processing, analysis and presentation

The KIIs and FGD recordings were transcribed and examined. To acquire a conceptual grasp of this study, the other content and the data summary were examined. With the help of SPSS version 16.0 (a statistical tool for social science) and MS Excel (version 2016), descriptive statistics were generated to sum up the dataset's characteristics.

RESULTS AND DISCUSSION

1. Social makeup of mangrove fishers

The fishing community was very distinct from the other professional communities in terms of socioeconomic status (Islam *et al.*, 2018b). The 205 house holds (HH) in the six fishing communities included 2100 residents. Among 205, 122± 2HH (mean standard deviation) engaged in intensive fishing, and 83± 4HH engaged in fishing, as well as other mangrove resource collecting (Table 1). The majority of the fishermen (84± 2%) used hired labor and lacked their own boats and fishing nets. All fishermen were subsistence farmers. Extremely poor fishers (land size 0 decimal), poor fishers (land size 5 decimal), and moderately poor fishers (land size >5 decimal), constituted 30± 2, 52± 4, and 18± 1% of the fishers, respectively.

Table 1. Social makeup of magrove fishers

Variable	Status	Mean (± SD)
Population	Total number	2100
House hold	Total number	205
	Number of exclusive fisher	122± 2
	Number of other	83± 4
Land size (decimal)	Extreme poor	0
	Poor	<5± 0.5
	Moderately poor	>5± 0.5
Extreme poor	Medium percentage	30%± 2%
Poor	High percentage	52%± 4%
Moderately poor	Low percentage	18%± 1%
Climatic hazards affect daily life	Yes	99%
	No	1%

2. Environmental changes and human wellbeing

The country's fishers were the worst affected by a variety of natural phenomena that frequently happened in Bangladesh (Sazzad *et al.*, 2023). Environmental disasters, such as hurricanes, erratic floods, cyclones, powerful winds and waves, untimely droughts, and frequent environmental dangers made their way of life more precarious (Fig. 2). Tides frequently inundated coastal fishing communities, clogging homes with water and making travel difficult. As a result, a number of water-borne illnesses spread throughout the population and harmed its health system. Environmental changes have a huge impact on this community's ability to survive due to its direct impact on the design of housing, income, savings, literacy, health, agriculture, and practically every aspect of daily life (Mizan & Bijoy, 2009; Rahman *et al.*, 2022).

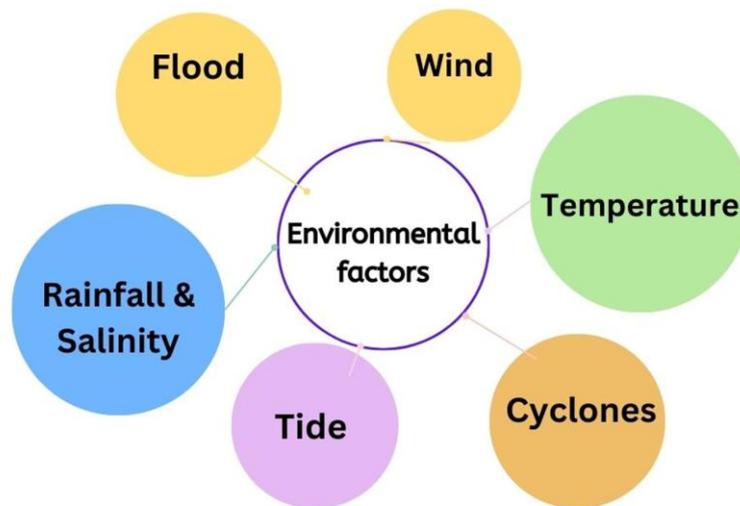


Fig. 2. Environmental factors affecting fishers wellbeing

The temperature trend in a changing climate gradually changed into periodic vicissitudes. As a result, it became extremely hot in the summer and bitterly freezing in the winter, resulting in countless hardships. Furthermore, it became a commonplace for having a lot of rain in one year and a severe lack in the next. Accidentally, heavy rainfall directly hindered fishing activities and destroyed fishing gears, which led people to adopt illegal fishing methods and prohibited gears. Environmental drivers impacting different sectors of day life of these communities. These drivers are described below.

2.1 Food and nutrition

Indicators like strong wind, increasing natural calamities, tidal inundation, flooding, and rainfall variation put adverse impact on food availability by reducing production, fertility of land and finally income. Fishers have less option to overcome their situation not only due to their vulnerable situation but also for their lack of knowledge on nutritious food, confidence on their ability, conservative thinking due to low literacy rate, etc. As a result, they often try to address their challenges by taking loans from 'dadondar' (Islam *et al.*, 2018c; Sunny *et al.*, 2021a).

2.2 Agriculture

Tidal inundation and soil salinity hampers the agricultural sector the most. Indiscriminate practice of shrimp culture by converting agricultural land is the main reason of hampered agricultural production. Now, people are becoming aware day by day against such devastating culture practice and people of 'Dacope' has become successful to diminish the 'gher' tradition by raising their voice via public movement. People of these communities are trying to produce some vegetables in their yard or unused lands beside their houses to meet up the growing food demand of the increasing population.

2.3. Fisheries resource

Increasing natural calamities, silt deposition, strong wind and temperature variation negatively impact the nursery and breeding grounds of various fish species, leading to a reduction in fish availability. Moreover, if the availability of the fish decreases, the income of the fishers are either stopped or decreased, putting an ultimate adverse impact on all the socioeconomic aspects of these communities. Fishers want to recover the collapse of income by engaging in different alternative income sources; however, due to the lack of enough skill, they cannot do so, except being engaged in a day laboring if possible or if they could afford it (Rahman & Asaduzzaman, 2010).

3. Impact of environmental change on small-scale fishers

People living to the adjacent communities of the Sundarbans are most vulnerable to the adverse impact of environmental changes. Moreover, people have severely already identified the changes and felt the adverse impacts of such changes on their daily lives (**Payo *et al.*, 2016; Romañach *et al.*, 2018**). Impact of environmental changes on the livelihood of this community is described below.

3.1. Housing scenario

Lifestyle of the resource users of the Sundarbans is totally different from the other parts of the country. Most of the fishers are landless and live in *khas* land. Some fishers who have land are very marginal in quantity and not able to fulfill their basic needs. Their houses are shabby, covered by water or remain dump; made by earth, natural thatching materials (*Golpata*), wood and iron sheets. Their housing structure and living place makes them more vulnerable to the environmental changes (**Agrawala *et al.*, 2003; Allison, 2005**).

3.2. Family status

Most fishers are leaving the tradition of joint family after the devastating flood of 1998 and love to live in single families now. Changing weather patterns, coupled with limited or insufficient capital, income, boats, and fishing gear, have compelled families to break apart and transition from joint families to single households. The increase in family size among fishers is notable, driven by easier access to resource exploration in the Sundarbans. A larger family size is advantageous as it leads to more extensive exploration, thereby increasing income. income (**Kuddus *et al.*, 2021**). Additionally, frequent environmental changes, including disasters like cyclones and storms, pose a significant risk, leading to the loss of lives and properties. It is also responsible for increased tendency of weakness, outbreak of diseases and sickness that reduce work, effort, and income. It is worth noting that, children are also engaged in fishing, while women are contributing simultaneously with male fishers though they have limited access in decision making. Dowry system is acute in these societies, and this is also influenced by the environmental change (**Chowdhury *et al.*, 2007; Sunny *et al.*, 2021b**).

One fisher mentioned that-“I didn’t want to take dowry, but uncertain weather forced me to take, as if some days later, there would be a cyclone or storm that would damage my house or fishing boat, then how I would bear my family. I could be sick from very cold weather or high temperature since the weather is becoming unpredictable day by day, then who will support my family as my income would be stopped at that time.”

3.3. Education and literacy status

We found that no fisherman passed class 5 who are now above 30 years old, and most of them are unable to write their names. Their illiteracy led them to illegal exploration of resources from the Sundarbans that ultimately causes environmental degradation since fishers don’t have the ability to figure out what environmental degradation could do. The illiteracy is very common among the elders and young generation. Moreover, it was also found that there is a discouragement to pursue education among elders, attributed to poor communication system and poverty (**Sunny *et al.*, 2021c**).

Children of most fishers do not go to school regularly. Frequent occurrence of adverse climatic condition is mainly responsible for this sine the extreme events make them poorer. Therefore, the fishermen need to increase their income that allures them to send their children to work instead of going to school. The declining income and resulting disillusioned lifestyle

thwart their aspirations, creating difficulties in affording the educational expenses of their children (Barua *et al.*, 2010; Mithun *et al.*, 2023).

There weren't many committed students who were sticking with their education in spite of many obstacles. In an attempt to supplement the family income and support themselves, they attempted to make a little money through tuition. However, since fewer parents could afford to send their kids to tutoring, the number of students fell, which in turn caused the income of the students to decline. The students' aspirations for a better life were thwarted by their ongoing battle with nature and their limited lifestyle.

3.4. Health and nutritional status

Health status and supporting facilities of these communities is not up to the mark (Fig. 3). The hapless status of health could be attributed to the several factors, such as distance of Upazila hospital from the community with lack of proper facility for necessary pathological test, scarcity of expertise doctor and nurse is also notable. Waterborne disease, including typhoid, jaundice, and diarrhea is now a common phenomenon and the percentage is increasing day by day after Sidr of 2007. Typhoid is very common in each and every home, and children are more susceptible than the adults (Kuddus *et al.*, 2020; Kuddus *et al.*, 2022; Ferdous *et al.*, 2023). Jaundice is another common disease in this area, however people suffer the most by typhoid than by jaundice. Additionally, fishers are unable to go for fishing since they suffer from diarrhea resulting from the lack of pure water, and subsequently makes them weaker and reduces their physical capabilities

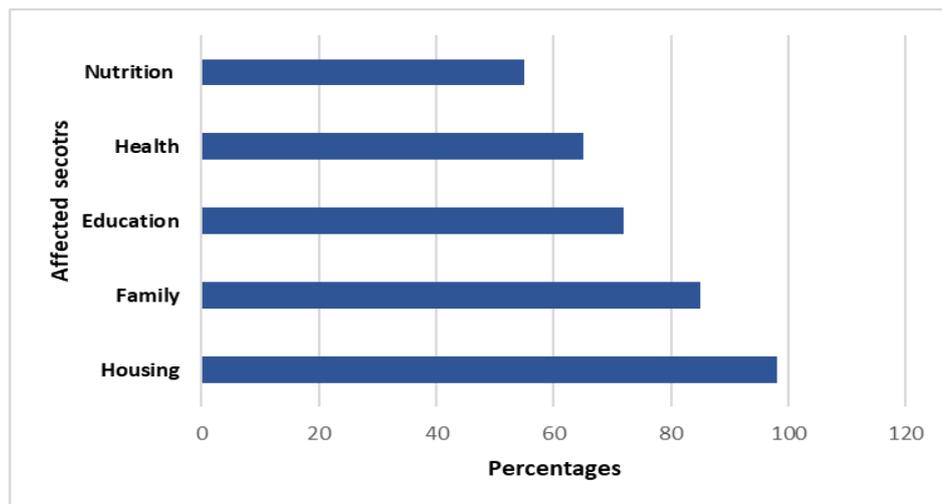


Fig. 3. Percentage of livelihood affected by environmental changes

4. Fishers' statements

“We had to drink water from the river and pond, since rain water is not available around the year, moreover the tube well is far from our houses. Drinking such water, we had to suffer from diarrhea, since we cannot collect the tube well water due to our illness and also for the distance”.

Fishers had to spend a long duration from 8 to 10 hours in the water for fishing. We found some other diseases during our interview among the fishers of these localities, such as different skin diseases due to fungal infection, rashes, lesions, etc. Vaginal fungal infection is very acute among the women fishers due to working in the water, especially those who are

engaged in fry collection. Furthermore, damp housing environment induces their illness, especially among the children who have to suffer from flu and fever.

In addition, fishers explained the reason of the illness of their children saying that “Our children always get in touch with the sloughy soil and water due to tidal inundation. This is the main reason of the illness of our children since they may eat food without washing their hands after touching clay that cause dysentery and other waterborne diseases. Furthermore, the illnesses of the children reduce our concentration during our work and consume huge money deduced from our daily income, enforcing extra pressure on us.”

Causes of illness are not only their housing condition and environmental change but also their unconsciousness. It is true that fisher can pay money willingly to buy medicine, however they are unwilling to spend some money to construct sanitary latrine, collection of pure water to ensure their sanitation (Islam *et al.*, 2018a). Some NGOs, are working to increase the awareness among the fishers regarding different health issues, however more initiatives are needed.

People eat three meals per day; nonetheless, the nutritional quality and food items are not up to the mark. Remarkably, this area has vast amount of fisheries resources, however their meals contain less percentages of proteins. People are not satisfied with the nutritional quality of their food, nonetheless they have to sell the fish in search of money, since they are defenseless to the poverty. Price of meat is beyond their capacity, hence they prefer eggs as a protein source due to eggs' low price. Price hike of food items is the main barrier for balanced diet. The unavailability of daily commodities and low production of vegetables, attributed to the increasing salinity of the soil, contribute to a rise in prices. Poor idea on nutritional quality of food and the negative effect of malnutrition is another cause for this incognizance.

5. Coping strategies

Environmental changes altered the flow of ecosystem services and livelihood of this community along with heavy loss of lives and properties. However, people bounced back in the regular flow of life by overcoming the shocks by following some initiatives. The existing literature highlights various mechanisms adopted by households to cope with crises, falling broadly into five categories: drawing upon household stores (of food, fuel, etc.) and adjusting current consumption patterns, drawing upon assets, utilizing communal resources such as village common lands and forests, leveraging social relationships including patronage, kinship, friendship, and informal credit networks, and diversifying sources of income, including seasonal migration (Agarwala *et al.*, 2003). In the present study the following strategies are adopted by the communities in the Sundarbans.

5.1. Household store and adjustment of current consumption

People tried to save money from their daily cost to keep some extra dry food (Biscuit, cake, puffed rice, etc.) in their house to be consumed in cases of any sudden calamities. They stored rain water to meet up the demand of daily potable water, attributed to the increased salinity in the surface (pond, river, etc.) and ground water (Tube well, well, pump, etc.). They had to collect drinking water from very long distance most of the time via boat due to poor communication system when there is scarcity of rain (Fig. 4).

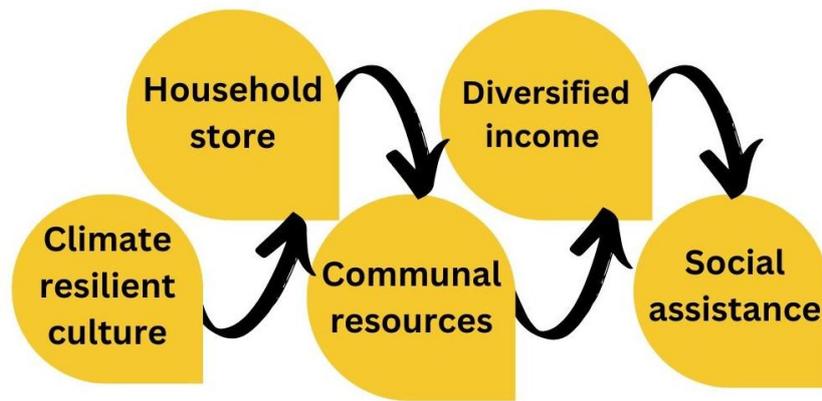


Fig. 4. Coping strategies of mangrove fishers

People were found to store dry food like biscuit, puffed rice etc. under the ground. People adopted various strategies to cope with crises, such as burying ornaments, cash, and valuable goods underground, covered with plastic bags to prevent theft during emergencies. Additionally, individuals reduced the number of daily meals from three to two and consumed smaller portions to minimize dietary costs. The saved money was then used for repairing or reinforcing their homes.

5.2. Diversification of income source

People were found to increase their working hours in order to increase their income and savings, since they could not go for fishing, honey, and wood collection, attributed to a sudden environmental change that reduced their income and hampered normal flow of life. People engaged in various forms of work throughout the day, participating in activities such as day labor, fishing, collecting forest products, rickshaw pulling, and working on the construction of damaged roads and embankments. The number of individuals involved in crab collection has been steadily increasing among fishers, fisherwomen, and children. Fisherwomen often switch to crab collection when the fishers are out fishing, contributing additional income to their families.

5.3. Dependence on communal resources

The Sundarbans plays a crucial role in developing the livelihood of poor households by diversifying income sources. People explored more resources from the Sundarbans to compensate the loss of natural calamities. Unfortunately, the pressure to sustain their livelihoods and repay loans has led to the overfishing and overexploitation of forest resources, including timber and fuelwood, causing harm to the Sundarbans Reserve Forest (SRF). The desperate circumstances have left communities with limited options, resulting in detrimental practices for the environment (Islam *et al.*, 2018a).

5.4. Concessionaire from social relationship

Assistance from the neighbor and better off relative plays a significant role to overcome the shock immediate after natural calamities due to sudden environmental changes (Fig. 4). Relatives help by providing money to repair house and fishing utensils and arranging other daily commodities, such as rice, pulse, oils, cloth, medicine, etc. Neighbors help each other to construct damaged houses and other physical assets like boat net, etc. If anybody lost any organ or became chronically ill, they would help him by collecting money from their society, as a sign of relief, including 5BDT, 10 BDT, 20BDT, 50 BDT, etc., whatever the people could. The businessmen in this area provide essential daily commodities to the affected people on a credit basis, allowing them to survive and repay the costs once they earn income.

People get relief from the government, NGOs, elite persons, social and cultural organization immediate after natural calamities. The relief included tin or money to repair house, potable drinking water and water purifying tablets, dry foods, essential medicines, etc. People get 5000 BDT for partial damage of their house and 10000 BDT for the whole damage; however, the amount is not enough. **Abdullah (2014)** in his study found that, following calamities, the government distributes rice among the affected people. The allocated amount varied from 20 to 10kg per month, depending on the severity of the situation.

People try to back the main flow of life by taking loan for construction of damaged properties (house, boat, net, etc.), as well as to maintain their family. People of this community would not take loan from bank due to complexity of the system and lack of enough property to mortgages in the bank. They take loan from different NGOs, including BRAC, ASA, PROSHIKA, World Vision, etc. However, NGOs provide a very little amount of loan that is not enough to fulfill their demand, in addition their pay system's interest is very hard (**Islam et al., 2018a**). On the other hand, individuals sought loans from mohajon at exorbitant interest rates, attracted by the accessibility of substantial amounts, such as 50,000 BDT or more. This trend persisted due to the protection provided by the moneylenders against pirates and the limited enforcement capability in the face of potential dangers. Additionally, **Abdullah (2014)** found that people comforted taking loan from the informal source like Mohajon (money lender).

5.5. Changing in culture pattern

Farmers changed their traditional rice culture practice, such as aus, aman, etc. They introduced a new variety of rice which is salinity, drought and flood tolerant to cope with high salinity intrusion, low fresh water flow, tidal inundation, flood, etc. People began cultivating crops such as jute, mustard, basil, beans, and fruits like guava and coconut instead of rice. Various trees were planted around the house's yard to mitigate the adverse impacts of natural calamities. Additionally, these trees played a crucial role in supporting the cultivation of spreading vegetables, akin to trellises. Moreover, the timber from these trees was utilized for house repairs (**Islam et al., 2018a**). People were also found to be involved in crab culture program initiated by different private organisation and local government. Some people in the

community work as daily laborers, while others opt to share profits after the cultivation period.

CONCLUSION AND RECOMMENDATIONS

The small-scale fishers in Bangladesh, considered one of the most climate-vulnerable communities, coexist with mainstream society amidst high levels of discrimination, economic exclusion, social domination, and significant stratification. They are entirely dependent on a single profession and continue to live below the poverty line, their earning patterns relegating them to a marginalized position in society. Due to the underdeveloped structure of their livelihoods, they are economically identified as a neglected class. Furthermore, socio-economic obstacles such as credit insolvency, low income, and a lack of alternative earning opportunities make their lives more vulnerable and challenging.

Urgent steps are required to improve the livelihood status of fishers. The state should promptly provide sufficient aid, especially financial assistance during the ban period and other crisis moments, to sustain their livelihoods. Both the state and relevant NGOs should collaborate to organize skill improvement programs and training facilities for fishers. Policy developers and resource personnel must ensure sustainable development and eco-management. It is imperative to highlight the conservation needs of aquatic resources and the climatic vulnerabilities of dependents on national and international platforms.

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