ADAPTABILITY OF HORTICULTURAL CROPS WITH RESPECT TO CLIMATE CHANGE: A CASE STUDY IN FAKIRHAT UPAZILA OF BAGERHAT DISTRICT

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*This is to certify that thesis entitled, "**ADAPTABILITY OF HORTICULTURAL CROPS WITH RESPECT TO CLIMATE CHANGE: A CASE STUDY IN FAKIRHAT UPAZILA OF BAGERHAT DISTRICT**" submitted to the **Faculty of Agriculture**, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **MD. TOUFIQUR RASHID, Registration No. 07-02544** under my supervision and guidance. No of part of the thesis has been submitted for any other degree of diploma.*

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ADAPTABILITY OF HORTICULTURAL CROPS WITH RESPECT TO CLIMATE CHANGE: A CASE STUDY IN FAKIRHAT UPAZILA OF BAGERHAT DISTRICT

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ABSTRACT

The survey study was conducted to determine adaptability of horticultural crops to climate change in Fakirhat upazila of Bagerhat district during 1st December 2012 to 25th March 2013. The area is moderately vulnerable to climate change. The study consisted of 80 randomly selected farmers through an interview by using survey schedules to identify their perceptions and their adaptation to climate change. The findings of the study indicate that the, farmer's perception about climate change was reasonable as majority of farmers claimed about decreased annual precipitation (47.5%), increased summer temperature (57.5%) and reducing winter temperature (48.75%). In case of extreme events, 38.75% farmers mentioned that the intensity of storms was increased and 58.75% farmers cited that the intensity of hotness in summer season was increased. However in case of the environmental hazards, the findings of the study indicated that spread of pest, dew, drought were the major problems of agricultural activities of them. The findings of the study also indicated that majority (76.25%) of the farmers had medium agricultural adaptation capability followed by low (23.75%) and high (6.25%). "Lack of information", "no subsidies on planting materials", "lack of access to improved adopted crop varieties" were the top three constrains faced by the farmers in adopting horticultural crops to climate change. Correlation analysis indicated that credit received had no significant relationship with farmers adaptation of horticultural crops to climate change. Age, education, farm size, annual income, cosmopoliteness of respondents had significant relationship with their adaptation of horticultural crops to climate change.

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LIST OF ABBREVIATIONS

Abbreviation	**Full Word**
BBS	Bangladesh Bureau of Statistics
UN	United Nations
FAO	Food and Agriculture Organization of the United Nations
DAE	Department of Agricultural Extension
a.s.l.	Above sea level
CV	Co-efficient of Variation
d.f.	Degrees of Freedom
et al.	And others
etc.	Etcetera
ha	Hectare
i.e.	That is
km	Kilometer
r	Pearson’s Product Moment Correlation Co-efficient
viz.	Namely
%	Percent
CEGIS	Center for Environmental and Geographic Information Services
WMO	World Meteorological Organization

CHAPTER I
INTRODUCTION

Bangladesh is located between 20° 34′ to 26° 38′ North latitude and 88° 01′ to 92° 42′ East longitude. It is bordered on the west, north and east by India, on the south-east by Myanmar and on the south by the Bay of Bengal. The country occupies an area of 147,570 sq. km (BBS, 2010). The fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007) stated that the average global surface temperature has increased by 0.74°C during last 100 years. It is also reported that the sea level rose at an average rate of 1.8 mm per year over 1961 to 2003, mountain glaciers, and snow cover have declined on average in both hemispheres. Project global warming in this century is likely to trigger serious consequences for mankind and other life forms, including global temperatures rise between 1.8° C and 4.0° C by 2100 depending on emissions of greenhouse gases and that global sea levels are likely to rise from anywhere between 180 mm and 590 (IPCC, 2007).

Bangladesh is highly vulnerable to the impacts of climate change, ranked fourth (formerly top) at the global climate risk index 2013, next to Honduras, Myanmar and Nicaragua for its exceptional geographical position, with a number of hydro-geological factors, jointly conducted by United Nations University (UNU), Germany and the Institute of Environment and Human Security said that Bangladesh ranked sixth among countries that are most vulnerable to natural disasters, while second among the Asian countries (Daily Star, 2011). Climate perturbation, in the form of erratic weather patterns, weather extremes and usual climate variability (signified by anomaly against long-term averages) can potentially affect people's livelihoods adversely, which in turn can induce additional stress and resulting vulnerability (Asaduzzaman *et al*., 2005). The arrogant Himalayas in the north and the funnel–shaped Bay of Bengal in the south have made Bangladesh a meeting place of the life-giving monsoon rains and the catastrophic devastation of floods, cyclones, storm surges, droughts etc. This disaster-prone country, in spite of the fertile land, networking people, is subject to food shortages because of heavy dependence of agricultural production on the vagaries of weather and natural disaster (Paramanik, 1991). As a consequence, total cultivable land would be affected. Three crores of people would lose their farms and homesteads. Threatening the richest and most productive region of the country, sea level rise could have dramatic consequences for its economy. Increased flooding from glacial melt, more intense monsoons, or more intense cyclones could also adversely affect agriculture in near term, periodically inundating much agricultural land. Sea level rise under climate change would also result in saline intrusion into the river system, which would enhance the backwater effect. Several hundred thousand tons of grain production could be lost as a result of increased salinization from sea level rise.

The climate in Bangladesh is changing and it is becoming more unpredictable every year. The impacts of higher temperature, more variable precipitation, more extreme weather events, and sea level rise are already felt in Bangladesh and will continue to intensify. Climate change poses now-a-days severe threat mostly in agricultural sector and food security among all other affected sectors. Crop yields are predicted to fall by up to 30%, creating a very high risk of hunger and only sustainable climate-resilient agriculture is the key to enabling farmers to adapt and increase food security (World Bank, 2011).

Adaptation to climate change is one of the approaches considered likely to reduce the impacts of long-term changes in climate variables. Adaptation is a process by which strategies to moderate and cope with the consequences of climate change, including climate variability, can be enhanced, developed and implemented (UNDP, 2004). Obviously, many countries already are adapting to current climatic events at national, provincial, state, district and local levels in short-, medium- and long-term time frame. In this situation, the adaptive capacities of the people need to be gradually increased to understand the probabilistic climate vulnerabilities and its consequences over the agriculture and agriculturally based livelihoods (CEGIS, 2002).

In a evoke to enhance Bangladesh's national capacity to presume climate induced adverse effects, especially for marginal and smallholding farmers in hot spots, there should be new impetus for innovation in agriculture. Hazard defying new varieties needs to be developed (Ahmed, 2000). A good number of hazard-tolerant crop varieties have already been developed and tested over the past few years (Ahmed, 2008; CEGIS, 2009).

The study area is mainly affected by different types of climatic hazards. So adaptation is very much essential for this area for all the sectors of agriculture specially horticulture. Thus, in this situation it is necessary to know the extent of climate change perception and horticultural adaptation that is why this study was drawn over this area with the following objectives:

- To find out the impacts of climate change on horticultural crops;
- To determine the extent of farmer's perception to climate change in the study area and
- To visualize the problems faced in adopting horticultural crops by the farmers.

CHAPTER II
REVIEW OF LITERATURE

This chapter is a review of past and recent studies having relevance to the research problem. Some research reports on climate change and impacts of climate change on agriculture, farmers perception and horticultural adaptation towards climate change have been found.

Climate is one of most important factor to have a profound impact on food availability and socio-economic conditions of the people in general and farming community in particular. The average condition of the atmosphere near the earth's surface over a long period of time, taking into account temperature, precipitation humidity, wind, cloud, barometric pressure etc. geographical location and physical settings govern the climate of any country (Attri, 2004).

Climate is changing continuously. In all points of the world, one year, one decade, one century differs from another. Temperature variations from year to year and from epoch to epoch generally increase towards high latitudes. Rainfall variations are greater in low latitudes, where the heaviest individual falls occur, rain and snowfall varies most in and near the warm and cold desert of the tropics and polar regions (WMO, 1999). Now, the available reports have been reviewed and briefly presented in the following paragraphs.

2.1 Climate change

Any climatic change in Bangladesh will, of course, be a part of worldwide climatic changes. It is generally claimed that the temperature of the earth has been increasing since the beginning of the 20th century. Bangladesh due to its geographical location is prone to several natural disasters, such as cyclone, flood, drought etc.

The Daily Star (2011) reported that, Bangladesh ranked sixth among countries that are most vulnerable to natural disasters, while second among the Asian countries.

Mahmood (2011) reported that, Bangladesh is one of the top 10 nations that are mostly vulnerable to climate change and by the end of the century, Bangladesh may be set to disappear under the waves. The government and non-governmental organizations have a key role to play.

Weigal (2005) reported that, change in the frequency. Duration and decree of extents (such as frost, heat, drought, hail, storms and floods) would affect agricultural crops, agro-ecosystem and agricultural productivity. He also stated that problems with drought are expected to increase, especially in Mediterranean countries.

Asaduzzaman *et al*. (2005) reported that, climate perturbation, in the form of erratic weather patterns, weather extremes and usual climate variability (signified by anomaly against long-term averages) can potentially affect people's livelihoods adversely, which in turn can induce additional stress and resulting vulnerability.

Hossain (2001) found that, the mean annual rainfall was 2387.20 mm from 1975 to 1995. May to September were the highest rainfall months when the rainfall was more than 300 mm in over 63.80%of the years and always more than 50 mm while May to June could be useful for Kharif (April to September) sowing, but the harvest may have to be postponed upto October.

2.2 Impact of climate change on horticultural and other agricultural crops

Sugiura (2009) sent a questionnaire to prefectural institutes for fruit tree research. All 47 prefectures in Japan replied that the recent warming had affected at least one tree species. This result shows that global warming have already affected the agriculture industry in Japan. The impacts had particularly extended to horticultural crops such as fruit trees, vegetables and flowers.

Moriguch (2009) observed changes of fruit quality such as enlargement of fruit size, reduction of acid and persimmon astringency, softening of flesh, rapid spoiling and increasing of sunscald due to climate change on a number of tree species.
Sugiura and Yokozawa (2004) showed the impact of global warming on the production in Japan of apples and Satsuma mandarins. The annual mean temperature was used to simulate possible changes in favorable regions for the cultivation of apples and satsuma mandarins. The temperature ranges assumed to be appropriate for fruit production were 6-14ºC for apples and 15-18ºC for satsuma mandarins, respectively.
Wang *et al.* (2009) stated in mirroring scientific research, economic studies demonstrate that climate change will impact agricultural production in varying degrees based on the crops analyzed and assumptions regarding CO_2 fertilization.
Selvaraju *et al.* (2006) reported that the impacts of climate variability and change are global concerns, but in Bangladesh, where large numbers of the population are chronically exposed and vulnerable to a range of natural hazards, they are particularly, critical. In fact, between 1991 and 2000, 93 major disasters were recorded, resulting in nearly 200000 deaths and causing US$5.9 billion in damage with high losses in agriculture. Agriculture is the largest sector of the Bangladesh economy, accounting for some 35% of the GDP and 63% of the labour force. Agricultural production is already under pressure from increasing demands for food and the parallel problem of depletion of land and water resources caused by overuse and contamination. The impacts of climate variability and change cause additional risks for agriculture. Within this context, FAO and the Asian Disaster Preparedness Center (ADPC) are guiding a project to assess livelihood adaptation to climate variability and change in the drought-prone areas of Northwest Bangladesh. The project implemented under the Comprehensive Disaster Risk Management Programme (CDMP) and in close collaboration with the Ministry of Agriculture. Department of Agricultural Extension (DAE) specifically looks at: characterization of livelihood systems; profiling of vulnerable groups; assessment of past and current climate impacts; and understanding of local perceptions of climate impacts, local coping capacities and existing adaptation strategies.
According to the recent IPCC (2007) assessment agricultural production in South Asia could fall by 30% by 2050 if no action would be taken to combat the effects of increasing temperatures and hydrologic disruption for South Asia, the area-average annual mean warming by 2020 was projected to be between 1.0 and 1.4^{0}C, between 2.23 and 2.87^{0}C for 2050 and might rise by 3-4^{0}C towards the end of the 21st century.
Peng *et al.* (2004) stated that variation in solar radiation, increased maintenance respiration losses or differential effects of night vs. day temperature in tillering, leaf-area expansion, stem elongation, grain filling and crop phenology might be possible causes.
Iglesias (2004) reported that the positive and negative effects of the climate change on the Mediterranean rain fed agriculture were analyzed through the prediction of models and changing scenarios. Key question for the assessment of vulnerability and adaptation of agriculture to climate change were discussed.
Bloomfield and Tubiell (2001) worked on the potential impact of climatic change on US agriculture: Critical findings for agricultural areas from the first national assessment of the potential consequences of climate variability and change. They suggested that future climate change and appropriate farmers adaptation could results in higher crop yields for the USA as a whole. Ways in which farmers could adapt to climate change are outlined.

Aggarwal and Mall (2002) observed that 2^0C increase resulted in a 15-17% decrease in grain yield of rice and wheat. Sea level rise would affect the vast coastal area and flood plain zone of the Ganges-Brahmaputra and Indus Deltas.

IPCC (2001) reported that climate change would also impact on rice production through risings sea level. Observation from tide Ganges indicated that the mean global sea level had risen by about 10 to 15 cm over the last 100 years and it appeared that this rise was related to the rise in global mean temperature recorded over same period. Model projections of future global mean sea level change, based on the temperature change projections, showed a rise of between 13 and 94 cm by 2100, with a central estimate of 49 cm.

World Bank (2000) reported that Bangladesh currently has extreme vulnerability to cyclones, both on account of its somewhat unique location and topography (that creates an inverted funnel), and because of the low (though growing) capacity of its society and institutions to cope with such extreme events. Cyclones originate in the deep Indian Ocean and track through the Bay of Bengal where the shallow waters contribute to huge tidal surges when cyclones make landfall. Existing literature records storm surges in the range of 1.5 to 9 meters, and some sources even city particular cyclones as having resulted in surge almost 15 m in height. A partial of listing of major cyclones and accompanying surge height is that over two-thirds of the countries are less than 5 m above sea-level and densely populated, storm surges contribute to flooding and loss of life and livelihood far beyond the coast. The intense precipitation that usually accompanies the cyclone only adds to the damage through inland and riverine flooding. A cyclone in 1970 led to the loss of 138,000 lives, although in recent years greater success in disaster management has significantly reduced the lives lost.

Paramanik (1991) found that the arrogant Himalayas in the north and the funnel-shaped Bay of Bengal in the south have made Bangladesh a meeting place of the life-giving monsoon rains and the catastrophic devastation of floods, cyclones, storm surges, droughts etc. This disaster-prone country, in spite of the fertile land, networking people, is subject to food shortages because of heavy dependence of agricultural production on the vagaries of weather and natural disaster.

2.3 Farmer’s perception of climate change

Santa (2013) found that the age of the farmers had positive but non-significant relationship with perception of positive effect of climate change. But education, annual family income, farm size and media contact had positive significant relationship with “Perception of positive effect of climate change” as well as higher the education, annual family income, farm size and media contact may be ensured the higher perception of positive effect of climate change.

Bewket (2012) found that, increased temperature and decreased rainfall are widely held perceptions; all respondents stated that they had observed increase in temperature and decrease in annual and seasonal rainfall amounts. The major impacts of climate change on local livelihoods as reported by respondents include decline in the length of growing period, increased crop damage by insects and pests, and increased severity of weed infestation. Some respondents also reported an increase in the incidence of livestock diseases.

Nzeadibe *et al*. (2011) noted that, the major constraints to climate change adaptation by farmers in the Niger Delta are lack of information, low awareness level , irregularities of extension services, poor government attention to climate problems , inability to access available information, lack of access to improved crop varieties, ineffectiveness of indigenous methods, no subsidies on planting materials, limited knowledge on adaptation measures, low institutional capacity, and absence of government policy on climate change. The results further showed that farmers in the Niger Delta generally have a low level of awareness of government policies/programmes on climate change. Furthermore, the study indicates that farmers of the region also have a poor perception of effectiveness of the policies/programmes and low awareness of the existence and impact of committees on climate change in the national assembly.

Rahaman (2010) reported that, in the study area occupies with semi braind soil and considered as semi drought prone area. It is an area of low and erratic rainfall with limited irrigation potential. The study consists of 60 randomly selected farmers. The finding of the study indicates that drought and spread of pest were the major problems for agricultural activities of the farmers. Flood and cyclone did not occur in the study area. Findings of the study also indicate that majority (89.9) of the farmers had low agricultural adaptation and 10.1% had medium adaptation. Correlation analysis indicates that age, education, environmental hazards and impact of climatic change had no significant relationships with their agricultural adaptation to climate change. Credit received for agricultural adaptation to climate change had positively significant relationships. Farm size, annual income, knowledge about climate change and cosmopoliteness with their agricultural adaptation to climate change had highly positive significant relationships.

Wang *et al.* (2009) also find that, climate change indirectly affects crop production as farmers react to changes in market signals. Second, the economic research accounts for the ways in which changes in trade flows and prices (which are direct consequences of climate change effects in other countries) will impact China's agricultural sector.

FAO & CEGIS (2006) reported people perceive that the current climate in the NW region of Bangladesh has been behaving differently from the past years. The seasonal cyclone has changed, drought became more frequent, pest and disease incidences increased average temperature has increased in the summer, winter has shortened and the severity of some winter days increased. However, people found difficulties in expressing the degree of change, local people in the study area have also perceived that their boro, aus, and winter vegetables, fruits (several varieties of mangoes) production remained affected due to temporal variations in rainfall, temperature and drought occurrences.

Mertz *et al.* (2007) stated that, communities studied have a high awareness of climate issues, but climatic narratives are likely to influence responses when questions mention climate. Change in land use and livelihood strategies is driven by adaptation to a range of factors of which climate appears not to be the most important.

CEGIS (2002) observed from the farmer's perspective, drought is an exceptional situation that is a deviation from expected, normal conditions. If the land and climate are not able to provide the crop with sufficient water, then the yield will be less than potential, which is the drought effect. When crop water requirements are not met, the growth and development of crops are affected by heat stress, which decreases the crop evapotranspiration rate, and thus yield is reduced.

2.4 Adaptation to climate change

Santa (2013) found that, the age, education, annual family income, farm size and media contact had positive significant relationship with agricultural adaptation of climate change as well as higher the age, education, annual family income, farm size and media contact may be ensured the higher agricultural adaptation of climate change.

Iglesias (2007) investigated that, adaptation strategies are put in place to deliver adaptations. An adaptation strategy is a broad plan of action that is implemented through policies and measures. Adaptation strategies are not only reactions to posed threats of climate change, but can comprise at the same time a large number of technical, social economic and environmental challenges.
IPCC (2007) recognizes in its Fourth Assessment Report that, some adaptation occurring, but on a very limited basis, and affirms the need for extensive adaptation across nations and economic sectors to address impacts and reduce vulnerability. Vulnerability to climate change may be defined as "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character. Magnitude and rate of climate variation to a system is exposed, its sensitivity and its adaptive capacity.
FAO and CEGIS (2006) identified that, there are some local adaptation practices existing in the NW region of Bangladesh. Four major types of adaptation practices: a) traditional response (e.g. pond and dighi excavation, retention of rainwater in khari and canals, shedding tillage, breaking topsoil); b) state supported response (e.g. DTW facilitated irrigation); c) alternative response (e.g. adaptation of mango farming, orchard developing) and d) some domestic response (e.g. alternative livestock and poultry / bird rearing) are existing.
UNDP (2004) reported that, adaptation is a process by which strategies to moderate and cope with the consequences of climate change, including climate variability, can be enhanced, developed and implemented.
Songcai and You (2001) studied on adaptation on agriculture to climate change by adopting the planned land use change strategy to overcome the water storage and to build the capacity to adapt to the expected climate change in Northern China. He stated that potential conflicts between different social interest groups, different regions, supply and demand, and present and future interests were analyzed to form a policy to implement the adaptation strategy.
Smith and Skinner (2002) reported that, most adaptation options are modifications to ongoing farm practices and public policy decision-making processes with respects to a suite of changing climate (including variability and extremes) and non-climatic conditions (political, economic and social).
World Bank (2002) reported that, it is difficult to determine Bangladesh's potential to adapt to climate change, but several key statistics give some insight as to the state of its infrastructure and social and human capital. In 2000, the World Bank estimated that only 9.5% of Bangladesh's 207,500 km network of roads was paved, putting it well below the average for low income countries of 16.5%, suggesting that its physical infrastructure in general might be less developed than that of low income countries. In the same year, the World Bank reported Bangladesh had only 51 scientists and engineers per million people, a number comparable to that for low income countries in general. Similarly, gross secondary and tertiary school enrollment stood at 47.5% and 4.8%, respectively, in 2000. A few numbers of organizations are engaged in studying climatic change in Bangladesh- A project undertaken by the World Bank (2001) entitled 'Bangladesh climate change and sustainable development' reported on this aspects. This report was a pioneering one and had specific sections on the adaptation. The document represented both; broad sectoral adaptation possibilities and the challenges of adaptation.
Ahmed (2000) concluded that, to enhance Bangladesh’s national capacity to presume climate induced adverse effects, especially for marginal and smallholding farmers in

hot spots, there should be new impetus for innovation in agriculture. Hazard defying new varieties needs to be developed.

2.5 Farmer's response of climate change adaptation

Rahman (2005) found that, findings of the study indicate that majority (49%) of the famers had medium agricultural adaptation while 34.3% had low adaptation and 16.7% had high adaptation.

Droogers (2004) stated that, adaptation strategies to climate change ware explored using a linked field-scale basin-scale modeling framework for Walwawe basin Srilanka. An integrated approach followed concentrating on enhancement of flood security and preservation of environmental quality. Impact and adaptation strategies were evaluated with a coupled modeling framework based on the soil-water-atmosphere-plant (SWAP) field scale model and the water and salinity basin model (WSBM) basin scale model. The overall impact of climate change on food security and environmental quality appears to be positive as a result of enhanced crop growth due to higher CO_2 level and a small increase in precipitation. However, extremes will be more profound in the future, making adaptation strategies necessaries. Results from the modeling framework were presented in a format accessible to water resources managers and policy makers to enable them to make sound decisions on the required adaptation strategies.

Smith and Skinner (2002) reported that, most adaptation options are modifications to ongoing farm practices and public- policy decision-making processes with respects to a suite of changing climate (including variability and extremes) and non-climatic conditions (political, economic and social).

Songcai and You (2001) worked on investment as an adaptation strategy in response to climate change in case study of drought damage in China. They concluded that, optimized investment taking climate change into consideration effectively reduced the damage due to climate change and promoted the capacity to mitigate drought damage due to climate variability

Rahman (2003) found that, ninety seven% of the pineapple growers adopted 2-4 intercrops *viz*, zinger, turmeric, sweet ground and aroid in pineapple cultivation.

Salam (2003) found that, an overwhelming majority (94%) of the respondents were found having high constraints in adopting environmentally friendly farming practices while 6% had medium constraints. No farmer was found having low constraint.

Hasan (2003) found that, majority (60%) of the farmers had adoption while 33% had low adoption and 7% had high adoption, recommended potato cultivation practices.

Rahman (2003) revealed that, about half (47%) of the growers had medium adoption, 44% had low and 9% had high adoption of year-round homestead fruit cultivation practices.

Sardar (2002) studied on "adoption of IPM practices by the farmers under PETRRA Project of RDRS. He observed that majority (45.9%) of the farmers had medium, 38.3% had low and 15.8% had high adoption of IPM practices.

Haider *et al.* (2001) observed that, one-third (37%) of the farmers fell in low adopter category compared to 32.5% falling in optimum adopter 23.5% above optimum adopter and only 7% had non-adopter on Nitrogenous fertilizer. In respect of extent of phosphoric fertilizer two thirds (68%) of the farmers had non adopter category compared to 23% having above optimum adopter, 5% optimum adopter and only 4% had below optimum adopter of phosphoric (P) fertilizer. In respect of extent of potassic fertilizer three quarters categories compared to 10% falling bellow optimum adopter, 8% optimum adopter and only 3% above optimum adopter of potassic (K) fertilizer.

Mostafa (1999) studied the adoption of recommended mango cultivate practices by the mango growers of Nawabganj sadar thana. He found that at half (49%) of the mango growers had "low adoption", 31% had "very low adoption" and 20% had "medium adoption" of fertilizers.

Muttaleb *et al.* (1998) found that, over all adoption of plant protection practices was medium. Among the plant protection practices high adoption were observed in fungicides, insecticide and soil treatment and low adoption were found that treatment and low adoption were found in suberization of cut tuber hand picking of cutworm and rouging of diseased plant.

Sardar (2002) found that, the age of the farmers had positive significant negative correlation with their adoption of IPM practices.

Aurangozeb (2002) observed that, there was significant negative relationship between age and adoption of integrated homestead farming technologies.

CHAPTER III
METHODOLOGY

The methodology for this study includes site selection, observation and field level data collection through inventory, questionnaire survey and interviews in formal and non-formal ways. The relevant secondary data for this research were mainly collected from the published and unpublished sources.

A chronological description of the methodologies followed in conducting this survey work has been presented in this chapter.

3.1 Study area

The study was conducted in four villages of Fakirhat upazila, under Bagerhat district (Fig. 3.1). Fakirhat upazila (Bagerhat district), with an area of 160.68 sq km, located in between 22°39' and 22°49' north latitudes and in between 89°34' and 89°47' east longitudes. It is bounded by Rupsa and Mollahat upazilas on the north, Rampal upazila on the south, Bagerhat sadar and Chitalmari upazilas on the east, Batiaghata and Rupsa upazilas on the west. It is located in South-Western region of Bangladesh. Location of the study area is shown in the map (Fig. 3.2).

Climate change causes severe damages in this area for a long period of time which mainly affects agricultural crops. Agriculture is the main occupation of the people in these areas. Other non-agricultural factors affects but livelihood mainly agriculture dependent. So, agricultural adaptation is very much essential for the improvement of livelihood activities in this area.

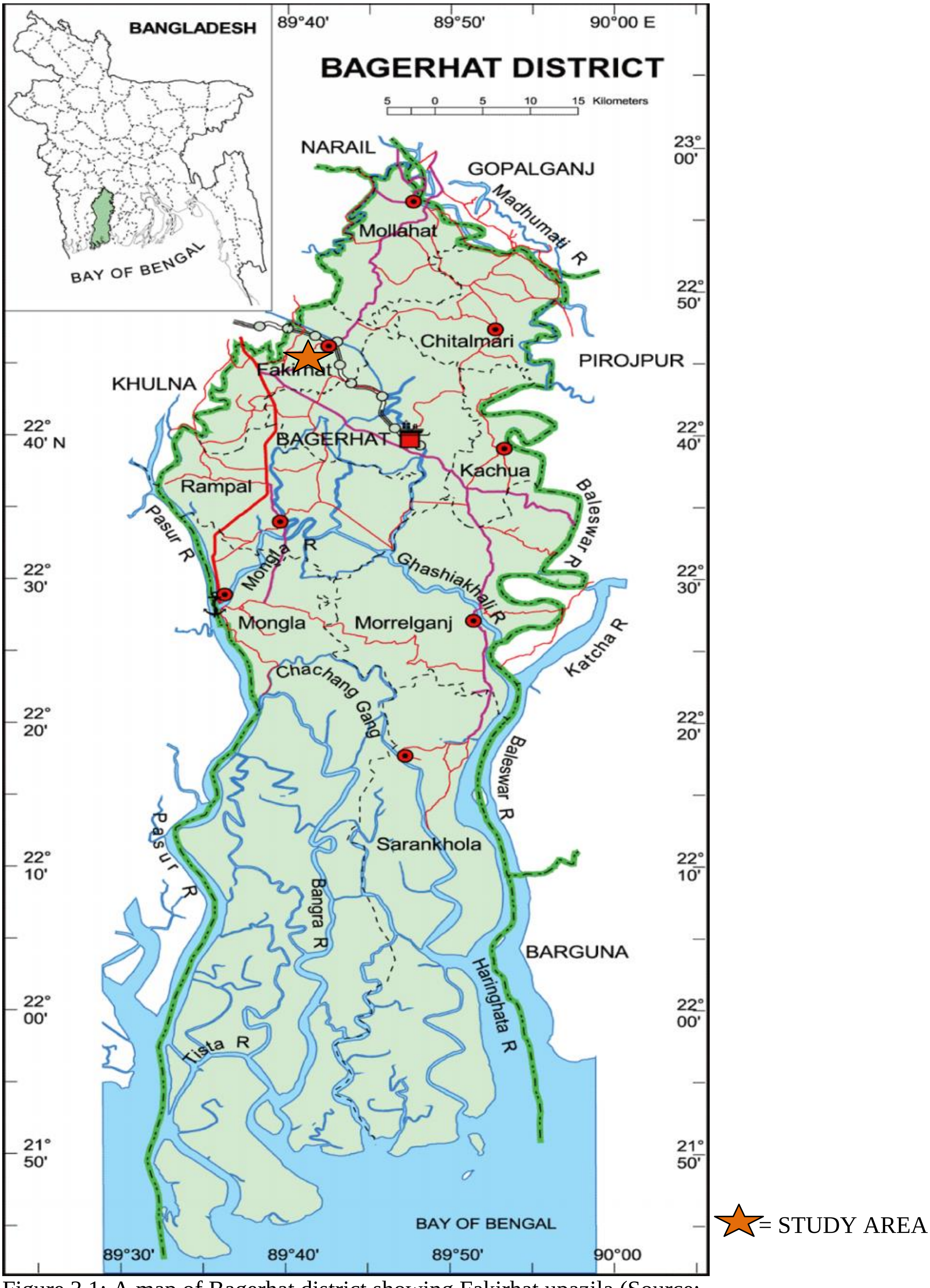


Figure 3.1: A map of Bagerhat district showing Fakirhat upazila (Source: http://www.lged.gov.bd/ViewMap.aspx)

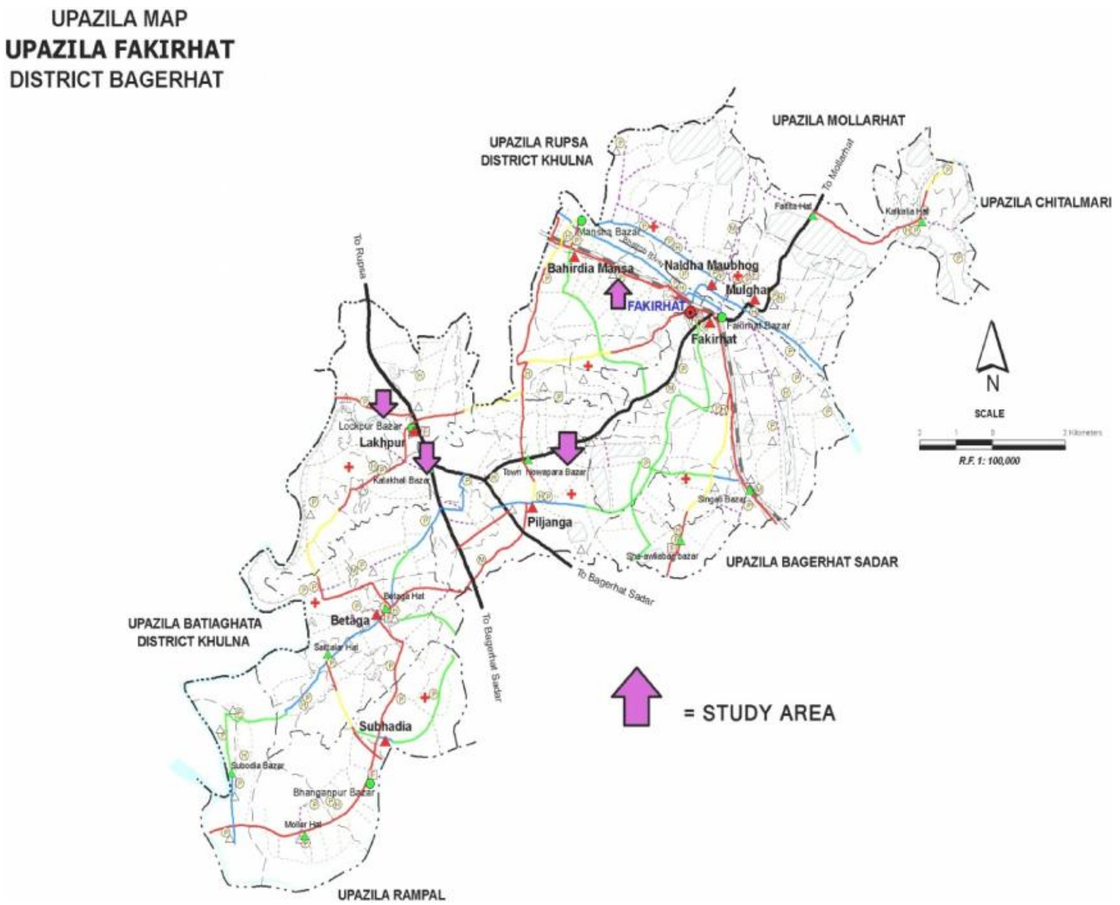


Figure 3.2: A map of Fakirhat upazila indicating the study area (Source: http://www.lged.gov.bd/ViewMap.aspx)

3.2 Physiography of study area

Fakirhat upazila lies in the physiographic unit Ganges Floodplain and Ganges Tidal Floodplain (AEZ-11, 13).

3.3 Soils

In Fakirhat upazila, three land types namely highland, medium highland and medium low land were identified. The textural classes of soil found were loam, clay loam and clay. Six soil groups were identified. Six major cropping patterns were found in the upazila. Total 53 soil samples were collected and analyzed and found that the soils of the upazila were deficient in almost all essential nutrient elements except K, S, B, Mg, Cu, Fe and Mn. The upazila comprises of highland, medium highland and medium low land, so the area is suitable for Boro, T. aman and upland horticultural crops. The area is also suitable for shrimp cultivation.

3.4 Climate

The climate of the Fakirhat upazila is humid and pleasant. It is humid during summer and pleasant in winter. The summer begins from the middle of March and continues till the middle June. The rainy season starts from the middle of June and continues till the end of September.

3.5 Population and sample of the study

With the help of Upazila Agriculture Officer, field staff and local leader, an updated list of farmers was collected. In Fakirhat Upazila 80 farmers were randomly selected. Thus, 80 farmers of the Upazila constituted the sample of the study. After the upazila selection with population determination, respondents were then selected at the rate of 5% following simple random method. But due to absence of some selected farmers during the data collecting the researcher made a reserve list of the farmers. The distribution of the selected farmers along with reserve list in the selected upazila is shown in Table 3.1.

Table 3.1 Distribution of the sampled farmers in Fakirhat Upazila

Name of villages	Total number of farmer	Number of sample drawn	Number of reserve farmers
Lakhpur	1066	20	2
Katakhali	997	20	2
Nowapara	1114	20	3
Bahirdia Mansa	1197	20	3
Total		80	10

Source: Upazila Agriculture Office, Fakirhat, Bagerhat

3.6 The research instrument and its preparation

An interview schedule was prepared for collection of data from the respondents keeping the objectives of the study in mind. The questions and statements contained in the schedule were simple, direct and easily understandable by the farmers. Simple and direct questions, different scales, closed and open form statements were included in the interview schedule to obtain necessary information. Appropriate scales were also developed to operationalise the selected characteristics of the farmers. The draft interview schedule was prepared in English and was pre-tested with 15 farmers. This pre-testing facilitated the researcher to examine the suitability of different questions and statements in general. On the basis of pretest result, corrections, modifications and adjustment were done in the interview schedule.

3.7 Variables of the study and their measurement

In a descriptive social research, selection and measurement of the variable is an important task. A variable is any characteristic which can assume varying or different values is successive individual cases. An organized research usually contains at least two identical elements *viz.* independent and dependent variable.

An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable varies as the experimenter introduces, removes or varies the independent variables (Townsend, 1953). According to the relevant research area, the researcher selected six characteristics of farmers as the independent variables and farmer’s perception of climate change and agricultural adaptation to climate change as the dependent variables.

This section contains procedures of measurement of the dependent and all independent variables of the study.

The independent variables of the study were age, education, farm size, annual income, credit received, cosmopoliteness. Procedure for measuring independent variables has been presented below.

3.8 Measurement of independent variables

3.8.1 Age

Age of the respondents was measured in terms of actual years from their birth to the time of interview. A score of one (1) was assigned for each year of one's age.

3.8.2 Education

Education of a respondent was measured on the basis of classes he had passed in formal educational institution. For example, if a respondent don’t know how to read and write, his education score was taken as zero (0). A score of 0.5 was given to that respondent who could sign his/her name only. Score 1 was given for each class have completed.

3.8.3 Farm size

The farm size of a respondent was measured in hectares. The data were first recorded in term of local unit *i.e.* 'bigha' and then converted to hectare.

3.8.4 Annual income

Annual income of a respondent was measured in taka on the basis of his total yearly earning from different sources (e.g. agricultural and non-agricultural) in last year- A score of one (1) was assigned for each thousand taka.

3.8.5 Credit received

Credit availability of a respondent was defined as the degree to which this credit requirement was fulfilled by the amount of credit actually received by her during last year.

3.8.6 Cosmopoliteness

Cosmopoliteness of a respondent was measured by the frequency of visit made by him to selected places (Table 3.2).

Table 3.2 Scales used for computing the cosmopoliteness scores

Place of visit	Nature of visit	Score
Visit to houses of friends, relatives and other known persons outside own village	Not even once a week	0
	Once a week	1
	2-3 times a week	2
	4-5 times a week	3
To own union headquarters	Not even once a year	0
	1-2 times month	1
	3-4 times/ month	2
	5 on more times/month	3
To own upazila headquarters	Not even once in 3 month	0
	One time/3 months	1
	2-3 times/3 months	2
	4-5 times/3 months	3
To other upazila (s)	Not even once in 4 month	0
	One time/4 months	1
	2-3 times/4 months	2
	4-5 times/4 months	3
To own districts town	Not even once in 6 months	0
	1-2 times/year	1
	3-4 times/year	2
	5 or more times/year	3
To other districts	Not even once a year	0
	Once times/year	1
	2-3 times/year	2
	4-5 times/year	3
To capital	Not even once a year	0
	One times/year	1
	2-3 times/year	2
	4-5 times/year	3

The above mentioned, score obtained from visit to each of the above categories of places where added together to get the cosmopoliteness score of a respondent. Thus the score of a respondent could range from 0 to 21, where 0 indicating no cosmopoliteness and 21 highest comopoliteness.

3.9 Measurement of the dependent variable

3.9.1 Environmental hazards as experienced by the farmers

A-four point rating from scale from “high” to “not ever” was developed to measured the extent of Environmental hazards in study area of the farmers. However, use of four point scales identical to one was found in many studies employed to ascertain the “extent of Environmental hazards” of the respondents (Rahman, 2005).

3.9.1.1 Scoring techniques

The method of assigning scoring to the four alternatives in each statement was as follows:

Extent of environmental hazards	Scored assigned
High	3
Medium	2
Low	1
Not ever	0

The range of environmental hazards score of the respondents could vary from 0 to 21, where, 0 indicate no environmental hazards and 21 indicated full environmental hazards. However, besides having calculated the “extent of environmental hazards” score for each of 80 respondents, an effort was also made to compare the relative hazards. An environmental hazards index (EHI) was developed to fulfill this objective using the following formula (Rahman, 2005):

$EHI = N_1 \times 3 + N_2 \times 2 + N_3 \times 1 + N_4 \times 0$

EHI= Environmental Hazards Index

N_1 = Number of farmers affected by the environmental hazards frequently

N_2= Number of farmers affected by the environmental hazards occasionally

N_3= Number of farmers affected by the environmental hazards rarely

N_4= Number of farmers not at all affected by the environmental hazards

The EHI for each of the environmental hazards ranged from 0 to 240.

3.9.2 Impact of climate change observed by farmers

A-four point rating scale ranging from "high" to "not ever" was developed to measured the extent of impact of climate change observed by farmers in the study area. However, use of four point scales identical to ones was found in many studies employed to ascertain the "extent of impact of climate change observed by farmers" of the respondents.

3.9.2.1 Scoring techniques

The method of assigning scores to the four alternatives in each statement was as follows:

Impact of climate change	Scored assigned
High	3
Medium	2
Low	1
Not ever	0

The range of impact of climate change observed by farmer's score of the respondents could vary from 0 to 30, where, 0 indicate no impact of climate change found by farmers and 30 indicate full impact of climate change observed by farmers However, besides having calculated the “extent of impact of climate change observed by farmers” score for each of 80 respondents, an effort was also made to compare the relative impact of climate change. An impact of climate change index (CCII) was developed to fulfill this objective using the following formula (Rahman, 2005):

CCII= $N_1 \times 3 + N_2 \times 2 + N_3 \times 1 + N_4 \times 0$

CCII= Impact of Climate Change Index

N_1= Number of farmers observed ‘high’ impact of climate change

N_2= Number of farmers observed ‘medium’ impact of climate change

N_3= Number of farmers observed ‘low’ impact of climate change

N_4= Number of farmers ‘not at all’ observed impact of climate change

The CCII for each of the impact of climate change observed by farmers ranged from 0 to 240.

3.9.3 Measurement of adaptation of horticultural crops by the selected farmers

The present study includes the dependent variable the extent of adaptation of horticultural crops to climate change. This variable was measured on the basis of different aspects of adaptation. The adaptation score was computed on basis of the respondents' adaptation on 21 aspects.

A-four point rating scale ranging from "high" to “not ever" was developed to measure the extent of adaptation of the farmers. However, use of four point scales identical to ones was found in many studies employed to ascertain the extent of adaptation of horticultural crops of the respondents.

3.9.3.1 Scoring techniques

The method of assigning scores to the four alternatives in each statement was as follows:

Adaptation of horticultural crops	Scored assigned
High	3
Medium	2
Low	1
Not ever	0

The range of adaptation of horticultural crops score of the respondents could be varied range 0 to 63, where, 0 indicated no adaptation and 63 indicated full adaptation. However, besides having calculated the “extent of adaptation of horticultural crops to climate change” score for each of 80 respondents, an effort was also made to compare the relative adaptation of horticultural crops to climate change. An AHI was developed to fulfill this objective using the following formula (Rahman, 2005):

AHI = $N_1 \times 3 + N_2 \times 2 + N_3 \times 1 + N_4 \times 0$

AHI = Adaptation of Horticultural crops Index

N_1= Number of farmers expressed ‘high’ adaptation of horticultural crops to climate change

N_2= Number of farmers expressed ‘medium’ adaptation of horticultural crops to climate change

N_3= Number of farmers expressed ‘low’ adaptation of horticultural crops to climate change

N_4= Number of farmers expressed ‘not ever’ adaptation of horticultural crops to climate change

The AHI for each of the adaptation of horticultural crops to climate change ranged from 0 to 240.

3.9.4 Measurement of problems faced by the selected farmers for adaptation of horticultural crops

The present study includes the dependent variable the extent of constraints to climate change adaptation. This variable was measured on the basis of different aspects of adaptation constraints. The adaptation constraints score was computed on basis of the respondents' adaptation constraints on 9 aspects.

A-four point rating scale ranging from "high" to “not ever" was developed to measure the extent of adaptation constraints of the farmers. However, use of four point scales identical to ones was found in many studies employed to ascertain the "extent of constraints to climate change adaptation" of the respondents.

3.9.4.1 Scoring techniques

The method of assigning scores to the four alternatives in each statement was as follows:

Constraints to climate change adaptation	Scored assigned
High	3
Medium	2
Low	1
Not ever	0

The range of constraints to climate change adaptation score of the farmers of Fakirhat upazila could vary from 0 to 27, where, 0 indicated no constraints to climate change adaptation and 27 indicated full constraints to climate change adaptation.

Constraints to climate change adaptation score for each of 80 farmers of Fakirhat upazila, an effort was also made to compare the relative constraints to climate change adaptation. An ABI was developed to fulfill this objective using the following formula (Rahman, 2005):

$ABI = N_1 \times 3 + N_2 \times 2 + N_3 \times 1 + N_4 \times 0$

ABI = Adaptation Barrier Index (ABI)

N_1= Number of farmers expressed ‘high’ adaptation barrier to climate change

N_2= Number of farmers expressed ‘medium’ adaptation barrier to climate change

N_3= Number of farmers expressed ‘low’ adaptation barrier to climate change

N_4= Number of farmers expressed ‘not ever’ adaptation barrier to climate change

The ABI for each of the adaptation barrier to climate change ranged from 0 to 240.

3.10 Data collection

Data were collected by means of interviewing the selected sampled farmers; the researcher himself collected data for this study. But to familiarize researcher with the selected farmers and establishing report during conducting the interview, the researcher had to seek help from local leaders of the study area.

Before going to the respondent's home for interviewing they were informed verbally to ensure their availability at home as per schedule date and time. If any respondent failed to understand any question, the researcher took great care to explain the issue. Seven respondents from the reserve list were interviewed because the respondents were repeatedly unavailable for date collection. In some cases the respondents felt shy to give answer at some aspect of questioning. Data were collected during 1st December 2012 to 25th March, 2013.

3.11 Data processing

To facilitate tabulation, the collected data were properly coded and transferred from interview schedule to a master sheet. Qualitative data were converted into quantitative forms by means of suitable scoring whenever necessary. Tabulation and cross tabulation was done on the basis of categorize developed by the researcher.

3.12 Data analysis procedure

The analysis was performed using SPSS (Statistical Package for Social Sciences) computer package.

3.12.1 Descriptive analysis

Such statistical measures as number, percentage, range, mean, standard deviation and rank order were used in describing the variables where ever applicable.

3.13 Hypothesis

The research hypothesis was put forward to test the relationship between the adaptation of horticultural crops to climate change and each of 6 selected characteristics of the farmers of Fakirhat upazila. The null hypothesis is, "there is no relation between the adaptation of horticultural crops to climate change and the selected characteristics of the farmers ". The selected characteristics were age, education, farm size, annual income, credit received, and cosmopoliteness.

CHAPTER IV
RESULTS AND DISCUSSION

In this chapter, the findings of the study and its interpretation are presented in different sections in accordance with the objectives of the study. The first section deals with the selected characteristics of the farmers, while the second section deals farmers perception of climate change and the third section deals with environmental hazards as experienced by the farmers and impact of climate change as observed by farmers. The forth section deals with adaptation of horticultural crops against climate change. Constraints to adaptation due to climate change have been discussed in the fifth section. The sixth section deals with the relationship between selected characteristics of the farmers and their adaptation of horticultural crops against climate change.

4.1 Selected characteristics of the farmers

The findings related to the selected characteristics of the farmers namely age, education, farm size, annual income, credit received and cosmopoliteness are described below.

4.1.1 Age

The age of the farmers in the study area ranged from 25 to 91 years, the average mean 49.70 years and the standard deviation 12.46. Based on their age, the farmers were classified (Table 4.1) into three categories namely, “young” (up to 35), “middle aged” (36-50) and “old” (above 50).

Table 4.1 Distribution of the farmers according to their age

Categories (Years)	Farmers		Mean	Standard deviation
	Number	Percent		
Young aged (upto 30 years)	4	5	49.70	12.46
Middle aged (31-50 years)	40	50		
Old aged (above 50 years)	36	45		
Total	80	100		

Data in table 4.1 indicates that the middle aged farmers in study area comprise the major proportion (50%) followed by old aged category (45%) and the young aged constitute the lowest (5%) proportion. Data also indicates that total 95% farmers belonged to the middle and old aged group. The middle and old aged farmers were generally tended to involve in adopting horticultural crops than the younger. Probably middle and old aged farmers were more sincere regarding the adaptation activities. Probably, the young community was more involvement in another income generating activities. Mahmood (2011) reported that, age is an important factor regarding knowledge because age had significant negative correlation with horticultural adaptation.

4.1.2 Education

The education level of the farmers was measured by their year of schooling and was ranged from 0 - 10 with an average of 5.68 and standard deviation of 2.92 (Table 4.2).

Table 4.2 Distribution of the respondents according to their level of education

Categories (Schooling years)	Farmers		Mean	Standard deviation
	Number	Percent		
No education (0)	3	3.8	5.68	2.92
Can sign only (0.5)	6	7.5		
Primary (1-5)	25	31.2		
Secondary or higher (6-10)	46	57.5		
Total	80	100		

Data in table 4.2 showed that 57.5% of the farmers had secondary or higher level of education whereas 3.8% of them were illiterate and 7.5% can sign only. 31.2% of them were completed primary level education. Education broadens the horizon of outlook of farmers and expands their capability to analyze any situation related to adaptation against climate change. An educated farmer is likely to be more responsive to the modern facts, ideas, technology and information of climate change. To adjust with the same, illiterate group would be vulnerable to adopt as well as involve with modern management practices of horticultural crop cultivation.

4.1.3 Farm size

In the study area the farm size was measured with the total land cultivated by the farmer. Data were collected in local unit and then converted in hectare. The farm size ranged from 0.203-4.182 hectare with an average of 0.93 hectare and the standard deviation of 0.81 (Table 4.3).

Table 4.3 Distribution of the respondents according to their farm size

Categories	Respondents		Mean	SD
	Number	Percent		
Marginal (0.2-0.5)	29	37.5	0.93	0.81
Small (0.51-1)	24	30		
Medium (1.01-2)	15	18.8		
Large (above 2)	11	13.7		
Total	80	100		

Among the farmers as showed in the table 37.5% was marginal, 30% was small and 13.7% was large farm holder. The medium category also constitutes 18.8%.

4.1.4 Annual income

Annual family income score of the farmers in Fakirhat upazila ranged from 35 to 780 thousands with a mean and standard deviation of 168.15 and 123.06, respectively. On the basis of their annual income, the farmers in Fakirhat upazila were classified into three categories, viz. low, medium and high annual family income category. The distribution of the farmers in Fakirhat upazila according to the annual income categories has been presented in Table 4.4.

Table 4.4 Distribution of the respondents according to their annual income

Categories ('000' Taka)	Respondents		Mean	SD
	Number	Percent		
Low income group (up to 100)	28	35	168.15	123.06
Medium income group (100-200)	29	36.3		
High income group (above 200)	22	28.7		
Total	80	100		

Data presented in Table 4.4 revealed that the farmers in Fakirhat upazila having medium income constitute the highest proportion (36.3%) followed by the low income (35%) and high annual income group constitute the lowest percentage (28.7%).

4.1.5 Credit received

Data presented in Table 4.5 indicate that the credit received scores of the farmers in Fakirhat upazila ranged from 0 to 25, the mean and standard deviation being 10.29 and 7.64 respectively. On the basis of the credit received, the farmers in Fakirhat upazila were classified into three categories namely, "no credit received (0)", "low (1-10)", "medium (11-20)"and "high (> 20)" group.

Table 4.5 Distribution of the respondents according to credit received by them

Categories ('000' Taka)	Respondents		Mean	SD
	Number	Percent		
No (0)	16	20	10.29	7.64
Low (1-10)	31	38.8		
Medium (11-20)	26	32.5		
High (above 20)	7	8.7		
Total	80	100		

Analyzed data indicated that the highest proportion (38.8%) of the farmer received low amount of credit, while 32.5% of the farmers received medium amount of credit, 20% did not get any credit, while only 8.7% received high amount of credit.

4.1.6 Cosmopoliteness

An individual orientation external to his own social is referred to as cosmopoliteness. Cosmopoliteness scores of the respondents ranged from 5 to 19 against the possible range of 0 to 21. The mean was 11.84 and standard deviation was 2.84. On the basis of the cosmopoliteness scores, the farmers in Fakirhat upazila were classified into three categories ‘low cosmopoliteness’ (up to 7), ‘ medium cosmopoliteness’ (8-14), ‘high cosmopoliteness’ (>14), The distribution of the farmers in Fakirhat upazila according to their cosmopoliteness is shown in Table 4.6.

Table 4.6 Distribution of the farmers in Fakirhat upazila according to their cosmopoliteness

Categories	Farmers		Mean	SD
	Number	Percent		
Low (up to 7)	4	6.3	11.84	2.84
Medium (8-14)	62	77.5		
High (above 14)	13	16.2		
Total	80	100		

Data presented in Table 4.6 indicate that the highest proportion (77.5%) of the farmers in Fakirhat had medium extension contact, while 16.2% had high cosmopoliteness and only 6.3% had low cosmopoliteness. The finding of this study indicates that the farmers in the study area had high to medium cosmopoliteness. Perception of the farmers depends on cosmopoliteness of the farmers. It helps individuals to become rational, conscious and get useful information to solve their day-to-day problems through different sources of information. Cosmopoliteness also helps to get new knowledge about climate change and adaptation technique to climate change. It could be concluded that extension agent or media of the study area were available to the farmers in Fakirhat. So, the farmers in Fakirhat upazila gained knowledge on adaptation against climate change by their innovative experience or cosmopolite behaviors.

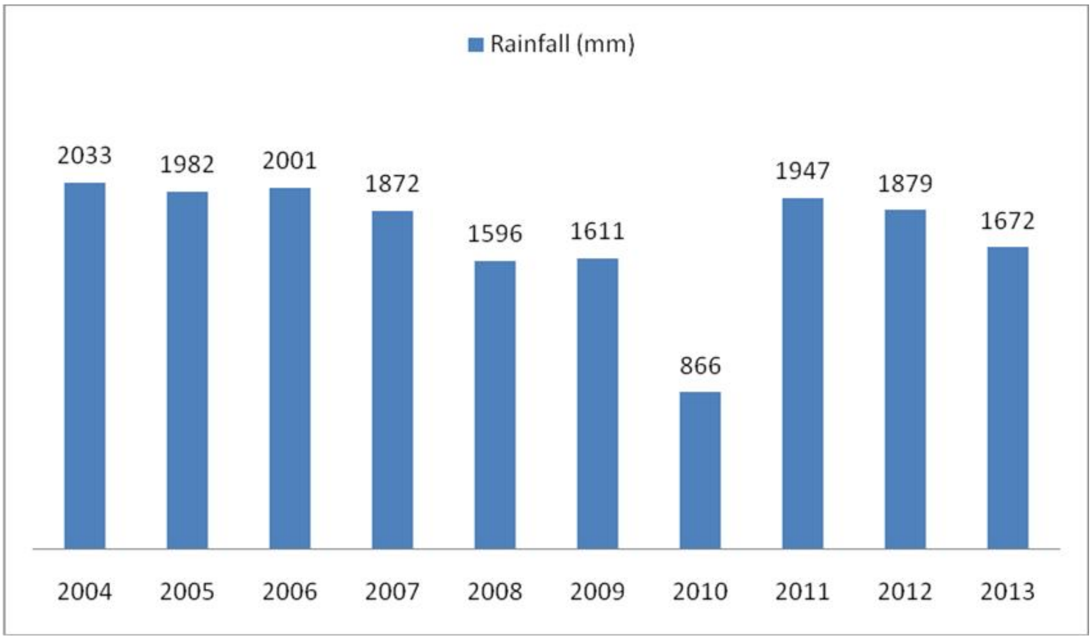
4.2 Farmers' perception of climate change and comparison with meteorological data of the study area

4.2.1 Rain fall:

Total rain fall at Fakirhat upazila was 1672 mm in 2013 (Fig. 4.1) and average rain fall was 1.74 mm. According to the record of Upazila Agriculture Officer, total rain fall was 646 mm in Kharip-1 season, 949 mm in Kharip-2 season and 77 mm in Rabi season. Approximately 86% of the annual average rainfall occurs between June and September (Fig. 4.2).

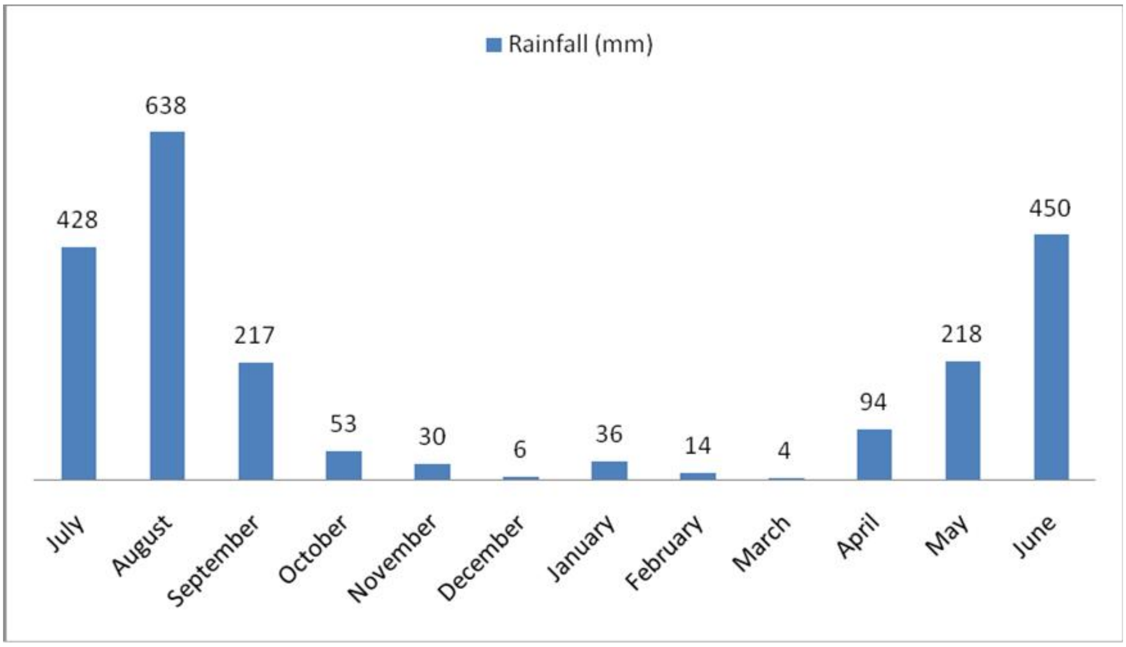
4.2.2 Temperature:

The highest temperature of this area was 37-39^{0}C that exists in the month of April-May in this area. As the same way in the winter season the lowest temperature was in 8-10^{0}C. Analyzing the last 10 years data (Fig. 4.4), it is shown that temperature increasing rate is upwards and relative humidity remained between 70-80%.

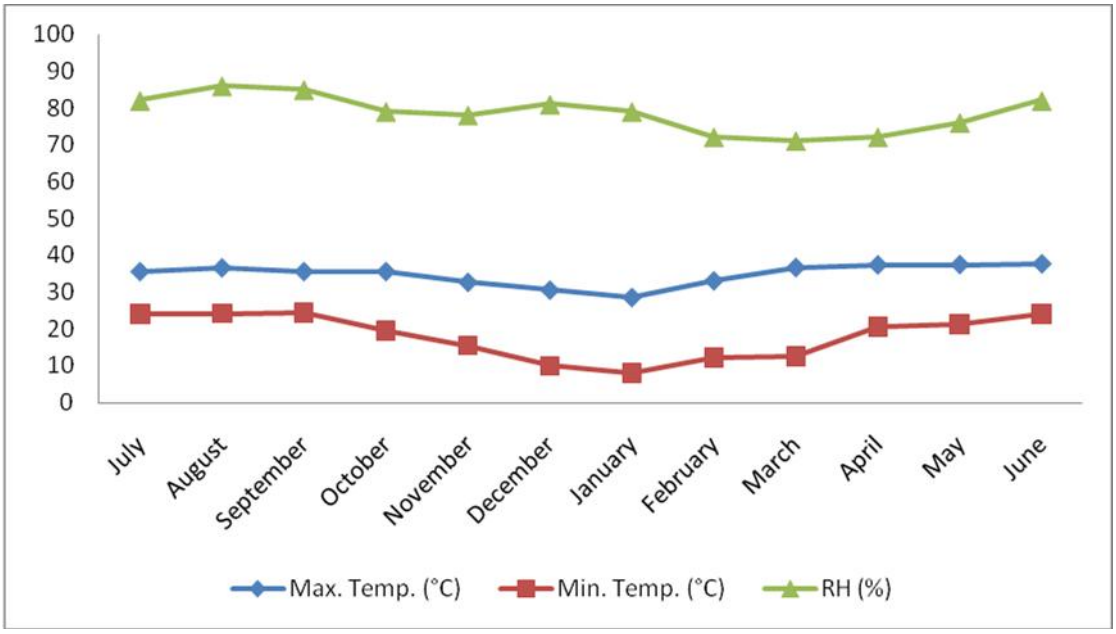


Source: Bangladesh Meteorological Department

Figure 4.1 Average annual rainfalls for the years 2004- 2013 in the study site

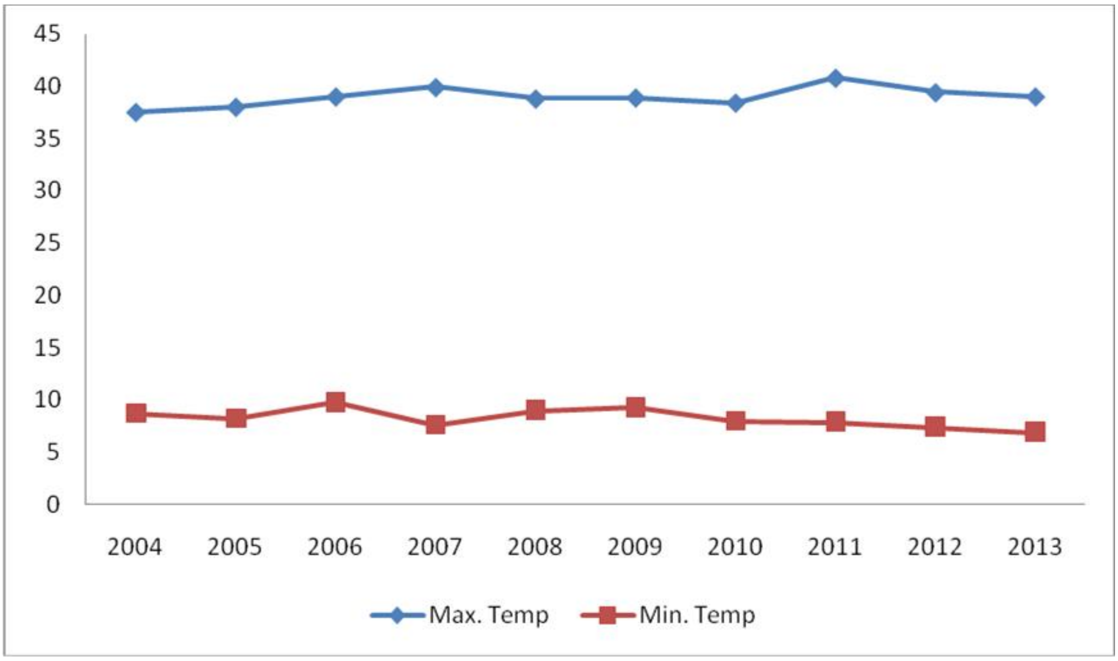


Source: Bangladesh Meteorological Department
Figure 4.2 Month wise rainfall of the study site (2012- 2013)



Source: Bangladesh Meteorological Department

Figure 4.3 Average monthly temperature (°C) and relative humidity (%) of the study site (2012-13)



Source: Bangladesh Meteorological Department

Figure 4.4 Annual minimum and maximum temperature for the years 2004- 2013 in the study site

4.2.3 Disaster, Hazard and Vulnerability:

Due to geographical condition Fakirhat Upazila is less vulnerable than any other Upazilas of Bagerhat District considering natural disaster (Fig. 4.5). Due to its high landscape the disaster pattern and impact is different than other disaster-prone area of Bangladesh. It's true that local people don't get rid of wear and tear of super disaster like SIDR.

According to experience of union level local representatives, community leaders and local people cyclone and tidal surges are main hazard of Fakirhat. Some time due to excess rainfall, water logging is created covering large area that becomes disaster. Water logging stays long time due to having no proper drainage system and community suffer long time. It creates a massive loss of different sector like local agro based economy, fishing, life and livelihoods, health, education, infrastructure etc. At the time of last flood caused by SIDR, water level was 5-6 feet height and water flow was 30-40 km hr^{-1}. Water logging caused by heavy rainfall stays here from June-July naturally.

Fakirhat is a Upazila of Bagerhat district closely linked to sea. Bagerhat district head quarter is 80-90 km far from the Bay of Bengal. Sundarban related several big rivers attached with Bagerhat go into sea. Considering this circumstances total Bagerhat district is more or less risk area from sea storm. Though Fakirhat upazila is less risk area than any other upazilas of Bagerhat but it is situated at a risky position for super storm like SIDR. Considering the risk of this kind of storm agriculture sector stays at the most vulnerable situation at present. Likewise infrastructure, communication, education, environment sectors are also in risky situation like agriculture.

Source: Upazila Parishad, Fakirhat, Bagerhat

Figure 4.5 Vulnerability map of the Fakirhat upazila

4.3 Farmers' perception of climate change

Farmers perception related to climate change is presented in the Table 4.7. Data showed that the 47.5% farmers said that average annual precipitation decreased from before 10 years (2004-2013), 36.25% farmers said annual precipitation increased from before 10 years, 7.5% farmers said annual precipitation had no changed from before 10 years and only 8.75% farmers had no comment on it. However, 31.25%, 42.5%, 15% and 11.25% farmers said in rainy season precipitation increased, decreased, no changed and don't know respectively from before 10 years. The13.75%, 37.5%, 32.5% and 16.25% farmers said in dry season precipitation increased, decreased, no changed and don't know respectively from before 10 years. The 26.25%, 48.75%, 13.75% and 11.25% farmers said length of rainy season increased, decreased, no changed and don't know respectively from before 10 years.

On the other side, the last 10 (2004-2013) years precipitation data of the study area indicated that the yearly mean precipitation of 2004 and 2013 were 2033 and 1672 mm respectively. The data indicated that yearly mean precipitation of last 10 years was changed from year to year and it showed a decreasing trend (Figure 4.1). So, farmer's perception about precipitation is reasonable as majority of farmers (47.5%) claimed that precipitation was decreased.

The farmers' perception about variability of annual average temperature, summer season temperature and winter season temperature of different years have shown in the table 4.2 in details where the maximum 51.25% farmers said annual average temperature increased from before 10 years and only 6.24% farmers said annual average temperature reduced from before 10 years.
The 48.75% farmers said annual average winter season temperature had reduced but only 20% farmers said winter season temperature increased from before 10 years. The 57.5% farmers said summer season temperature increased from before 10 years and where only 25% farmers said summer season temperature reduced from before 10 years.

Table 4.7 Distribution of the respondents based on their perception of climate change

Sl. No.	Name of the Statement		Extent of perception (Total respondents: 80) (No.=Number and %=Percentage)							
			Increased		Reduced		No change		Don't know	
			No.	%	No.	%	No.	%	No.	%
1.	Precipitation	Annual	29	36.25	38	47.50	6	7.50	7	8.75
		In rainy season	25	31.25	34	42.50	12	15.00	9	11.25
		In dry season	11	13.75	30	37.50	26	32.50	13	16.25
		Length of rainy season	21	26.25	39	48.75	11	13.75	9	11.25
2.	Temperature	Annual	41	51.25	5	6.25	21	26.25	13	16.25
		Winter season temperature	16	20.00	39	48.75	18	22.50	7	8.75
		Summer season temperature	46	57.50	20	25.00	9	11.25	5	6.25
		Length of cold period	24	30.00	27	33.75	18	22.50	11	13.75
		Length of hot period	45	56.25	18	22.50	11	13.75	6	7.50
3.	Extreme events	Intensity of storms	31	38.75	22	27.50	15	18.75	12	15.00
		Intensity of hotness	47	58.75	20	25.00	9	11.25	4	5.00
		Intensity of rainfall events	23	28.75	27	33.75	14	17.50	16	20.00
		Saline water intrusion	51	63.75	3	3.75	17	21.25	9	11.25

However, 30% and 33.75% farmers said length of cold period increased and decreased, respectively. The 56.25% and 22.5% farmers said length of hot period increased and decreased respectively from before 10 years.

On the other side, the last 10 (2004-2013) years temperature data of the study area indicated that the yearly mean minimum temperature of last 10 years which stated as the yearly mean minimum temperature of 2004 and 2013 were 8.7^0C and 6.9^0C, respectively. The data indicated that yearly mean minimum temperature of last 10 years was changed from year to year and it showed a decreasing trend (Figure 4.2). So, farmer’s perception about winter season temperature is reasonable as majority of farmers (48.75%) claimed that winter season temperature was decreased. The last 10 (2004-2013) years temperature data of the study area indicated that the yearly mean maximum temperature of last 10 years which stated as the yearly mean maximum temperature of 2004 and 2013 year were 37.5^0C and 39^0C, respectively. The data indicated that yearly mean maximum temperature of last 10 years was changed from year to year and it showed an increasing trend (Figure 4.2). So, farmer’s perception about summer season temperature is reasonable as majority of farmers (57.5%) claimed that summer season temperature was increased.

In case of extreme event, the maximum 38.75 farmers said that the intensity of storms was increased and 27.5% farmers had said that the intensity of storms was decreased from before 10 years. Besides, 58.75% farmers said that the intensity of hotness in summer season was increased and 25% farmers had said that the intensity of hotness in summer season was decreased from before 10 years and the highest 33.75% farmers said that intensity of rainfall events was decreased from before 10 years. In case of saline water intrusion maximum%age (63.75%) of farmers claimed that it was increased gradually.

4.4 Environmental hazards experienced by the farmers

The data of the Table 4.8 indicated that the environmental hazards scores of the farmers in Fakirhat upazila ranged from 4 to 17 with a mean of 12.30 and standard deviation 2.83. On the basis of environmental hazards score, respondents were classified into three categories, “low” (up to 9), “medium” (10-14), and “high” (>14).

Table 4.8 Overall categories of farmer based on environmental hazards experienced by them

Probable range	Observed range	Environmental hazards categories	Famers'		Mean	SD
			Number	Percent		
0-21	4-17	Low (up to 9)	14	17.5	12.30	2.83
		Medium (10-14)	49	61.25		
		High (>14)	17	21.25		
Total			80	100		

Data presented in Table 4.8 indicated that the majority (61.25%) of the farmers in Fakirhat upazila had medium environment hazards scores while 17.5% had low environment hazards scores and 21.25% high environmental hazards was found in the study area.

After calculated the “extent of environmental hazards” scores for each of 80 respondents, and effort was also made to compare the relative hazards. An environmental hazards index (EHI) was developed to fulfill this objective.

Percent of distribution of the farmers in Fakirhat upazila according to environmental hazards in each of 7 items was been shown in the Table 4.4. Along with EHI and rank order of each environmental hazard, Environmental hazards index of the respondents of the 7 items ranged from 0 to 240. The problems identified by the farmers in Fakirhat upazila are listed according to their importance.

Table 4.9 Environmental hazards experienced by the farmers

Problems	Farmers (N=80)				EHI	Rank order
	High	Medium	Low	Not at all		
Drought	25	25	21	9	146	3
Spread of pest	23	44	13	0	170	1
Flood	17	27	34	2	139	4
Hail Stone	16	15	38	11	116	7
Cyclone	28	22	26	4	154	2
Dew	16	16	39	9	119	6
Cold	6	38	30	6	124	5

Data presented in the Table 4.9 Indicates that most of the farmers of the study area faced drought to a considerable extent rather than others environmental hazards. The highest hazard index (170) was found in case of spread of pest. The next index was found in case of cyclone (154).

4.5 Impact of climatic change

The data of the Table 4.10 indicated that the impact of climatic change scores of the farmers in Fakirhat upazila ranged from 10 to 25 against the possible range of 0 to 30 with an average of 18.46 and standard deviation 3.09. On the basis of impact of climatic change score, the farmers in Fakirhat upazila were classified into three categories, low (up to 15), medium (11-20) and high (> 20).

Table 4.10 Overall categories of farmer based on their observation on impacts of climate change

Probable range	Observed range	Impacts categories	Famer		Mean	SD
			Number	Percent		
0-30	10-25	Low (up to 15)	9	11.25	18.46	3.09
		Medium (16-20)	54	67.50		
		High (>20)	17	21.25		
Total			80	100		

Data presented in the Table 4.10 indicated that the majority (67.5%) of the farmers had medium impact of climate change while 21.25% had high impact of climate change and 11,25% respondents had low impact of climate change.

After calculated the "extent of impact of climatic change" scores for each of 80 respondents, and effort was also made to compare the relative impacts. Impacts score for each statement was calculated by using Impact of Climate Change Index (CCII) and it has been arranged in rank order according to their extent of impact level which appears in Table 4.11. The CCII could range from 0 to 240, where 0 indicating no impacts and 240 indicating maximum impacts of a single statement on impact of climate change as observed by the farmers in Fakirhat upazila.

Combined result of climate change was the most severe impact (227) faced by the farmers in Fakirhat upazila regarded as top in ranking order followed by next five impacts based on their descending order of severity or ranking were change in rainfall pattern (218), saline water intrusion (201), decrease soil fertility (168), scarcity of surface water (155) and reduced ground water recharge (133). The Table 4.6 also shows that the last three least severe problems are impact of drought (118), cropping pattern change (103) and beneficial impact of climate change (2).

Table 4.11 Statement-wise score of impacts of the climate change

Impacts	Farmers (N=80)				Impact of climate change index (CCII)	Rank order
	High	Medium	Low	Not at all		
Climate change is beneficial	0	0	2	78	2	10
Climate change is a problem	71	7	0	0	227	1
Is here occur any major climatic hazard	7	37	28	8	123	7
Is here any impact of drought	19	29	30	2	118	8
Change in rainfall pattern	65	9	5	1	218	2
Cropping pattern change	2	31	35	12	103	9
Scarcity of surface water	27	25	24	5	155	5
Reduced ground water recharge	17	24	34	5	133	6
Saline water intrusion	48	25	7	0	201	3
Decrease soil fertility	30	30	18	2	168	4

4.6 Adaptation of horticultural crops to climate change

Adaptation of horticultural crops to climate change is the depended variable of this study. The adaptation of the farmers of Fakirhat upazila score range from 6 to 48 against the possible range of 0 to 63 with an average of 33.4 and standard deviation 8.36. Based on their adaptation score, the respondents were classified into three categories, low (up to 25), medium (26- 45) and high (> 45). The distribution of the respondents according to their overall agricultural adaptation to climate change is shown in 4.12.

Table 4.12 Overall categories of farmers' based on their adaptation of horticultural crops

Probable range	Observed range	Adaptation categories	Famers		Mean	SD
			Number	Percent		
0-63	6-48	Low (up to 25)	14	17.50	33.4	8.36
		Medium (26-45)	61	76.25		
		High (>45)	5	6.25		
Total			80	100		

Data presented in the Table 4.12 indicates that majority of the farmers of Fakirhat upazila 76.25% of the farmers had medium agricultural adaptation compared to 17.50% had low adaption and 6.25% had high adaptation. The above findings show that a large number of the farmers of Fakirhat upazila had low to medium adaptation of horticultural crops to climate change.

Adaptation of horticultural crops to the climate change is investigated in this research. The extent of agreement against each statement as perceived by the farmers was assessed in this regard. Adaptation score for each statement was calculated by using AHI and it has been arranged in rank order according to their extent of adaptation level which appears in the Table 4.13. The AHI could range from 0 to 240, where 0 indicating no adaptation and 240 indicating maximum adaptation of a single statement on adaptation of horticultural crops to climate change.

Table 4.13 Statement-wise score of adaptation of horticultural crops to climate change

Adaptations	Farmers (N=80)				AHI	Rank order
	High	Medium	Low	Not at all		
Homestead horticulture with micro irrigation	16	28	31	5	135	7
Cultivate salt resistance horticultural crops	32	6	6	36	114	12
Introduce multiple water use techniques	6	11	38	25	78	19
Introduce rain water harvesting techniques	9	18	27	16	90	17
Introduce short duration varieties	34	39	3	4	183	2
Increase cropping intensity	10	22	28	10	102	15
Increase vegetable cultivation	16	58	13	3	177	3
Increase fruit tree cultivation	12	41	24	3	142	5
Support arrangement for creeper vegetables	14	25	29	12	121	11
Cultivation of spices & condiments in shady place	7	32	24	17	109	13
Collection & preservation of seed	8	10	45	17	89	18
Increase cultivation of resistant variety	33	13	14	20	139	6
Increase cultivation of short durable crops	8	28	19	25	99	16
Increase tendency of conserving water for irrigation	4	43	26	7	124	10
Increase use of water canal for irrigation	7	39	28	6	127	9
Increase the use of irrigation machineries	2	31	34	13	102	15
Increase the use of mulching to conserve water	6	28	29	17	103	14
Increase cultivation of shade crop	10	30	24	16	114	12
Increase the use of mixed fertilizer	64	8	8	0	216	1
Increase multiple cropping	10	35	28	7	128	8
Integrated pest management (IPM)	28	30	21	1	165	4

Table 4.13 represented, increase the use of mixed fertilizer got the 1st rank among the statements. It was found that 80% of the respondent had highly adaptation to this statement and 10% of the farmers of Fakirhat upazila had medium adaptation to this statement with the total AHI of 216. “Introduce short duration varieties” got the second highest score and thus stood in the rank order. 42.5% among the respondents had highly adaptation, 48.75% of them had medium adaptation and 8.75% of them had low adaptation to this statement with the total AHI of 183. Increase vegetable cultivation obtained the third highest AHI (177) and stood third in the rank order. “Introduce multiple water use techniques” obtained the least score (78) and so got the last position in rank order regarding the adaptation of horticultural crops to climate change.

Santa (2013) found that, most farmers (82.5%) of the South-Western Coastal Region of Bangladesh had medium adaptation to climate change and 6.25% farmers had low adaptation and 11.25% farmers had high adaptation where Increase irrigation machineries, Increase use of water canal for irrigation, Changing sowing and planting time of crops, Increase cultivation of saline resistant variety, Increase cultivation of short durable crop, Increase application of organic matter etc. are the common agricultural adaptation. Rahaman (2010) also found that the majority (89.9%) of the farmers had low agricultural adaptation and 10.1% of the farmers had medium agricultural adaptation of climate change in braind region of Bogra. Rahman (2005) found that that the majority (49.0%) of the farmers had medium agricultural adaptation while 34.3% of the farmers had low and 16.7% of the farmers had high agricultural adaptation to climate change in the selected drought prone area of Bangladesh. Where increase irrigation machineries, increase use of water canal for irrigation, changing sowing and planting time of crops, increase cultivation of drought resistant rice variety, increase cultivation of short durable crop, increase application of organic matter etc are the common agricultural adaptation.

4.7 The actual scenario of adaptation of horticultural crops

The trend of horticultural crop cultivation is growing fast because of increasing demand and short duration facility. Day by day farmers are changing pattern of crop cultivation. Once they cultivated cabbage and cauliflower immensely but they are now cultivating turnip cabbage, bean and brinjal. Because cabbage and cauliflower cultivation is easily affected by pest and diseases and it rotes easily. Short duration of winter due to climate change is the major barriers of Cabbage and Cauliflower. Cultivation of turnip cabbage, bean and brinjal were comparatively less affected by pest and diseases. On the other hand its production cost is very low.

Vegetable farming in Fakirhat Upazila can be grouped into 3 categories based on scale of production and objectives of farming: (i) vegetable production on homestead (Plate 1), (ii) vegetable production for commercial market and (iii) vegetable farming for seed production.

During winter when the land becomes dry, they cultivate some vegetables like red amaranth, bottle gourd, etc. Farmers of this upazila depend entirely on chemical fertilizers and insecticides and it is difficult for them to get access to these agricultural inputs in the rural areas. The farmers also shared their observation that the productivity of land is decreasing day by day due to excessive use of chemical fertilizers. Therefore, they need training on bio fertilizer and Integrated Pest Management (IPM). They have requested for more outreach and training from the Department of Agricultural Extension (DAE) at the union level.

The area under vegetable farming has increased over time. The major winter vegetables are cabbage, cauliflower, tomato, brinjal, radish, hyacinth bean, bottle gourd, and major summer vegetables are pumpkin, bitter gourd, teasle gourd, ribbed gourd, ash gourd, okra, yard-long bean, and indian spinach among others. some vegetables like brinjal, pumpkin, okra, lady's finger and red amaranth were found to grow in both the seasons. Various vegetables were grown in those seasons of the study area is shown in the table 4.14 and 4.15.

Table 4.14 Winter season vegetables (Source: AEO, Fakirhat Upazila, 2012)

Types of crop	**Land use in hectares**			
	2010-11	2011-12	Increase	Decrease
Turnip cabbage	35	50	√	-
Brinjal	40	53	√	-
Bean	25	30	√	-
tomato	8	7	-	√
Radish	5	5	-	-
Carrot	2	2	-	-
Cauliflower	2	1	-	√
Cabbage	3	2	-	√

Tables 4.15 Summer season vegetables (Source: AEO, Fakirhat Upazila, 2012)

Types of crop	**Land use in hectares**			
	2010-11	2011-12	Increase	Decrease

Pumpkin	85	100	√	-
Amaranth	43	50	√	-
Bitter gourd	28	25	-	√
Lady's finger	9	10	√	-
Yard-long bean	8	10	√	-

4.8 Constraints to climate change adaptation

The purpose of this section was to understand on problems faced by the farmers of Fakirhat upazila in implementing agricultural adaptation. The constraints to climate change adaptation of the farmers of Fakirhat upazila score range from 15 to 36 against the possible range of 0 to 42 with an average of 29.02 and standard deviation 5.90. Based on their constraints to climate change adaptation score, the farmers of Fakirhat upazila were classified into three categories, low (up to 10), medium (11- 20) and high (> 20). The distribution of the farmers of Fakirhat upazila according to their overall constraints to climate change adaptation is shown in 4.16.

Table 4.16 Overall categories of farmer based on their constraints to climate change adaptation

Probable range	Observed range	Constraints categories	Famers		Mean	SD
			Number	Percent		
0-42	5-26	Low (up to 10)	7	8.75	18.20	5.15
		Medium (11-20)	42	52.50		
		High (>20)	31	38.75		
Total			80	100		

Data presented in the table indicated that majority of the respondents (47.50%) faced high constraints to climate change adaptation followed by 36.25% of the farmers faced medium constraints to climate change adaptation and 16.25% of the farmers faced low constraints to climate change adaptation. The above findings show that a large number of the respondents had medium to high constraints to climate change adaptation.

After calculating the extent of constraints to climatic change adaptation scores for each of 80 respondents, an effort was also made to compare the relative constraints. Constraints score for each statement was calculated by using Adaptation Barrier Index (ABI) and it has been arranged in rank order according to their extent of constraints level which appears in the Table 4.17. ABI could range from 0 to 240, where 0 indicating no constraints and 240 indicating maximum constraints of a single statement of constraints to climatic change adaptation.

Table 4.17 Statement-wise score of constraints to climate change adaptation

Constraints	Farmers (N=80)				ABI	Rank order
	High	Medium	Low	Not at all		
Lack of information	52	19	6	3	200	1
No subsidies on planting materials	46	24	7	3	193	2
Lack of access to improved adopted crop varieties	51	15	8	6	191	3
Absence of water management technique	41	16	15	8	170	4
Low awareness	35	21	22	2	169	5
Limited knowledge on adaptation measures	8	28	16	28	96	8
Inability to give up traditional value	20	18	23	19	119	7
Poor government attention to climate problems	22	47	10	1	170	4
Absence of government policy on climate change	21	32	23	3	150	6

“Lack of information” was the most severe constraints (200) faced by the farmers of Fakirhat upazila regarded as top in ranking order followed by next five problems based on their descending order of severity or ranking were no subsidies on planting materials (193), lack of access to improved adopted crop varieties (191), absence of water management technique and poor government attention to climate problems (170), low awareness (169) and absence of government policy on climate change (150). The Table also showed that the last three least severe problems were inability to give up traditional value (119) and limited knowledge on adaptation measures (96).

Santa (2013) found that, inability to access available information was the most severe problem (202) faced by the respondents of the South-Western coastal region of Bangladesh regarded as top in ranking order followed by next five problems based on their descending order of severity or ranking were limited knowledge on adaptation measures (180), low awareness level (178), absence of water management techniques (174), absence of government policy on climate change (167) and irregularity of extension services (165).

4.9 Relationship between the selected variables with farmers' adaptation of horticultural crops to climate change

This section deals with the relationship between six selected characteristics of the farmers and their adaptation of horticultural crops to climate change. The selected characteristics were: age, education, farm size, annual income, credit received and cosmopoliteness. To explore the relationships between the selected characteristics and their adaptation Pearson's Product Moment co-efficient of correlation (r) has been used. The relationships of the selected characteristics of the farmers of Fakirhat upazila with their adaptation have been showed in Table 4.18. However a correlation matrix for all variables has been presented in Appendix-III.

Table 4.18 Computed co-efficient of correlation (r) between farmers' adaptation of horticultural crops to climate change and selected variables (N = 80)

Selected variables	Values of 'r' with 78 df	Table value of 'r' of 78 df	
		0.01	0.05
Age	-0.230*	0.254	0.195
Education	0.595**		
Farm size	0.415**		
Income	0.287**		
Credit received	-0.113NS		
Cosmopoliteness	0.904**		

NS = Non significant

** = Correlation is significant at 0.01 level of probability

* = Correlation is significant at 0.05 level of probability

4.9.1 Relationship between age and adaptation of horticultural crops to climate change by the selected farmers

The relationship between age of the farmers and their adaptation of horticultural crops to climate change examined by testing the following null hypothesis: “There is no relation between the adaptation of horticultural crops to climate change and the selected characteristics of the farmers.” The computed value of ‘r’ (-0.230) was found larger than that of the tabulated value (r = 0.195) with 78 degrees of freedom at 0.05 level of probability as shown in Table 4.13. Thus the concerned null hypothesis was rejected. The relationship between the two concerned variables also showed negative trend. Therefore, it was concluded that there was negative significant relationship between age of the farmers and their adaptation of horticultural crops to climate change. This means the higher the age of the farmer the lesser their adaptation tendency.

4.9.2 Relationship between education and adaptation of horticultural crops to climate change by the selected farmers

The relationship between education of the farmers and adaptation of horticultural crops to climate change was examined by testing the following null hypothesis: “There is no relationship between education of the farmers and adaptation of horticultural crops to climate change.” The computed value of ‘r’ = (0.595) was greater than the tabulated value (r = 0.254) with 78 degrees of freedom at 0.01 level of probability as shown in Table 4.18. Based on the above findings, the null hypothesis was rejected and it was therefore, concluded that farmers' education had positive significant relationship with their adaptation of horticultural crops to climate change.

4.9.3 Relationship between farm size and adaptation of horticultural crops to climate change by the selected farmers

The relationship between farm size of the farmers and their adaptation of horticultural crops to climate change was examined by testing null hypothesis: "There is no relationship between farm size of the farmers and their adaptation of horticultural crops to climate change." The computed value of 'r' (0.415) was found greater than the table value (r =0.254) with 78 degrees of freedom at 0.01 level of probability as shown in Table 4.18. The relationship between the two concerned variables also showed positive trend. Hence, the concerned null hypothesis was rejected. The findings indicate that farm size of the farmers had a positive significant relationship with their adaptation.

4.9.4 Relationship between income and adaptation of horticultural crops to climate change by the selected farmers

The relationship between the farmer’s income and their adaptation of horticultural crops to climate change was studied by testing the following null hypothesis: "There is no relationship between income of the farmers and their adaptation of horticultural crops to climate change." The computed value of 'r' (0.287) was greater than the tabulated value of 'r' (r = 0.254) with 78 degrees of freedom at 0.01 level of probability as shown in Table 4.18. The relationship between the two concerned variables also showed positive trend. Hence the concerned null hypothesis was rejected. The findings indicate that farmers' income had positive significant relationship with their adaptation. Hence, one can say that larger the income higher their adaptation of horticultural crops to climate change.

4.9.5 Relationship between credit received and adaptation of horticultural crops to climate change by the selected farmers

The relationship between credit received of the farmers and their adaptation of horticultural crops to climate change was examined by testing the following null hypothesis: "There is no relationship between credit received of the farmers and their adaptation of horticultural crops to climate change." The computed value of 'r' (0.113) was smaller than the tabulated value (r = 0.254) with 78 degrees of freedom at 0.01 level probability as shown in table 4.18. Therefore, the concerned null hypothesis was accepted. Hence, there is no significant relationship between credit received and adaptation of horticultural crops to climate change.

4.9.6 Relationship between cosmopoliteness and adaptation of horticultural crops to climate change by the selected farmers

The relationship between cosmopoliteness of the farmers and their adaptation of horticultural crops to climate change was examined by testing the following null hypothesis: "there is no relationship between cosmopoliteness of the farmers and their adaptation of horticultural crops to climate change." The calculated value of 'r' (0.904) was greater than the tabulated value (r = 0.254) with 78 degrees of freedom at 0.01 level of probability as shown in the Table 4.13. The relationship between the two concerned variables also showed positive trend. Therefore, the concerned null hypothesis was rejected. Hence, there is a positive significant relationship between cosmopoliteness of the farmers and their adaptation tendency about horticultural crops to climate change. The result indicates that the higher the cosmopoliteness of the farmers, the higher their adaptation desire.

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary

The study was conducted in four villages of Fakirhat upazilla in Bagerhat district. Sites were selected purposefully according to the extent of vulnerability towards climate change of the area. Among approximately 4000 farm families in these villages a total of 80 farmers of the four villages constituted the population of study.

In order to collect the relevant information from the farmers an interview schedule was carefully designed. Direct and open form question and different scales were used to obtain information. Data were collected through field group discussion as well as personal interview by the researcher herself from the sampled farmers during December 2012 to March 2013. The collected data were coded, compiled, tabulated and analyzed in according to the objectives of the study.

Adaptation of horticultural crops to climate change was the dependent variable of the study. Six selected characteristics of the farmers were taken as independent variables. The characteristics were age, education, farm size, annual income, credit received and cosmopoliteness. Appropriate methods and procedures were followed to measure the independent and dependent variables of the study.

Descriptive statistics like range, mean standard deviation, frequency, percentage and rank orders were used to describe both the independent and dependent variables. Tables were presenting data for the clarity of understanding. For test of hypothesis Pearson's product moment correlation co-efficient (r) was used. 1% level of significance was used as the basis for rejecting a null hypothesis.

It is well identified that different types of climatic hazards are experienced by the farmers of Fakirhat upazila. Most of them are more or less concerned about the trends and impacts of climate change of that area. So, they are always tried to cope the situation by adopting different strategies. From the last few years maximum farmers of Fakirhat upazila ran into cultivating horticultural crops specially vegetables.
Out of six selected variables of the farmers five were markedly significant at 1% level of significance and the rest one was non-significant. The significant variables were age, education, farm size, annual income and cosmopoliteness.
The findings lead to the conclusion that the 'credit received' characteristics of the farmers had no significant contribution on adaptation of horticultural crops to climate change.
Climate change poses significant challenges to agricultural sector (crop production) and therefore to livelihoods and the country's overall economic development. Adverse impacts include increased soil salinity, saline water intrusion and massive declines in cereals production, which are induced by an overall warmer, wetter and less predictable climate. New weather conditions will be particularly characterized by a rise in precipitation and sea levels, whereas extreme events such as floods, droughts and cyclones are also going to occur more frequently.
Several barriers to effective adaptation have been identified through the study, including the lack of awareness and training for farmers. Furthermore, inorganic fertilizers and pesticides are found to be too expensive and thus are not applied to the

required extent. On the other hand, farmers are hardly seen using organic fertilizer and pesticides due to their lack of knowledge and skill. The impact of climate change on horticultural crops is undeniable and will most certainly worsen if governments and donors fail to take suitable steps right now. Bangladesh urgently needs support to develop climate-resilient horticultural production system for its people to survive and prosper in the long term.

5.2 Conclusion

Adaptation to the adverse effects of climate change is vital in order to reduce the impacts of climate change that are happening now and increase resilience to future impacts. Community-based adaptation can greatly benefit from knowledge of local coping strategies. It was found from the study that the climatic parameters have changed within the study period. The tendency of monthly temperature found mostly increasing whereas and relative humidity change remains almost same. On the other hand the trend of annual and monthly rainfall was decreasing in the study period. Farmers of the study area are more or less concerned about the extent of climate change and taking adaptation measure accordingly. For the last few years horticultural crops are cultivating vastly as a consequence of adopting strategies to climate change. However, cooperation and coordination of DAE and NGOs is required for the success. A balance is to be maintained among the quality and supply of planting materials, maintaining sustainability of the environment and natural resources to cope with the climate change.

5.3 Recommendations

To address the impact of climate change and its adaptation, the following things should be considered as the major focus:

1. A specific agricultural development plan based on costal livelihoods, ecosystem and economy should be introduced to create awareness in the community as well as national and international level.

2. Enhanced capacity building for government and non-government authorities, as well as restructuring existing institutional frameworks in order to make farmers more capable of responding to the challenges imposed by climate change.

3. The implementation of a follow-up mechanism consisting of monitoring and evaluation procedures is also required in terms of efficiently scaling up initiatives on climate change adaptation.

4. Many farmers are currently using their traditional knowledge to cope with changes in climatic patterns. In order to achieve more efficient results regarding adaptation and benefit sharing, these local measures should be combined with advanced, scientifically-tested techniques.

5. Innovative farming practices should be promoted for large scale adoption in vulnerable areas for increasing production, income generation and livelihood

improvement of the people living in those areas.

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APPENDICES

APPENDIX-I

Interview schedule (English version)

EFFECT OF CLIMATE CHANGE AND ADAPTABILITY OF HORTICULTURAL CROPS IN FAKIRHAT UPAZILA OF BAGERHAT DISTRICT

Serial No:
Name of respondent:
Union:
Village:
Upazila:
District:

1. Age:

Please mention your age? .... years.

2. Education

Is the level of your education?

a) Illiterate

b) Can sign only

c) Have passed class..................

3. Farm size

Please mention your size

SL No.	Type of land	Land area	
		Local unit	Hectare
1.	Inherited		
2.	Purchased		
3.	Leased		
4.	Others		

4. Annual income

Please state the income of your family from others sources during last year

Sources	Total price (Taka)
A. Agricultural income	
B. Income from livestock and fisheries	
C. Non-agricultural source	
Total (A+B+C)	

5. Credit received

Have you received any credit from different source? Yes ☐ ☐

SL No.	Name of organization	Amount
1.	Bank	
2.	NGO	
3.	Village money lender	
	Total	

If yes, furnish the following information

6. Cosmopoliteness

Please indicate the number of time you visit the following places within special period

SL. No.	Place of visit	Extent of visit			
		Frequently (3)	**Occasionally (2)**	**Rarely (1)**	**Not at all (0)**
1	Visit to houses of friends, relatives and other known persons outside own village	4-5 times a week	2-3 times a week	once week	
2	To own union headquarter	5 or more times/month	3-4 times/month	1-2 times/month	
3	To own upazila headquarter	4-5 times/3 months	2-3 times/3 months	One time/3 months	
4	To other upazila(s)	4-5 times/4 months	2-3 times/4 months	One times/3 months	
5	To own districts town	5 or more times/year	3-4 times/year	1-2 times/year	
6	To other districts	4-5 times/year	2-3 times/year	One times/year	
7	To capital	4- 5 times/year	2-3 times/year	One times/year	

7) Do you believe climate is changing?

Yes ☐ No ☐

8)What are the causes of climate change?

a) Deforestation

b) Industrial activities

c) Agricultural practices

d) Urbanization

e) Use of motor vehicle

9. Farmers perception of Climate Change

Sl. No	Name of the Statement		Extent of perception			
			Increased	**Reduced**	**No change**	**Don't know**
1.	Precipitation	Annual				
		In Rainy season				
		In Dry season				
		Length of Rainy Season				
		Length of summer Season				
2.	Temperature	Annual				
		Winter season temperature				
		Summer season temperature				
		Length of Cold period				
		Length of Hot period				

3.	Extreme events	Intensity of storms				
		Intensity of hotness				
		Intensity of Rainfall events				
		Saline water intrusion				

10. Environmental hazards as experienced by the farmers

Please indicate the extent of damage caused due to climate change

Sl. No.	Name of the hazardous	Extent of damage			
		High	Medium	Low	Not ever
1.	Drought				
2.	Spread of pest				
3.	Flood				
4.	Hail stone				
5.	Cyclone				
6.	Dew				
7.	Cold				

11. Impact of climate change as observed by farmers

Please indicate the extent of impact experienced due to climate change.

SL. No.	Impact	Extent of impact			
		High (3)	Medium (2)	Low (1)	Not ever (0)
1.	Climate change is beneficial				
2.	Climate change is a problem				
3.	Is here occur any major climatic hazard				
4.	Is here any impact of drought				
5.	Change in rainfall pattern				
6.	Cropping pattern change				
7.	Scarcity of surface water				
8.	Reduced ground water recharge				
9.	Saline water intrusion				
10.	Decrease soil fertility				

12. Adaptation of Horticultural crops

Please indicate your extent of adaptation of horticultural crops to climate change.

Sl. No.	Aspect of adaptation	Extent of adaptation			
		High	Medium	Low	Not at all
1.	Homestead horticulture with micro irrigation				
2.	Cultivate salt resistance horticultural crops				
3.	Introduce multiple water use techniques				
4.	Introduce rain water harvesting techniques				
5.	Introduce short duration varieties				
6.	Increase cropping intensity				
7.	Increase vegetable cultivation				
8.	Increase fruit tree cultivation				
9.	Support arrangement for creeper vegetables				
10.	Cultivation of spices & condiments in shady place				
11.	Collection & preservation of seed				
12.	Increase cultivation of resistant variety				
13.	Increase cultivation of short durable crops				
14.	Increase tendency of conserving water for irrigation				
15.	Increase use of water canal for irrigation				
16.	Increase the use of irrigation machineries				
17.	Increase the use of mulching to conserve water				
18.	Increase cultivation of shade crop				
19.	Increase the use of mixed fertilizer				
20.	Increase multiple cropping				
21.	Integrated pest management (IPM)				

13. Constraints to climate change adaptation

Please indicate your extent of constraints to climate change adaptation.

Sl. No.	Name of the Constraints	Extent of opinion			
		High	Medium	Low	Not ever
1.	Lack of information				
2.	No subsidies on planting materials				
3.	Lack of access to improved adopted crop varieties				
4.	Absence of water management techniques				
5.	Low awareness level				
6.	Limited knowledge on adaptation measures				
7.	Inability to give up traditional values				
8.	Poor Government attention to climate problems				
9.	Absence of government policy on climate change				

Thank you for your kind cooperations.

....

Signature of interviewer with date

Appendix II

Farmers' group discussion guideline

1. Do you know about climate?
2. Can you tell anything about climate change?
3. What types of disasters usually happen here?
4. What types of disasters do you usually face in your locality?
5. Why does disaster happen and when? Or can you tell the causes of disaster?
6. What is the impact of climate change on cropping?
7. What types of crops are usually found in the disaster period?
8. Is there any problem you notice due to saline water? If yes, how do you overcome it?
9. Do you cultivate any saline tolerant variety?
10. What challenges do you face in cultivation due to climate change?
11. Do you have reservoir of sweet water for irrigation?
12. What type of crops do you cultivate using cannel water?
13. How do mitigate disasters?
14. What types of problems do you face due to irregular rain pattern?
15. What new crops/varieties do you cultivate due to climate change?
16. What types of disease do you face in cultivation?
17. How do you overcome diseases?
18. What types of pesticides do you prefer and why?
19. Is there any change in using fertilizer?
20. Do you cultivate more area with horticultural crops than past?

Appendix - III

Correlation matrix showing inter correlations between dependent and independent variables

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	1.000						
X_2	-0.161	1.000					
X_3	-0.005	0.122	1.000				
X_4	-0.027	0.109	0.697**	1.000			
X_5	-0.011	-0.038	- **	- **	1.000		
X_6	-0.246*	0.480**	0.450**	0.309**	-	1.000	
X_7	-0.230*	0.595**	0.415**	0.287**	-	0.904**	1.000

*   = Correlation is significant at 0.05 level of probability
** = Correlation is significant at 0.01 level of probability
Tabulated value of 'r' at 0.01 = 0.254 and at 0.05 = 0.195 respectively with 78 df

X_1 = Age X_2 =Level of education X_3 = Farm
X_4 = Annual income X_5 = Credit received X_6 = Cosn

Dependent variable
X_7 = Adaptation of horticultural crops to climate change

PLATES


01 28 2013

Plate 1: Farmers of Fakirhat upazila cultivate horticultural crops in their homestead for their own consumptions and aesthetics

Plate 2: Researcher collects information from the farmers of Fakirhat upazila of Bagerhat District