Exploring farmers' perception on climate-induced events and adaptation practices to protect crop production and livestock farming in Haor area of northeastern Bangladesh

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Abstract

Bangladesh is confronting terrible impacts of climate change on agriculture across the country, especially in the low-lying area like- *Haor*, coastal region, and islands. This behavioral study (N = 320) examines the perception and knowledge of farmers on climate-induced events and experiences, and explores the adaptation practices they adopt to protect crop production and livestock farming from the impact of climate change in the Northeastern *Haor* area of the country. Using triangulation method, it is detected that farmers of the study area have erroneous idea on climate change and the causes of frequent climate extremes. Study results show that respondents' perception and experiences on climate-induced event are verified positively with the historical trend and time-series analysis of climate indicators as well as with the findings of researchers using PRA tools and techniques. This study explores the traditional and systematic adaptation approaches of farmers which are practiced in individual or community level. The rationale of each of the approach from respondents' side is also analyzed in the study. It is statistically tested using chi-square that some of the scientific and systematic adaptation options for crop production is predominantly influenced by the educational qualifications of the respondents. The study reveals that lack of proper information prevents subsistence farmers to find the most effective adaptation pathways.

1. Introduction

Climate change has been emerged as one of the most burning issues of our time triggering perilous effects on natural and human systems across the world (Intergovernmental Panel on Climate Change [IPCC], 2014, p. 3). Increasing piles of empirical evidence identify anthropogenic emissions is mostly responsible for global climate crises. According to the fifth IPCC report, anthropogenic GHG emissions as well as other forcings are responsible together for increasing more than half of the average surface temperature worldwide from 1951 to 2010 (Easterling, Kunkel, Wehner, & Sun, 2016, p. 17; Bindoff et al., 2013, pp. 869–870; Knutson, Kossin, Mears, Perlwitz, & Wehner, 2017, pp. 114–115). Due to its topography, Bangladesh is regarded as one of the most climate-vulnerable deltas of the world holding 7th position in the "Long-Term Climate Risk Index (CRI)", calculated using 4 indicators for the twenty-year period (1999–2018). Climate change poses vital threats to food security, livelihood, agriculture, ecosystem services etc. in Bangladesh (Eckstein, Kunzel, Schafer, & Winges, 2019, p. 9; Coirolo, Commins, Haque, & Pierce, 2013, p. 75; Alam, 2018, pp. 195–197; Becker et al., 2020, p. 1867; Anik & Khan, 2012, pp. 879–880). "Climate Crisis" is responsible for decreasing food production around the world, particularly in the developing countries (International Fund for Agricultural Development, IFAD, 2010, p. 15; The Guardian, 2019). Researchers recognized risk of climate extremes, changes in mean precipitation and temperature, increasing concentration of atmospheric CO_2, climate change induced pest attack etc. are affecting global crop production (Wreford, Moran, & Adger, 2010, pp. 18–19; IPCC, 2014, pp. 6–7; Deryng, Conway, Ramankutty, Price, & Warren, 2014, p. 2). Contrarily, some studies report that increased temperature driven carbon fertilization will moderately increase production (Chen, Zhang, & Tao, 2018, p. 559; Deryng, Conway, Ramankutty, Price, & Warren, 2014, p. 2). Map of global decrease in crop production

by Cline (2007) recognizes 30% decrease in production even with carbon fertilization in Indian subcontinent due to changing climate.

There isn't much scientific evidence to show the interaction between climate change and livestock farming (Thornton, van de Steeg, Notenbaert, & Herrero, 2009, p. 114; Escarcha, Lassa, & Zander, 2018, pp. 1–2). However, contemporary studies suggest that climate change is expected to arrest livestock farming by affecting animal production as well as quantity and quality of food and forage; by worsening health, growth, and reproduction; by generating disease and pest attack; and by affecting livestock through climate extremes (Mader & Gaughan, 2011, p. 42; Rotter & Van de Gejin, 1999, p. 652; Food and Agriculture Organization of the United Nations, FAO, 2016, p. 5).

Bangladesh is principally an agricultural land. According to Bangladesh Bureau of Statistics, BBS (2020), agriculture sector adds 14.23% to the GDP of Bangladesh and more than 40.60% people labor for this sector (p. 3). Changing climate and climate extremes (e. g. flood, drought, salinity, cyclone, tidal surge, heavy rainfall, high temperature, excessive fog etc.) are affecting yielding of crops and livestock farming across Bangladesh where coastal region, islands and *Haor* area are exceedingly affected (Monwar et al., 2014, p. 126; Hossain, Nayeem, & Majumder, 2017, pp. 42–43). *Haor* is a low lying large tectonic depression covering 8584.6 square km, situated in the northeastern 7 districts of Bangladesh. Three hundred and seventy three *Haor*s of Bangladesh receive surface runoff water from several rivers descending from the hills of India, where water remains either stagnant or in flash flooding condition during the months of June to November and *Haors* remain dry next of the year (Alam, Quayum, & Islam, 2010, p. 88; Center for Environmental and Geographic Information Services [CEGIS], 2012, pp. 1–2; Kamruzzaman & Shaw, 2018, pp. 40–41). Most of the *Haor*s of Bangladesh are situated in Sunamganj, Netrokona, Kishoreganj, Sylhet, Habiganj, Moulvibazar, and Brahmanbaria Districts. *Haor* economy is principally based on agricultural activities as most of the inhabitants are farmers or fishermen. In the dry season they cultivate *Rabi* crops (crops cultivated from mid-November to mid-March) in their own land or work as sharecroppers and landless agricultural labors; whereas in the wet season they go for fishing in the *Haors* and rivers. 2017 flash flood severely affected *Haor* area of Bangladesh, caused suffering of 1 million people, damage of crops worth USD 450 million and loss of thousands of livestock they used to rear (Kamal et al., 2018, p. 482; CEGIS, 2012, p. 2). Though, according to Huq (2017), attributing climate change to 2017 flash flood in *Haor* area is very difficult, some researchers accuse climate change responsible for that flood (Ferdushi, Ismail, & Kamil, 2019, pp. 1–2; Mahtab, Ohara, & Rasmy, 2018, pp. 6–7).

Proper adaptation strategies can mitigate the impacts of climate change on crop production and livestock farming and help people coping with the extreme climatic conditions (Nelson, Adger, & Brown, 2007, p. 396; Alam, Alam, & Mushtaq, 2017, p. 52). Farmers of either technologically advanced or developing countries, are using modern as well as traditional techniques to adapt to the quickly changed global climate. Integration of modern technology and traditional or indigenous knowledge is bringing out the best pathway of adaptation (Ferdushi, Ismail, & Kamil, 2019, p. 2). According to IPCC (2014), climate change adaptation refers to *"the process of adjustment to actual or expected climate and its effects. In*

human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (p. 5). Effectiveness of adaptation strategies towards crop production and livestock rearing is widely dependent on farmer's perception and knowledge on climate and climate induced events (Mertz, Mbow, Reenberg, & Diouf, 2009, pp. 804–805). According to Maddison (2007), adaptation process includes two components- perception on climate change and adaptation approaches. Whereas adaptation process itself includes "people's perception" as a main component, inevitably this element is significant while choosing the best adaptation approach by the native farmers. Therefore, this study has been undertaken with the aims to i) find out farmer's perception on climate induced events and ii) explore the adaptation strategies adopted by local people to strengthen their resilience (p.2).

2. Materials And Methodology

2.1 Profile of the Study Area

Netrokona, a northeastern district of Bangladesh, surrounded by *Garo Hills* of Meghalaya of India on the north, Kishoreganj District on the south, on the east by Sunamganj District, and Mymensingh District on the west. Netrokona District is situated in between 24°34´ and 25°12´ north latitudes and in between 90°00´ and 91°07´ east longitudes. The district has an area of 2794.28 square kilometers (1078.87 square miles). The annual average temperature of Netrokona is highest 33.3°C and lowest 12°C; while the annual average rainfall is 2174 mm (BBS, 2013, p. 3; Banglapedia, 2015a).

This study was conducted in *Haor* area of Netrokona District. Sixty-five *Haor*s are found in the district covering 6 upazilas (sub-districts) [Netrokona District has 10 upazilas] with approximately 78,266 hectares of land. After examining the area and quantity of *Haor*, settlement, exposure, intensity, and sensitivity of people and assets to different climate extremes- 3 upazilas were purposively selected for the study: Khaliajuri, Madan, and Mohanganj.

2.2 Methods of Data Collection

This study is a behavioral research. Mixed method was applied to conduct the study which facilitated to find out elaborated and in-depth information to better understand the problems. Quantitative data was collected by a survey using a structured questionnaire. After collecting quantitative data, it was crosschecked with qualitative (Key Informant Interview- KII and Focus Group Discussion- FGD) and secondary data which ensures proper data triangulation of the study. Primary and secondary both types of data were collected. To prepare the climatic hazard index, Participatory Rural Appraisal (PRA) tools and techniques- FGD, transect walk, mapping, and hazard calendar were used.

2.3 Sampling Frame, Technique, Sample Selection, and Distribution

2.3.1 Sampling Frame: Farmers of all socioeconomic status, land owners, agricultural and non-agricultural laborers, housewives (who also work for processing crops and/or rear livestock), and people

of diverse occupations who are associated with agricultural activities as secondary occupations were surveyed for quantitative part of the study. For qualitative part, local important persons, representatives of local government, government officers, NGO activists, academics, and experts were included.

2.3.2 Sampling Technique: The approach to the study involves two stages: i) Field survey and ii) Qualitative interview with the local people, key informants, and experts. Probability sampling was employed in the quantitative part of the study. Stratified random sampling has been applied to represent the population groups which are involved in crop cultivation and livestock rearing in the selected study area.

2.3.3 Sample Selection and Distribution: 320 respondents were surveyed while conducting the study. The number of respondents has been assigned considering the establishment of the area and number of population and degree of exposure and sensitivity of the people as well (Table 1). Besides, 22 KII and 6 FGD participants participated in qualitative part of the study (Table 2).

Table 1 Sample Size Distribution for Quantitative Study

Upazila (Sub-district)	Union	Village	Sample Size
Khaliajuri	Chakua	Bolli	51
	Mendipur	Nurpur Boali	49
Madan		Gobindasree	59
	Gobindasree	Padamsree	41
Mohanganj	Suair	Bhatia	31
	Gaglajur	Barantar	52
	Tethulia	Bara Paikura	37
Total			320

Table 2 Quantity of Qualitative Study Participants and FGDs

2.4 Data Analysis

IBM SPSS Statistical Software (version 25) and Microsoft Excel were used to analyze collected data. Coding of questions helped quantify data where about 95% of the quantitative variables were categorical. Correlation, chi square, and likelihood ratio- these tests have identified if there is any association between the variables and the measured the strength of association. Significance value $p<0.05$ (Confidence level 95%) was considered to verify the statistical significance. Using trendline in Microsoft Excel helped to find

Type of participants	Number of KIIs	Name of Upazila (Sub-district)	Number of FGDs
Local important persons	5	Khaliajuri	2
Representatives of local government	7		
NGO activists	2	Madan	2
Government officers	5	Mohanganj	2
Experts/Academicians	3		
Total	22	Total	6

out the trend of climatic indicators. The map of the study area was prepared using ArcMap 10.8.

3. Results

3.1 Profile of the Respondents of Quantitative Part of the Study

Total 320 people were surveyed for quantitative part during the field study. All the respondents are either directly or indirectly associated with agricultural activities. Most of the respondents are in the age group 31–40 (33.4%) where age of 0.9% respondents are below 20. Only 3.1% people could pass higher secondary degree, 33.8% have primary education, and 41.9% have no schooling. So, most of the agrarian people of *Haor* area are formally uneducated, though most of them fall in the age group 41–50 (42.54%) who were born in between 1970s and 1980s when the literacy rate of Bangladesh was between 16.4% (1974) to 29.23% (1981) (Banglapedia, 2015b; The Global Economy, 2020). Among the respondents, 55.3% respondents have family members between 4 and 6. Data show that 98.8% respondents do farming during dry period, 41.56% are fishermen, and 84.38% rear livestock. Among the respondents, people of other occupations are daily agricultural laborers (19.69%), daily non-agricultural laborers (14.69%), rickshaw/van pullers (12.5%), businessmen (14.7%), teachers (2.81%), housewives (10.9%), and students (0.9%) etc. Average monthly income of most of the households is within BDT 10001–14000 [USD 118–165] (33.8%).

3.2 Major Climatic Hazards affecting Crops and Livestock in the Study Area (Respondents' View)

According to the respondents, specifically flash flood is the frequently happening (85.6%) climatic hazard in the study area. It is occurred here from the last of March to July. Sometimes flash flood washes away *Boro* rice as well as other *Rabi* crops, and creates economic and social disruption in this region. People identified hailstorm (61.6%), excessive fog (53.8%), storm/nor'wester (48.1%), drought (44.4%), and

lightning (38.8%) as major climatic hazards which affect crop production and livestock farming. They also took cold wave (37.8%) and heat wave (32.8%) as two of the major hazards (Fig. 2).

3.3 People's Perception on Climate Induced Events

3.3.1 Understanding about Climate Change: 48.1% people don't have idea about climate change at all. Other people interpreted climate change as a form of different hazards and perturbations. 37.2% reported that they think climate change as frequent flood, which is the characteristic of the study area. While 27.8% perceive climate change as extreme heat and 24.7% find irregularity of seasons as an instance of climate change. Others perceive climate change as frequent storm (20.3%), excessive cold (18.8%), irregular weather (13.4%), heavy precipitation (6.6%), and less precipitation (2.8%). From FGDs, it is revealed that most of the people know the term "Climate Change" but meaning of the term is unknown to them.

3.3.2 Community Perception and Experience of Climate Change:

Table 3
Community Perception and Experience of Climate Change

Parameters	Respondents' Response	Khaliajuri (%)	Madan (%)	Mohanganj (%)	Total (%)
		N = 100	N = 100	N = 120	N = 320
Change in temperature (last 10 years)	Increased	96	95	95.83	95.63
	Decreased	1	2	2.5	1.88
	No change	0	1	0.83	0.63
	Don't know	3	2	0.83	1.88
Change in the rainfall pattern during past 10 years	Increased	34	29	25.83	29.38
	Decreased	50	57	60.83	56.25
	No change	9	10	6.67	8.44
	Don't know	7	4	6.67	5.94
Length of summer season	Increased	78	75	74.17	75.63
	Decreased	10	6	13.33	10
	No change	7	6	6.67	6.56
	Don't know	5	13	5.83	7.81
Length of winter season	Increased	46	32	50.83	43.44
	Decreased	40	45	35.83	40
	No change	12	9	2.5	7.5
	Don't know	2	14	10.83	9.06
Length of rainy season	Increased	46	27	32.5	35
	Decreased	36	48	53.33	46.25
	No change	13	17	6.67	11.88
	Don't know	5	8	7.5	6.88
Change in the inundation time in the *Haor* area during the past 10 years	Late inundation	43	46	60	50.31
	Early inundation	41	35	28.33	34.38
	No change	13	15	10	12.5
*Multiple Response					

Parameters	Respondents' Response	Khaliajuri (%) N = 100	Madan (%) N = 100	Mohanganj (%) N = 120	Total (%) N = 320
	Don't know	3	4	1.67	2.81
Climatic hazards occur more frequently than before	Yes	92	95	96.67	94.69
	No	3	3	1.67	2.5
	Don't know	5	2	1.67	2.81
Types of flood, occurring in the area*	Flash flood	83	92	90.83	88.75
	Rain fed flood	76	84	70	76.25
	River flood	9	6	12.5	9.38
*Multiple Response					

3.3.3 Perception on the Reasons of Frequent Hazards/Disasters:

The study finds that 45.9% people still think "Act of God" is the reason of frequent hazards/disasters and 19.7% identified "Act of Nature" in this regard. Only 18% respondents recognized "Climate Change" as responsible for frequent hazards and disasters. Other identified reasons are embankment breaching (17.8%), onrush of upstream water (12.8%), low geographical location (11.6%), poverty (9.1%), unplanned development (8.4%), and population growth (4.7%). 11.6% respondents don't know any reason of frequent hazards/disasters.

3.4 Climatic Trends and Hazard Index to Validate People's Perception

To validate people's perception on climatic parameters (temperature and precipitation), Time-series (TS) Data of Climatic Research Unit (CRU) of University of East Anglia was collected which provides 0.5×0.5 degree high resolution gridded data (Version 4.03) for 1901–2018 (Harris & Jones, 2020). Figures 5 and 6 show TS data on annual average temperature (˚C) and annual precipitation (mm) for 38 years (1981–2018). It is evident from the trendlines (Figs. 5 and 6) that during the l981-2018 average temperature of Netrokona District increased where annual precipitation decreased which supports respondents' perception and experience. Figure 5 illustrates that after 2000 average annual temperature has been increased remarkably.

The parameters of the climatic hazards used to rank are: frequency, area impact, and magnitude of hazards, where each of the parameter got value from 1 to 5 indicating their levels of strength. Ranking of the hazards were based on total score obtained from the formula- Total Score= (Frequency + Area Impact)

× Magnitude. Flash flood ranked top and hailstorm followed it; whereas cold wave scored the lowest. The hazard ranking partially endorses identified major hazards affecting crop production and livestock farming by the respondents.

Table 4
Climatic Hazard Index of the Study Area

Hazard	Frequency (Value 1–5)*	Area Impact (Value 1–5)*	Magnitude (Value 1–5)*	Total Score [a]	Rank
Flash flood	4	4	4	32	1
Drought	2	3	4	20	4
River bank erosion	2	3	3	15	7**
Storm/Nor'wester	4	3	3	21	3
Lightning	4	2	3	18	5**
Heat wave	3	2	3	15	6**
Cold wave	3	2	2	10	8
Excessive fog	4	2	3	18	5**
Hailstorm	5	3	3	24	2
a = Total score= (Frequency + Area Impact) × Magnitude					
* Value 1–5 indicates the levels of strength where 1 is the lowest and 5 is the highest value					
** If scores are level, priority selection is based on the values of 1. Magnitude, 2. Frequency, 3. Area Impact					

3.5 Adaptation Strategies followed by the Local People

Researchers agreed that vulnerable communities can be resilient by following local level adaptation strategies (Alam, Alam, & Mushtaq, 2017, p. 54; Hiwasaki, Luna, Syamsidik, & Shaw, 2014, p. 17) which can mitigate the impacts of climatic hazards and minimize the losses. The adaptation strategies of the study area are categorized in 3 categories below:

Table 5
Adaptation Strategies followed by the Local People of the Study Area

Category	Adaptation Options	Percentage			
		Khaliajuri (%) N = 100	Madan (%) N = 100	Mohanganj (%) N = 120	Total (%) N = 320
Crop Production	Crop rotation	17	15	24.17	19.06
	Changing crop varieties (e.g. fast-growing crop)	30	46	37.5	37.81
	Using stressor tolerant crops species	30	31	34.17	31.88
	Early harvesting of immature Boro rice	40	27	40.83	36.25
	Changing crop planting dates	55	64	61.67	60.31
	Using mechanical irrigation system	30	28	18.33	25
	Rainwater harvesting for irrigation	13	17	12.5	14.06
	Using pesticide to the crops	53	49	55.83	52.81
	Preservation of crop seeds	19	23	11.67	17.5
	Homestead gardening	33	41	40	38.13
	Planting *Hijol* and *Koroch* trees to protect crop lands from intense current of flood	15	20	23.33	19.69
	Using Kanda (High fallow land in *Haor*) for cultivating crops other than rice	41	52	42.5	45
	Planting palm trees to prevent lightning	27	33	43.33	35
Livestock and Poultry Farming	Preservation of feeds for livestock for the period of feed scarcity	30	33	35.83	33.13
	Purchasing feeds for the animals during the time of feed scarcity	33	32	27.5	30.63
	Putting cotton/jute made cover on the animals in winter	36	41	32.5	36.25
	Constructing permanent sheds/shelters for animals	20	19	20	19.69
	Take animals to the veterinary physician	46	37	40.83	41.25

	Grass cultivation for livestock	16	18	15.83	16.56
	Duck rearing	45	47	36.67	42.5
	Integrated livestock and poultry farming	12	9	14.17	11.88
Non-agricultural Activities	Migration of farming family	44	46	54.17	48.44
	Using different means of livelihood	54	50	49.17	50.94
	Cottage industries				
	Taking loans (with high interest) from lenders	47	39	42.5	42.81
	Selling/Mortgaging property	48	37	52.5	46.25
	Selling of livestock in the emergency period	48	37	36.67	40.31
	Seeking early warning of different disasters from the authority	7	5	5	5.63

3.6 Rationale (Respondents' View) for Available Adaptation Options in the Study Area

Table 6
Rationale (Respondents' View) for Available Adaptation Options

Sl.	Adaptation Options	Addressed Climatic Risks	Rationale (Respondent's View)
1	Crop rotation	Flash flood, drought	As cultivating only *Boro* rice creates financial risk, people are leaving their traditional practice to grow only rice during dry season in the *Haor* area. Hence, some people are cultivating wheat, spices, maize, pulses, potato, vegetable etc., which is ensuring sustainable livelihood practice.
2	Changing crop varieties (e.g. fast-growing crop)	Flash flood	Some people change crop varieties so that they can harvest the crops earlier. This adaptation approach saves their crops from the impacts of flash flood (e.g. lifetime of most common rice variety of *Haor* area BRRI-29 is 160 days. Contrastingly, lifetime is 140 days for BRRI-28. Though BRRI-29 variety provides more crops, some people are cultivating BRRI-28 for early harvesting).
3	Using stressor tolerant crops species	Flash flood, excessive fog, drought, nor'wester, thunderstorm, heat wave/extreme temperature	Local farmers consult with the local officers of Agricultural Extension Department and plant stressor tolerant crop species which can withstand different climatic stressors; e.g. BRRI-28 Rice, BARI Mustard- 14, BARI Onion-1 etc.
4	Early harvesting of immature *Boro* rice	Flash flood	Sometimes people harvest crops earlier when there is any probability of occurring early flash flood. Almost half amount of the rice is not ripe that time, but this strategy can save up to 60% of rice. The unripe rice is used as fodder.
5	Changing crop planting dates	Flash flood	Usually farmers plant seedlings of *Boro* rice in Mid-*Poush* (Beginning of January). But as an adaptation strategy, to protect the rice from early flash flood, they occasionally plant seedlings in the beginning of *Poush* (Mid-December).
6	Using mechanical irrigation system	Drought, heat wave, extreme temperature	During dry season, if crop fields are affected by drought or lack of water for irrigation, people use mechanical irrigation system (e.g. shallow pump) to water the crops and moisturize soil.
7	Rainwater harvesting for irrigation	Drought, heat wave, extreme temperature	Practice of rainwater harvesting to irrigate croplands is in small range in the *Haor* area. This strategy is used as Community Based Planned Adaptation (CBPA), executed by NGOs
8	Using pesticide to the crops	Climate induced pest attacks to the crops	Due to climate change induced warming, insect pests are increasing in the *Haor* area which is destroying crops. To control pest attacks, people are using pesticides increasingly.

Sl.	Adaptation Options	Addressed Climatic Risks	Rationale (Respondent's View)
9	Preservation of crop seeds	Extreme rainfall, flood (monsoon)	Preservation of crop seeds for the next cultivation time ensures availability of good seeds even though there is any climatic hazard occurring. Based on indigenous knowledge, people are practicing this as Individual Level Adaptation (ILA).
10	Homestead gardening	Flood (flash and monsoon)	Available land in the homestead are used for gardening which is a sustainable livelihood option for the *Haor* people as croplands are submerged under water at most of the time of a year. Homestead gardening also ensures proper nutrition of the family members.
11	Planting *Hijol* and *Koroch* trees	Flood (flash and monsoon)	As *Hijol* (*Barringtonia acutangula*) and *Koroch* (*Pongamia pinnata*) trees can live in the submerged or inundated area and can withstand the intense current of flood, some NGOs and government organizations are serving to plant these trees as part of Community Based Planned Adaptation (CBPA) strategy.
12	Using *Kanda* (High fallow land in *Haor*) for cultivating crops other than rice	Flash flood	*Kanda* means high fallow land which isn't inundated by flood. Traditionally these lands remain fallow all the year round. But now some people are using these lands for planting vegetables, pulses, spices, fruits etc.
13	Planting palm trees	Lightning	Government of Bangladesh (GoB) has taken initiative to plant palm trees across the country to reduce fatalities due to lightning. In the study area this adaptation strategy is being executed by the government organizations.
14	Preservation of feeds for livestock for the period of feed scarcity	Flood (flash and monsoon), extreme rainfall	People store grass, hay, corns in their houses to feed their animals in rainy season. This adaptation strategy helps their livestock to be survived during any climatic disaster.
15	Purchasing feeds for the animals during the time of feed scarcity	Flash flood, drought, nor'wester/storm	Due to heavy rainfall, flood, and storm, sometimes animal fodders are damaged. At that time subsistence farmers have no other option except purchasing fodders.
16	Putting cotton/jute made cover on the animals in winter	Cold wave	To keep livestock safe from the effect of cold wave, local people use cotton and/or jute made cover in the winter season.
17	Constructing permanent sheds/shelters for animals	Flood (monsoon), heavy rainfall, extreme temperature, heat wave, hailstorm, nor'wester/storm, lightning	Previously, it was seen that livestock are kept in the open places during day or night which posed the risks of being affected by climatic hazards. To cope with the situation, people are constructing permanent sheds/shelters at their houses for animals.

Sl.	Adaptation Options	Addressed Climatic Risks	Rationale (Respondent's View)
18	Take animals to the veterinary physician	Climate change induced pest-attack and diseases	Traditionally people of remote area are reluctant to bring their sick cattle to the veterinary physician. At present, the situation has been changed. People consult veterinary physician if their domestic animals are affected by climate induced pest-attack and diseases/ other diseases.
19	Grass cultivation for livestock	Climate change induced fodder scarcity (flash flood, monsoon flood, heavy rainfall, drought etc.)	Climate change impacts are reducing pasture lands in the *Haor* area which is exaggerating scarcity of feeds for the livestock. To meet the demand, farmers are cultivating grass for feeding their animals.
20	Migration of farming family	Climatic hazards caused livelihood activities disruption	People of the study area migrate to urban and suburban areas for seeking new income generating activities. Usually, this type of migration is seasonal which is happened when crops are damaged by flash floods, or in the rainy season. Seasonal migrants come back to their villages in crop cultivation time.
21	Duck rearing	Flood (flash and monsoon)	As most of the lands are submerged under water in wet season, traditionally local people have been practicing duck rearing as an adaptation option.
22	Integrated livestock and poultry farming	Climate change induced livelihood activity disruption	With the help of Government of Bangladesh and NGOs, people are rearing goat, sheep, duck, and hen combinedly as these can cope with the climatic condition of *Haor* area. This livelihood initiative is increasing income of the subsistence farmers.
23	Using different means of livelihood	Climatic hazards induced livelihood activities disruption	As an adaptation option, diversified means of livelihood decrease the risk of financial crisis triggered by climate change. From the study we found that most of the respondents have more than one income sources.
24	Cottage industries	Climatic hazards caused livelihood activities disruption	Cottage industry is an adaptive livelihood option for women of the *Haor* area. Women, associated with cottage industry have a sustainable income as there is institutional arrangement of marketing the products with the help of different NGOs.
25	Taking loans (with high interest) from lenders	Climatic hazards caused livelihood activities disruption	In *Haor* area, lenders provide loan with high interest to the farmers. Usually small farmers take loan during crisis period, which in fact leads them towards another trouble.
26	Selling/Mortgaging property	Climatic hazards caused livelihood activities disruption	Farmers sell or mortgage their properties when there is lack of livelihood opportunities due to any stressor, and they are in need of cash to survive.

Sl.	Adaptation Options	Addressed Climatic Risks	Rationale (Respondent's View)
27	Selling of livestock in the emergency period	Climatic hazards caused livelihood activities disruption	Some people have no other option except selling their livestock while they are in financial crisis. Selling livestock helps them to cope up with the terrible condition in the emergency.
28	Seeking early warning of different disasters from the authority	Flash flood, monsoon flood, heavy rainfall etc.	Seeking early warning of different disasters is very rare in the *Haor* area of Bangladesh. One of the reasons is- traditionally people can forecast disasters by observing sky and water of *Haor* and river. Nevertheless, nowadays people are seeking early warning from Union Councils and Department of Agricultural Extension (DAE) so that they can take precautions to save their crops.

3.7 Educational Level Influencing some Systematic Adaptation Options

Some scientific and systematic adaptation options for crop production is largely influenced by the educational qualifications of the respondents. From the quantitative and qualitative analysis, it has been observed in the *Haor* area of Netrokona District that farmers having no formal education or lower level of education are more reluctant to follow scientific recommendations of adaptation techniques like- crop rotation, changing crop varieties, using stressor tolerant crop species etc. than the educated ones. Traditional farmers hardly can accept scientific and new strategies.

It is statistically tested through that switching crop varieties (crop rotation), changing crop varieties, and using stressor tolerant crops species have strong association with the level of education in the study area (Table 7).

Table 7
Educational Qualifications have Strong Relationships with some Scientific Adaptation Options

Variable	Adaptation Option	Statistical Test	Value	df	Significance*
Educational Qualifications	Switching crop varieties (Crop rotation)	χ^2	25.041^a	7	.001
	Changing crop varieties	χ^2	15.525^a	7	.030
	Using stressor tolerant crops species	χ^2	16.567^a	7	.020

*$P < 0.05$

3.8 Causes of not Taking Adaptation Measures

107 farmers responded on the reasons of not taking proper adaptation measures. 63.4% respondents identified lack of information as the main reason of not taking any adaptation measure. 33.9% people

said that lack of money prevents them to take adaptation measures, although money is not so required for adaptation. 30.6% respondents don't know the reason; 26.2% are not aware of climate change which can motivate them to take adaptation measure. On the other hand, 9.8% respondents aren't interested in this matter.

4. Concluding Remarks

Climate change-induced reduced crop production and livestock is affecting food security, livelihood, health, and exaggerating the extent of poverty and social insecurity in the country (Chen, Zhang, & Tao, 2018, p. 543; Barnett & Adger, 2007, pp. 639–640). This study examined the perception and knowledge of farmers on climate-induced events and experiences, and explored the adaptation practices they adopt to protect crop production and livestock farming from the impact of climate change in the *Haor*s of northeastern area in Bangladsh. Study result shows that respondents' perception and experiences on climate-induced events are verified empirically, but most of the respondents have vague idea on climate change. The study extensively explored the adaptation approaches of the farmers which include some good practices like- crop rotation, changing crop varieties, using stressors tolerant crop species, integrated livestock and poultry farming, using different means of livelihood etc. It is observed that farmers of *Haor* area are reluctant to follow crop diversification strategy; rather they stick to traditional *Boro* rice cultivation. Department of Agricultural Extension can work here exclusively to motivate people on crop diversification. More research and innovation are also needed in this arena. Local livestock department can commence awareness activities to aware livestock rearers. As naturally agriculture is very vulnerable here due to geographic location, non-farm activities should be enhanced as adaptation options. Government and non-government bodies can work closely to promote more non-farm adaptation activities. As the global temperature trend is going upward, risk of climate extremes is also being accelerated. Therefore, to adapt to changed climate, policy level interventions are required for livelihood diversification and integrating indigenous and scientific knowledge which will efficiently increase resilience of native people of the *Haor* area.

Declarations

Funding

Conflict of Interest/Competing Interest

Availability of Data and Material

Data and materials are available. It can be shared upon editor's/reviewers' suggestions.

Code Availability

No code availability

Authors' Contribution

Mr. Tasneem Chowdhury Fahim executed the research in field level with his own funding. He collected data with his team, analyzed data and wrote the research paper under the supervision of Mr. Bivuti Bhushan Sikder. Mr. Bivuti Bhushan Sikder also reviewed the article when needed.

Ethical Approval

This article is original and the manuscript hasn't been submitted to more than one journal for simultaneous consideration. The submitted work hasn't been published elsewhere before. The data is original, honest and hasn't been fabricated.

No people or animals were harmed during executing the research in the field level.

Consent to Participate

In this research, the respondents and participants are human and prior consent was ensured before conducting the study.

Consent for Publication

The respondents and participants of this research have given their consent to publish their opinion in the research paper. All the authors are agreed to publish this research paper.

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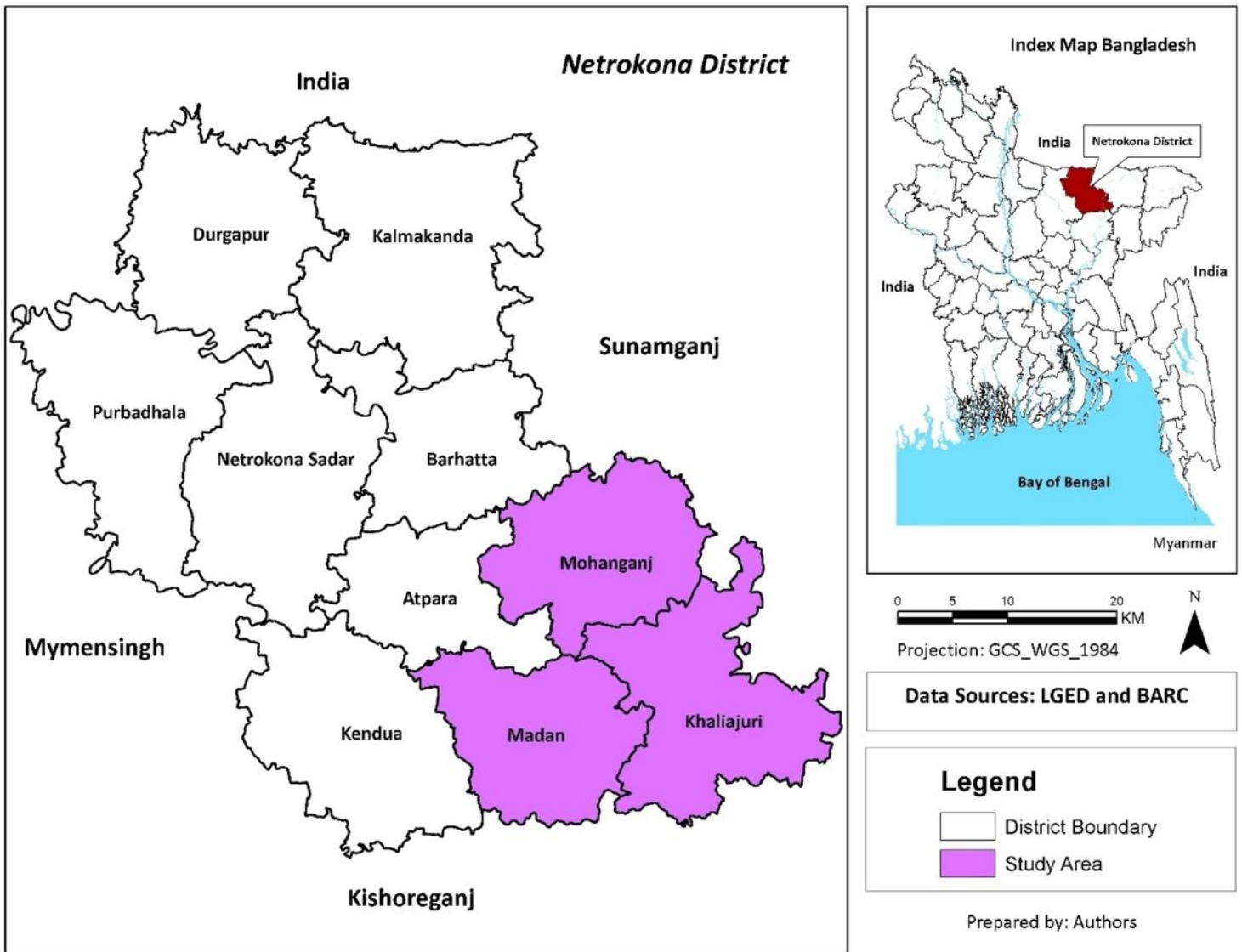
Figures

Figure 1

Map of Study Area. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area o bbnhjr of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.
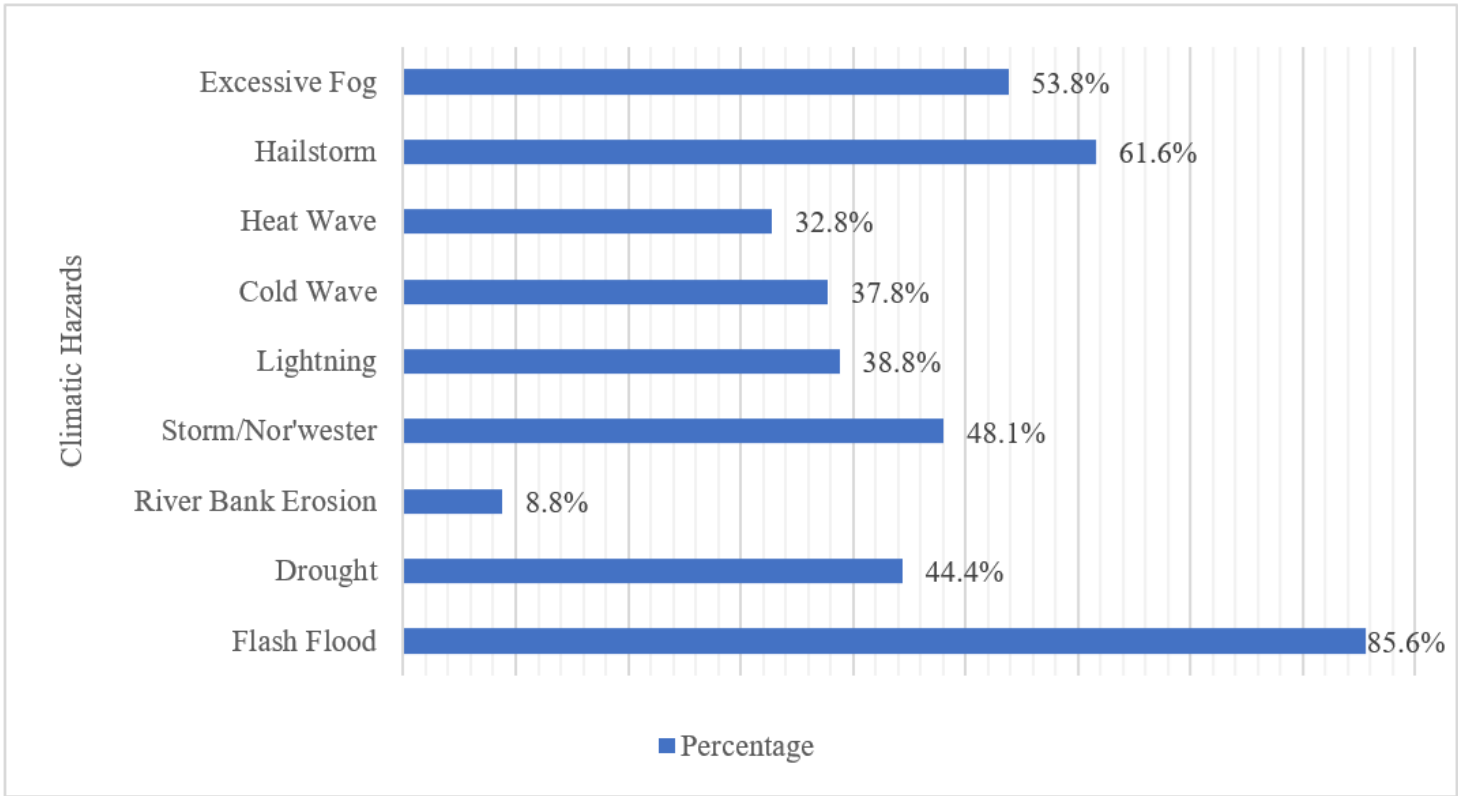
Figure 2
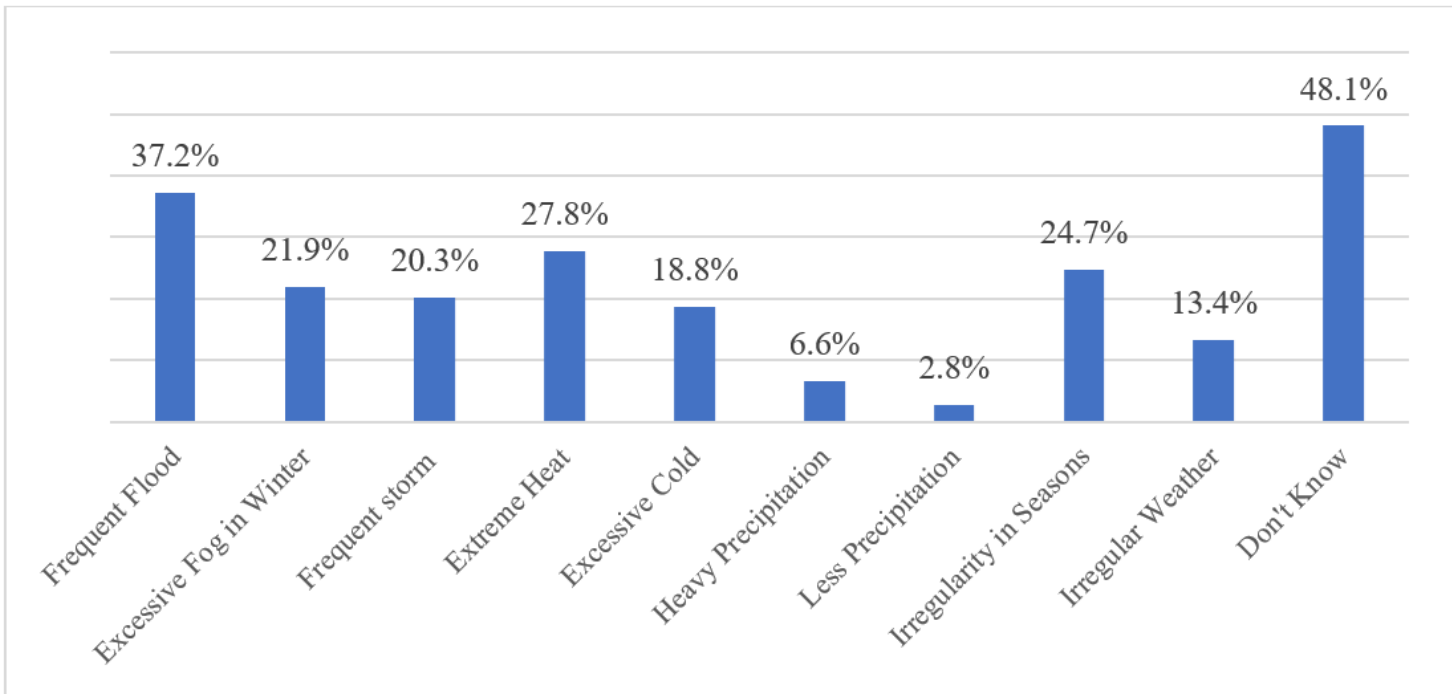
Major Climatic Hazards in the Study Area (Respondents' View)

Figure 3

Respondents' Understanding about Climate Change
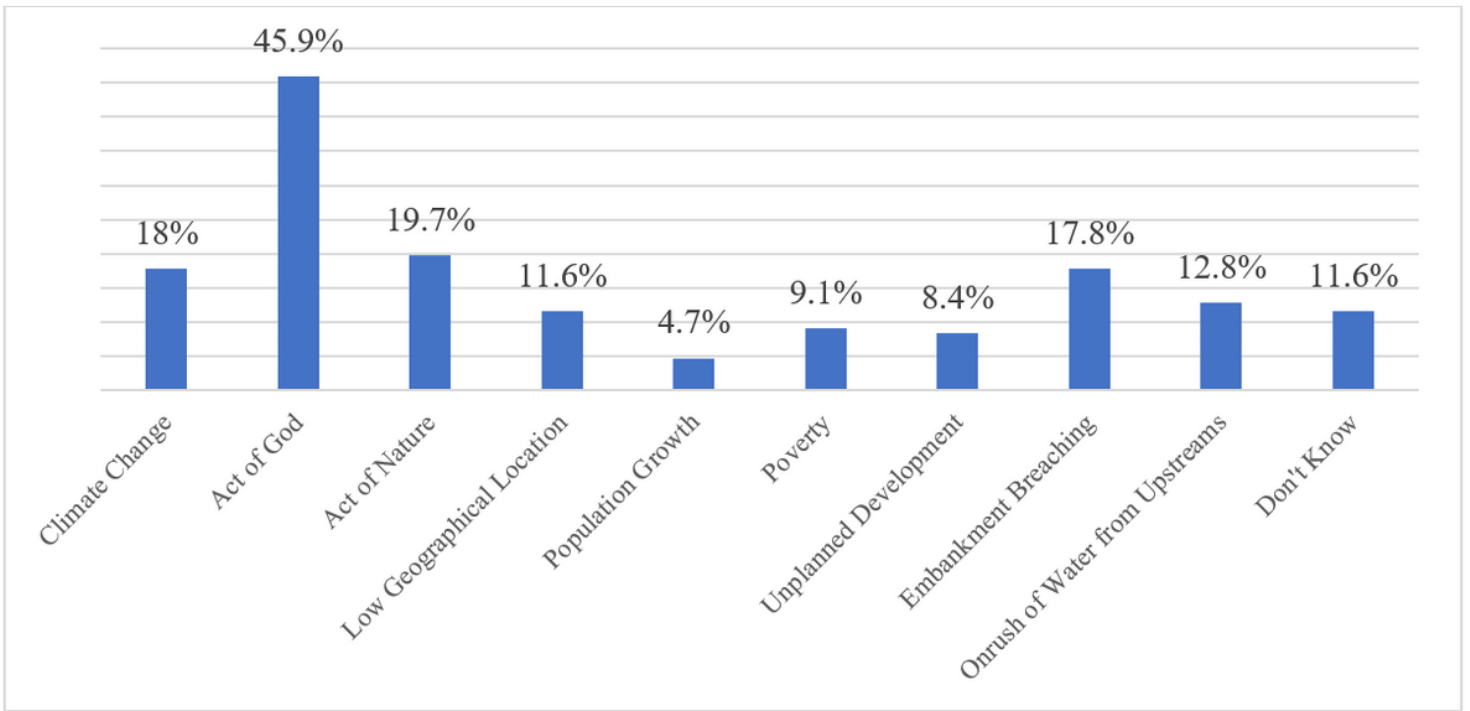
Figure 4

Respondents' Perception on the Reasons of Hazards/Disasters
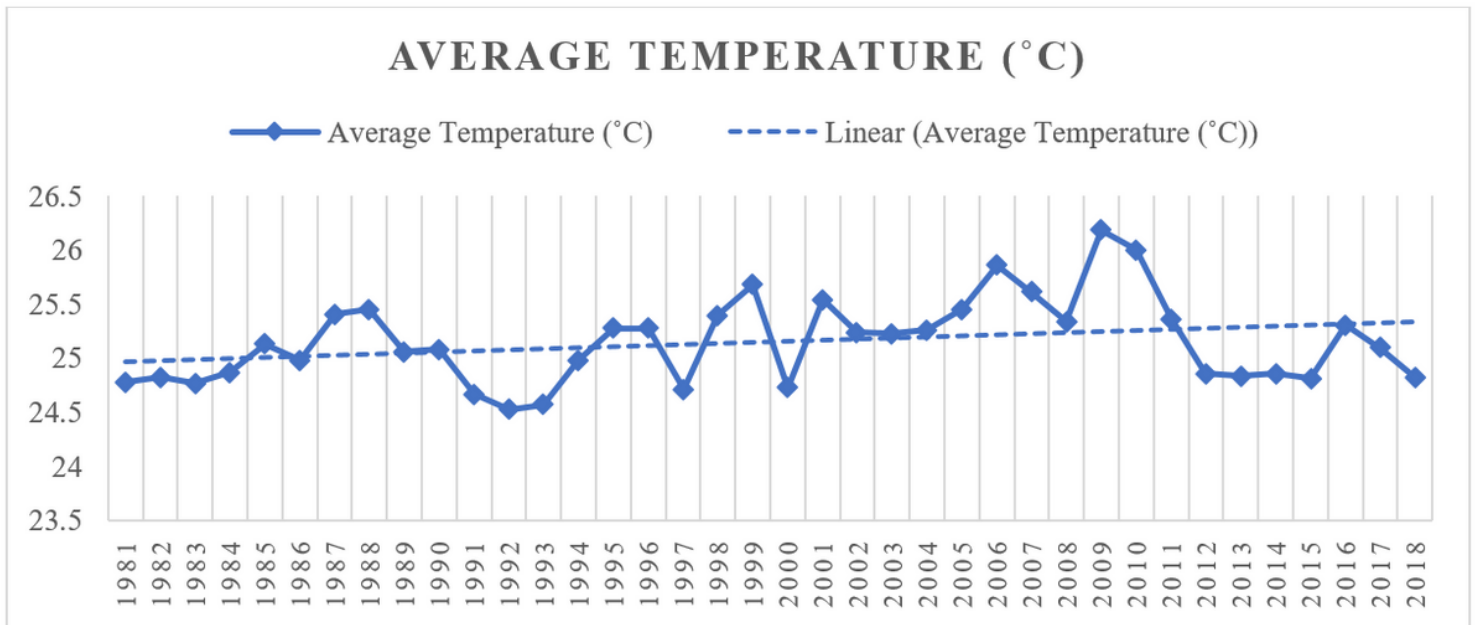

Figure 5

Average Annual Temperature (˚C) of Netrokona District with the Trendline (1981-2018)
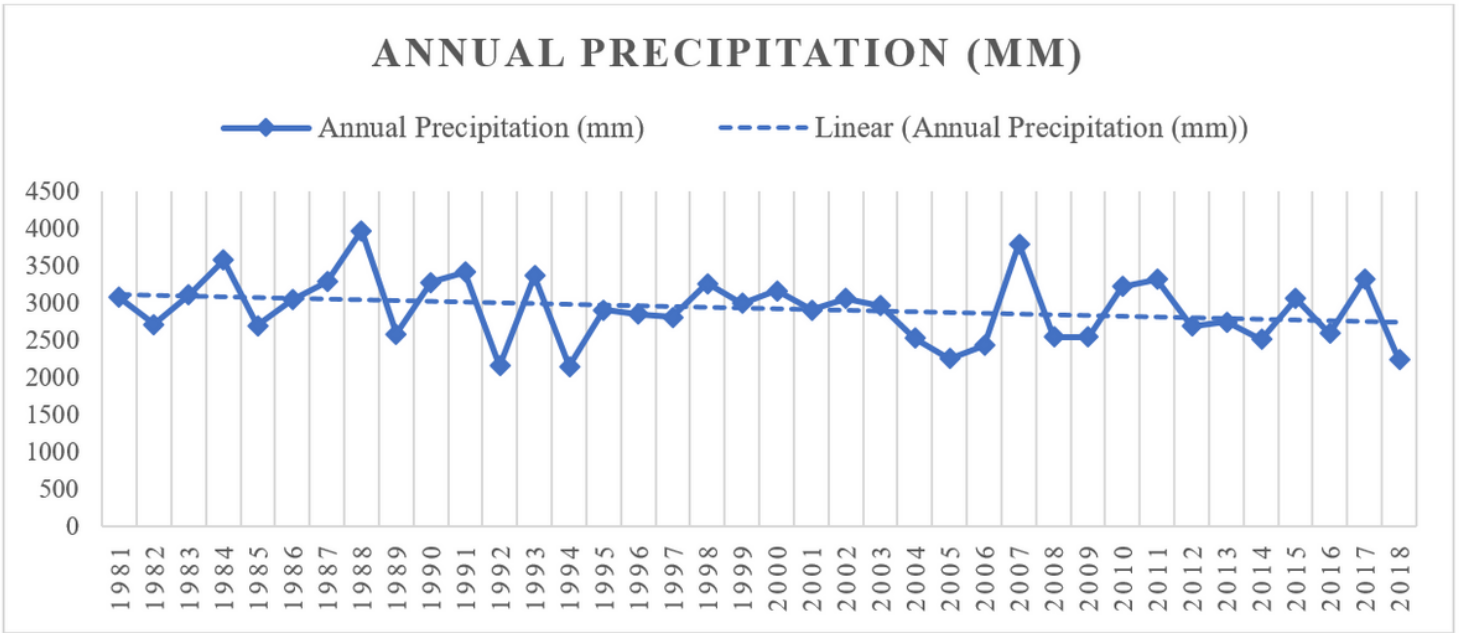
Figure 6

Annual Precipitation (mm) of Netrokona District with the Trendline (1981-2018)
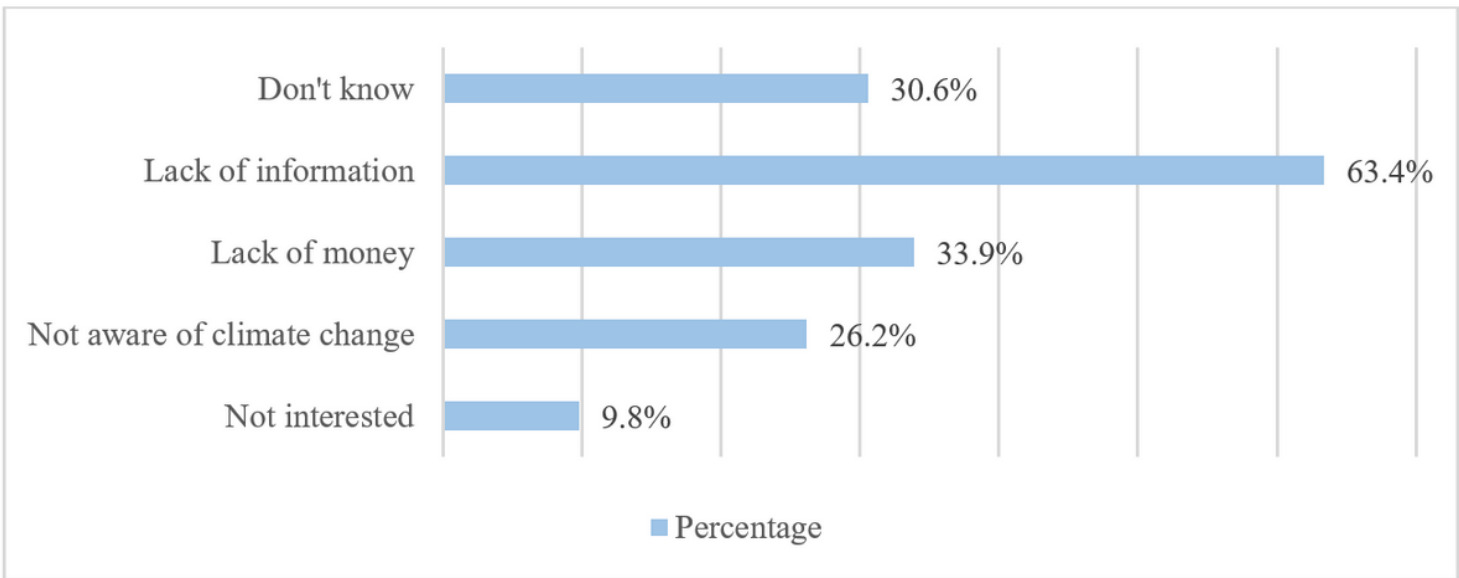

Figure 7

Reasons of not Taking Adaptation Measures