Farmer's Perception and Factors Influencing Adoption of Adaptation Measures to Cope with Climate Change: An Evidence from Coastal Bangladesh

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ABSTRACT

Farmers in the south-west coastal Bangladesh are frequently affected by climate change due to their proximity to the Bay of Bengal and heavy reliance on agriculture for their livelihoods. In this case, farmers need to know the best implementation methods (adaptation strategies) to reduce crop losses in a changing climate. The present research evaluated the perceptions of farmers to climate change and determine the socio-economic factors which influence the farmers in choosing the right adaptation decisions. Data were collected through close-ended and open-ended structured questionnaire from 52 coastal households and analyzed through descriptive statistics and logistic regression using SPSS V.16. Results revealed that almost all farmers perceived increasing temperature and changes in rainfall patterns over the last 15 years. In response to a changing climate, farmers adopted 13 adaptation strategies where irrigation ranked the first and crop insurance was the last. The logit analysis suggests that household age, education, family income, family member, farm size, farming experience, organizational participations, and training received have a significant influence on farmer's adaptation choices. Despite various support and technological interventions being available, changing weather, natural disaster pattern, lower income, and lack of credit facilities ranked as the highest problems farmers encountered during adaptation. This study helps to identify important household characteristics that can be applied in the future to formulate and implement a successful adaptation policy. Finally, this study recommends that effective training and early warning systems and provision of credit and market access facilities are necessary to enhance farmer's resilience to climate change.

1. INTRODUCTION

Geographically, Bangladesh lies between 20°34' to 26°38' N latitude and 88°01' to 92°42' E longitude, covers an area of 147,570 km^2 (BBS, 2012) of which 47,211 km^2 is coastal area, which covers 32% of the total land area of the country (Huq and Rabbani, 2011). The 711 km long coast, consisting of 19 coastal districts, which occupies 35.1 million people (BBS, 2011), are known as the most climate change vulnerable areas in Bangladesh (Sarker et al., 2020; Alam et al., 2020; Kabir et al., 2016) due to its close proximity to sea, lower elevation, funnel shaped coast, recurrence of natural disasters, high population density, and dependency on agriculture (MOEF, 2005; DOE, 2007; Shahid and Behrawan, 2008; Abedin and Shaw, 2013). However, several indicators such as sea level rise, saline water intrusion, higher temperature, erratic rainfall, frequency and intensity of cyclones, storm surge, and coastal flooding, have proved that the impacts of climate changes are already happening (Khan et al., 2011; Rana et al., 2011; Thurlow et al., 2012; Yu et al., 2010). In every year during the pre-monsoon (April and May) and post-monsoon (October and November) season, coastal areas are affected by

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cyclones. A report from the GoB (2009) showed that from the year 1877 to 1995, coastal regions have experienced 154 cyclones and, on average, every two to three years a severe cyclone hits these coastal regions that have caused a great immediate and long term impact on coastal agriculture (Uddin, 2012), particularly rice production (MOEF, 2005; Yamin et al., 2005). In addition, a result from BBS (2021b) showed that flood (56.41%), river/coastal erosion (14.99%), and cyclones (14.25%) were the most responsible disasters that caused the highest damage and losses in Bangladesh and the first most affected sector was land degradation including reduced valuation (52.56%) where a crop (28.90%) was the second most affected sector.

Coastal agriculture contributes about 25% of the total rice production in the country (BBS, 2013) and generates livelihoods and food security for 70% of the coastal dwellers (Lázár et al., 2015). These areas have been continuously exposed to drought, floods, cyclones, storm surges, salinity intrusion, water-logging, and riverbank erosion. A longitudinal data analysis conducted by Islam et al. (2022) showed that cyclone and saline-prone areas of the country are more vulnerable compared to drought and flood-affected areas of cereal food consumption. Among the other hazards, salinity intrusion is a great threat to coastal agriculture (Molla, 2016; Shaibur et al., 2017), which impedes the growth of vegetation, and deteriorates the natural environment, agricultural ecosystem, and biodiversity; that highly influences the socio-economic conditions of these areas (Hoque et al., 2013; Shaibur et al., 2019). Coastal agriculture is gradually facing incredible challenges due to the inverse relationship between agriculture and climate change, which is responsible for large-scale loss of agricultural production by changing crop physiology (Chakraborty et al., 2000) and severely affecting farming activities (Uddin et al., 2014). However, in this case, several researchers have considered that adaptation is the best possible option for fighting against these negative impacts of climate change (Huang and Sim, 2021; Dorward et al., 2020; Turner-Walker et al., 2021).

Climate change adaptation is defined as the adjustments of a system (natural and human) to reduce the negative effects of climate change and to enhance the favorable opportunities of climate change (Parry et al., 2007; Adger et al., 2003). Adaptation strategies can be adopted by farmer's willingness (autonomous adaptation) or by government/organization supported policies (planned adaptation) and also achieved at different stages such as individual/farm, regional, national, sub-national, local, and international (Asrat and Simane, 2018). However, the farm level adaptation will be effective if the farmers have a clear understanding of climate change and its associated risk. In this case, knowledge, and access to information act as the principle driver. The most common agricultural adaptations are: increasing irrigation facilities, use of new crop varieties, crop rotation, crop diversification, crop intensification, changing planting times, cultivating short-duration varieties, mix crop cultural and livestock farming systems, monitoring weather forecasts on radio, homestead gardening, planting trees and migration, and water resource exploitation (Ahmed et al., 2021; Aidoo et al., 2021; Alam et al., 2017; Habiba et al., 2012). Moreover, adaptation decisions are influenced by different factors including socioeconomic status (farmer’s age, gender, education level, farm-size, family size, family income, off farm income, experience of farming, training received), access to climate information, agricultural subsidies, better access to electricity and institutional facilities, accessibility of technology, remaining infrastructure, more secure tenure rights, an awareness of climatic effects, perceptions about the impact and intensity of climate change, drought severity, extent of groundwater depletion, agro ecological system, existing policies, and capacity (Aidoo et al., 2021; Jha and Gupta, 2021; Uddin et al., 2017; Alam, 2015). These influencing factors are needed to design suitable adaptation policies for specific areas based on sensitivity and vulnerability. But, unfortunately, there is no exploratory research on which adaptation strategies are the best suited for the saline-prone vulnerable coastal areas and how the farmers adapt with their agricultural activities during these extreme climate variability and events. Also, no specific scientific study has been conducted yet in Bangladesh regarding farmer’s perception and factors influencing the adaptation decision to cope with climate change. Most of the study conducted so far in Bangladesh regarding farmer’s perception and response to climate change has focused only on drought-prone areas (Alam, 2015; Alauddin and Sarker, 2014; Sarker et al., 2013; Habiba et al., 2012), saline-prone areas (Kabir et al., 2017; Uddin et al., 2017; Hasnat et al., 2016; Rashid et al., 2014), riverbank erosion-prone areas (Alam et al., 2017; Ahmed, 2015; Karim, 2014) and riverine char islands (Ahmed et al., 2021). Therefore, there is an urgent necessity to identify the strategies that are best suited to support farmers and farming communities in this period of climate change and to identify the factors influencing farmers' adoption of adaptation strategies to cope with climate change. So, a research initiative was needed for this purpose. In this context, the current research paper ascertains farmer's perceptions on various climatic events from farmers experience, agricultural practices, adaptation strategies, constraints, etc., and also determines the underlying socio-economic factors which influence the farmers adaptation decisions.

2. METHODOLOGY

2.1 The study area

Khulna, a south-western coastal district of Bangladesh, was selected to conduct this study. The fourth largest city of Bangladesh in respect of area, Khulna, is considered as one of the worst affected coastal districts due to recurrent natural disasters like cyclones, storm surges, tidal flow, river bank erosion, salinity intrusion, and even drought during the summer season. Khulna district, covers an area of 4,394 km^2 (of which 607.80 km^2 is riverine and 2,028.22 km^2 is under forest), which represents 2.97% of the country's total area (BBS, 2021a). This area is characterized by Ganges tidal floodplain agro-ecological zones (AEZs), and is the most vulnerable climate change affected coastal zone among the 30 AEZs (Rahman et al., 2018). The climate of this district is characterized by a hot summer and a mild winter. The monthly average maximum temperature goes up to 31.1°C during the month of May and the monthly average minimum temperature falls down to 21.8°C in the month of January. The annual rainfall recorded in 2011 was 162.3 mm (BBS, 2021b). The main agricultural products are: rice, jute, sesame, betel nut, and fruits and vegetables, and the major occupation of the villagers are rice cultivation, although the area has been known as a shrimp cultivation area since the 1990s (Barai et al., 2019). Khulna district consists of nine upazilas (sub-districts) and 67 unions (officially called union parishad or union council, the smallest administrative unit in Bangladesh) with having a population of 2,318,527 with 547,347 households (in 2011 census) with the density of 537 persons/km^2. Among the nine upazilas (sub-districts) of Khulna District, Dacope upazila was the worst victim of tropical cyclone Aila, formed on 25th May, 2009 (Roy et al., 2009). Due to the high tidal surge of cyclone Aila, seven unions of Dacope upazila were inundated by high saline water and about 100,000 people have lost their livelihoods. This intrusion of high saline water into agricultural land caused damages to about 1,094 ha of crop land and thus the land also became unsuitable for crop production (Kumar et al., 2010) which eventually caused suffering to the farmers of these unions. Another research on assessing climate change vulnerability of Dacope upazila, Bangladesh was conducted by Razzaque et al. (2019), where they found out of seven unions, the Kamarkhola union of Dacope upazila was highly vulnerable to climate change stress and is in the frontline to face various disasters like cyclones, storm surges and salinity in soil and water. Thus, it is the most fragile area in the aspect of climate change point of view.

Therefore, by following the above discussion with considering the worse scenarios of the affected unions, the Kamarkhola union of dacope upazila (sub-district) of Khulna District, Bangladesh was selected purposively to understand the perceptions of farmers regarding climate change and the factors determining their adaptation decisions to cope with these climate change situations.

Kamarkhola union covers an area of 29.20 km^2, with 3,670 households and a population of 15,407 (population density 154 persons/km^2), out of which 60% are farmers. Geographically, this union is bounded by Dhaki River and Bhodra River in the North, Sutarkhali union in the South, Bhadra River on the East, and Dhaki River on the West. Average literacy rate of this union is 47%. The main occupation of this union is farming. Major crops/products grown in this region are: rice cultivation and fish culture, and the major source of income comes from agriculture. The total number of poor people and landless families are 705 and 338 respectively (BBS, 2011). Here, the study area where we conducted our research is shown in (Figure 1).

2.2 Sampling questionnaire and data collection

The present research was conducted on Kamarkhola union of Dacope upazila in Khulna district of south-western coastal Bangladesh. About 3,670 households with a population of 15,407 (out of which 60% are farmers) live in this union. Out of total households, 500 household heads were first identified through conducting a household census survey by considering the following criteria: those who are the head of the household and who are related with agriculture. Then, with the help of a background survey and the opinion of local experts, 52 farmers were randomly selected from 500 households considering the following criteria: whose primary occupation is agriculture, who are actively involved in agriculture, and who have more than 15 years of farming experience.

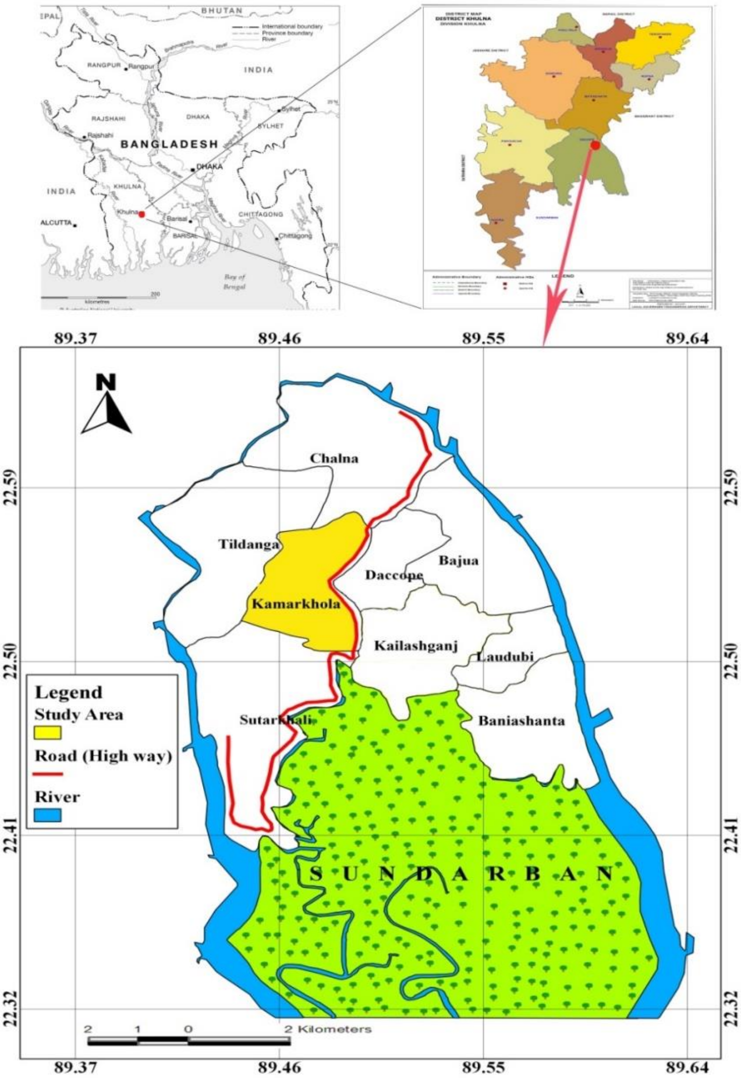

Figure 1. Map of the study area (Kamarkhola Union)

This study was conducted based on primary data sources, and a simple random sampling technique was applied to collect the data. The data collection methods were personal interviews and field observation by using closed-ended (with multiple response options) and open-ended (without multiple response options) structured questions focusing on questions regarding demographic and socioeconomic information, perceptions on the changes of climatic variables over the past 15 years, adaptation techniques to cope with climate change, and problems faced by the farmers during adaptation. This pre-tested structured questionnaire for interview schedule was set up in English but during data collection, the question was translated into Bengali. The questionnaire used was pre-tested on some selected households in the study area before the actual survey started. All the secondary data were collected from various related government and non-government offices, statistical reports, articles, published materials, and official websites. The data were collected from different ages of farmers of having short, medium, and long range of experiences, including various farm sizes, to get data representative of the whole union.

The data collection from personal interviews were gathered through farmer's self-elicitation answer by using a 4-point Likert scale (3=high, 2=medium, 1=low, and 0=not at all) (Sarker et al., 2020; Akanda and Howlader, 2015; Alam et al., 2017; Uddin et al., 2014). After an extensive literature review, 13 adaption strategies/options were selected. The farmers were asked to rate the strategy for how effective they believed the strategy would be as a suitable adaptation options. Moreover, we selected 33 statements according to the major climatic events (8) perceived by the farmers, major adaptation strategies (13) adopted by the farmers, and the major problems (12) faced by the farmers during adaptation. Then we selected eight socio-economic characteristics as an attitudinal statements which were amended from the existing literature, e.g., Uddin et al. (2017), Ahmed et al. (2021), Uddin et al. (2014), and Jha and Gupta (2021). These attitudinal statements give a proper perception about how climate change affects agriculture and what strategies they prefer.

2.3 Variables of the study for empirical model

In this study, adaptation was selected as a dependent variable, where the value of adaptation strategies was assigned as "1" for those farmers who had taken at least one adaptation strategies from the adaptation list to minimize the negative impact of climate change, on the other hand "0" value was assigned to those farmers who had never taken any types of adaptation strategies from the selected list. However, the socio-economic characteristics of the farmers were selected as independent variables (Table 1) which were collected from the extensive literature review of some research scholars, e.g., Uddin et al. (2017) Ahmed et al. (2021) Uddin et al. (2014), and Jha and Gupta (2021) as it increases the level of perceptions about climate change and its associated risk as well as influences the farmer's in taking various adaptation decisions to cope with climate change (Diggs, 1991; West et al., 2008).

Table 1. Definition of variables of binary logistic model

Dependent variable	Independent variable
The value of "1" for who take adaptation strategies and "0" otherwise	X_1=Age of the farmer, measured in years
	X_2=Farmer's education level: "1" if able to read and write; and "0" otherwise
	X_3=Number of family members of the household
	X_4=Family income, measured in Bangladeshi taka per month
	X_5=Farm size, measured in acres
	X_6= Farming experience, measured in years
	X_7=Training received, "1" if received and 0 otherwise
	X_8=Organizational participation: "1" if participated and "0" otherwise

Different types of adaptation models are traditionally used in adaptation studies, for example: probit model (Maddison, 2007; Aidoo et al., 2021), socio-cognitive model (Grothmann and Patt, 2005), multinomial choice model (Hassan et al., 2008), multinomial logit (MNL) model (Deressa et al., 2009), and binary logit regression model (Jha and Gupta, 2021; Uddin et al., 2017; Ahmed et al., 2021; Uddin et al., 2014). Multinomial logistic regression is the extension of binary logit regression. It is used when the dependent variables of the study are three and above, whereas, binary logit is used when the dependent variable of the study is two. According to their formulation and results, both the probit and logit models are the same, but the probit models are most used for experimental data and do not give accuracy in robustness as it cannot approve the modeler to adjust for covariates. On the other hand, logit models confirm the rise of estimated probability and never cross the range of 0 to 1. This model is recognized as the best fit and is widely accepted by all. So, by considering all of these conditions and factors, the binary logit regression model was applied in this study to determine how the demographic and socio-economic factors influence the farmer's in taking the adaptation decisions to cope with climate change. This logit model was expressed in Equation (1-3) (Gujarati and Porter, 2009).

$$P_i = \frac{1}{1} + e^{-(\beta_\theta + \beta_i X_i)} \quad (1)$$

For simplicity, equation (1) can be written as:

$$P_i = \frac{1}{1} + e^{-Zi} \quad (2)$$

Where; Pi: probability of adaptation of the i^{th} respondent; e^{zi}: stands for the irrational number e raised to the power of Z_i; Z_i is a function of N-explanatory variables and expressed in equation (3) as follows:

$$Z_i = \beta_\theta + \beta_1 X_1 + \beta_2 X_2 + \cdots\cdots\cdots + \beta_n X_n + \mu_i \quad (3)$$

Where; β_0=Constant term; μ_i=the error term, which has a standard logistic distribution; $\beta_1 \dots \beta_n$=regression co-efficient; $X_1 \dots X_n$= explanatory variables presented in (Table 1).

2.4 Data analysis process

The data analysis was performed by descriptive statistics and binary logit regression model using SPSS (V.16). The descriptive statistical tools were used to analyze and present the demographic and socio-economic characteristics of the farmers, the perceptions of farmers to various climatic events, their major adaptation practices, and the major problems that were faced during adaptation. Factors influencing farmer's perception were analyzed in a logistic regression model framework. In this research, we implemented Environmental Hazard Index (EHI), Adaptation Strategy Index (ASI), and Problem Facing Index (PFI) to determine the perceptions of farmers regarding climate change, to find out the rank of adaptation strategies, and to identify the problems of farmers for adopting climate change adaptation strategies respectively where the calculation equation were adopted from Ndamani and Watanabe (2017).

2.4.1 EHI: EHI help to investigate the perception of farmers regarding the climate change issues. In this study, perceptions regarding climate change impact were collected from eight climate change concerns, which were perceived by the farmers. The ranking was computed by using the Equation (4) as:

$$\mathrm{EHI} = \mathrm{EH_n} \times 0 + \mathrm{EH_l} \times 1 + \mathrm{EH_m} \times 2 + \mathrm{EH_h} \times 3 \quad (4)$$

Where; EHI=environmental hazard index; EH_n=number of farmers who were affected by no environmental hazards; EH_l=number of farmers who were affected by low environmental hazards; EH_m=number of farmers who were affected by medium environmental hazards; EH_h=number of farmers who were affected by high environmental hazards.

2.4.2 ASI: The ASI is used to find out the rank of adaptation strategies, which are necessary for farmers to continue their farming activities. Here thirteen adaptation strategies were selected from kinds of literature and the priorities of adaptation strategies to climate change were calculated by using the Equation (5) as:

$$\mathrm{ASI} = \mathrm{AS_n} \times 0 + \mathrm{AS_l} \times 1 + \mathrm{AS_m} \times 2 + \mathrm{AS_h} \times 3 \quad (5)$$

Where; ASI=adaptation strategy index; AS_n=number of farmers who stated no agricultural adaptation to climate change; AS_l=number of farmers who stated low agricultural adaptation to climate change; AS_m=number of farmers who stated medium agricultural adaptation to climate change; AS_h=number of farmers who stated high agricultural adaptation to climate change.

2.4.3 PFI: PFI is applied to identify the problems of farmers for adopting the climate change adaptation strategies. In this case, twelve problems were listed, where farmers expressed their opinion and the ranking of the problems was calculated by applying the Equation (6) as:

$$\mathrm{PFI} = \mathrm{P_n} \times 0 + \mathrm{P_l} \times 1 + \mathrm{P_m} \times 2 + \mathrm{P_h} \times 3 \quad (6)$$

Where; PFI=problem facing index; P_n=number of farmers who stated the problem as not encountered; P_l=number of farmers who stated the problem as low; P_m=number of farmers who stated the problem as moderate; P_h=number of farmers who stated the problem as high.

All the index (EHI, ASI, and PFI) scores were ranging from 0 to 208, where '0' indicating the minimum and '208' indicating maximum and finally ranking was made in the order of maximum to minimum score.

3. RESULTS AND DISCUSSION

3.1 Demographic and socio-economic status of the respondents

The variables that describe the demographic and socio-economic characteristics of the respondents in this study were household head's age, education level, family member, farm size, family income, farming experience, training received, and organizational participation which are presented in (Table 2).

Data shows that 36% of the household head were in the young age group (≤35) followed by 35% and 29% within the middle age (36-50) and old age (>50) group, respectively, where the average age of the respondents were around 43 years which represents the age between young to middle-aged (71%). Uddin et al. (2017) found that most of the farmers in the coastal areas of Bangladesh were young to middle-aged.

Another important characteristic considered in this socio-demographic analysis was the level of education. Data in Table 2 shows that more than half of the respondents (52%) combined have completed their primary (1-5), secondary (6-10) and above secondary (>10) level of education while (48%) of the respondents have a low level (illiterate and can sign only) of education. There was not a single household head found who had completed graduation or above. So, we can conclude that majority 79% (including can sign only) of the farmers in this study area were literate and the average years of schooling was around four years. Data from the Bangladesh National Portal showed that a total of 17 educational institution existed in Kamarkhola union, where the number of government and non-government primary schools was six and seven, respectively, while there were only four secondary schools, and no higher secondary schools were found in this study area. So, for this, the level of education from primary to above secondary is gradually decreasing. Uddin et al. (2017) also found the similar types of literacy rates in their research.

Family size is also considered an important variable in demographic analysis. From the table, we can see that about half (50%) of the respondents have a small family (up to 4) members, while 44% have a medium (5-7), and 6% a large (>8) number of family members. The average number of family members was 4.83, which is similar to the national average family-sized 4.54 (BBS, 2021b).

In addition, about 83% of the respondents have a small farm (up to 2 acres), while only 13% of the respondents had medium (2.01-5.00 acres) and 4% had large farm sizes (>5 acres). The most common monthly family income (73%) belonged to the medium income group (BDT 5,001-10,000) while the rest (19%) and (8%) were fall under the low (up to BDT 5,000) and high income (>10,000 BDT) groups, respectively. The monthly average income of the farmers was BDT (Bangladeshi Taka) 7,538 (89 USD), which is less than the national monthly average income of BDT 9,353 (111 USD) (Uddin et al., 2017). The main sources of family income came from crop production, fish culture, cattle rearing, and non-farming sources (e.g., day labor).

Table 2. Demographic and socio-economic status of the respondents (n=52)

Characteristics	Categories	Scoring method	Respondent (%)	Mean±SD
Age	Young (up to 35)	Year	36	43.55±15.06
	Middle aged (36-50)		35	
	Old (Above 50)		29	
Education level	Illiterate (0)	Year of schooling	21	3.99±1.08
	Can sign only (0.5)		27	
	Primary (1-5)		31	
	Secondary (6-10)		19	
	Above secondary (>10)		2	
Family member	Small (Up to 4)	Number	50	4.83±1.65
	Medium (5-7)		44	
	Large (Above 8)		6	
Farm size	Small (Up to 2 ac)	Acres	83	4.68±4.14
	Medium (2.01-5.00 ac)		13	
	Large (Above 5 ac)		4	
Family income	Low (Up to 5,000)	BDT/month	19	7,538±2,654
	Medium (5,001-10,000)		73	
	High (Above 10,000)		8	
Farming experience	Short (3-19)	Years	62	18.19±12.67
	Medium (20-30)		25	
	Long (Above 30)		13	
Training received	Yes	Dummy	8	
	No		92	
Organizational participation	Yes	Dummy	31	
	No		69	

Additionally, 62% of the farmers have short range (3-19) years of farming experience while 25% and 13% have the medium level (20-30) years and long range (>30) years of farming experience, respectively. The average farming experience of the surveyed farmers was about 19 years, which is a critical factor that influences farmers for making adaptation decisions and better understanding climate change events (Asrat and Simane, 2018). The study from Uddin et al. (2017) also showed the same results where the farmers of southwest coastal Bangladesh have an average 20 years of farming experience.

Nearly 92% of the farmers had no training experience regarding climate change impact on agriculture and about 69% of the farmers did not participate in any agricultural organizational program.

3.2 EHI based on farmer's perception

The results from the environmental hazard index (EHI) showed that increased temperature and reduction in rainfall were ranked the first and second environmental hazard. Kabir (2015) also found similar results. He found that about 95% and 89% participants of southwestern coastal Bangladesh perceived an increase of annual temperature and decrease of rainfall pattern, respectively.

In addition, salinity was the third environmental hazard of concern and is considered as the most common disaster in the coastal areas of Bangladesh. Islam et al. (2015) had found that after just nine years (from 2000 to 2009) in the southwestern coastal region of Bangladesh, salinity level was changed from 23.93 dS/m to 28.64 dS/m.

Other changes in various climatic events perceived by the farmers of this study were long summers (4th), erratic rainfall due to delayed monsoons (5th), floods (6th), cyclones (7th), and short winters (8th); which are presented in (Figure 2).

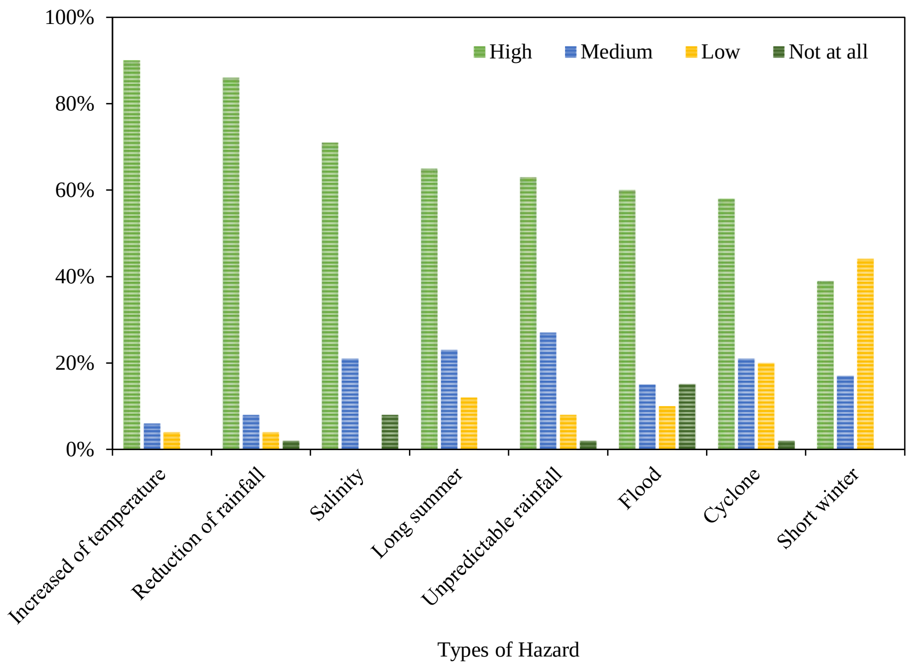

Figure 2. Farmer's perception of changes in different climatic events

However, the perception of farmers about climate change and climatic variability also matched with the scientific report that had been provided by Mondal et al. (2012).

Analysis of the findings concluded that farmers had a good perception on local climate change and climate variability, which provokes them to adopt various adaptation strategies for reducing the negative effects of climate change.

3.3 ASI based on farmer's perception

The results of Adaptation Strategy Index (ASI) are presented in (Table 3). Out of 13 adaptation strategies, increased use of irrigation was ranked the first, which is the most vital among farmers because irrigation makes the nutrients available for the plants and also influences crop production. About 80.2% of Himachal Pradesh farmers in India think that irrigation is the best adaptation strategies to climate change impacts (Loria and Bhardwaj, 2016).

The second adaptive strategy was crop diversification, which is most favorite to farmers because through practicing diversified cropping strategy, they can minimize their risk due to crop failure, and can earn more by increasing crop yield; which ultimately causes increasing opportunities for the farmers to expand their farm. About 57.9% of Indian farmers (Loria and Bhardwaj, 2016), and 61% of Kenya farmers (Judith et al., 2017) think that crop diversification at the farm level is a good adaptation option to cope with climate change.

Table 3. Rank order of the major adaptation strategies adopted by the farmers (n=52)

Adaptation strategies	High	Medium	Low	Not at all	ASI	Rank
Increased use of irrigation	116 (56%)	63 (40%)	2 (2%)	1 (2%)	182	1st
Practicing crop diversification	112 (54%)	51 (33%)	10 (9%)	2 (4%)	175	2nd
Find off-farm job	100 (48%)	51 (33%)	14 (13%)	3 (6%)	168	3rd
Integrated farming system	72 (35%)	60 (38%)	18 (17%)	5 (10%)	155	4th
Use of salinity tolerant varieties	72 (35%)	57 (37%)	12 (11%)	9 (17%)	150	5th
Cultivating short duration crops	60 (29%)	63 (40%)	14 (14%)	9 (17%)	146	6th
Practicing crop rotation	52 (14%)	54 (40%)	22 (19%)	10 (27%)	138	7th
Use of drought tolerant varieties	40 (19%)	57 (37%)	20 (19%)	13 (25%)	130	8th
Practicing intercropping	28 (14%)	63 (40%)	20 (19%)	14 (27%)	125	9th
Agroforestry	28 (14%)	60 (38%)	16 (15%)	17 (33%)	121	10th
Soil conservation techniques	36 (17%)	9 (6%)	40 (39%)	20 (38%)	105	11th
Zero tillage	16 (8%)	24 (15%)	26 (25%)	27 (52%)	93	12th
Crop insurance	8 (2%)	0 (0%)	12 (11%)	44 (85%)	64	13th

Finding an off-farm job was the third most important adaptation strategy; it was applied by those farmers whose farm income was gradually decreasing by adverse climatic conditions. Both Morton (2007) and Loria and Bhardwaj (2016) have found similar results.

The fourth strategy was the integrated farming practices. It is more popular throughout the country due to its large economic benefits (Uddin and Takeya, 2005).

Due to the salinity in soil and water of this study area, the use of saline tolerant varieties (5th) was also an important adaptation strategy among farmers (Abedin et al., 2012). Next in order of adaptation techniques are the followings: short-duration crops > practicing crop rotation > drought-tolerant varieties > practicing intercropping > agroforestry > soil conservation techniques > zero tillage > crop insurance (Table 3). Similar types of work were done by Varadan and Kumar (2014) and Uddin et al. (2014).

3.4 PFI based on farmer's perception

The problems faced by the farmers during adaptation were identified by the perception of farmers and were listed in rank order by using Problem Facing Index (PFI) presented in Table 4. The results indicate that changing weather and natural disaster pattern was ranked first where farmers faced a lot of problems, for example: crop loss, crop failure, low yield production, increasing pest infestation, etc. due to high temperatures, shortage of rainfall, and recurrent natural calamities. Although we know that the agriculture of Kamarkhola union is highly influenced by weather and climatic condition. According to Howlader and Akanda (2016), the farmers of Patuakhali district of Bangladesh also faced a similar problem.

The second most important problem faced by the farmers was insufficient family income, and due to low income they could not adopt new technologies to continue their agricultural practices. Lack of credit facilities is another problem faced by farmers during adaptation and with their low household income and lack of adequate financial or micro-credit institutions to provide them with credit facilities, this acts as an additional barrier for farmers when adopting climate change adaptation strategies. According to Judith et al. (2017), in Kenya, about 61% farmers did not have enough money, which was the main barrier for adopting agricultural adaptation.

Table 4. Rank order of the problems faced by the farmers (n=52)

Problems	High	Medium	Low	Not at all	PFI	Rank
Changing of weather and natural disaster pattern	176 (85%)	24 (15%)	0 (0%)	0 (0%)	200	1st
Insufficient family income	148 (71%)	45 (29%)	0 (0%)	0 (0%)	193	2nd
Unavailability of credit facilities	152 (73%)	30 (19%)	4 (4%)	2 (4%)	188	3rd
Lack of available water (Irrigation)	140 (67%)	9 (6%)	16 (15%)	6 (12%)	171	4th
Lack of access of information	140 (67%)	9 (6%)	14 (14%)	7 (13%)	170	5th
Lack of market access	112 (54%)	21 (14%)	20 (19%)	7 (13%)	160	6th
Unavailability of salinity tolerant species	104 (51%)	33 (21%)	16 (16%)	7 (12%)	160	7th
Shortage of farm inputs	84 (40%)	54 (35%)	12 (12%)	77 (13%)	157	8th
Traditional practices/beliefs	80 (38%)	39 (25%)	30 (29%)	4 (8%)	153	9th
Non-availability of storage and processing of agro-product	60 (29%)	27 (17%)	18 (17%)	19 (37%)	124	10th
Government's inadvertence to monitor climate risk management programs	64 (31%)	15 (10%)	16 (15%)	24 (44%)	119	11th
Poor soil fertility	32 (15%)	21 (14%)	20 (19%)	27 (52%)	100	12th

Lack of available water for irrigation was ranked as the fourth problem and was considered the biggest problem for farmers in coastal areas because the agricultural system is completely dependent on water for irrigation, but the sources of irrigation facilities are affected by various kinds of natural disasters like floods, droughts, cyclones, and salinity intrusion.

Uddin et al. (2014) found that the lack of irrigation water was the top most problem for crop cultivation in the southwest coast of Bangladesh.

Next in order of the problems faced by the farmers during adaptations are the following: inadequate access of information > lack of market access > unavailability of salinity tolerant species > shortage of farm inputs > traditional practices/beliefs > non-availability of storage and processing of agro-product > government's inadvertence to monitor climate risk management programs > poor soil fertility (Table 4). Similar types of work were done by Satishkumar et al. (2013) and Uddin et al. (2014).

3.5 Empirical model results

The result of the regression model (Table 5) showed that age positively influenced the farmer's adaptation strategies to climate change impacts. It highlighted that the adoption of adaptation strategies was significantly increased among young and middle-aged farmers, rather than old farmers, and they were more interested in taking adaptation decisions and preferred modern techniques for combatting climatic impacts. Akanda and Howlader (2015) and Adeogun et al. (2008) have found the same result that age acts as a positive influencing factor for farmer's adaptation strategies.

The findings of the regression model showed that education was positive and significantly related to farmer's adoption of climate change adaptation strategies because an educated farmer is more knowledgeable and skilled rather than an uneducated farmer. Educated farmers have a clear perception about climate change-related impacts and future scenarios, and also have better access to different types of information and facilities, etc., which influence a farmer to take better adaptation decisions than others. Quayum and Ali (2012) and Adeogun et al. (2008) have found the same result that education positively influences a farmer for adopting new adaptation technology.

On the other hand, there was a negative relationship between family size and farmer's adaptation strategies. The levels of adaptation strategies are gradually reduced with the increasing number of family members. Uddin et al. (2014) have found a similar result.

Family income has a significant positive relation between adoptions of adaptation strategies. The farmers with high household incomes are more adaptive than the farmers with less family income because the high-income families earn money from diverse sources such as off-farm activities. So they can tackle climate change effects and can continue their agricultural activities. In contrast, the reverse relationship is found in the lower-income families. Uddin et al. (2014) and Nhemachena and Hassan (2007), also explained a similar relationship.

Table 5. The results of binary logistic regression model

Dependent variable	Independent variable	β-value	Std. error	p value
Adoption of adaptation strategies to climate change	(Constant)	0.407	0.575	0.483
	Age	0.017	0.006	0.010*
	Education	0.003	0.059	0.959
	Family size	-0.001	0.035	0.977
	Family income	0.00004	0.000	0.042*
	Farm size	-0.016	0.013	0.209
	Farming experience	-0.017	0.008	0.038*
	Training received	0.088	0.229	0.704
	Organizational participation	-0.281	0.116	0.020*

*95% significant level

The regression model also represented a negative relationship between farm size and adaptation strategies to climate change impacts. Large farm size requires large farm inputs such as large investment, labor force, seeds, agro-chemicals, fertilizers, irrigation, etc. which creates a problem for proper management. So, the large farm is not able to take adaptation decisions effectively. Uddin et al. (2014) and Adeogun et al. (2008) found that farm size negatively influences the adoption of adaptation strategies.

A negative and meaningful relationship was found between farming experience and adoption of adaptation strategy. Experienced farmers are not interested to take adaptation strategies regarding climate change impact. They expressed their interest in traditional methods rather than modern agricultural practices. A similar outcome was also found by Howlader and Akanda (2016) and Adeogun et al. (2008).

Another positive relationship was found between training received and adaptation to climate change. Through receiving training, farmers can easily determine climate change issues and can take more adaptation strategies for minimizing the negative effects of climate change than those who do not receiving any training. Uddin et al. (2014) also found a positive relationship between training and the adoption of adaptation strategies.

Organizational participation was negative and significantly related to farmer's adaptation strategies to climate change impact. The farmers who are not interested in participating in different types of organizational agricultural program, and don't have diversified knowledge about agricultural-related information, modern farming practices, etc., don't take part in any role in climate change adaptation measures. Moreover, they follow traditional methods rather than modern farming techniques. This result is also supported by Loria and Bhardwaj (2016).

4. CONCLUSION

Kamarkhola union (study area) is one of the most vulnerable areas to climate change due to: impact of repeated natural calamities every year, low adaptive capacity due to resource constraints, poverty and high dependence on agriculture for livelihood which greatly impacts on agricultural sector. The urgent need in this situation is to give utmost priority to farmer's understanding of climate change and the factors affecting them to adopt the best adaptation decisions to cope with these situations. However, farmer's perception of climate change is a prerequisite for introducing adaptation strategies, so policymakers would benefit from such understanding to introduce new adaptation strategies at the policy level. In terms of understanding farmer's perceptions of climate change based on their past experiences and long-term observation of climate variables like temperature and precipitation levels, the survey results show that farmer's perceptions of climate variability are very similar to what is happening in reality; for example, increase in temperature and reduction of rainfall, long summer and shorter winter, and erratic rainfall due to delayed monsoon is very common today. This eventually causes the formation of cyclones, storm surges, coastal flooding, and saline water intrusion in the coastal area. To cope with these adverse conditions, most farmers adopt strategies related to sustaining agricultural practices, changing farm systems and income-generating activities using their own local strategies, indigenous knowledge and skills to overcome difficulties during adaptation as well as increase their level of financial status. Among all the strategies, irrigation, off-farm jobs, and integrated farming are the most adopted practices. Furthermore, adaptation decisions are significantly influenced by age, education, family income, family members, farm size, and farming experiences. To ensure the effectiveness and sustainability of adaptation practices, the study recommends increasing the provision of effective training and early warning systems and credit and market access facilities.

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