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## Fishermen's Livelihood Adaptation in Response to Climate Change: An Empirical Study on South-Western Coastal Zone of Bangladesh

S. M. Rayhan<sup>1,‡</sup>, Anika Tahsin Mou<sup>2,‡</sup>, Bably Akter<sup>3</sup>, Md. Shajahan Kabir<sup>4,\*</sup> and Md. Najmol Hoque<sup>5,\*</sup>

‡: Equally contributed as 1st author

<sup>1</sup>Interdisciplinary Institute for Food Security, Bangladesh Agricultural University, Mymensingh-2202; <sup>2</sup>Department of Agricultural Economics, Khulna Agricultural University, Khulna-9202; <sup>3</sup>Department of Aquaculture, Khulna Agricultural University, Khulna-9202; <sup>4</sup>Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh-2202; <sup>5</sup>Department of Biochemistry and Molecular Biology, Khulna Agricultural University, Khulna-9202.

\*Corresponding author: Md. Najmol Hoque; E-mail: najmulhaque466@gmail.com

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### ABSTRACT

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This study aimed to understand the livelihood status of the fishery-dependent communities in the South-Western coast of Bangladesh and their livelihood adaptation in response to climate change. The study was carried out in two villages of Dacope upazila in Khulna District. Data were collected from a purposively drawn sample of 60 fisher's households through household interviews, key informants' interviews, and transect walk as well as from secondary sources. The adverse climatic variability influences all the livelihood capitals and strategies of fishing communities. Most households have lower access to sanitation, market transportation, health facilities, GO, and NGO services during the adverse climatic situation. Increased levels of cyclones and floods result in greater damage to fishing equipment, livelihood assets, and lower level of fish catch. Income generation from fisheries-related activities is reducing gradually which affects the livelihoods of the fishers. The study has identified four different practices of adaptation to climate change by those fishing communities where about 71.67% adopted livelihood diversification. To cope with the changing climate and variability most of the fishing households (95%) have taken multiple adaptation strategies while the rest (5%) did not. The fishermen are exploited financially by the local credit facility provider. Diversification of livelihoods included agriculture (23.26%), fish trading (2.33%), fish farming (18.60%), and other different types of diversification found in the study area due to climate impacts but not always sufficiently fruitful. This situation may worsen over the next few decades and an improved level of responsiveness would be required.

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[www.agroid-bd.org/ralf](http://www.agroid-bd.org/ralf), E-mail: editor.ralf@gmail.com

## INTRODUCTION

The coastal areas of Bangladesh are different from the rest of the country not only because of unique geophysical characteristics but also for different socio-political consequences which limit people's access to resources and perpetuate risk and vulnerabilities. There is a proximity between the livelihoods of the coastal people and such vulnerabilities because the way of livelihood earning of one people class became a catastrophe to others. Small-scale fisheries and dependent communities are predicted to be affected by climate variability and change in coastal and marine environments. Examining the vulnerability of fishing communities and households to climate variability and change can help identify and characterize actions that can ameliorate adverse impacts. Despite its importance, knowledge of climate-induced impacts and vulnerability on the local scale of fishery-based livelihoods remains limited (Islam et al., 2014). In summary, despite considerable studies on the impact of climate change on aquatic ecosystems and fish populations, on macro scale fishery-dependent economies and their people, income vulnerability as well as adaptation in agricultural communities, there has not yet been a sufficient examination of the vulnerability and adaptation of small-scale fishing communities to climate variability and change. However, several studies were conducted on the socioeconomic condition of fishermen but the improvement in their livelihood remains in the less important category. (Apine et al., 2019; Baki et al., 2015; Das et al., 2015; Billah et al., 2018; Kamruzaman and Hakim, 2016; Sunny et al.). A comprehensive study is indispensable for understanding the factors that constrain or enhance small-scale fishermen's livelihood opportunities (Tikadar et al., 2022). In the study, the fishing household's area is more exposed to climatic variability and change that promoted the impacts of sea level rise, land erosion, cyclones, and associated flooding which influence all the livelihood assets and strategies of fishing communities. The vulnerability of fishery-dependent peoples resulting from fluctuation in fishing incomes can be reduced by diversifying their livelihoods, which helps them adapt to change to better living (Turner et al., 2007; Westlund et al., (2007). According to Coulthard (2009), diversification in specialized activities 'outside fishing' such as agriculture or rural service-type enterprises alongside traditional fishing pursuits is also encountered. In the case of small-scale fisheries, Salas and Gaertner (2004) found that being "generalists" allowed small-scale fishers to switch between target species with changes in their circumstances. Hazell and Norton (1986) reported that developing portfolios of income-generating activities with low covariate risk among their components was the main purpose of diversification.

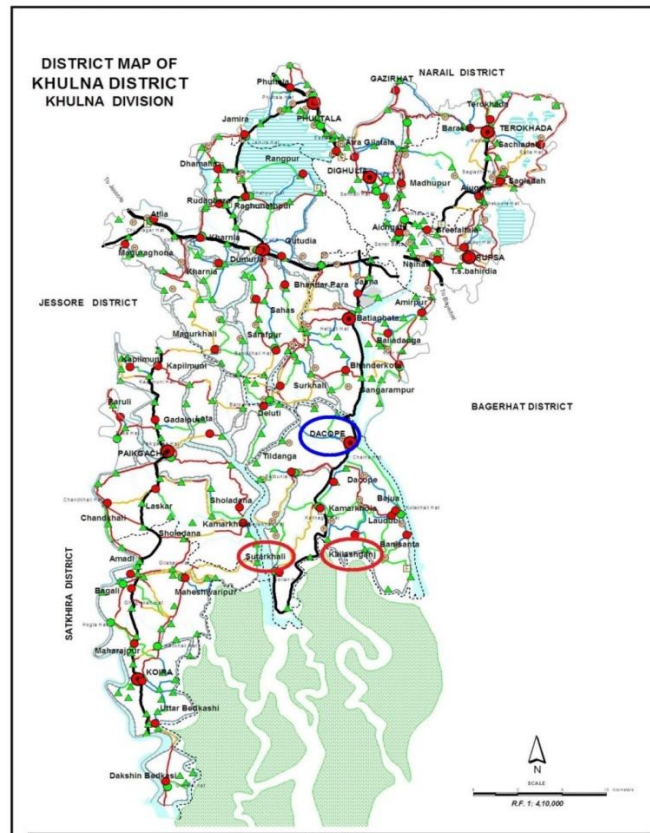
This research aims to assess the vulnerability and adaptation of Bangladeshi coastal small-scale fishing communities to the impacts of climate variability and change. To achieve this aim, the specific objectives are (i) To find out the livelihood status of the coastal fishing community; (ii) To evaluate the vulnerability and impacts of climate change on the coastal fishing community's livelihood, and (iii) To determine the adaptation strategies to overcome the impacts of the climatic changes. This research provides an important starting point for directing future research into the vulnerability of fishery-based livelihood systems to climate variability and change. This study aims to contribute to an increased understanding of these issues and, in particular, of the situation facing Bangladesh. Overall, based on empirical evidence this research contributes to current debates on climate change by enhancing an understanding of the characteristics of fishing communities and determinants of their vulnerability, and the limits and barriers to the adaptation of fishing communities to climate variability and change.

## MATERIALS AND METHOD

### Selection of study sites

The researcher selected two villages of Dacope Upazila namely Kailasganj and Sutarkhaliof Khulna District using purposive random sampling to achieve the ultimate objectives of the research. A preliminary household survey was conducted to get a clear idea about the research area. The reasons behind the selection of the two villages were:

- I. A majority portion of households earn their living through fishing-related activities;
- II. The expected number of respondents was found from these two villages;
- III. This type of study was not carried out previously in these villages;
- IV. Easy accessibility to the respondents for the collection of reliable data.



**Figure 1.** Map showing the study area (Red circle) at Dacope upazila (Blue circle) in Khulna district.

### Sample size

The total number of households in these two villages was 255 among them 70 households were involved in fishing activities. The sample size was determined according to the Yamane formula (1973) as below,

$$\text{Sample size, } n = \frac{N}{1 + N(e)^2}$$

Here,

N= Total number of fishers in both study sites

e = Deviation of sampling at the rate of 5%

So, sample size=  $70 / 1 + 70 (.05)^2$

= 59.57

= 60

So, the final sample size was 60 for the household survey;

The members were male and selected from each household who are being involved in fishing and who are not being involved in fishing at this time through purposive sampling. Male respondents were selected for sampling because they were directly involved with fisheries. For better information, almost all of the respondents were household heads because they have a good sense of household vulnerability, security, and livelihood.

### Preparation of the survey schedule and data collection

A draft survey schedule was prepared in such a way that all the information related to the livelihood of the fisherman which can create income vulnerability could include in the questionnaire. Thus, the draft schedule was improved, rearranged, and modified in light of the actual and practical experiences before finalization. Data were collected through personal interviews with the selected respondents' from September-November, 2019. For analyzing vulnerability, most of the data were collected from 10 October to 30 October because the government of Bangladesh banned catching fish at that time.

### Method of data collection

Both primary and secondary data were collected through mixed-method approaches. The sources of primary data were collected through household and key informant interviews.

#### Household interviews

To acquire household data, a face-to-face interview using a pretested semi-structured questionnaire was conducted. Information was collected on climatic phenomena, their impact on their livelihood, and the socio-economic status of the fishing communities. Before asking questions, the main purpose of the study was clearly explained to the fisherman.

#### Key informant interviews

Key informant interviews were conducted with the fisher's community (e.g., fisher's leader, stakeholder, experienced fishers) and another fisher's relevant authority. A total of 4 key informant interviews were conducted during the data collection.

#### Transect walk

A transect walk was done during the reconnaissance study and got assistance from local people to introduce water bodies and fishing communities of the study sites. Secondary data were collected from different types of books, journals, government, and non-government organizations, and different official documents.

#### Processing and tabulation of data

The collected data were manually edited and coded. Both qualitative and quantitative data collected from various methods were summarized and scrutinized. Data were analyzed using Microsoft Excel and SPSS software.

#### Ethical consideration

Broadly, five main ethical issues were considered for data participants: voluntary participants, informed consent, no harm, privacy, and confidentiality anonymity (De vaus, 2002).

## RESULTS AND DISCUSSIONS

### Socio-Economic Profile of the Respondents

In this study, it was found that all of the respondents were male. No female fishers were found in any of the study areas which was supported by Faruque and Ahsan (2014) and Ahmed *et al.*, (2009). From the selected households, the highest number of family members is 7. The maximum number of families is small consisting of 4 members (61.67%).

In estimating potential productive human resources, knowledge about the age structure of fishermen was important. From Table 1 it was estimated that among the selected samples, the majority of the fishermen (56.67%) belonged to the age group of 15-49 years which was close to the national average (54.6%) (BBS, 2015) and only 16.66% were in the above 60-year age group which was higher than the national average 7.9% (BBS, 2015). In above Table 1, 50% of the respondents had passed primary, 28.33% were illiterate and only 21.67% had passed secondary. The illiteracy rate of the study area was also higher 28.33% than the national illiterate percentage. The marital status of household heads might influence farm size, livestock choice, and other agricultural decisions to a greater extent. Table 1 shows that most of the household heads (about 90%) were married. The average working hour of the fisherman was almost 7 hours. The maximum working hours were 12 hours and the lowest 5 hours.

### Livelihood Status of the Fishing Households

Livelihood consists of the capabilities, the assets (natural, physical, human, financial and social capital) and the activities required for fulfilling basic needs (Chambers and Conway, 1992).

### Human Capital

Human capital includes skills, knowledge, the ability to labour, and good health. Hence, key features of human capital are highlighted in this section.

**Table 1.** Socio-economic profile of the respondents

<b>Family Size</b>		
<b>Categories</b>	<b>No. of household</b>	<b>Percentage of the respondent (%)</b>
Small (Up to 4 members)	37	61.67
Medium (5-6 members)	19	31.67
Large (> 6 members)	4	6.66
<b>Age Distribution</b>		
<b>Age Group (Years)</b>	<b>No. of Respondent</b>	<b>Percentage of the respondent (%)</b>
0-14	0	0.00
15-49	34	56.67
50-59	16	26.67
>60	10	16.66
<b>Educational Status</b>		
Illiterate	17	28.33
Primary	30	50.00
Secondary	13	21.67
<b>Marital Status</b>		
Married	54	90.00
Unmarried	2	3.30
Divorcee	1	1.70
Separated	3	5.00

Source: Author's estimation, 2019.

**Table 2.** Human capital of the studied areas

<b>Indicators</b>	<b>Particulars</b>		<b>Percentage (%)</b>		
Earning members of the selected households	No earning member		0		
	One earning member		0		
	Two earning members		31.67		
	Three earning members		68.33		
Unemployed members of the selected households	No Unemployed member		43.33		
	One Unemployed member		46.67		
	Two Unemployed members		10		
	Three Unemployed members		0		
Gender	Male		100		
	Female		0		
Health status of the respondents	No. of days sick in last 12 months	No. of days unable to carry out work in the past 12 months	6-10	18.33	25.0
			11-15	21.67	8.33
	16-20	23.33	41.67		
	21-25	16.67	11.7		
	26-30	20.0	13.3		
	36-40				
Participation in a skill enhancement program	Trained		25.15		
	Untrained		74.85		

Source: Author's estimation, 2019.

In the selected households, there were no households that had no earning members. The number of households with two earning members and three earning members was 19 (31.67%) and 41(68.33%) of the total selected 60 households. Among the selected households, there were 26 (43.33%) households with no unemployed members. The number of days fishermen sick in the last 12 months ranged from 6 to 30 days. Of this, they were unable to carry out work in several days in the past twelve months. About 41.67% of fisherman's unable to work for 26-30 days for their sickness (Table 2). Ali *et al.* (2008) found that 46% of the farmers received health services from village doctors, 18% from the upazila health complex, 14% from the district hospital and 20% from MBBS doctors. Only 25.15% of respondents received skill enhancement training and the rest weren't trained at all in fishing operative activities. Islam *et al.*, (2013) reported that 80% of fishermen considering all gear were not received any training whereas 205 had training experience in the river system of the Purnavaba River.

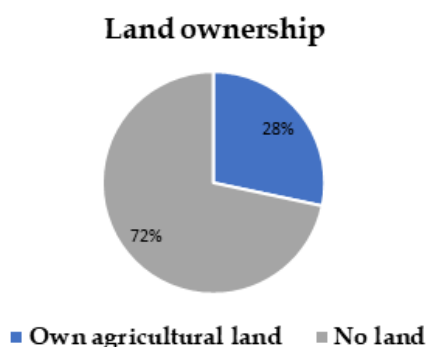
**Table 3.** Natural Capital of the respondents from the studied areas

Indicators	Particulars	Percentage (%)
Agricultural land	Proprietorship	28.33
	No proprietorship	71.67
Pond	Proprietorship	35.67
	No proprietorship	64.00
Access to open water		100
Access to the usable forest		0
Access to open aquatic resources		100

Source: Authors' estimation, 2019

### Natural capital

It was found that only 28.33% of the fishermen had agricultural land and the majority (71.67%) of fishermen had no agricultural land (Figure 2). Agriculture is the second occupation for most of the fishermen but lack of agricultural land they choose others. Most of the rural household's family used pond water for cooking, bathing, and washing clothes. It was found that only 35.67% of fishermen's families had a pond. The majority (64%) of fisherman families had no pond they used neighbours' pond water. Sometimes fishermen's families used river water for household activities.



**Figure 2.** Ownership of agricultural land

### Physical Capital of the respondents from the studied areas

House, fishing gear, boat Vehicles, roads, communication systems, market, electricity, water supply, sanitary and health facilities were the physical capital of the fishing community. Physical capital can be divided into two categories: fishery-related and non-fishery-related physical capital.

Ahamed (1999) found that 92.22% of people were likely to live in their own house but in these study areas 100% of respondents had their own house. About 62% of the household's fishery-related physical capital. Most of them admitted that the existing fishing equipment is no longer sufficient for current fishing activities. 61.67% of households own private boats and net. Only 3 households had ownership of Arot. The households also possess some physical assets related to agricultural production and recreational activities such as motor tiller (11.67%), wooden plough (35.0%), modern furniture (10.0%), and Jewelry (28.33%). The households use radio (31.67%) and television (28.33%) to enjoy drama, movies, and recreational programs. Around 85% of the fishermen had electricity facilities, whereas 76.67% had solar panels for supplying electricity facilities at their residences. The present results suggest there is an excellent electricity facility in the study area. Almost all the households had at least one mobile phone which helps them to communicate with each other during climatic shocks and stressful situations. 8.33% of the household members use internet facilities. 48.33% of households rear livestock and poultry which ensure their food security in a crisis (Table 4).

**Table 4.** Physical capital of the respondents from the studied areas

Indicators	Particulars	Percentage of households (%)	Average current market price (Tk.)
Ownership of fishery-related assets	Fishing boats	61.67	86238.10
	Fishing nets	61.67	50642.86
	Warehouse	5.00	50000.00
Ownership of other physical capital	Motor tiller	11.67	55000.00
	Wooden plough	35.00	3023.26
	Radio	31.67	666.67
	Television	28.33	13000.00
	Modern furniture	10.00	11000.00
	Jewelry(gm)	28.33	34800.00
	A solar panel that produces electricity	78.33	22826.09
	Own house		
	Tube well for water	100.00	70500.00
	Livestock and Poultry	11.67	6583.33
	Trees	48.33	27615.38
	Sanitary toilet	88.33	68125.00
	Mobile phone	85.00	3280.00
	Access to the internet (hrs)	98.33	4328.33
		8.33	100.00

Source: Authors' estimation, 2019

### The financial capital of the respondents from the studied areas

In this study, household financial income was calculated as the summation of savings, income from fishery and non-fishery-related activities, access to credit from different institutions, etc.

**Table 5.** The financial capital of the respondents from the studied areas

Indicators	Particulars	Percentage of households (%)	Average income level (Tk.)
Loan/ Credit and Savings	Involvement with NGOs	46.00%	15,000
	The receiver of Government Support	70.00%	10,000s
Annual household income from fishery-related activities	Crew/ Fisherman	100.00	59583.33
	Labour in other fisheries activities	100.00	11200.00
	Fish trading (net income)	20.00	2000.00
	Fish farming (net income)	15.00	2777.78
Annual household income from non-fishery-related activities	Agricultural farming (net income)	31.67	24285.71
	Agricultural labourer	23.33	3454.55
	Cattle/poultry rearing (net income)	13.33	2342.25
	Business (net income)	10.00	3856.00

Source: Authors' estimation, 2019.

Most of the respondents did not have any savings or bank accounts. A vital portion of the studied fishing community (46%) was involved with NGOs. They took a loan from these organizations and deposit their savings. This study revealed that most of the fishermen (about 70%) receive government support during the banned period of fish catch which is not sufficient for them. Islam *et al.*, (2013) observed that 60% of fishermen received government facilities and 40% of received NGO facilities. Zaman *et al.*, (2006) revealed that poor fish farmers had no access to bank loans because of the lack of mortgage assets. Now mobile financial services (MFS) played a big role in the study area. In this study, it was found that almost all respondents received loans from NGOs (BRAC, Asa, BASD, Proshika and World Vision). The interest rate of NGO loans was reported as too high by all the fishermen. Kostori (2012) mentioned the high-interest rate of the NGO loan. In the study, area income is divided into three broad categories: Fishery, non-fishery, and other sources of income. The average annual income of the household as serving crew or fisherman was Tk. 59583.33. Income from selling labour in fish drying, net making, and boat repairing was Tk. 11200.00. A few percent of the households are involved in fish trading (20%) and fish farming (15%). The average annual income from fish trading is Tk. 2000 and fish farming Tk. 2777.78 was not satisfactory in the study area. Some of the households involved in non-fishery-related activities are farming (31.67%), agricultural labour (23.33%), Cattle/poultry rearing (13.33%), and business (10%). It has been observed in this study most of the fishermen had lower incomes. Only a few had higher annual incomes because they were involved with other activities. Islam *et al.*, (2013) found that the mean monthly income of the fishermen was BDT 9,470.00 in Monirampur sub-district of Jashore, Bangladesh.

**Table 6.** Relations with relatives and other social organizations

Types	Yes (%)	No (%)	Total
Households have contacts in the village.	81.67	18.33	100.0
Households have relatives outside the village (including abroad).	91.67	8.33	100.0
Households have contacts outside the village (including abroad)	83.33	16.67	100.0
Household members participate in a social organization	28.33	71.67	100.0
Participation of household in a group support program during climatic hazard	16.67	83.33	100.0
Household members have membership in political parties	6.67	93.33	100.0
Household have any insurance	3.33	96.67	100.0

Source: Field survey, 2019



### Social capital

Most of the respondent's households have contacts in the village (81.67%) and outside the villages (83.33%). They also maintain good relations with their relatives, friends, and neighbours in the villages and outside the villages. Table 6 it is revealed that 28.33% of households participate in different social organizations whereas 16.67% of households participate in a group support program during a climatic hazard. Only a few households (6.67%) members were involved in different political activities. The insurance facilities for the fisherman households were not satisfactory in the study area.

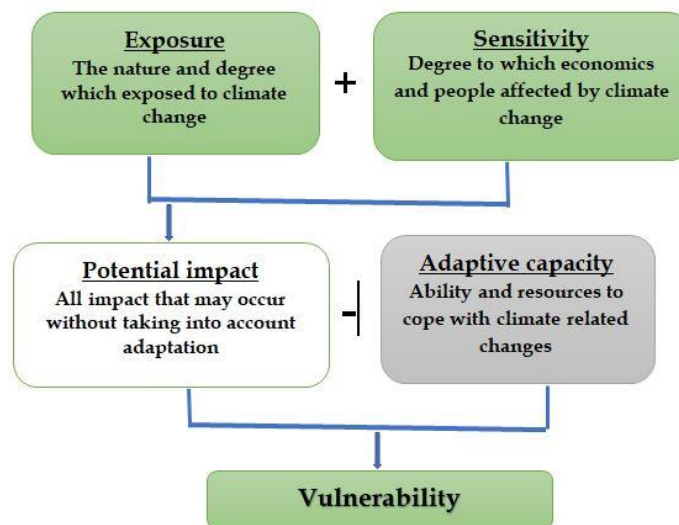
About 97% of the households support each other, especially during adverse climatic conditions. The household members maintain a positive trend of help/ support towards relatives and others in the villages or outside the village. About 51.7% of the household shows constant support for each other.

### Livelihood Vulnerability of the Fishing Households

The framework in figure 3 recognizes the sensitivity of livelihood vulnerability which is influenced by the exposures and this livelihood vulnerability can be reduced by taking some adaptive capacity of the fishing households.

### Vulnerability

Fishing households experienced significantly higher livelihood vulnerability in the selected area. The most experienced shock and stress was a decline in fish catch suffered by the respondents. This was followed by a decline in income and an increase in expenditure as well as Access to livelihood entitlements, assets, or services. Higher sensitivity and lower adaptive capacity typically combine to create higher livelihood vulnerability.



**Figure 3.** Details of the exposures, sensitivity and adaptive capacity component of the vulnerability framework. (Source: Turner *et al.*, 2007).

### Exposure

According to almost all participants' floods is the most important determinant of vulnerability inland, while at sea it is cyclones. About 66.67% of households were more vulnerable to sea level change whereas 63.33% and 56.67% were to floods and cyclones respectively. A high level of vulnerability was found in the case of cyclones (28.33%).

In the study areas, cyclones are typically followed by surges (floods) and together they cause vastly adverse impacts on household livelihood assets (11.7%), infrastructure (6.7%), Livelihood activities (13.3%), and overall livelihood (63.3%) (Table 7). Other exposures have little or no impact on livelihoods. The level of shock and stress created by climatic factors had been ranked based on their effects on livelihood.

**Table 7.** Secondary effects of shocks and stresses

Shocks and stresses	Secondary effects on (%)					
	Livelihood capital assets	Infrastructure	Social services	Access to markets	Livelihood activities	Overall livelihoods
Cyclones	11.7	6.7	0.0	5.0	13.3	63.3
Floods	11.7	6.7	0.0	5.0	13.3	63.3
Land erosion	6.7	13.4	5.0	5.0	0.0	69.9
Sea level changes	6.7	13.4	0.0	5.0	16.67	58.23
Variations in temperature and rainfall	6.7	0.0	0.0	11.67	15.0	66.63
Others	0.0	0.0	0.0	0.0	0.0	0.0

Source: Field survey, 2019

Land erosion and sea-level rise have resulted in the displacement of the different infrastructures of about 13.4% of the households. While variations in maximum temperature and rainfall have an impact on the fish-drying process. Decreased catches may increase the risk of malnutrition or undernutrition for communities highly dependent on fish for a source of protein (Ogutu-Ohwayo *et al.*, 1997).

### Sensitivity

According to 53.34 % of respondents in the study site, the trend in fish catch is decreasing slowly. Nearly 33.33% of respondents claimed that fish catch was remaining constant (Table 9). Reduced water levels and high temperatures affected fish spawning, nursing grounds, and migration (Ali *et al.*, 2008; Bhuyan *et al.*, 2016; Allison *et al.*, 2009b) which results in reduced fish catch. About 63.3% of respondents claimed that fish consumption among people was increasing day by day. But reduced fish catch results in fish supply reduction for processing which may result in market instability. It revealed that the operational capacity of 33.33% of household members deteriorated whereas 53.34% of household members' capacity remains constant. Table 6 reveals that 50% of the households responded that their household income decreased while 35% opined that no change in their household income has taken place. In the case of household expenditure, 58.33% of the households felt that their expenditure was increasing with the increase in the price of various commodities. In the case of saving 65% of the household responded as their household saving got decreased due to income earned from fishing decreasing and expenditure increasing while 18.33% of respondents mentioned that no change in saving took place. Ownership of fishery and non-fishery-related assets also decreased after the income decreased due to climatic shock and stress were resulted by 35.0% and 41.67% responded respectively, while 46.67% and 43.33% of respondents answered an unchanged condition on such factors after the climate changing situation.

In the case of a relationship with relatives and neighbours, 13.33% of the respondent household advocated that their relationship with relatives and neighbours has increased while 63.33 % responded saying no change in their social relation among fishers and local people. About 23.33% of households reported their relationship with others decreased. No significant change was found in the support received by the fishing households from different government and non-government organizations. Only 6.66% of respondents said that the support from GO and NGOs was increased and 76.67% of respondents claimed that the support system was constant.

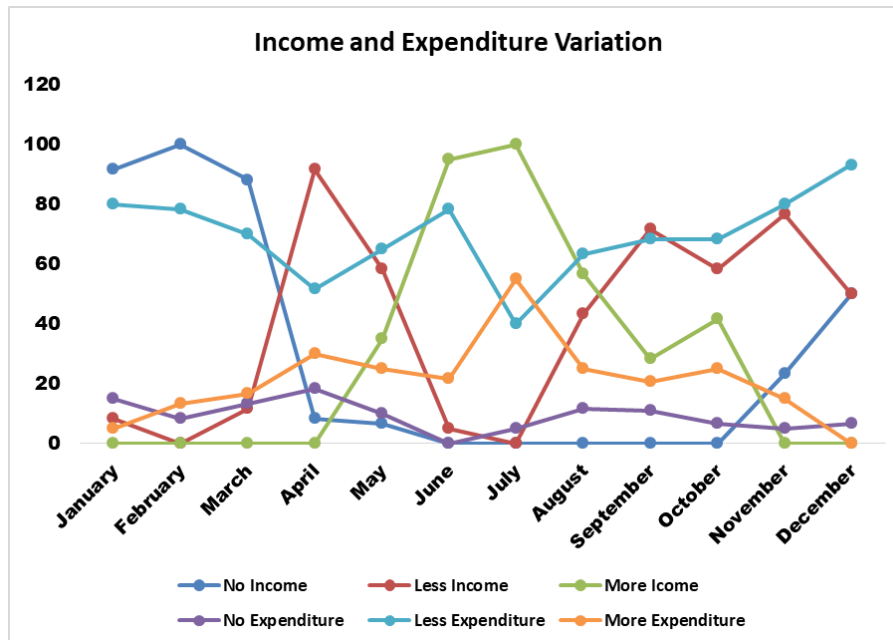
**Table 8.** Impact of climate change on different capital

Types	Degree of changes (%)		
	Increased	Constant	Decreased
Fish catch	13.33	33.33	53.34
Fish consumption	63.3	36.7	0.0
Household members capability	13.33	53.34	33.33
Household income	15.0	35.0	50.0
Household expenditure	58.33	36.67	5.0
Households saving	16.67	18.33	65.0
Ownership of fishery-related assets	18.33	46.67	35.0
Ownership of non-fishery-related assets	15.0	43.33	41.67
Relations with relatives and neighbours	13.33	63.34	23.33
Support from GO and NGO	6.66	76.67	16.67

Source: Field survey, 2019

#### Variation of income and expenditure throughout the year

The level of income and expenditure among the household members are treated as significant factors for the household-level study. Income influences the purchasing power of households to meet their basic needs.



**Figure 4.** Percentage of monthly income and expenditure variation

A wide range of variations in monthly income and expenditure was found among the respondent households in the study area. In January, February, and March income recession prevails. During this period the livelihood condition of the fishing community become more vulnerable. The trend in the highest income generation was found in June, July, and August. For another six months, they had an average income for maintaining their household expenditure. Table 7 it is revealed that if the income increases then the expenditure of the fishing family also increases and vice versa.

### Adaptation capacity

The highest proportion of the households (76.7%) claimed that the condition and access to the cyclone centre in the study area were good (Table 9). Only 6.6% of households opined no cyclone centre. Most of the respondents (95%) took the adaptation strategy and only 5% did not. They adapted strategies to cope with the adverse climatic impacts and support their livelihoods. This study revealed that occasional and part-time fishing households adapted to climatic change situations by diversifying their livelihoods only. The diverse strategy followed by full-time fishing households was not found in the case of occasional and part-time fishing households. Only a few households (6.67%) reported that they migrated to others during adverse climatic conditions. According to the fishers in both study sites, due to decreasing fish catch, they increased the duration of fishing for better income. About 5% of households adopted increasing the number of hours spent fishing.

**Table 9.** Adaptation strategies of respondents based on the category of fishers

Adaptation strategies	Fishing of respondent (month/ year)				Percentage (%)
	Occasional	Part-time	Full-time	Total	
Migration	0	0	4	4	6.67
Diversifying livelihoods	17	12	14	43	71.67
Increasing the number of hours spent fishing	0	0	3	3	5.0
Using more efficient fishing gear and boat	0	0	2	2	3.33
Others	0	0	5	5	8.33
Total	17	12	28	57	95
Percentage (%)	28.33	20.0	46.67	95	

Source: Field survey, 2019

### Livelihood diversification

Livelihood diversification was found as one of the important adaptation strategies in this study site. A household survey revealed that nearly 71.67% of respondents adopted diverging livelihoods. The livelihood diversification strategies were agriculture, selling farm labour, driving vehicles, small business, intensive fish farming, and fish trading.

**Table 11.** Level of diverging strategies based on the category of fishermen (%)

Adaptation strategies	Category of fishermen			Total
	Occasional	Part-time	Full-time	
Agriculture	35.29	33.33	0.0	23.26
Farm labour	5.6	0.0	0.0	2.33
Driving vehicles	0.0	0.0	0.0	0.0
Fish farming	5.6	0.0	0.0	2.33
Intensive fish farming and fish trading	5.88	16.67	35.71	18.60
Taking a loan from different sources	23.53	16.67	28.57	23.26
Agriculture and fish trading	11.76	33.33	0.0	13.95
Others	11.76	0.0	35.72	16.27

Source: Field survey, 2019

Agriculture was found as the major adaptation strategy. This study found that among full-time fishers, no households adopted agriculture as a strategy. On the other hand, occasional fishers (35.29%) and part-time fishers (33.33%) converted fishing to agriculture farming as their adaptation strategy (Table 11). Among fishers, only occasional (5.6%) took adaptation strategy as farm labour (Table 9). In this study, no households were found that drive different types of vehicles such as small vans, motorbikes, battery-driven autos, and CNG-driven auto rickshaws. In this study, fish farming was found as another adaptation strategy. Among the different categories of respondent fishers, only occasional fishers (5.6%) adapted to fish farming as a strategy (Table 9). Some respondents farm fish in their ponds while some farmed in leased ponds and/or farmed fish together. Fish trading was found as an important adaptation strategy. In this study in both sites, it was found that among fishers, occasional part-time and full-time fishes adapted to fish trading at 5.88%, 16.37%, and 35.71% respectively. On the other hand, around 18.60% of respondents adapted to fish trading among the total number of households adopted different strategies. It was also found that occasional fishers and part-time fishers of both sites adapted to agriculture and fish trading at 11.76%, and 33.33% respectively (Table 9). About 23.26% of fishing households received a loan from different sources. The highest proportion of loans was found among the full-time fishing households in the study area. Therefore, fishers had to adapt to selling livestock or reducing household consumption, borrowing loans from friends or relatives.

## CONCLUSION

In Bangladesh, fishing communities especially in the coastal areas are one of the most vulnerable groups in terms of livelihood convenience and also under the serious threat of climate shocks and stress. This study assessed the impacts of climatic change and adaptation strategies among fishing communities of Khulna district, Bangladesh. The socioeconomic condition of the fishers was not favourable due to social, economic, and technical barriers because most of the families in the study area were directly engaged in fishing to maintain their livelihood throughout the year. Organization of a fishery co-operative society should be done and community-based fishing initiatives can be introduced. The education level of the fishermen was so poor. Climate change promoted the impacts of sea level rise, land erosion, cyclones, and associated flooding which influence all the livelihood assets and strategies of fishing communities. Most of the households have lower access to sanitation, market transportation, health facilities, GO, and NGO services during adverse climatic situations. Hence, awareness and education facilities should be developed in the study areas. Without adaptation, increased levels of cyclones and floods result in greater damage to fishing equipment, and livelihood assets, especially a loss of fishery-related income. Due to reducing fish catch, the income from fisheries-related activities had reduced. They fully depend on fishing and do not earn money from off-farm activities. Due to a lack of awareness as well as the poor income, the fishermen take a loan from local credit markets at high interest; in that case, Government can introduce no collateral loan facilities with low-interest rates. This study revealed that occasional and part-time had traditionally coped with or adapted different strategies such as migration, agriculture, fish farming, fish trading, and small business to the normal range of climate impacts but not always sufficiently well. To reduce local vulnerability sustainable land use planning through community involvement is needed to be adapted to the environmental changes.

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## DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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