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Climate Change Perception and Adaptation Strategies of Southwest Coastal Bangladesh

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Abstract

Bangladesh is cited as one of the most vulnerable countries to the impacts of climate change. Climate change poses serious impacts on agricultural sustainability, food security, natural resources and rural livelihood pattern. The study investigates farmers' perception to climate change and their agricultural adaptation in the coastal area of Bangladesh. Two hundred household survey were conducted in Satkhira and Barguna district. Study revealed that farmers were well aware of climate change and they observed an increased temperature, rainfall, number of cyclones, flood intensity etc. over the years in the study area. Farmers' thought that weed and pest infestation, disease outbreak and pesticide use have been increased due to the change in temperature and rainfall. Water logging, cyclone, river erosion and salinity were identified as the major environmental problems in the study area. However, the study identified 28 adaptation strategies that have been adopted by the farmers to reduce the impact of climate change. Crop diversification, introduction of new crops that can resist climatic stress, crop rotation, mix cropping, change in planting and harvesting date, shortening growing season, homestead gardening, application of organic fertilizers and pesticide, increased use of irrigation, different soil conservation techniques and income diversification were found as the most common adaptation measures. The results of the regression analysis showed that socioeconomic characteristics of the farmers (age, education, farming status and experience, farm income etc.) and their perception to climate change influenced the farmers in choosing different adaptation strategies. The adaptation measures were economically profitable as well as agriculturally sustainable though lack of experience and knowledge, agricultural extension services, availability of inputs and lack of credit facilities were identified as the major challenges in the area.

Keywords: Climate change impacts; farmers' perception; agricultural adaptation; southwest coastal Bangladesh .

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1. Introduction

Climate change is one of the major global environmental issues threatening sustainable development of the world [1]. The excessive GHGs emission from different anthropogenic sources are responsible for the observed climate change [2]. The concentration of CO_2 has been increased about 100 ppm over the period of 1880 to 2010 [3]. Moreover, global surface temperature has been increased about 0.85 °C in the same time period and it is predicted to be increased from 1.8° C to 4° C by the end of the century [3]. On the other hand, mean sea level rose 0.19 meters during 1901 to 2010 and is also predicted to be rose between 0.18 to 0.59 meters by 2100 [2, 3]. Along with these, increase of heavy precipitation and heat waves events have already been observed [3]. More than 526000 people died because of extreme weather event during 1998-2017 where the developing countries were mostly affected [4, 5]. In developing countries, people are more vulnerable to these extreme events because of the less availability of natural resource to cope with this condition [6]. Ecosystem functioning and agriculture are mostly affected by the changing climate [2]. Climate change also poses risk to the global food security [7]. However, agricultural sector is mostly affected by the extreme climatic events along with soil salinity, incidence of epidemic pest and disease [8]. Bangladesh is one of the most vulnerable countries to climate change due to its dependency on agriculture [9, 10]. The agricultural sector currently employs about 48% of the country's labor force and contributes about 19% of country's gross domestic product (GDP) [11]. Despite of high contribution of agriculture to this country's economy, this sector is confronted by different climatic factors such as change of temperature, rainfall pattern, drought and natural disasters (tropical cyclones, storm surges etc.). The climatic factors are affecting the agricultural production which leads to the high risk to the food security of the large population of Bangladesh [12, 13]. More than 30% of the cultivable land in Bangladesh is in the coastal area [14] and about 1.0 million ha of arable lands were affected by varying degrees of salinity in coastal region [15]. Salinity has been increased to 26% in the coastal region over the last 35 years [10]. Aman production was decreased due to the increase of maximum temperature [16]. Moreover, production of wheat and potato would be reduced to 48% and 39% respectively due to change of temperature by 5.32 ºC. [17]. Adaptation to climate change is recognized as one of the key policy instruments to minimize the vulnerability in developing countries though it was not received much attention in early days [18]. Adaptation is necessary to reduce the vulnerability and negative impacts [19]. Local knowledge can promote better understanding of climate change and its impacts [20]. Perceptions of local communities about climate change play significant role in policy framework as perceptions influence people's decisions to act and suggest what adaptive measures should be taken [21]. Therefore, local observations and perceptions are needed to be considered in efforts to understand climate change, its impacts, adaptation and mitigation [20]. Several studies have been conducted to identify the impact of climate change in Bangladesh [13, 18, 22-24]. These studies attempted to identify the preferred adaptation strategies in the agricultural sector of Bangladesh. But few of these studies tried to identify the influence of socioeconomic status of the community people on choosing the preferred adaptation options. Moreover, scientific study of farmers' perception and agricultural adaptation is very scarce in the study area. As the agriculture in the coastal area is threatened due to different climatic factors, it's very necessary to find out what rural communities are thinking about climate change and how they are coping with this change. Moreover, their capacities and challenges to climate change and adaptation are needed to be explored for a sustainable agricultural sector. Therefore, the main objective of the study has been set to

identify the perception of farmer about climate change and their adaptive methods. The specific objectives of this study are:

a) To know farmers' perceptions on climate change and its impact on agriculture;
b) To identify different adaptation strategies in agricultural sector;
c) To assess the influence of their socioeconomic characteristics on taken adaption measures.

However, lack of funding restricted the attempts of taking higher degree of sample size which could provide better results. Moreover, respondents sometimes don't feel inspired to provide proper information in survey. Lastly, respondents who didn't respond to survey might have different view than who responded and thus creating bias. These are the limitations of the study.

2. Review of Related Literature

Bangladesh is mainly agro-based economic country [25]. The land is very fertile, and weather is favorable and therefore, agricultural production contributed about 19% of the national GDP in Bangladesh [11]. Agriculture is also employing about 48% of the total labor force in Bangladesh [11]. Moreover, about 85% rural population are directly or indirectly involved in agriculture [26] whereas in coastal area, about 40 million people depend on it [27]. Bangladesh ranked as the sixth most vulnerable country according to the Global Climate Risk Index [5]. Bangladesh, locating between the Himalayas and the Bay of Bengal, is also cited as the worst affected country due to natural disasters [28]. Climate change is adversely affecting the people's livelihood in the coastal areas of Bangladesh [29]. Moreover, the changes in climate also affect the agriculture, food security, ecosystems, infrastructure, water resources and human health. [2]. However, climate remains as the key determinant of the agricultural productivity where temperature and rainfall are considered as the primary drivers. Crop production is predicted to be decreased by 30% by 2100 due to increase in temperature, irregular and heavy rainfall [30]. Cropping season, evapotranspiration and water requirements for irrigation will be affected due to temperature change [31]. The sea level of the coast of Bangladesh is increasing up to 3mm in a year [32]. Land salinization and degradation of water resources negatively affect the crop production [33] and reducing crop yield in the worldwide [34]. Soil and water salinity and waterlogging are cited as the main constraints to the crop production in southern Bangladesh [35]. The economy of Bangladesh will be affected as a result of change in agricultural pattern [36]. Impacts of climate change on the livelihood and natural resources have already been felt by local communities [37]. Adaptation is needed to minimize the impact of climate change in agriculture and these adaptation measures vary in regional agro-ecological context [38]. Adopting different adaptation measures can be effective in agricultural production as well as to the development of a country [39]. Adaptation in agriculture is required for ensuring food security [40]. Climate adaptive agriculture is currently implemented, such as, crop varieties (saline and drought resistant rice), sustainable wastewater use, fish breeding technologies, community awareness building and ensuring a flow of climate related information in policy and planning [41]. Change in crop varieties, introduce new crops and crop rotations were found as few of the ways to adapt with climate change [42]. On the other hand, Fosu-Mensah and his colleagues (2012) found crop diversification, use new crops, plantation of short season varieties and shifting in planting date as the major adaptation measures in their study [43]. Moreover, switching the livelihood frequently was common in responding climate change [22, 44].

Pender (2007) revealed that people were found adapting with the situation by sharing losses, modifying threats, changing location, preventing effects etc. in Bangladesh [23]. Anik and Khan (2012) found few different measures like floating garden, cage aquaculture, wave protection wall etc. in the eastern region of Bangladesh [22]. Crop rotation, using new varieties and adjustment in production process and marketing policy allowed the farmers to reduce the impact of change in local weather and resource condition [39]. Farmers are well-aware of the issues regarding local climatic variability [45]. Moreover, Haque and his colleagues (2012) found that most of the respondents (95%) perceived an increasing summer temperature which was damaging the agriculture and livelihood [46]. And their perception aligned with the ongoing climate change [37, 40] though few studies found vice-versa [22]. Alauddin and Sarker (2014) found that farmers could even perceive micro-level climatic variability [13]. Study found a significant relationship between smallholder farmers' perception on floods and droughts and their adoption of different practices such as zero tillage, crop rotations, application of organic fertilizers [47]. Lack of technical knowledge, information, funds and access to inputs and land were found as major challenges while taking these adaptation measures [40, 48]. Non-climatic factors were considerably important than climatic factors for agricultural adaptation of small farmers as they said. Human cognition and social networks were also influenced the adaptation measures. Fosu-Mensah and his colleagues (2012) found that lack of extension services, credit facilities, soil fertility, and land tenure were most significant factors that affect farmers' perception and adaptation [43]. Planned adaptations are needed to be designed and promoted that befit with local context [49]. Farmers' education is also required to effectively adopting adaptation measures [48].

3. Materials and methods

3.1. Study area

Coastal zone of Bangladesh consists of 19 districts, covering 32% of the country having more than 35 million people [50]. The study was conducted in two districts namely Satkhira and Barguna (Figure 01) which belong to south western coastal region of Bangladesh. The southwest coastal region of Bangladesh is the most disaster-prone areas in Bangladesh as well as very vulnerable to the effects of climate change [51]. However, Satkhira district lies between 21º36' and 22º54' north latitudes and between 88º54' and 89º20' east longitudes. The total area of the district is 3817.29 km2 of which 1534.88 km2 is under reserve forest. On the other hand, Barguna lies between 21º48′ and 22º29′ north latitudes and between 89º52′ and 90º22′ east longitudes. The total area of the district is 1,831.31 km2 of which 399.74 km2 is riverine and 97.18 km2 is under forest. Four unions (Agardari, Labsha, Sorulia and Asasuni) were selected from Sadar, Tala and Asasuni upazila of Satkhira whereas two unions (Burir Char and Naltona) were selected from Barguna Sadar upazila. Most of the peoples of Satkhira depend on agriculture, fishing and shrimp farming [52]. On the other hand, the economy of Barguna is primarily dependent on agriculture where the principal crops include rice and pulses [53].

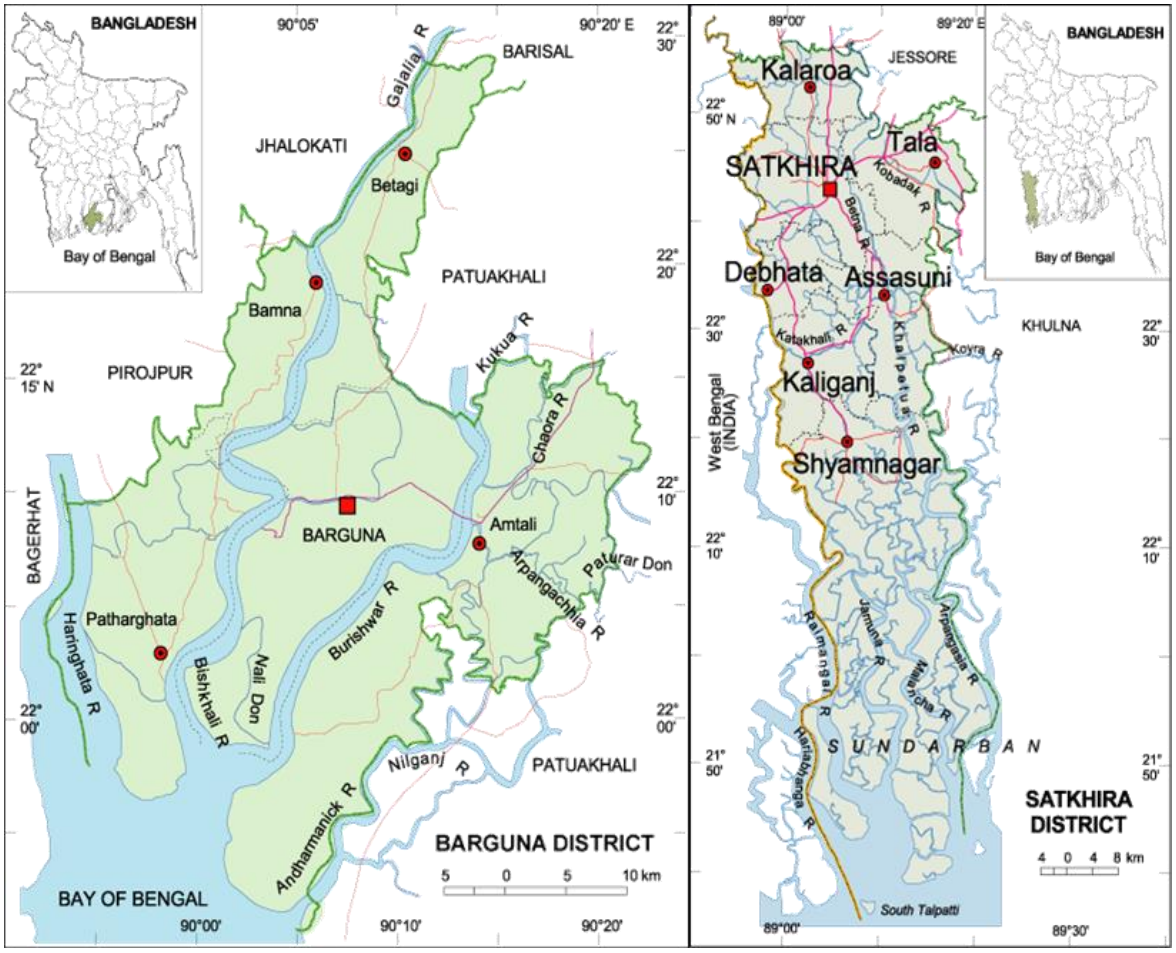

Figure 1: Study Area

3.2. Methods

The study area was selected purposively as the area is considered as most vulnerable region due to impact of climate change. A reconnaissance survey was conducted in both of the districts to get basic information about the locality, agricultural system and existing adaptation techniques. After that, quantitative data was collected using semi-structured questionnaire from household to know farmers' perception to climate change and adaptation techniques. A sample of 200 households (Satkhira-110, Barguna-90) have been selected randomly for the present study. Primary data was analyzed using descriptive statistics. Multinomial logistic regression was performed to prepare a Multinomial Logit Model (MNL) using SPSS software to assess the statistical significance of socioeconomic characteristics on agricultural adaptation. The regression was performed between 19 socioeconomic and climatic variables (explanatory variables – Table 01) and 20 adaptation techniques from 28 adaptation techniques (dependent variables – Table 05).

Table 1: Explanatory variables (socioeconomic status) used in the regression analysis

Sl. No	Explanatory Variables	Description
1	Age of the Respondents	Continuous
2	Farming Experience	Continuous
3	Education	Continuous
4	Farm Income	Continuous
5	Non-farm Income	Continuous
6	Cultivable land	Continuous
7	Land holing size	Continuous
8	Total expenditure	Continuous
9	Farming Status	Dummy, takes the value of 1 if full time farmer and 2 otherwise
10	Climate Change Perception	Dummy, takes the value of 1 if knew and 2 otherwise
11	Predict Disaster	Dummy, takes the value of 1 if yes and 2 if no
12	Affect Water Availability	Dummy, takes the value of 1 if yes and 2 if no
13	Change in Temperature	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know
14	Change in Total Rainfall	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know
15	Change in Cyclone & storm surges	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know
16	Change in flood intensity	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know
17	Change in water logging condition	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know
18	Change in Yield (Temperature)	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know
19	Change in Yield (Rainfall)	Dummy, takes the value of 1 if yes and 2 if no; In case of 1, mode of change was increase or decrease and for 2, No change or don't know

4. Results

4.1. Socio-economic characteristics

The study found that more than half of the respondents (n=116, 58%) in the study area were in the age group of 30-49 years (Table 02). On the other hand, about half of respondent (n=112, 56%) had farming experience between 11-30 years. Most of them (n=135, 67.5%) were full time farmers and took farming as the primary occupation (n=122, 61%). About 29% (n=58) of them had no formal education. About 47% (n=94) of the respondents had yearly income of about 70,001-110,000 BDT whereas about 75% (n=150) had monthly expenditure of about 3,001-9,000 BDT. About 30% (n=60) and 46.5% (n=93) of the respondents were found as marginal (5-50 Decimal) and small farmers (51-247 Decimal) respectively. On the other hand, about 58% of the farmers found cultivating 1-100 decimal of land. The study also found that about 46.5% (n=93) of the respondents took different types of loan from different organizations.

Table 2: Socioeconomic characteristics of the respondents

Group	Classification	Satkhira	Barguna	Total
		Number of respondents, n (%)	**Number of respondents, n (%)**	**Number of respondents, n (%)**
Age	30-39 years	22 (20)	31 (34.4)	53 (26.5)
	40-49 years	43 (39.1)	20 (22.2)	63 (31.5)
Experience	11 to 20 years	24 (21.8)	30 (33.3)	54 (27)
	21 to 30 years	35 (31.8)	23 (25.6)	58 (29)
Farming status	Full Time	75 (68.2)	60 (66.7)	135 (67.5)
	Part Time	35 (31.8)	30 (33.3)	65 (32.5)
Educational Status	No formal education	31 (28.2)	27 (30)	58 (29)
	Primary	12 (10.9)	9 (10)	21 (10.5)
Primary Occupation	Farming	67 (60.9)	55 (61.1)	122 (61)
	Sharecropping	23 (20.9)	24 (26.7)	47 (23.5)
Secondary occupation	No Profession	7 (6.4)	1 (1.1)	8 (4)
	Small trading	5 (4.5)	3 (3.3)	8 (4)
Yearly income (in BDT)	70001-110000	54 (49.1)	40 (44.4)	94 (47)
	110001-150000	29 (26.36)	9 (10)	38 (19)
Monthly expenditure (in BDT)	3001-6000	30 (27.3)	47 (52.2)	77 (38.5)
	6001-9000	45 (40.9)	28 (31.1)	73 (36.5)
Distribution of land (Decimal)*	Marginal farmer (5-50)	37 (33.6)	23 (25.6)	60 (30)
	Small farmer (51-247)	48 (43.6)	45 (50)	93 (46.5)
Distribution of cultivated land (Decimal)	1-100	67 (60.9)	49 (54.4)	116 (58)
	101-200	22 (20)	26 (28.9)	48 (24)
Loan status	Yes	42 (38.2)	51 (56.7)	93 (46.5)
	No	68 (61.8)	39 (43.3)	107 (53.5)

4.2. Farmers' perception to climate change

Farmers' perception towards climate change is a prerequisite for devising subsequent adaptation strategies. The study revealed that the farmers heard the term "Climate Change" in both Satkhira (n=81, 73.6%) and Barguna

(n=55, 61.1%). They study found that about 86% (n=94), 65% (n=71), 70% (n=77), 77% (n=85), 56% (n=62) and 76% (n=84) of the respondents observed an increasing temperature, total rainfall, rainfall variability, number of cyclone and storm surge, flood intensity and waterlogged condition respectively in Satkhira (Table 03). On the other hand, farmers in Barguna also observed an increasing trend in temperature (n=78, 87%), total rainfall (n=61, 68%), rainfall variability (n=69, 77%), number of cyclone and storm surge (n=78, 87%), flood intensity (n=60, 67%) and waterlogged condition (n=62, 69%). Only a significant number of respondents said that they observed a decreasing total yearly rainfall in both Satkhira (n=37, 33.6%) and Barguna (n=26, 28.9%). They study also found that an insignificant number of farmers observed no change and few of them didn't have any idea about these climatic variables.

Table 3: Farmers' perception to climate change

	Number of Farmers, *n* (%)							
	Increase		**Decrease**		**No change**		**Don't know**	
Parameter	**Satkhira**	**Barguna**	**Satkhira**	**Barguna**	**Satkhira**	**Barguna**	**Satkhira**	**Barguna**
Temperature	94 (85.5)	78 (86.7)	7 (6.4)	3 (3.3)	7 (6.4)	5 (5.6)	2 (1.8)	4 (4.4)
Total rainfall	71 (64.5)	61 (67.8)	37 (33.6)	26 (28.9)	1 (.9)	2 (2.2)	1 (.9)	1 (1.1)
Rainfall variability	77 (70)	69 (76.7)	13 (11.8)	7 (7.8)	12 (10.9)	7 (7.8)	8 (7.3)	7 (7.8)
Cyclone & storm surge	85 (77.3)	78 (86.7)	12 (10.9)	7 (7.8)	12 (10.9)	3 (3.3)	1 (.9)	2 (2.2)
Flood intensity	62 (56.4)	60 (66.7)	15 (13.6)	14 (15.6)	26 (23.6)	12 (13.3)	7 (6.4)	4 (4.4)
Waterlogging	84 (76.4)	62 (68.9)	11 (10)	11 (12.2)	12 (10.9)	11 (12.2)	3 (2.7)	6 (6.7)

4.3. Effects of climate change on agriculture

The ongoing climate change have a negative impact on the agriculture. The study found that farmers perceived an increasing crop production (n=77, 70% and n=70, 78%), weed infestation (n=90, 782% and n=61, 68%), pest infestation (n=95, 86% and n=63, 70%), disease outbreak (n=84, 76% and n=57, 63%) and pesticide use (n=89, 81% and n=76, 84%) in both Satkhira and Barguna due to the change in temperature (Table 04). However, few of the farmers thought that didn't observe any impact of temperature change on agriculture though few other perceived that it decreased crop production, weed infestation, pest infestation, disease outbreak and pesticide use. Most of the people also thought that the change in temperature affected growing season (68%) and water availability (68%). On the other hand, most of the farmers thought that the change in rainfall increased the crop production (n=71, 65% and n=69, 77%), grain size (n=61, 56% and n=65, 72%) and weight (n=61, 56% and n=64, 71%) both in Satkhira and Barguna. The study also found that water logging, cyclone and salinity were the major environmental problems in Satkhira as the people thought. On the other hand, cyclone, river erosion and salinity were the major environmental problems mentioned by the people of Barguna.

Table 4: Effect of temperature and rainfall change on agriculture

Effect of Temperature Change	Increase (%)		Decrease (%)		No Change (%)	
	Satkhira	Barguna	Satkhira	Barguna	Satkhira	Barguna
Change in yield	77 (70)	70 (77.8)	23 (20.9)	18 (20)	10 (9.1)	2 (2.2)
Change in weed	90 (81.8)	61 (67.8)	10 (9.1)	22 (24.4)	10 (9.1)	7 (7.8)
Infestation						
Change in Pest	95 (86.4)	63 (70)	10 (9.1)	19 (21.1)	5 (4.5)	8 (8.9)
Infestation						
Change in disease	84 (76.4)	57 (63.3)	6 (5.5)	15 (16.7)	20 (18.2)	18 (20)
Outbreak						
Change in	89 (80.9)	76 (84.4)	3 (2.7)	5 (5.6)	18 (16.4)	9 (10)
pesticide use						

Effect of Temperature Change	Yes (%)		No (%)	
	Satkhira	Barguna	Satkhira	Barguna
Change in	75 (68.2)	61 (67.8)	35(31.8)	29(32.2)
growing season				
Affect water	72 (65.5)	64 (71.1)	38(34.5)	26(28.9)
Availability				

Effects of Change in Rainfall	Increase (%)		Decrease (%)		No Change (%)	
	Satkhira	Barguna	Satkhira	Barguna	Satkhira	Barguna
Change in yield	71 (64.5)	69 (76.7)	34 (30.9)	20 (22.2)	5 (4.5)	1 (1.1)
Change in grain						
Size	61 (55.5)	65 (72.2)	25 (22.7)	12 (13.3)	24 (21.8)	13 (14.4)
Change in grain						
Weight	61 (55.5)	64 (71.1)	25 (22.7)	13 (14.4)	24 (21.8)	13 (14.4)

4.4. Farmers' adaptation strategies

Farmers adopted 28 adaptation strategies to reduce the impact of climate change in agricultural sector though their frequency varied depending on the geographical characteristics and practices in Satkhira and Barguna (Table 05). The study found that about 67% and 79% of the respondents used diversified crops in Satkhira and Barguna respectively. On the other hand, about 66% and 56% farmers introduced new crops in Satkhira and Barguna respectively. In Satkhira, about 57%, 36% and 11% of the farmers used new crops that required less

water, could tolerate high temperature and high saline condition respectively. On the other hand, 47%, 29% and 24% of the farmers used new crops that required less water, could tolerate high temperature and high saline condition respectively in Barguna. About 61% and 67% of the respondents practiced crop rotation in their agricultural field in Satkhria and Barguna respectively.

Table 5: Respondents choice of adaptation technique in the both study area

Sl.	Adaptation Measures	No. of Respondents, n (%)	
		Satkhira	**Barguna**
1	Crop Diversification	74 (67.3)	71 (78.9)
2	Introduction of New Crops	73 (66.4)	50 (55.6)
3	New Crops that Requires Less Water	63 (57.3)	42 (46.7)
4	New Crops that Adapted Higher Temperature	39 (35.5)	26 (28.9)
5	New crops that adapted to saline condition	12 (10.9)	22 (24.4)
6	Crop Rotation	67 (60.9)	60 (66.7)
7	Change in planting and harvesting date	78 (70.9)	63 (70)
8	Shortening Growing Season	75 (68.2)	63 (70)
9	Homestead gardening	86 (78.2)	47 (52.2)
10	Plantation in Heap	34 (30.9)	60 (66.7)
11	Mix cropping	70 (63.6)	71 (78.9)
12	Application of pesticide	99 (90)	86 (95.6)
13	Construction of Embankment	15 (13.6)	52 (57.8)
14	Gardening in *Mucha*	56 (50.9)	45 (50)
15	Planted Shade Trees	25 (22.7)	47 (52.2)
16	Change the time of fertilizer use	72 (65.5)	63 (70)
17	Use of Organic Fertilizer	97 (88.2)	37 (41.1)
18	Enhancing the efficiency of fertilizer use	69 (62.7)	62 (68.9)
19	Measures to decrease salinization from field	18 (16.4)	29 (32.2)
20	Water conservation	44 (40)	57 (68.3)
21	Increased use of supplementary irrigation	66 (60)	0
22	Floating Garden	9 (8.2)	13 (14.4)
23	Cage aquaculture	13 (11.8)	23 (25.6)
24	Re-digging of Canal	66 (60)	48 (53.3)
25	Used Ground Water	70 (63.6)	0
26	Soil Conservation Techniques	60 (54.5)	62 (68.9)
27	Off farm employment	52 (47.3)	61 (67.8)
28	Leased crop land	55 (50)	36 (40)

About 71% and 70% of the respondents in Satkhira and Barguna changed the planting and harvesting date in according to the changing climatic pattern respectively. Among the respondents, about 68% in Satkhira and

about 70% in Barguna found cultivating short duration crop species. Around 78% of the respondents in Satkhira found practicing homestead gardening whereas only 52% of the interviewee in Barguna practiced this measure. However, the respondents of Barguna showed more interest on plantation in heap (67%) whereas about 31% of the farmers took plantation in heap as an adaptation measure in Satkhira. However, about 64% farmers in Satkhira and 79% farmers in Barguna practiced mixed cropping. More than 90% farmers found using different types of pesticides in their land in both areas. Around 14% and 58% of the farmers constructed or repaired embankments in Satkhira and Barguna respectively. Many of the farmers (Satkhira- 51% and Barguna-50%) found making garden in Mucha (bamboo and net made structure). About 8% and 14% farmers were found building floating garden and cultivated different types of vegetables. Farmers of Barguna (52%) preferred planting shade trees than from Satkhira (23%). The study found that 88% respondents in Satkhira and only 41% of the respondents used organic fertilizer. About 66% farmers in Satkhira and 70% farmers in Barguna changed the time of using fertilizer to increase their farm productivity. On the other hand, about 63% farmers in Satkhira and 69% farmers in Barguna used new techniques during applying fertilizers in their field. They also adopted measures to decrease salinization of agricultural field in Satkhira (16%) and Barguna (32%). About 68% of the respondents of Barguna practiced different water conservation techniques whereas about 40% found practicing in Satkhira. Surprisingly, none of the farmers depended on supplementary water and groundwater for irrigation in Barguna whereas about 60% and 64% farmers used supplementary water and groundwater for irrigation respectively in Satkhira. The study also found that respondents practiced cage aquaculture in both Satkhira (12%) and Barguna (26%) area. Moreover, farmers in Satkhira (60%) and Barguna (53%) were found re-digging the canal. About 55% and 69% farmers used different types of soil conservation techniques in Satkhira and Barguna respectively. Farmers were found taking different off farm employment in both Satkhira (47%) and Barguna (68%). The study found that about 50% and 40% of the farmers leased crops in Satkhira and Barguna respectively.

4.5. The Determinants of Farmers' Choice of Adaptation Methods

A regression analysis was performed to find out the factors affecting the choice of adaptation techniques adopted by the farmer community. The results of regression analysis (Table 06) showed that different explanatory variables (socio-economic factors and climatic factors) significantly influences the probability of farmers' choice of adaptation. The age of the farmers significantly increased the likelihood that they used ground water and decrease the probability that farmers changed the planting and harvesting date and took measures to decrease salinization as methods of adapting with changing climate. Farming experience of the farmers had a significant positive impact on changing in planting & harvesting date, used ground water, leased crop land. Full time farmers were likely to introduce new crops in their land and planted shade trees in agricultural land. But farming status had a negative relation with taking off farm employment of the farmers. Education of the farmers significantly increases the probability to use groundwater in the agricultural land. Farm income of the respondents had a significant positive influence on the re-digging of canal, used ground water, took measure to decrease salinization, introducing the new crops that requires less water and crop rotation practice in their farmland. On the other hand, non-farm income significantly increases the likelihood that they adopted mix cropping, leased crop land to adapt with climate change.

Table 6 (A): Results of regression analysis between socioeconomic status, perception and adaptation strategies

	Crop Diversification		**Introduction of New Crops**		**New Crops that Requires Less Water**		**New Crops Adapted to saline condition**		**Crop Rotation**		**Changing in Planting & Harvesting date**		**Shortening growing season**		**Mix cropping**		**Gardening in Mucha**		**Enhancing efficiency of fertilizer use**	
Explanatory Variables	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**	**Coefficients**	**P Value**
Age of the Respondents	1.042	.677	-.012	.130	-.004	.681	-.007	.267	.008	.293	-.016	**.037**	.003	.664	-.005	.496	-.010	.220	.002	.762
Farming Experience	-.003	.716	.001	.866	-.002	.848	-.001	.812	-.013	.081	.015	**.041**	-.003	.695	.001	.931	.006	.413	-.012	.116
Farming Status	.003	.868	.238	**.012**	.073	.474	.077	.286	-.089	.334	-.005	.954	-.040	.657	.158	.088	.052	.595	.068	.461
Education	.016	.745	-.006	.557	.001	.934	-.011	.151	.014	.148	-.005	.589	-.004	.652	.008	.435	.012	.242	-.015	.134
Farm Income	.003	.600	-0.000	.323	.126	**.036**	.113	.060	.436	**.001**	.177	.348	.090	.608	.441	.810	0.000	.960	.756	**.004**
Non-farm Income	-.124	.204	-.195	.085	.009	.544	-0.000	.136	.129	.056	-.023	.289	-.009	.977	.125	**.041**	-0.000	.833	-.267	.721
Total Expenditure	-0.000	.349	.000	.791	-.432	.752	0.000	.316	.376	**.026**	.280	.199	-0.000	.359	.230	.071	.087	.121	-.432	.838
Land holding size	.001	.327	.000	.855	.000	.597	.000	.055	-0.000	.868	.000	.280	.000	.526	.001	.084	.000	.519	.000	.235
Cultivable land	.000	.163	.000	.786	.000	.559	.000	.413	.000	.755	.001	.340	.000	.602	-.002	.008	.000	.860	.000	.165
Perceive	.002	.985	.038	.675	.072	.457	.096	.165	-.041	.642	-.067	.456	-.086	.319	.190	**.032**	.012	.897	.244	**.006**

Climate Change																			
Predict Disaster	.149	**.038**	.008	.920	-.114	.211	-.100	.118	.103	.206	-.016	.849	.026	.745	.109	.180	-.090	.300	-.053	.514
Change in Temperature	-.116	.387	-.057	.669	.156	**.021**	.058	.569	.196	.130	-.086	.513	.062	.625	.022	.865	.001	.995	-.110	.395
Change in Rainfall	-.069	.751	-.303	.170	-.006	.969	-.170	.315	-.287	.182	-.111	.611	.033	.876	-.008	.969	.454	**.048**	-.167	.434
Cyclone & Storm surges	.095	.442	-.217	.081	-.010	.943	-.003	.977	.102	.400	.118	.338	-.092	.438	.101	.403	-.119	.357	-.213	.077
Changes in Flood intensity	-.085	.333	.050	.572	-.123	.204	.057	.406	-.240	**.006**	-.030	.736	.149	.081	-.042	.632	.057	.536	-.078	.368
Changes in Water logging	.032	.751	.114	.259	.105	.338	.203	**.009**	-.202	**.040**	.062	.535	.211	**.030**	-.078	.431	-.120	.250	.327	**.001**
Affect Water Availability	.119	.139	.180	**.028**	.110	.212	.017	.781	.136	.086	-.116	.149	.291	**.000**	.074	.349	-.171	**.042**	-.010	.901
Change in Yield due to Temp	.235	.169	.176	.305	.206	.268	.251	.057	.060	.717	.496	**.004**	-.120	.464	-.219	.190	.257	.149	.114	.494
Change in Yield due to Rainfall	-.200	.355	-.145	.507	-.201	.396	-.147	.380	.529	**.013**	-.402	.065	.269	.198	-.030	.888	-.013	.953	.426	**.045**

Table 06 (B): Results of regression analysis between socioeconomic status, perception and adaptation strategies

Explanatory Variables	Re-digging of canal		Used ground water		Soil conservation		Off farm employment		Leased crop land		Supplementary irrigation		Water conservation		Measure to decrease salinization		Planted shade trees		Reduce tillage and deep ploughing	
	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value	Coefficients	P Value
Age of the Respondents	-.002	.853	.017	**.023**	-.002	.830	.003	.654	.045	.007	-.002	.784	-.011	.188	-.013	**.048**	-.010	.202	-.009	.234
Farming Experience	-.010	.206	.023	**.015**	-.003	.742	-.004	.459	.015	**.012**	-.002	.810	.007	.416	.001	.861	.003	.631	.006	.378
Farming Status	-.062	.521	-.080	.355	.075	.455	-.305	**.000**	-.074	.307	-.080	.392	.039	.704	.051	.529	.180	**.045**	-.047	.581
Education	.005	.617	-.018	**.047**	-.004	.681	-.004	.548	-.003	.699	-.006	.538	.001	.928	-.010	.240	-.003	.747	.003	.729
Farm Income	.493	**.011**	.756	**.001**	-0.000	.367	-.678	.145	-.219	.146	-.634	.182	.089	.627	.415	**.006**	.126	.094	.078	.647
Non-farm Income	.006	.117	.234	.892	-.804	.804	-0.000	.543	.517	**.001**	-.192	.314	-0.000	.766	-.876	.375	-.234	.130	.219	.093
Total Expenditure	-0.00	.099	.124	.061	.083	.720	.128	**.001**	-0.00	.092	-.098	**.024**	-0.00	.932	-.312	.558	-0.00	.640	-.076	**.002**
Land holding size	-.001	.079	.001	.290	.000	.688	-0.000	.974	-.003	**.000**	.000	.635	.000	.381	.000	.608	.000	.376	.000	.760
Cultivable land	.000	.774	.001	.187	.000	.513	-.001	**.015**	.003	**.000**	.001	**.034**	.000	.664	.000	.055	.000	.214	.000	.606
Perceive Climate Change	-.045	.621	-.095	.251	.083	.389	.009	.897	-.053	.441	.004	.966	.109	.262	.200	**.010**	.137	.109	-.076	.353

Predict Disaster	.111	.194	-.002	.976	.142	.112	-.046	.455	-.012	.855	-.044	.597	.198	**.010**	-.082	.256	.046	.561	-.048	.596
Change in Temperature	.152	.261	-.062	.614	-.107	.450	-.048	.620	-.004	.966	.135	.308	.103	**.032**	-.078	.496	.075	.550	-.026	.831
Change in Rainfall	.527	**.020**	.266	.191	-.024	.920	.054	.741	.216	.205	-.138	.530	.350	.134	-.261	.169	.163	.435	-.061	.761
Cyclone & Storm surges	.093	.461	-.084	.461	.264	**.047**	.083	.362	-.057	.548	-.081	.511	.143	.287	.011	.921	-.020	.863	-.009	.939
Flood intensity	.008	.931	-.260	**.002**	.024	.797	-.031	.638	.032	.643	.011	.898	.229	**.018**	.033	.661	.320	**.000**	.107	.187
Water logging	.193	.062	.082	.377	-.077	.472	-.027	.715	.024	.762	.304	**.003**	-.025	.819	.136	.116	-.009	.922	-.026	.773
Affect Water Availability	-.103	.215	.004	.961	.079	.361	.174	**.004**	.030	.630	.005	.948	.090	.306	.058	.407	-.053	.492	-.041	.580
Change in Yield due to Temp	.378	**.032**	-.396	**.013**	.073	.688	.295	**.020**	-.118	.372	.066	.696	.033	.859	.312	**.035**	-.177	.275	-.019	.901
Change in Yield due to Rainfall	-.224	.313	-.311	.123	.088	.706	.322	**.046**	.341	**.044**	.498	**.023**	-.106	.653	.103	.583	.047	.819	-.030	.878

Total expenditure of the family had a significant positive association with crop rotation and off farm employment and had a negative influence on use of supplementary irrigation and reduce tillage and deep ploughing. Land holding size of farmers significantly decrease the likelihood that they leased crop land from others. Cultivated land of farmers had a significant negative association with off-farm employment but positive significant impact on leased crop land and use of supplementary irrigation. Perception of climate change increases the likelihood of adopting mix cropping, enhancing efficiency of fertilizer use and measures to decrease salinity in agricultural field. The perception of waterlogged condition also negatively impacts on crop rotation.

The perception of affect water availability significantly increases the probability of introducing new crops, shortening growing season and off-farm employment and decrease the probability of Gardening in *Mucha*. However, change in yield due to rainfall had a positive impact on crop rotation, enhancing the efficiency of fertilizer use, off-farm employment, leased crop land and use of supplementary irrigation. On the other hand, the change in yield due to temperature had a positive impact on change in planting and harvesting date, re-digging of canal, off-farm employment, measure to decrease salinity and negative impact on used ground water.

5. Discussion

The study identified farmers' perception of climate change in Satkhira and Barguna. Most of the farmers perceived the climate change very well. They observed an increasing trend in temperature, total annual rainfall and rainfall variability. They also perceived that the number of cyclones has increased over years as well as the intensity of flooding and waterlogged condition. Scientific evidence supports their perception. Farmers also perceived that the change in climate had a negative impact on the agricultural sustainability. They thought that the change in temperature affected the change in crop yield. Moreover, increase of weed and pest infestation, disease outbreak and pesticide use due to change in temperature were found in the study area. Farmers also thought that it affected the crop calendar as well as water availability. However, change in total rainfall and rainfall variability positively affected the crop yield, grain size and grain weight as they thought. The study also identified a total of 28 common adaptation strategies in Satkhira and Barguna. Most of these adaptation measures were based on indigenous knowledge though few adaptations were supported by Govt. organizations and local NGO's. Farmers used diversified crops such as different kind of vegetables, fruits, oilseeds, pulses etc. which allowed to maintain nutrient balance in the agricultural field. The farmers also introduced new crops such as mustards, sesames, peas, potatoes, tomatoes, etc. in their land that could adapt in stressed climatic condition. Farmers also introduced new crops that could tolerate high temperature, live in less water and saline condition. Farmers practiced a series of dissimilar crops such as rice-mustard-rice, rice-potato-rice in the same field in sequential season. They also changed the planting and harvesting date in according to the changing climatic pattern. Bangladesh Rice Research Institute (BRRI) invented genetically modified species for different areas considering their geography and weather that has high production rate as well as short life span. Farmers were also found to cultivate these species (BRRI- 28, 36, 39) in their land. Homestead gardening was a common practice in the study area which could provide additional food support to the family. Significant number of the farmers practiced plantation in heap which helped to sustain in waterlogged condition. However, farmers practiced mixed cropping (rice-turmeric, rice-pulse, chilli-garlic-onion, pulse-chilli, sunflower-sesame-pulse) in their land which improved the fertility of the soil and increased crop yield. Moreover, crop diseases and pest attack are increasing due to the changing climate. Farmers used increased amount of pesticide to get rid of it. Barguna was vulnerable in river erosion and therefore, farmers constructed or repaired embankments to protect their land from being eroded. The number was very low in Satkhira. On the other hand, many of the farmers found cultivating vegetables in Mucha in saline affected and flood prone area as well as they built floating garden and cultivated different vegetables in flood prone area. Use of organic fertilizers were very common in Satkhira than Barguna as livestock animals were comparatively available there. The study also found that farmers changed the time of using fertilizers as time of sowing and harvesting has been changed. Farmers also used new techniques such as using Guti Urea during applying fertilizers in their field as excessive use of

fertilizer could hamper the sustainability of the land. The salinity of land was increasing in both area as the upstream flow of the river water were decreasing and therefore, the people were taking measures like use of farmyard manure, deep ploughing, drainage management etc. Farmers didn't depend on ground water and supplementary irrigation for their agricultural production in Barguna though a remarkable number of farmers used supplementary water and groundwater for irrigation in Satkhira. The surface water is comparatively less saline in Barguna and farmers used it for their irrigation. Few of the farmers practiced cage aquaculture to protect fishes from being flooded in heavy rainfall and frequent flooding. Moreover, farmers re-dug the canal to protect themselves from frequent flooding events. Canals are also used to reserve the water in monsoon for irrigation. Farmers adopted different soil conservation techniques such as conservation tillage, making earthen bundh, crop rotation, use of organic matter etc. to protect the soil from being eroded. Farmers were found taking different off farm employment to reduce uncertainty of agriculture due to climate change. Off farm employment played an important role in poverty reduction as well as in reducing climate vulnerability. Marginal farmers were also found to lease crop land from the big farmers. The study found notable differences in terms of number of occurrence and characteristics in few of the adaptation strategies though most of the measures were found almost similar. Farmers learned most of these adaptation measures from their experiences and through observing other farmers. A few techniques were learnt from agricultural extension office and different NGOs. Moreover, the farmers thought that the adaptation strategies benefited them both economically and environmentally. But many of the farmers indicated about challenges during their adaptation. Lack of experiences and knowledge along with lack of agricultural extension services were mentioned by the farmers. Moreover, few indicated about the lack of input and credit facilities in their area. Moreover, the results of Multinomial Logit Model (MNL) found that the socioeconomic status of the farmers influenced their choice of adaptation strategies. The results revealed that the socioeconomic characteristics and human cognition played important role in climate change adaptation. For example, Aged farmers had a possibility to use groundwater for irrigation than young farmers and they were not likely to change the planting and harvesting date of crops. Moreover, farming experiences significantly increased the probability to adopt measures like changing in planting & harvesting date, used ground water and leased crop land. Other socioeconomic variables such as education, farming status, farm and non-farm income, total family expenditure, owned and cultivatable land were statistically significant for choosing different adaptation strategies. Moreover, perception of climate change also significantly affected these adaptation choices. For example, the more the farmers could perceive climate change, the more chances that they adopted adaptation measures such as mix cropping, enhancing efficiency of fertilizer use and measures to decrease salinity in agricultural field. Other variables of perception were found statistically significant for different adaptation strategies.

6. Conclusion and Recommendations

The study analyzed the perception and adaptation of smallholder farmers to climate change in both Satkhira and Barguna district. It is apparent that people observed an increasing temperature, total rainfall, rainfall variability, number of cyclone and storm surge, flood intensity and waterlogged condition in both places. Farmers used both indigenous knowledge and planned adaptation strategies to reduce the vulnerability of climate change. People found it very difficult to cope with few climatic problems like cyclone in Satkhira and river erosion in Barguna. Different crop, land, water management practices and income diversification techniques were commonly found

adaptation measures. Statistical analysis was performed to find out the association between socioeconomic variables and their choice of adaptation strategies. Results of chi square test revealed that different socio-economic factors influenced their perception towards adaptation. Moreover, multinomial regression analysis expressed the impact of socioeconomic status on adopting different adaptation measures. Farmers reported that few of the measures weren't much effective and sustainable. Access to input, technology, training and extension services were mentioned to be ensured for sustainable adaptation practices. Government should incorporate adaptation issues in all development planning. External supports from agricultural extension offices and NGO's would be useful to effectively adopt those strategies. Lastly, it is strongly recommended that community-based adaptation options are needed to be prioritized to strengthen the adaptive capacity of the local community to reduce the impact of climate change.

References

[1]. World Bank. "World development report: development and climate change". World Bank, Washington, DC, USA, 2009.

[2]. IPCC. "Climate change 2014- Fifth Assessment Synthesis Report". Intergovernmental Panel on Climate Change, Geneva, 2014.

[3]. G.A. Meehl, et al. "Global climate projections". In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 749–845, 2007.

[4]. UN-DESA. "World economic and social survey 2009—promoting development saving the planet". United Nations, New York. pp. 227, 2009.

[5]. Global Climate Risk Index. "Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017". 2019. Available: https://www.germanwatch.org/sites/germanwatch.org/files/Global%20Climate%20Risk%20Index%202019_2.pdf. [November 05, 2019].

[6]. UNDP. 2009. "Countering climate change". Available: http://www.undp.org.in/index.php?option=com_content&task=view&id=295&Itemid= 45. [December 17, 2019].

[7]. A.P.K. Tai, M.V. Martin and C. Heald. "Threat to future global food security from climate change and ozone air pollution". Nature Climate Change, Vol. 4, pp. 817-821, 2014.

[8]. M.S. Hossain, L. Qian, M. Arshad, S. Shahid, S. Fahad and J. Akhter. "Climate change and crop farming in Bangladesh: an analysis of economic impacts". International Journal of Climate Change Strategies and Management, ISSN: 1756-8692, 2019.

[9]. K. Alam. "Farmers' adaptation to water scarcity in drought-prone environments: a case study of Rajshahi District, Bangladesh". Agricultural Water Management, vol. 148, pp. 196-206, 2015.

[10]. M. Z. Alam, L. Carpenter-Boggs, S. Mitra, M.M. Haque, J. Halsey, Rokonuzzaman, B. Saha, and M. Moniruzzaman. "Effect of Salinity Intrusion on Food Crops, Livestock, and Fish Species at Kalapara Coastal Belt in Bangladesh". Journal of Food Quality, Vol. 2017, pp. 1-23, 2017.

[11]. MoA. “Agricultural Statistics”. Ministry of Agriculture, Government of Bangladesh, 2014.

[12]. A.K. Rawlani and B.K. Sovacool. “Building responsiveness to climate change through community-based adaptation in Bangladesh”. Mitigation and Adaptation Strategy Global Change, Vol. 16, pp. 845–863, 2011.

[13]. M. Alauddin and M.A.R. Sarker. “Climate change and farm-level adaptation decisions and strategies in drought-prone and groundwater depleted areas of Bangladesh: an empirical investigation.” Ecological Economics, Vol. 106, pp. 204-213, 2014.

[14]. S.A. Haque. “Salinity problems and crop production in coastal regions of Bangladesh”. Pakistan Journal of Botany, Vol. 38(5),1359–1365, 2006.

[15]. SRDI. “Saline Soils of Bangladesh”, Bangladesh, 2010. Available: http://srdi.portal.gov.bd/sites/default/files/files/srdi.portal.gov.bd/publications/bc598e7a_df21_49ee_882e_0302c974015f/Soil%20salinity%20report-Nov%202010.pdf. [December 7, 2019].

[16]. M.N. Islam, M.A. Baten, M.S. Hossain and M.T. Islam. “Impact of few important Climatic Parameters on Aman Rice Production in Mymensingh District”. Journal of Environmental Science & Natural Resources, Vol. 1(2), pp. 49-54, 2008.

[17]. A. Rahman, M.A. Mojid, and S. Banu. “Climate change impact assessment on three major crops in the north-central region of Bangladesh using DSSAT”. International Journal of Agricultural and Biological Engineering, Vol. 11(4): pp. 135-143, 2018.

[18]. I. Delaporte and M. Maurel. “Adaptation to climate change in Bangladesh”. Climate Policy, Vol. 18(1), pp. 49-62, 2018.

[19]. S.A. Wheeler, A. Zuo and H. Bjornlund. “Farmers’ climate change beliefs and adaptation strategies for a water scarce future in Australia”. Global Environmental Change, Vol. 23, pp. 537–547, 2013.

[20]. A. Byg and J. Salick “Local perspectives on a global phenomenon: climate change in Eastern Tibetan villages”. Global Environmental Change, Vol. 19, pp. 156–166, 2009.

[21]. L. Alessa, A. Kliskey, P. Williams, and M. Barton. “Perception of change in freshwater in remote resource-dependent Arctic communities.” Global Environmental Change, Vol. 18, pp. 153–164, 2008.

[22]. S.I. Anik and M.A. Khan. “Climate change adaptation through local knowledge in the north eastern region of Bangladesh”. Mitigation Adaptation Strategy Global Change, Vol. 17, pp. 879-896, 2012.

[23]. J. Pender. “Community-led adaptation in Bangladesh- Case study.” In the 2nd international workshop on community-based adaptation to climate change, Dhaka, 2007.

[24]. M.T. Sikder. “The Impacts of Climate Change on the Coastal Belt of Bangladesh: An Investigation of Risks and Adaptations on Agricultural Sector” Proc. of International Conference on Environmental Aspects of Bangladesh, Japan, 2010.

[25]. Bangladesh Economic Review. “Chapter 07: Agriculture.” Economic Adviser's Wing, Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh, pp. 98-112, 2017.

[26]. BBS. “Statistical Yearbook of Bangladesh”. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People’s Republic of Bangladesh, Dhaka, pp. 33, 2009.

[27]. BBS. “Population and Housing Census Report”. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh, 2011.

[28]. World Bank. “Bangladesh – Country Assessment Strategy FY 2011 – 2014”. Bangladesh Country

Management Unit, South Asia Region, The World Bank Office, Dhaka, 2010.

[29]. MoP. "Sixth Five Year Plan of Bangladesh". General Economics Division, Planning Commission, Dhaka, 2011.

[30]. M.R. Karim, M. Ishikawa, M. Ikeda and M.T. Islam. "Climate change model predicts 33 % rice yield decrease in 2100 in Bangladesh". Agronomy for Sustainable Development, Vol. 32 (4), pp. 821-830, 2012.

[31]. J.P. Aryal, T.B. Sapkota, R. Khurana, A. Khatri-Chhetri, D.B. Rahut and M. Jat. "Climate change and agriculture in South Asia: adaptation options in smallholder production systems". Environment, Development and Sustainability, 2019.

[32]. NAPA. "National Adaptation Programme of Action". Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, 2005. Available: https://unfccc.int/resource/docs/napa/ban01.pdf. [November 30, 2020].

[33]. N. Hossain, M.A. Muhibbullah and M.M. Hossan. "Relationship between Soil Salinity and Physico-chemical Properties of Paddy Field Soils of Jhilwanja Union, Cox's Bazar, Bangladesh". Journal of Agricultural Science, Vol. 7(10), pp. 166-180, 2015.

[34]. R. Munns and M. Gilliham. "Salinity tolerance of crops - what is the cost?". New Phycologist, Vol. 208, pp. 668-673, 2015.

[35]. MoA and FAO. "Master Plan for Agricultural Development in the Southern Region of Bangladesh". Ministry of Agriculture. Government of Bangladesh, pp. 136, 2013.

[36]. M.B. Islam, M.Y. Ali, M. Amin and S.M. Zaman. "Climatic Variations: Farming Systems and Livelihoods in the High Barind Tract and Coastal Areas of Bangladesh". In Climate Change and Food Security in South Asia, R. Lal, M. Sivakumar, S. Faiz, M.A. Rahman and K. Islam (eds), Springer, Dordrecht, pp. 477-497, 2010.

[37]. P. Halder, R. Sharma and A. Alam. "Local perceptions of and responses to climate change: experiences from the natural resource-dependent communities in India." Regional Environmental Change, Vol. 12, pp. 665–673, 2012.

[38]. M.T. Niles, M. Lubell and M. Brown. "How limiting factors drive agricultural adaptation to climate change". Agriculture, Ecosystems & Environment, Vol. 200, pp. 178-185, 2015.

[39]. S. Malcolm, E. Marshall, M. Aillery, P. Heisey, M. Livingston and K.D. Rubenstein. "Agricultural Adaptation to a Changing Climate: Economic and Environmental Implications Vary by U.S. Region". Economic Research Report, United States Department of Agriculture, Report Number 136, 2012.

[40]. M. Esham and C. Garforth "Agricultural adaptation to climate change: insights from a farming community in Sri Lanka". Mitigation Adaptation Strategy Global Change, Vol. 13, pp. 28-35, 2012.

[41]. M.T. Islam and M. Nursey-Bray. "Adaptation to climate change in agriculture in Bangladesh: The role of formal institutions". Journal of Environmental Management, Vol. 200, pp. 347–358, 2017.

[42]. R.D. Lasco, C.M.D. Habito, R.J.P. Delfino, F.B. Pulhin and R.N. Concepcion. "Climate Change Adaptation for Smallholder Farmers in Southeast Asia". World Agroforestry Centre, Philippines, pp. 65, 2011.

[43]. B.Y. Fosu-Mensah, P.L. G. Vlek, and D.S. MacCarthy. "Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana". Environment, Development and

Sustainability, Vol. 14, pp. 495–505, 2012.

[44]. M.R.U. Khan, A.K. Azad and J. Nusrat. "Farmers' Perception on Climate Variability". Lambert Academic Publishing, Saarbrücken, 2012.

[45]. H.L. Dang, E. Li, J. Bruwer, and I. Nuberg. "Farmers' perceptions of climate variability and barriers to adaptation: lessons learned from an exploratory study in Vietnam". Mitigation and Adaptation Strategies for Global Change, Vol. 19, pp. 531–548, 2014.

[46]. M.A. Haque, S.S. Yamamoto, A.A. Malik and R. Sauerborn. Households' Perception of Climate Change and Human Health Risks: A Community Perspective". Environmental Health, Vol. 11(1), pp. 12, 2012.

[47]. P.H. Nyanga, F.H. Johnsen, J.B. Aune and T.H. Kalinda. "Smallholder Farmers' Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia". Journal of Sustainable Development, Vol. 4, pp. 73-85, 2011.

[48]. S. Silvestri, E. Bryan, C. Ringler M. Herrero and B. Okoba. "Climate change perception and adaptation of agro-pastoral communities in Kenya". Regional Environmental Change, Vol. 12, pp. 791–802, 2012.

[49]. J.A. Tambo and T. Abdoulaye. "Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna". Regional Environmental Change, Vol. 13, pp. 375–388, 2013.

[50]. S. Huq and G. Rabbani. "Adaptation Technologies in Agriculture; The Economics of rice farming technology in climate vulnerable areas of Bangladesh", in Technologies for Adaptation: Perspectives and Practical Experiences, L. Christiansen, A. Olhoff and S. Traerup (eds.), Denmark: UNEP, 2011.

[51]. M.H. Minar, M.B. Hossain and M. Shamsuddin. "Climate change and coastal zone of Bangladesh: Vulnerability, resilience and adaptability". Middle East Journal of Scientific Research, Vol. 13, pp. 114-120, 2013.

[52]. LCBCE. "District Equity Profile-Satkhira". Local Capacity Building and Community Empowerment (LCBCE) Programme, Supported by- UNICEF, pp. 21, 2014.

[53]. BBS. "Yearbook of Agricultural Statistics-2017". Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, pp. 595, 2018.