Spatio-Temporal Analysis of Climatic Parameters and Farmers' Perception, Adaptation to the Climate Change in Gazipur Area

M. Phil Dissertation

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February, 2021

DECLARATION

I would like to declare that the dissertation entitled, ***Spatio-Temporal Analysis of Climatic Parameters and Farmers' Perception, Adaptation to the Climate Change in Gazipur Area*** submitted to the University of Dhaka for the Degree of Master of Philosophy is an original work and has not been submitted to anywhere for any degree or publication.

Signature ……..

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Session: 2015-2016

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CERTIFICATION

This is to certify that the work incorporated in the dissertation titled ***Spatio-Temporal Analysis of Climatic Parameters and Farmers' Perception, Adaptation to the Climate Change in Gazipur Area*** submitted by Tashmiah Binte Shams (Registration number-31) to the University of Dhaka, through the Department of Geography and Environment for the degree of **Master of Philosophy in Geography and Environment** is based on the results of investigations carried out by her under my direction and guidance. To the best of my knowledge, it is a original work done by her. I am recommending this dissertation to the University of Dhaka for final submission to the authority concerned.

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For any kind of errors or inadequacies that may stay in this research, of course, I am completely responsible for that.

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ABSTRACT

Bangladesh is the hotspot of climate change whose economic growth depends on the agricultural sectors significantly. To reduce the vulnerability in the agriculture sector, this research firstly focused on the microclimate changes in Gazipur district, then analyzed farmers' perception on climate change and different types of local adaptation mechanisms which they pursued in the study area. To capture the data from 384 samples, household questionnaire survey and focus group discussion used. To analyze the data descriptive statistics and linear regression model were employed. The results confirmed that temperature of the annual, summer season and rainy season augmented by 0.1785^0C, 0.408^0C, 0.6273^0C respectively, but in the winter season it decreased by 0.561^0C from the year 1968 to 2018. Conversely, annual rainfall declined 619.85 mm followed by summer season 194.28 mm, rainy season 406.15 mm and winter season 21.20 mm from the year of 1963 to 2013 (51 years). It implies that the climate of the Gazipur district has been changed over 51 years. The investigation result more revealed farmers' level of the knowledge and their consciousness about the environmental change due to climate change are high. Vis-a-Vis temperature increase; there was no deviation between farmers' opinion and the real data. In contrast, regarding rainfall, there is no resemblance between farmers' knowledge and annual rainfall data. The major adaptation strategies employed by the majority of farmers were changing seeding, planting and harvesting time (74%), irrigation time (88.28%), using more herbicides (78.90%), chemical medicine (75.26%), organic farming (87.50%), motor for irrigation (82.55%). Besides, growing different types of crops with the main crop (70.05%), cultivated high yielding (52.34%), shorter cycle crops (32.03%), mulching for retaining soil moisture (54.95%), covered crops (61.20%) and planting trees (51.56%). The main constraints farmers faced to adjust with their farming practices in the response of changing climate were lacking of money,credit,savings (89.32%), high cost of irrigation (76.56%), high cost of improved seeds (78.38%), knowledge about different methods of agriculture adaptation to climate change (88.28%), pest attack (96.06%), unreliable weather forecast information (78.38%) and help from the government (96.87%). In conclusion, the research result will be useful at different levels of decision making to develop climate change policies and strategies towards shrinking farmers' susceptibility for present and future changes.

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Abbreviation

BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute for Nuclear Agriculture
BMD	Bangladesh Meteorological Department
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh water development board
CARE	Cooperative for Assistance and Relief Everywhere
DAE	Department of Agriculture Extensions
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	Green House Gases
GoB	Government of the People's Republic of Bangladesh
IPCC	Intergovernmental Panel for Climate Change
MoEF	Ministry of Environment and Forests
ND-GAIN	Notre Dame Global Adaptation Initiative
NGO	Non-Governmental Organization
RCP	Representative concentration pathway
RVCC	Reducing Vulnerability to Climate Change
SAAO	Sub-Assistant Agricultural Officers
SPSS	Statistical Package for Social Sciences
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WRI	World resource Institute

Chapter-1

Introduction

1.1 Background of the study

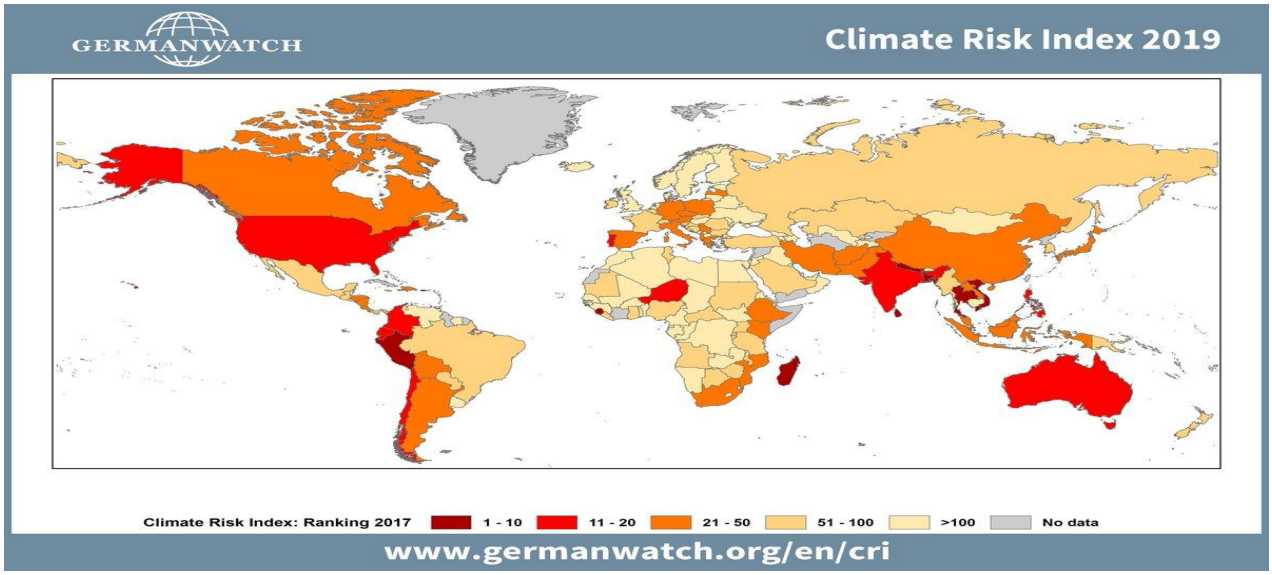


Figure 1: Climate Change Risk Index (2019)

Climate change is a potential hazard; its environmental, social and economic impact throws the whole planet into the face of risk which can be easily understandable from the above climate change risk index map (figure 1). According to IPCC forth (2007) and fifth report (2014) global anomaly temperature augmented 0.74^0C and 0.85^0C respectively. On the other hand, the temperature increased by means of 0.98^0C according to NASA (2020) from 1880 to 2019. The trend is increasing and it is projected that the global mean surface temperature is likely to augment at 2.6°C to 4.8°C under RCP (Representative concentration pathway) 8.5 at the last part of the 21st century (2081-2100) compared with 1986-2005 (IPCC, 2014). One of the reasons for climate change is the excessive presence of GHG in the atmosphere. The IPCC fifth report (2014) confirmed that atmospheric carbon dioxide concentration was 390.5 ppm (390.3 to 390.7) which was 40% greater than in 1750, in addition to, nitrous oxide (N_2O) became 324.2 ppb (324.0 to 324.4) which increased by means of 20% since 1750 (IPCC, 2014).

Climate change makes the agriculture one of the most vulnerable sector because of elevating of CO_2 in the air, higher temperature, alter precipitation and transpiration regimes, increased pests, weeds and pathogen (Easterling et al., 1993). There is a chance to reduce crop production by 2%-6% by this decade (Smith et al., 2014). In 2019, IPCC published a report in which it states climate shock already threatens the four principles of food security that are availability, access, utilization and stability. For that reasons, millions of populaces are suffering. Priyadarshi Shukla, Co-Chair of IPCC Working Group III said due to the negative effect of climate change crop production will be declined. As a result, automatically prices will be increased, nutrient quality will be declined as well as total supply chain system will be broken. All the country will not face that in the same way. Africa, Asia, Latin America and the Caribbean countries will face drastic impact of food insecurity because of climate changes (IPCC, 2019).

According to Germanwatch (2019), the 9th most susceptible country in the world is Bangladesh (Eckstein et al., 2019). The major causes of the susceptibility not only by its biophysical aspect such as being a plane, low, delta country which is exposed to floods and cyclones (Ayers et al., 2014), but also its socio-economic aspect for example high reliance on agriculture sector, population density and poverty (Thomas et al., 2013). As an agrarian country whose (Bangladesh) 40.60% of the total populace openly relies on agriculture (Bangladesh Bureau of Statistics, 2018) and 14.23% of the Gross Domestic Product (GDP) comes from agriculture sector (Bangladesh Bureau of Statistics, 2019). In addition, 149.77 million people's primary source of food is crop farming (Bangladesh Bureau of Statistics, 2015).

However, the farming system of Bangladesh still now depends on the climate. So, a small amount of deviation from the normal rainfall, temperature, evaporation, relative humidity has a direct effect on agriculture, fisheries, ecosystem and hydrological condition (Nowshin, 2013). There is a chance to reduce 40% crop production in the northwest by 2050 due to enhance of drought in future. Conversely, on account of erratic rainfall, crop production is likely to decline by 30% (Thomas et al., 2013). Not only it will effect on the performance of agricultural production but also the livelihood of farmers (Dhanya and

Ramachandran, 2015). Most importantly, farmers are directly involved in the agriculture sector and facing the impact of climate shock openly that is why they are recognized one of the vulnerable groups. To reduce their vulnerability it's extremely momentous to know how much they are aware regarding the climate change issue along with their coping techniques. The way farmers perceive a problem, same the way they responded with the change and can give the best solution to cope up with the change. For that reason; this study will investigate the spatio-temporal analysis of climatic parameters to prove micro-climate change along with farmers' perception and adaptation strategies in response to climate change in Gazipur district.

1.2 Statement of the problem

Climate change is an unavoidable phenomenon which is occurring and can be worse within the upcoming future. Like other sectors, this global climate change is affecting the world farming sector. In the same way, it is also disturbing the Bangladeshi agriculture sector and making Bangladesh more vulnerable. Now the question can come, how climate change is making Bangladeshi's farming sector vulnerable. Number one reason is, its yield production still now relies on the climatic factors like temperature, rainfall, light intensity, radiation and sunshine duration, which are predicted to be unpredictable in future (MoEF). The second one, most of the farmers in the rural area are poor and their livelihood depends on it. Finally, Bangladesh is principally an agricultural country whose farming sector plays a fundamental role in accelerating the economic growth (Ministry of Finance, 2017). If in this way climate change continues then the result will be devastating.

Bangladesh's temperature has already been shown to increase by 1.2°C per century. Recently yearly average temperature level (1980-2010) is almost twofold (2.4 degree Celsius for every century). According to PRECIS, it is expected that temperature will augment 4.6 degree celsius per century (CDMP II, 2014) and by 2060 and 2090 the average yearly temperature will rise 1.8 degree celsius and 2.7 degree celsius respectively (Roy, Rahaman and Kumar 2009). In the dry winter season, the temperature is likely to increase 4.1°C by 2070 (Roy, Rahaman and Kumar 2009).

Regarding rainfall, in the pre-monsoon summer season rainfall augmented 3.4% and in the monsoon season rainfall reduced 1.7% (Karmalkar et al., 2012). In the monsoon season rainfall is likely to enhance 14% by 2090 (Karmalkar et al., 2012) and in post-monsoon season rainfall is likely to enhance 17% by 2070 (Roy, Rahaman and Kumar 2009).

It has been anticipated that as a result of enhancing drought in the future, there is a chance to reduce 40% yield production in the northwest of Bangladesh by 2050. Conversely, on account of erratic rainfall, crop production is likely to decline by 30% (Thomas et al., 2013). About 8% of the total rice production will reduce by 2050 (compared to 1990). Other research showed 80 million tons of rice will be decreased from 2005 to 2050 which is equivalent to two years of rice production. As a result of heat stress, there is a chance to be lost 32% of total wheat production in Bangladesh by 2050 (Khatun and Islam, 2010; GoB, 2009).

From the above it is clear in future climate shock has a divesting consequence over the crop production, food security, livelihood, crop price and economy. In this case, the quantitative study examined the micro climate of Gazipur district to prove whether any change happened or not. Then the qualitative study explored what the farmers' perception regarding this climate change and how they were observing different types of indicators of climate shock in the environment. Then, the researcher addressed different types of adaptation strategies and barriers to adjusting with the climate change in Gazipur district. Many studies have been done on farmers' perception and adaptation to the climate change in the coastal region but as to the knowledge of the researcher, no earlier study was conducted at Gazipur distinct. Hence, considering this knowledge gap, the researcher studied the spatio-temporal analysis of the climatic parameters and farmers' perception, adaptation to climate change.

1.3 Justification and significant of the study

Bangladesh is a rain-fed agriculture-based country whose two fifth (40.60%) of entire populace directly relies over agriculture (Bangladesh Bureau of Statistics, 2018) and in GDP the involvement of the agriculture is 14.23% (Bangladesh Bureau of Statistics, 2019). Moreover, Bangladesh is known as one of the world's leading climate-vulnerable countries. To minimize the climate change risk, appropriate adaptation practices have to be implemented. This can only be accomplished by generating empirical evidence and synthesizing knowledge on climate-related variables, farmers' perception and their adaptation mechanisms which they are practiced in the farm level.

It is known to all of us, climate change, its impact, vulnerability and adaptation mechanisms vary place to place due to the different location, socio-economic and environmental conditions. Farmers across Bangladesh are tackling the impact of climate change. Gazipur district is not exceptional from that. Already farmers of this district are suffering due to climate shock. No study has been done in the Gazipur district regarding this topic. Approximately 42.74 percent of the total of 538,597 holdings are engaged in agricultural activities. (Census, 2011). Moreover, the temperature of the Gazipur district has been rise up by 0.0045°C and it will continue in future (Miah et al., 2016). If in this way it augments then the result will be divesting. As we all know farmers are the hardest hit of the climate change (Dhanya and Ramachandran, 2015) and in the study area's farmers are poor which make them more vulnerable. Therefore, to reduce their vulnerability, promote successful adaptation and make sure future food safety in the Gazipur district requires knowing the present state of the climate change in the study area, what are the perceptions of farmers regarding this change, how they are adapting with change and what are the constraints farmers' are facing to adjust with the adaptation. However, the outcomes of this study will be beneficial at multiple stages of decision-making about development of climate change policies and strategies to minimize the susceptibility of growers to present and expected future changes. (Mngumi, 2016). Furthermore, the research will also serve as baseline information for future research and will add knowledge to the scientific world through

publications. Hence, this study will be a unique work as well as will open a new dimension in the area of agriculture and climate change.

1.4 The objective of the study

Objectives of the study are as follow:

1. to analyze the annual trend of temperature from 1968 to 2018 and rainfall data from 1963 to 2013 in Gazipur district;
2. to assess the farmers' perception towards change in climate in Gazipur district;
3. to identify current adaptation mechanisms which are employed in response to perceived climate changes in Gazipur district;

1.5 Major research questions

1. Are temperature and rainfall changing in Gazipur district?
2. Are farmers aware of climate change? How do farmers perceive the indicators of climate change in the environment?
3. What are the farmers' adaptation response/adoption mechanisms to climatic shocks?
4. What are the main barriers faced by farmers in adjusting their agricultural practices in response of climate change?

1.6 Limitation of the study

1. While efforts have been made to secure data for most of the study variables, there are no meteorological stations in Gazipur district that is why cannot collect the exact data of temperature in the study area. This was one of the setbacks.

2. No women show interest to give an interview during the questionnaire survey. Either they left in the middle of the interview or disagree to help fulfil the questionnaire. Despite

they are doing farming activities at home even in the field, but they deny this. They considered those works as household works rather than agricultural activities.

1.7 Organization of the thesis

This research is organized into eight chapters, besides this introductory section.

Chapter 2 evaluates the current literature regarding climate change, adaptation and agriculture in the context of the global and Bangladesh.

Chapter 3 emphasis on the study area as well as research methods and techniques which are used to data collection and data analysis

Chapter 4 investigates the microclimate of the study area. Basically, analyzed two climatic parameters that are temperature and rainfall data.

Chapter 5 focuses on demographic and other socioeconomic characteristics of the respondents in the perspective of the research.

Chapter 6 documents farmers' perceptions regarding climate change, measures how respondents identify the indicators of climate change in the environment.

Chapter 7 presents results on farmers' adaptation response/adoption mechanisms to climatic change

Finally, Chapter 8 Provides a summary of the study's outcomes and offers policy recommendations.

Chapter 2
Literature Review

2.1 Introduction

In keeping the overall objectives of the research this literature review section is divided into two parts. The first part is a theoretical literature review that explores the recent condition of the global and Bangladesh climate change, future climate change, effects of climate change on agriculture and the Bangladeshi agriculture, different classifications of adaptation, adaptation to climate change in agriculture and different types of local agricultural adaptation techniques that have been adapted by Bangladesh. The second part focuses on the empirical study on farmers perception and adaptation to climate change in Bangladesh. This study reviewed the relevant books, articles, journals, case study and other available research documents.

2.2 Theoretical literature review

2.2.1 What is climate change?

According to the definition of the Intergovernmental Panel on Climate Change (IPCC, 2007), climate change is ''*any change in climate over time, whether due to natural variability or as a result of human activity.* IPCC (2014) has further given a more elaborated definition to climate change stating that climate change is "*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods*" (IPCC, 2014a) Both definitions acknowledged that climate change is happening due to human activities which are altering the atmospheric composition, and climate variability. Climate change is not only focusing on the icebergs melting, sea level rises, changing time and amount of rainfall, increases severe weather incidents but also it observes and projects rise in average global temperature as well as its impacts (CARE, 2011).

2.2.2 Evidence of global climate change

Last every three decades, the earth's surface has sequentially warmer than any other decades since 1850. However, from 1983 to 2012, probably the Northern Hemisphere was the hottest 30 years of the previous 1400 years (IPCC, 2014).

According to the IPCC fifth (2014a) report the average global temperature augmented by 0.85^0C from 1880 to 2012. On the other hand, due to ice melting and warming the global average sea level ascended by 19 cm from 1901 to 2010. In the Arctic, per decade ice loss is 1.07*106 km^2. It is predicted average sea level will rise 24-30 cm by 2065 and 40-63 by 2100 relative to the reference period of 1986-2005 (UN, 2020).

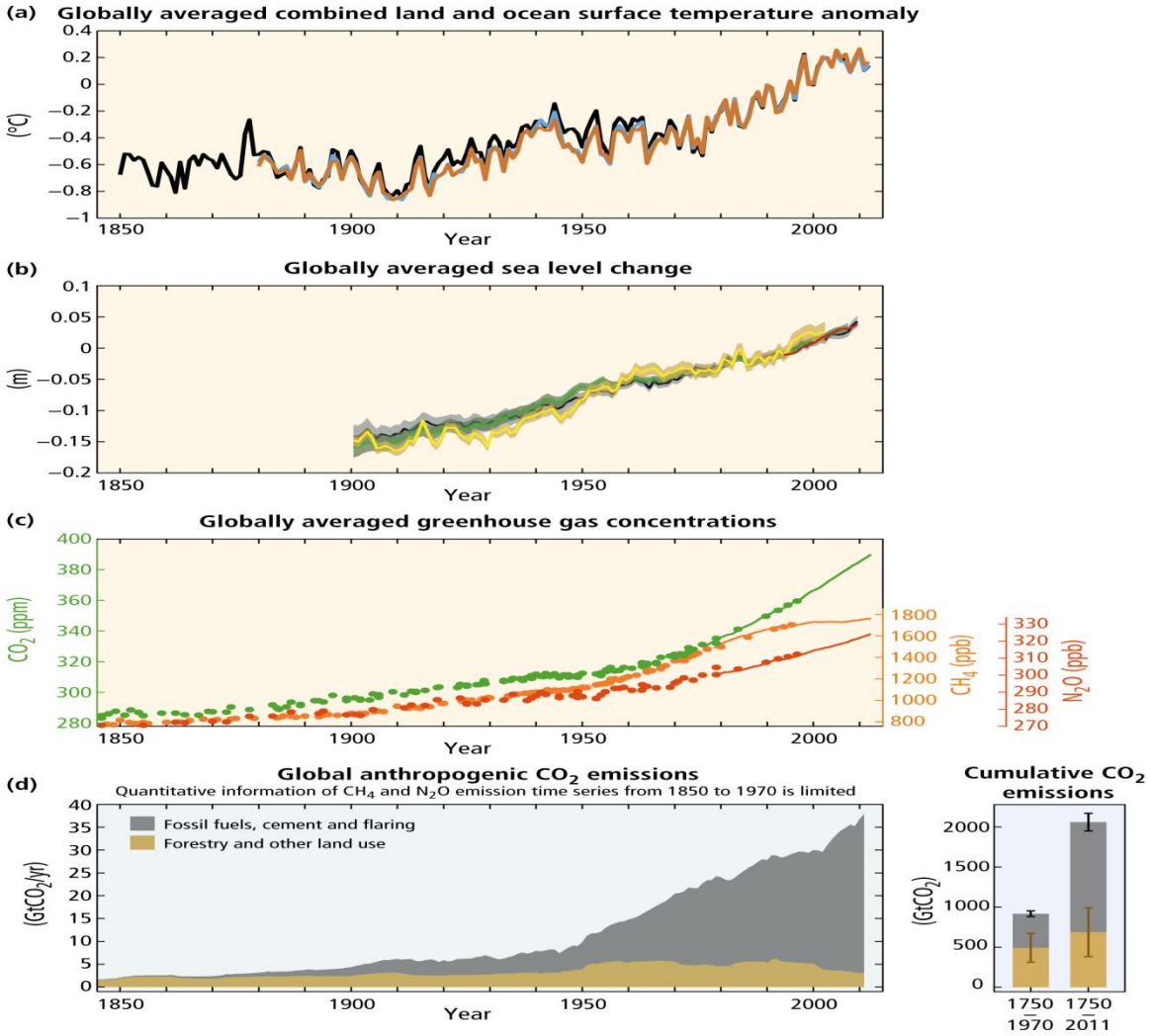


Figure 2: ''The complex relationship between the observations (panels a, b, c, yellow background) and the emissions (panel d, light blue background). Observations and other

indicators of a changing global climate system. Observations: (a) Annually and globally averaged combined land and ocean surface temperature anomalies relative to the average over the period 1986 to 2005. Colours indicate Black-HadCRUT4 (Version 4.1.10), Blue-NASA GISS, Orange-NCDC MLOST (Version 3.5.2). (b) Annually and globally averaged sea-level change relative to the average over the period 1986 to 2005 in the longest-running dataset. Black-Church and White (2011), Yellow-Jevrejeva et al., (2008), Green-Ray and Douglas (2011), Red-Nerem et al.,(2010) tide gauge reconstruction. (c) Atmospheric concentrations of the greenhouse gases carbon dioxide (CO_2, green), methane (CH_4, orange), and nitrous oxide (N_2O, red) determined from ice core data (dots) and from direct atmospheric measurements (lines). Indicators: (d) Global anthropogenic CO_2 emissions from forestry and other land use as well as from the burning of fossil fuel, cement production, and flaring. Cumulative emissions of CO_2 from these sources and their uncertainties are shown as bars and whiskers, respectively, on the right-hand side. The global effects of the accumulation of CH_4 and N_2O emissions are shown in panel c.'' (IPCC, 2014) Source: IPCC Fifth Assessment Report (AR5), (Climate Change 2014, Synthesis Report, Summary for Policymakers)

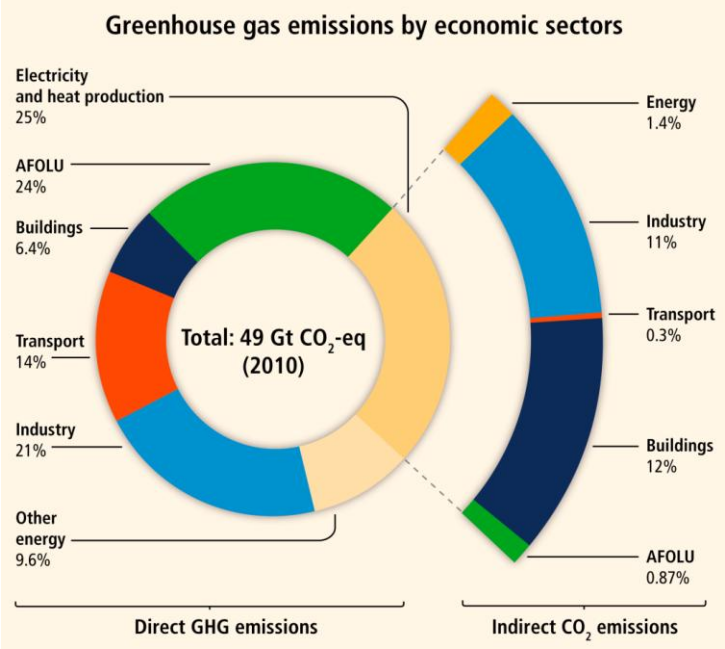


Figure 3: Total anthropogenic greenhouse gas (GHG) emissions (gigaton of CO2-equivalent per year, GtCO2-eq/yr) from economic sectors in 2010. Source: IPCC Fifth Assessment Report (AR5), (Climate Change 2014, Synthesis Report, Summary for Policymakers)

According to IPCC (2014), in 2011, atmospheric carbon dioxide concentration was 390.5 ppm (390.3 to 390.7) which was 40% greater than in 1750 as well as atmospheric nitrous oxide (N_2O) was 324.2 ppb (324.0 to 324.4) which had been increased by 20% since 1750.

From 2005 to 2011 the average annual CO_2 and N_2O were augmented which were comparable with the year of 1996 to 2005. In 2011, the methane concentration was 1803.2 ppb (1801.2 to 1805.2) in the environment (CH4) which was 150% more than before 1750. CH_4 was steady from 1999 to 2006, but in 2007 it started to augment. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and Sulphur hexafluoride (SF_6) all were rapidly increased. But their contributions to radiative forcing are less than 1% of the total by well-mixed GHGs (IPCC, 2014).

Recent Climate Change according to NASA and Statista

According to NASA (2020), anomaly temperature has been augmented 0.98^{0}C (1.76 F) from 1880 to 2019 (NASA, 2020). On the other hand, according to Statista, the land and ocean surface temperature anomaly stood at 0.95^{0}C from 1880 to 2019 (Statista, 2020).

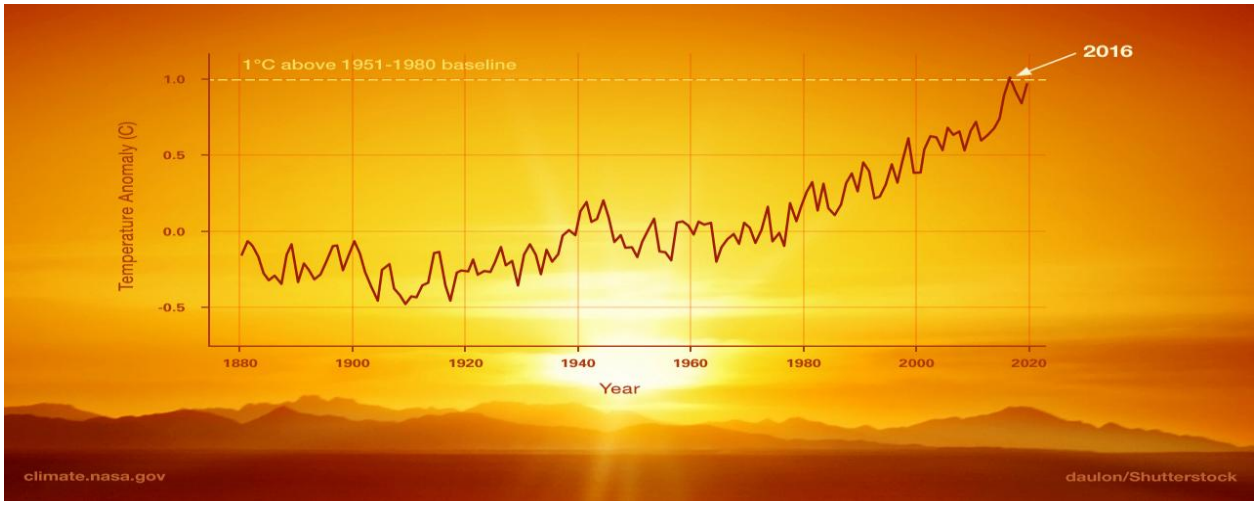


Figure 4: This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures. Source: NASA's Goddard Institute for Space Studies. (Cited in Shaftel, 2020)

2.2.3 Future Climate Change

Temperature- The global mean surface temperature is likely to rise up at 0.3°C to 1.7°C under RCP 2.6 (Representative concentration pathway), 1.1°C to 2.6°C under RCP 4.5, 1.4°C

to 3.1°C under RCP 6.0, and 2.6°C to 4.8°C under RCP 8.5 by the end of the 21st century (2081-2100) relative to 1986-2005. The Arctic region will be more warmed rapidly compare with the global mean temperature (IPCC, 2014).

Global mean sea level rise- The global mean sea level is likely to increase in the ranges of 0.26m to 0.55m for RCP 2.6, and of 0.45m to 0.82m for RCP 8.5 (medium confidence) relative to 1986-2005 for the period 2081-2100. The sea level is likely to increase in more than about 95% of the ocean area by the end of the 21st century. It has been projected that about 70% of the coastlines worldwide are likely to experience a sea-level change within ±20% of the global mean (IPCC, 2014).

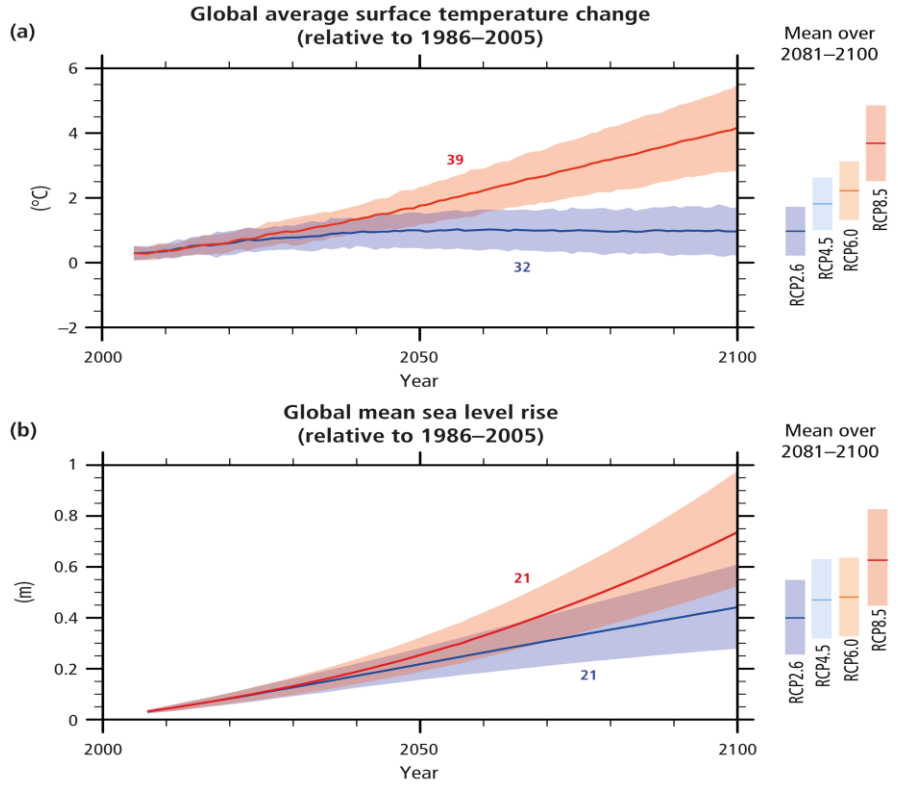


Figure 5: "Global average surface temperature change (a) and global mean sea level rise (b) from 2006 to 2100 as determined by multi-model simulations. All changes are relative to 1986–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP 2.6 (blue) and RCP 8.5 (red). The mean and associated uncertainties averaged over 2081-2100 are given for all RCP scenarios as colored vertical bars at the right-hand side of each panel. The number of Coupled Model Inter Comparison Project Phase 5 (CMIP5) models used to calculate the multi-model mean is indicated." Source: (IPCC, 2014).

2.2.4 Effects of climate change on agriculture

Scientific evidence has been proved that climate change has a significant impact on agriculture and livestock. The negative impact can be felt at the regional level due to change in the weather, pest attack, change in ground-level ozone, pollutants in technology and bad management practice in the agriculture sector. Agricultural production is expected to increase in high and mid-latitude on account of enhancing growing season. But it will not amplify new large areas of production. It will mainly be limited to the Northern Hemisphere (Belay, 2010).

2.2.4.1 How does climate change affect the agricultural sector?

Climate change affects agricultural production through influencing atmospheric carbon dioxide (CO_2), temperature, precipitation, solar radiation, soil characteristics and other things which are all direct or indirect inputs for production.

a. Effects of climate change on atmospheric carbon dioxide

CO_2 is a vital factor for plant photosynthesis. It has negative and positive both impact on the production of the crops. The more CO_2 concentration, the more photosynthesis and the more carbon responsive crop production. Resulting in C3 crops (wheat, rice, and soybean) production will be increased. On the other hand, non-carbon responsive C4 plant's (maize, sorghum, sugarcane, millet) production will be reduced (Belay, 2010). The IPCC report (1990) gives the impression that an increased concentration of carbon dioxide may lead to an improvement in crop yields as well as their adaptation to stressful environments (IPCC, 1992).

b. Effects of climate change on soil properties

One of the sources of GHG is soil. Global climate change will affect the soil through changes in soil moisture, soil temperature and soil organic matter. Greater evapotranspiration and higher soil temperatures are the results of high temperature. It can enhance chemical

solution reaction rates and diffusion-controlled reactions solubility of soil. It may raise or decline gaseous component, but the result of these changes may take many years to become remarkable. Higher temperature will be accelerated the decay of soil organic matter. In a consequence, the CO_2 concentration will be increased and carbon/nitrogen ratios will be reduced in the atmosphere. (Belay, 2010).

c. Effects of climate change on the prevalence and distribution of agricultural pests and diseases

Pest and diseases one of the hinders to achieve higher crops production. The prevalence of pest and disease high in the lower latitude due to high temperature. Higher temperature, precipitation and humidity three together create conducive conditions for the pest infestation. Pimentel (1992) did a study on the effects of temperature increases 2^0 C on USA and Africa. The result is if North America becomes warmer and drier crop losses due to plant disease is expected to reduce 30% from current levels. On the other hand, if Africa becomes warmer and wetter, crop losses to diseases will augment up to 133% above current levels for some crops. It has been projected that USA crop losses will be enhanced between 5% and 50% (depending on the crop) due to weeds. Herbicidal controls have a propensity to be less effective under hot/dry circumstances than they are under the cooler/ wet existing situation (Pimentel *et al.,* 1990)

d. Effects of temperature on agriculture

The flowering of plants depends on the temperature and day length. Per unit production will be lower if the crop duration becomes shorter. Most importantly; higher temperature decreases crop production because of greater stress as well as increased evaporation from the soil. In the low and mid-latitudes crop production will be decreased, if temperature rises. On the other hand, in the higher latitudes, crop production will be enhanced due to temperature increase(Belay, 2010).

e. Effects of water availability on agriculture

Water unavailability reduces crop production. To complete the crop cycle it needs an adequate supply of water in timely. Any slight shift in the timing of rains in the agricultural calendar brings severe damage to crops. Early raining before harvesting that damages crops as well as proliferate crop diseases and pests. Again heavy rainfall destroys crops and enhances soil erosion. Conversely, lack of water creates drought and Africa is suffering most for that reason. Any reduction of precipitation not only influences the monsoon season's crops but also creates a problem for irrigation. The traditional seasonal crops are unable to complete their growing cycle due to high temperature and rainfall. High temperature and low rainfall are together responsible for declining crop production (Belay, 2010).

f. Effects of change radiation on agriculture

The rapport between radiation and photosynthesis rate has been studied. The saturation limits for radiation depends on the nature of the species and other reactants. However, there are numerous researches on wheat and other crops which confirm a linear connection between radiation and photosynthesis rate within a certain range. It will affect crops and livestock if UV-radiation at a ground level increases. (Belay, 2010).

g. Economic and social impacts of climate change on agriculture

There is a possibility to produce various socio-economic consequences due to climate change. It can affect the price of agricultural products, food security, consumer welfare, water, land market, production pattern and trade structure (Gbetibouo et al., 2005). There is likely to be an increased risk of famine, particularly in subtropical and tropical semi-arid and arid location (Rosenzweig *et al.,*1994). In 2019 the National Bureau of Economic Research found that an increase in average global temperature of 0.04^0C per year, without mitigation policies would reduce world real GDP per person by 7.22% by 2100 (Kahn et al.,2019).

2.2.5 Climate change in Bangladesh

Bangladesh is recognized as a hotspot owing to climate change vulnerability. There are two reasons, number one is the high biophysical condition and the other one is socio-economic condition. In Bangladesh, the central and western coastal area, the north-western highlands, and along the main rivers are the most affected area.

2.2.5.1 The overall ranking of Bangladesh

According to WRI, Bangladesh ranks 152 out of 188 countries for per capita GHG releases and contributes less than 0.36% of global emissions (WRI, 2017). Despite releasing a small amount of GHG, Bangladesh considers the highly vulnerable country in the context of climate change. By the Global Climate Risk Index 2017, Bangladesh ranked sixth among the most affected countries by climate change (Kreft et al., 2017). According to the ND-GAIN index (2017), Bangladesh was 160 out of 181 countries for climate susceptibility. Bangladesh is ranked 33rd most vulnerable country and the 25th least prepares country in the world (Ministry of Foreign Affairs of the Netherlands, 2018)

2.2.5.2 The current trend of climate change in Bangladesh

Climate change has been noticed in Bangladesh. Overall, weather patterns have been erratic and less predictable than before (World Bank, 2011).

Temperature- A significant increase has been observed throughout the monsoon season (June-August) where temperature augmented at 0.07°C per decade and during early winter (September-November) increased at 0.12°C per decade (Karmalkar et al., 2012). Another research reported the average daily temperature in Bangladesh has increased by 1.2°C per century. Recently yearly average temperature level (1980-2010) is almost twofold (2.4 degree Celsius for every century) (CDMP II, 2014) .The cold and dry season has been also declined in length (Thomas et al., 2013).

Rainfall- As a whole, total rainfall has not been changed significantly from 1960 to 2003 but research finds notable rainfall changes in the west and northwest. (Ministry of Foreign Affairs of the Netherlands, 2018). The rainy season has become shorter, and heavy rainfall occurs within a shorter period (Thomas et al., 2013). In the pre-monsoon summer season, rainfall augmented 3.4% and reduced 1.7% for the period of the monsoon rainfall (Karmalkar et al., 2012). A relatively new phenomenon is landslides which have been occurring more frequently in Bangladesh, thanks to heavy rainfall (Sharmin and Islam, 2013)

Cyclone- Cyclone frequency has been increased during the 'cyclone seasons' in November and May (World Bank, 2011). According to UNDP, Bangladesh has been ranked first among all countries in the perspective of tropical cyclones vulnerability (Government of the People's Republic of Bangladesh, 2009). Every three years a severe cyclone hits Bangladesh that's why Bangladesh is known as a hotspot of disasters (Government of the People's Republic of Bangladesh, 2009).

Sea level rise- It has been observed that sea level rises at 4 mm, 6mm and 8 mm per year at the Hiron Point in the west, Char Changa in the centre of the country and Cox's Bazar in the southeast correspondingly (Sharmin and Islam, 2013). Due to sea level rises soil salinity has been amplified in the southern part of Bangladesh. In 1973, 2007 salinity was found in the soil 1.5 million and 3 million hectares respectively (Khatun and Islam, 2010). About 1.2 million hectares of arable land out of 2.85 million hectares of coastal areas are already affected by salinity (World Bank, 2011).

Flood- Himalayan glaciers declined 21% since 1980 (World Water Assessment Programme, 2009) and lost 174 gigatons of water between 2003 and 2009, which contributed to catastrophic floods in GBM Basin (Laghari, 2013). Bangladesh is a giant floodplain area where 80% of the land is formed because of the flood (Ayers et al., 2014). Almost every year floods occur in July and August (Ayers et al., 2014). In an average year, about 25% of the country is swamped. A severe flood occurs every 4-5 years, as a result, 60% of the country goes underwater (Sharmin and Islam, 2013).

2.2.5.3 Future climate change of Bangladesh

Temperature- It has been projected that annual mean temperature will be augmented 1.8°C and 2.7°C by 2060 and 2090 respectively. Though some projections suggest temperature will be increased up to 4.1°C (compared to 1970-2000 mean) (Karmalkar et al., 2012).

In the dry winter season, the temperature is likely to increase 4.1°C by 2070 (Roy et al., 2009). There is a chance to increase the temperature in northern regions compared to the southern region (Karmalkar et al., 2012). Projection also indicates that by 2060 'hot' days will be enhanced 17%–39% of days (Karmalkar et al., 2012).

Rainfall- It has been anticipated that Bangladesh has a chance to be 4% wetter by the 2050 (World Bank, 2011). It is also expected that mean annual rainfall is possible to increase 7% compared to 1970-2000 mean climate (although some models project increases by up to 24%) by 2090 (Karmalkar et al., 2012).

Seasonal Rainfall- Regarding monsoon rainfall, it is likely to enhance 14% by 2090 (Karmalkar et al., 2012) and post-monsoon rainfall is expected to increase 17% by 2070 (Roy et al., 2009). For the dry winter season, projections are mixed, some models show future rainfall has a chance to be decreased (Khatun and Islam, 2010). On the other hand, another model shows rainfall has a possibility to increases of about 10% by 2070 (Roy et al., 2009).

Extreme events- In Bangladesh extreme events such as cyclones and floods, will be both more frequent and intense (Thomas et al., 2013).

Sea level- The IPCC states that sea level will be raised 14 cm, 32 cm, 88 cm by 2030, 2050 and 2100 correspondingly (compared to 2000) (Khatun and Islam, 2010). There is a chance to be affected by about 27 million people by 2050 in consequence of sea-level rises. If sea level rises 1-meter, then 18% of the country's land will inundate (World Bank, 2010).

For that reason by 2050, soil salinity is likely to increase from 26% to 55% (Mahmood, 2012).

Food security and water availability- Food security and water availability will be influenced by climate change soon(Thomas et al., 2013).

2.2.5.4 Socio-economic vulnerability

Biophysical factors and social, cultural, and economic both factors are responsible for the climate change vulnerability in Bangladesh (Ministry of Foreign Affairs of the Netherlands, 2018). In Bangladesh socio-economic features plays a significant negative role for the susceptibility of climate change such as country's dependency on agriculture (most notably rice cultivation) and other resources-dependent sectors, its economic growth and poverty (which forms a vicious cycle with climate change effects), health, gender, population growth, population density and migration (Ministry of Foreign Affairs of the Netherlands, 2018).

2.2.5.5 The effects of climate change will differ per region

The Northwest part of Bangladesh will suffer most owing to the increase of temperature and drought, on the other hand, the centre and northeast part will experience mostly due to enhance flood frequency and intensity. Besides, in the Bangladesh most vulnerable area is a coastal area which will be influenced negatively by the sea-level rise, salinity intrusion as well as intense and frequent cyclone. However, the urban coastal areas will experience due to drainage congestion (Thomas et al., 2013). Many studies already proved that Barguna, Barisal, Bhola, Khulna, Jhalokati, Pirojpur and Satkira districts are severely affected by the saline water and it has been expected that salinity will be increased from 26% up to 55% in most affected areas, by 2050 (World Bank, 2015).

2.2.5.6 Effect of climate change on agriculture in Bangladesh

Bangladesh is an agriculture-based country whose 55% of the total population directly depends on agriculture and 17.22% of the gross domestic product (GDP) comes from this sector (Bangladesh Bureau of Statistics, 2015). The contribution of crop cultivation, fisheries, livestock and forestry are 8.73%, 3.29%, 2.07% and 1.42% in GDP respectively (Thomas et al., 2013). It has been projected that due to enhance of drought in future, there is a chance to reduce 40% of crop production in the northwest by 2050. Conversely, on account of erratic rainfall, crop production is likely to decline by 30% (Thomas et al., 2013).

a) Rice

Rice is the staple food of Bangladesh. About 65% of the people employ in the rice cultivation and cultivate rice 77% of the total crop land (Thomas et al., 2013). It supplies 95% of all food grain consumption (Thomas et al., 2013) and 63% of urban consumers intake caloric from rice followed by 71% rural consumers (Xenarios et al., 2014). It is projected that about 8% of the total rice production will be reduced by 2050 (compared to 1990). Another projection showed 80 million tons of rice will be decreased from 2005 to 2050 which is equal to two years' worth of rice production. As a result of drought, 60% of the rice cultivation area will be affected within 2030. Again as a consequence of flood, 55,000 hectares of paddy land and 121,000 tons of paddy rice will be lost. However, about 20% of the total paddy cultivation area will be wrapped with saline water, resulting 395,000 tons of rice will be lost. It has been expected that due to sea level rising Aus, Aman and Boro rice will be lost 10%, 10% and 18% respectively in Khulna district (World Bank, 2010). In contrast, lack of surface water and groundwater boro rice production will be lost (Khatun and Islam, 2010; Government of the People's Republic of Bangladesh, 2009; World Bank, 2010).

b) Wheat

As a result of heat stress, there is a chance to be lost 32% of total wheat production in Bangladesh by 2050 (Khatun and Islam, 2010; Government of the People's Republic of Bangladesh, 2009). In this condition, if farmers use fertilizer, different varieties of crops then there is a possibility to reduce 15% of yields (Thomas et al., 2013). In the South Asian 50% of the region's total wheat yields may be lost. As a consequence, the price will be high and Bangladesh will be face problem to import wheat from other countries (Wright et al., 2014).

c) Potato

Owing to moisture stress and untimely rainfall 64% of potatoes production has been reduced. By 2030, it is expected that this loss will be increased up to 76% and 22% more irrigation will be necessary to cope with this change (Roy et al., 2009).

d) Maize

It has been anticipated that rain-fed maize production can be declined 10%-20% from the period of 2000-2050, if current planting dates and varieties are used. There is a chance to be augmented maize price 209% than any other commodity by 2050. Some expert-recommended if farmers of Bangladesh shift rice production to maize production it will be more profitable for them (Thomas et al., 2013).

e) Sugarcane, soybeans and sorghum

Sugarcane, soybeans and sorghum are rain-fed crops. It is projected 7.5%-10% production will be reduced from 2000 to 2050 unless any change brings in farming practices (Thomas et al., 2013).

2.2.5.7 Impact of climate change on livestock

Climate shock has direct and indirect impact on livestock. It is already proved that drought, saline water intrusion, heat waves, cyclones and floods have a direct negative influence on livestock (Thomas et al., 2013). Not only human being but also livestock will suffer due to food insecurity (World Bank, 2010).

2.2.5.8 Impact of climate change on fisheries

Floods, riverbank erosion, cyclones, and storm surges have a great impact on the fisheries sector such as aquaculture infrastructure can be destroyed. However, due to longer period of cyclones fishers may have to stay at home (Thomas et al., 2013). Furthermore, due to saline water intrusion, sweet water's fishes are under threat but it will create scope for the shrimp cultivation (World Bank, 2010).

2.2.5.9 Impact of climate change on forest resources

Sundarbans is seriously affected by the saline water intrusion, floods, and cyclones which has a great negative impact on the livelihoods of the poor in this area because they fully depend on the forest resources. For example cyclone Sidar and Aila destroyed the Sundarbans. Prolonged droughts will prevent the growth of trees (Thomas et al., 2013).

2.2.5.10 Impact of climate change on economic

Each year the contribution of agriculture in GDP will be decreased by 3.1% which is equal to a cumulative loss in the added value of USD 36 billion between 2005 and 2050. Climate change is expected to increase this lose 129 billion if include the indirect impact of climate change on complementary industries (World Bank, 2010a).

2.2.5.11 Impact of climate change on poverty

The economic effects of climate change will enhance the poverty of Bangladesh (World Bank, 2010a). Urban poor and rural poor are the most vulnerable group due to climate change (Ayers et al., 2014). As a result of climate change, poverty is expected to increase by 15% between 2000 and 2030 (Wright, 2014).

2.2.5.12 Impact of climate change on food insecurity

The food insecurity in Bangladesh is very high. The research found each year 56% of the people of Bangladesh face food shortages in Bangladesh and one third faces food scarcity for over half the year (Wright, 2014).In future, there is a chance to increase the result. Poverty and food insecurity will reduce resilience and the capacity to adapt to climate change (Ministry of Foreign Affairs of the Netherlands, 2018).

2.2.5.13 Impact of climate change on health

Infectious diseases are expected to outbreaks due to change of climate. High temperature creates favorable circumstance for cholera and vector diseases such as malaria. Bangladesh is already suffering for that (Mahmood, 2012).

2.2.6 What is adaptation?

The definition of adaptation is taken from IPCC 2001 and 2014 reports, where adaptation refers ‘‘the *process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects*’’ (IPCC, 2014). “*Adjustments in ecological, social or economic systems in response to actual or expected stimuli and their or impacts. This term refers to changes in processes,*

practices and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC, 2001). Therefore, adaptation means to reduce the vulnerability of communities, regions, and nations to climate variability and change adjust with that as well as uphold sustainable development (IPCC, 2001). According to UNDP, "*A process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented*" (Cite in Levina, E., et al.,2005). Another definition of UNFCC, "*Actions were taken to help communities and ecosystems cope with changing climate conditions, such as the construction of flood walls to protect property from stronger storms and heavier precipitation, or the planting of agricultural crops and trees more suited to warmer temperatures and drier soil conditions*" (Cite in Levina, E., et al., 2005). Different types of adaptation need to cope up with the climate change such as in geographical scales (local, national, regional, global), temporal scales (coping with current impacts and take preparation for a long-term change) and must be addressed within complex and uncertain conditions (IPCC, 2001).

2.2.6.1 Type of adaptations

There are many ways to classify adaptation. The most commonly discussed classifications are listed below.

Based on intent/purposefulness

Autonomous adaptation: Autonomous adaptation is not the conscious response to climate change, for example, when a farmer changes harvest and planting or sowing time or change crops due to the change of the pattern of precipitation is called autonomous adaptation. It is also referred to as spontaneous adaptation.

Planned adaptation: Planned adaptation is the conscious or well-planned response to the changed condition or about to change the condition of climate. The deliberative policy decision is the main characteristics of planned adaptation. The action in planned

adaptation is required to maintain or to achieve the desired state. For example, conscious crops selection and distribution policies across different agri-climatic zones, replacement of new crops for old ones and resource replacement (Easterling et al., 1993).

Based on timing

Reactive adaptation: Reactive adaptation refers to take any kind of adaptation steps after observing the impacts of climate change. It is also called proactive adaptation.

Anticipatory adaptation: Anticipatory adaptation means take any kind of adaptation steps before the impact of climate change visible. It is also called proactive adaptation.

Based on agents

Private Adaptation: When adaptation actions are taken and executed by individuals, households or private companies is called private adaptation. Private adaptation is usually in the actor's rational self-interest or self-motivation.

Public Adaptation: When adaptation actions are taken and executed by governments is called public adaptation.

Based on the temporal scope

Short-Run Adaptation: The responses of the decision-makers to climate change is controlled by a fixed capital stock. That is why; the major options availabilities are limited to variable inputs to production (Stern, 2007).

Long-Run Adaptation: The decision-makers can regulate capital stock in reaction to climate change.

		Anticipatory	Reactive
Natural System			1. Changes in length of growing seasons. 2. Change in ecosystem composition. 3. Wetland migration.
Human System	Private	1. Purchase of insurance 2. Construction of a house on stilts. 3. Redesign of oil rigs.	1. Changes in farm practice. 2. Change in insurance premiums. 3. Purchase of air condition.
	Public	1. Early warning systems. 2. New building codes. 3. Incentives for relocation.	1. Compensatory payments and subsidies. 2. Enforcement of building code. 3.Beach nourishment.

Table 1: Classification of adaptation options. Source: IPCC, 2001.

2.2.6.2 Adaptation to climate change in agriculture

The result of climate change-induced agriculture productivity impacts is decided by the greater extent of human adaptation (Mc Carl *et al.,* 2001). The adaptive capacity of each region or each country will be determined by the following factors: the range of available technological options, resources and their distribution, the structure of the institutions, the reserve of human capital, assets rights, the system's access to risk dispersion processes, the ability of decision-makers to deal with information and make decisions, and the public's insight of attribution (Mendelsohn, 2001). The regions or country that would be able to adapt to future climate change will lessen the effects of climate change on agriculture.

There are two types of scales in agriculture adaptation that are –

(a) farm-level adaptation or micro-level adaptation
(b) national level or macro-level adaptation.

(a) Farm-level adaptation or micro-level adaptation: Where a farmer decides how he/she will adjust with climate change. In the farm level adaptation crop diversification, mixed

crop-livestock farming systems, using different crop varieties, changing planting and harvesting dates, drought-resistant varieties and high-yield water-sensitive crops are included (Bradshaw *et al.,* 2004). These decisions are influenced by seasonal climatic variations, local agricultural cycle, and several socio-economic factors that include household characteristics, household resource endowments, access to information (seasonal and long-term climate changes and agricultural production) and availability of formal institutions (input and output markets) for smoothening consumption

(b) National level or macro-level adaptation: Where the government takes the decision based on domestic and international policy (Bradshaw *et al.,* 2004; Kandlinkar and Risbey, 2000).

Some events may be taken at the individual or farm level, others need cooperative action (rainwater harvesting) or by the agency or government level, for example building dams, introduce novel cultivars that are more water-efficient (Jawahar and Msangi, 2006).

There are two types of modifications in production systems of agriculture adaptation that are -

a) crop diversification
b) crop management practice.

a) Crop diversification

Crop diversification related to the production activities such as practice drought, flood and temperature tolerable crop to cope up with the climate change. Besides, Crop diversification can provide insurance against rainfall unpredictability since different crops are affected differently by climate shock (Orindi and Eriksen 2005).

b) Crop management practice

The second strategy focuses on crop management practices. Modifying the length of the crop growing period and changing planting and harvesting dates according to change of climate is the part of crop management practice (Orindi and Eriksen, 2005). However, by using irrigation it is possible to increase agriculture production during the dry period. Sustainable land management actions are the essential approaches that households can employ to adjust to climate susceptibility and alter. For example, most farmers in Ethiopia consider soil and water conservation techniques a key strategy to adapt to global warming (Temesgen, 2007).

Adaptation procedures can be supply-side measures (for instance provide more water), demand-side measures (for example reuse of water) and blend of both (for instance altering crop varieties).

Reilly and Schimmelpfennig (1999) mentioned the following major classes of adaptation:

a) seasonal changes and sowing dates;
b) different variety or species;
c) water supply and irrigation system;
d) other inputs (fertilizer, tillage methods, grain drying, other field operations);
e) new crop varieties;
f) forest fire management, promotion of agro-forestry, adaptive management with suitable species and silvicultural practices" (FAO, 2005).

2.2.6.3 Potential side effects of some well-practiced adaptation measures

Adaptive responses can also have adverse effects. Adaptive responses are expected to have a hostile effect on health or the environment (Shriner et al., 1998). By changing planting dates, introduce new crop species it is possible to reduce the impact of climate change in the agriculture sector but it no longer gives guarantee equivalent levels or nutritional quality of food production or equivalent avails for cultivators. Too much pick out of groundwater will let down the water level of the underground. However, in the first IPCC assessment, it mentions there is a chance to increase demand for irrigation with global warming. To adapt to the change of climate farmers are using intense pest chemical to control pest attack but it harms the farmers' health and as well as the environment (IPCC, 2001).

2.2.6.4 Agricultural adaptation to climate change in Bangladesh

Table 2: Strategic approaches envisaged for farming adaptation for RVCC Project

Strategy	**Measure**	**Brief Description of Measure**
Household-level strategy in agriculture (crop, fishery, agro-forestry, & livestock)		
Enhance food through farming	Drought-tolerant crops/vegetables	Introduce drought-tolerant crops such as groundnuts, watermelon, etc.
	Floating gardens	Growing of vegetables on floating beds of water hyacinth (hydroponics)
	Low-cost irrigation	Demonstration of treadle pump and other easy equipment for irrigation
	Homestead gardening	Growing of vegetables and fruits on homestead plots for consumption and market
	Saline tolerant non-rice crops	Introduce salt tolerable diversity of chili, mustard, maize and potato
Augment income by substitute livelihoods	Embankment cropping	Grow beans, gourds, okra & other vegetables on embankment surrounding prawn ghers (ponds)
	Integrated farming system	Using a small area of land, small water body, and surrounding embankments to produce rice, fish and vegetables

	Cage aquaculture	Small-scale fish cultivation in cages, household ponds or common water bodies
	Prawn fish poly-culture	Prawn and fish culture in sweet-water ghers (ponds)
	Shrimp fish poly-culture	Shrimp and fish culture in saline-water ghers (ponds)
	Cattle rearing	Rearing cattle in support of consumption and market
	Poultry rearing	Rearing chickens for meat and eggs intended for consumption and market
	Crab fattening	Collection, rearing and feeding of crabs for 15 days to increase their market value
	Duck rearing	Rearing ducks for meat and eggs in support of consumption and market
	Goat rearing	Rearing goats in favor of consumption and market
	Apiculture & honey processing	Beekeeping and processing of honey for market
	Nursery & homestead afforestation	Development of community nurseries and allocates (with handling directions) of indigenous varieties of tree saplings (mango, coconut, sofeda, korai, guava, mehaguni, neem, kewra, etc.) to beneficiaries for homestead planting
	Saline tolerant tree plantation	Promote saline tolerant fruit and timber trees for long term income generation
	Mele (reed) cultivation	Promote reeds that are employed to make mats that are broadly used for sitting and sleeping on
Increase food availability/ storage	Improvement of food storage	Promote native methods for protecting food stores from flood
	Introduction of cooking stoves	Promote flood-proof cooking stoves prepared by native materials
Improve health and personal safety	Improvement of hygiene and sanitation	Create awareness regarding personal cleanliness and sanitation and promote the employ of hygienic latrines
	Protection against cyclones	Work with the local people to help minor groups to access existing cyclone safety amenities
Increase access to safe water	Deep Tube Wells	Dig deep tube wells to supply safe water to households for cooking and drinking
	Household pond protection	Protect small ponds to provide safe water for cooking and drinking
	Indigenous methods of water collection	Collect and store rainwater in the sanitary earthen pots

	Pond sand filters (PSF)	Build pond-sand-filters to supply safe water for cooking and drinking
	Rainwater harvesting	Better technology for precipitation collection from roofs and storage in a tank
	Safe water & sanitation	Create awareness regarding methods for collecting & storing safe water and sanitation
Improve the safety of housing and other property	Safe havens for domestic animals	Create safe places for animals to defend from flood, storm and cyclone
	Storm-resistant housing	Develop storm-resistant construction features, including native technologies
	Windbreak tree plantation	Promote plantation for protecting from storms and cyclones

Strategy	**Measure**	**Brief Description of Measure**
Community-level Strategies		
Increase access to common property resources	Access to common property regimes within the waterlogged areas	Negotiations with locally elected bodies and powerful people for allowing other folks to employ common water bodies.
Reduce threats through community-based initiatives	Canal excavation	Promote canal excavation for better drainage to lessen water-logging/flooding
	Cyclone preparedness	Create awareness regarding cyclone preparedness and develop cyclone shelters
	Raise the height of embankments	Raise the height of embankments to defend from flooding
	Tidal River Management (TRM)	Develop tidal river management to safe from waterlogging

Source: Ahmed, 2017

Rice Variety

Table 3: Bangladesh invented saline tolerable different types of crops. Those are given below:-

Tolerable Crops	**Invented Crops**
Salinity tolerant Aman variety	BRRI dhan 40, BRRI dhan 41
Salinity tolerant Boro variety	BRRI dhan 47
Aman Variety for Cyclone affected areas	BINA dhan-7
BINA variety for saline areas	BINA China badam-1, BINA China badam-2
Salinity Resistant Jute variety by BJRI	HC-2, HC 95, CVL 1
Saline tolerant sugarcane variety	ISWARDI-40 BY BSRI

Bottle gourd, bean and sweet gourd are additional profitable than other roots (radish, carrot) and fruit type vegetables (Lady's finger, bitter gourd). To adapt with the salinity farmers can grow salt tolerable non-rice crops such as chili, carrot, sugar beet, barley (Ahmed, 2012).

2.3 Reviews of empirical studies on farmers perception and adaptation to climate change

Rashid et al. (2014), revealed that weather became more unpredictable than before in Khulna district. Local people found the summer period had been extended, resulting pest infestation increased, crop growth's duration and total yield decreased. Rainfall pattern also changed consequently rice planting period had been delayed. Moreover, sesame and mungbean damaged due to waterlogging which decrease the total yield. Day by day saline water intrusion is increasing. To cope up with the change, communities were practicing salt tolerable rice, cultivate sesame and moonbeam. Furthermore, they are practicing rice-fish culture such as tilapia, carp and prawn as an alternative of salty water shrimp. To capture the data used only focused group discussion. Similar research needs to conduct in Gazipur area to measure farmer's perception and adaptation techniques.

Uddin et al. (2017), the study disclosed 88% of the farmers in Shatkhira perceived climate shock in their district. Over the last 20 years, farmers found that temperature, droughts,

floods, cyclones, salinity level increased and rainfall decreased. There is a significant relationship between socioeconomic factors and climate change. The questionnaire survey conducted on 100 farmers'. Logit model along with weighted indexes for ranking and descriptive statistics were used to examine the result. This study was conducted in the three villages of Shatkhira but did not find out how they are adapting with the changing condition. So, this new study will investigate the farmers' perception and how they are coping up with the climate change in Gazipur district.

Kamruzzaman (2015), published an article. This article exposed most of the farmers observed changes in the climate of Sylhet district between the last 5 to 15 years. Maximum farmers mentioned natural cause was the main reason for climate change than the man-made causes. The temperature was increasing and rainfall was decreasing which enhanced drought in the Sylhet district. However, the summer season's duration had been extended and the winter season's duration had been reduced than before in Sylhet district. Regarding flood, most of the farmers confirmed flood had been decreased than the previous time in the study area. The main gap was how they were coping with the changes that did not bring out in this article. Likewise, an investigation is needed in Gazipur area to understand farmers' perception and their coping techniques in the response of climate change. This new study will help other farmers inside and outside of the country.

Miah et al. (2016) compared Gazipur, Comilla, Jessore, and Dinajpur district's climatic variability and analyzed how climatic variability effected on the major food crop's yield. Primary data collected through FGD survey and secondary data collected from BMD and DAE. This article revealed that per year maximum temperature was increased at Jessore (0.0165°C) followed by that of Gazipur (0.0045°C) and Comilla (0.0035°C). On average, the increment rates of rainfall were 6.72 mm, 4.98 mm, and 3.84 mm per year in Dinajpur, Jessore, and Gazipur, respectively. The trend of annual rainfall showed an increasing pattern in Gazipur at the rate of 3.24 mm. Among the Gazipur, Comilla, Jessore and Dinajpur highest rainfall was recorded in Gazipur (about 610 mm). The maximum drought frequency was found in Gazipur district same thing observed in Dinajpur and Jessore regions. The Aus, Aman and Boro rice's cropping area had been reduced among all four

areas. There are various causes such as unavailability of irrigation, the uncertainty of rainfall and increasing temperatures are responsible for decreasing cropped area. Due to technological development such as modern variety, management technique, and protection options crop production did not decrease. Irregular rainfall and temperatures made the farming community more vulnerable. This research did not analyze how the farmers were adapting with the change of climate at Gazipur. This is the gap and this study will fill up the it.

Chapter 3
Study Area and Research Methodology

3.1. Introduction

This chapter aims to discuss the study areas and the research methodology which is adopted in the context of the research objectives. Accordingly, the first part of this chapter describes the study area which emphasizes the physical attributes, socio economic activities, administration and land use features that relate to the theme of the research. The second part of the chapter gives a clear explanation of the philosophy of the research methodology, sampling procedures, data collection tools and data analysis techniques.

3.2 Description of the study area

3.2.1 Location-

This study was conducted in 2 Upazilas and in a ward (City Corporation) in Gazipur district that are Sreepur Upazila, Kaliganj Upazila and Gazipur City Corporation. From the Sreepur Upazila researcher selected Majhipara which is located at Barkul village, Barmi union and from Kaliganj Upazila chose Satanipara which is located at Satanipara village, Baktarpur union and 30 no ward (Moholla and road-Kanay) was selected from the Gazipur city corporation. All the village are located near the river. During the rainy season, all fields remain underwater for the six months due to waterlogging or flood. They only cultivate boro rice during the winter period.

3.2.2 Background and geographic area

The district of Gazipur is situated at the north of Dhaka city in Bangladesh. "Joydebpur" was the previous name of this region and was under the thick jungle of Vowal Pargana. (Sub-Division). In 1984, it was formed as a district under the Dhaka Division. It is hemmed on the north by Mymensingh and Kishoreganj Districts, on the east by Narsingdi District, on

the south by Naranyanganj and Dhaka Districts and on the west by the Tangail District. The Geolocation of Gazipur District is between 23˚53’ to 24˚20’ North latitudes and between 90˚09’ to 90˚42’ east longitude. The entire area of the district is 1806.36 sq. km of which 17.53 sq. km was riverine and 273.42 sq.km. is the forest area (Census,2011).

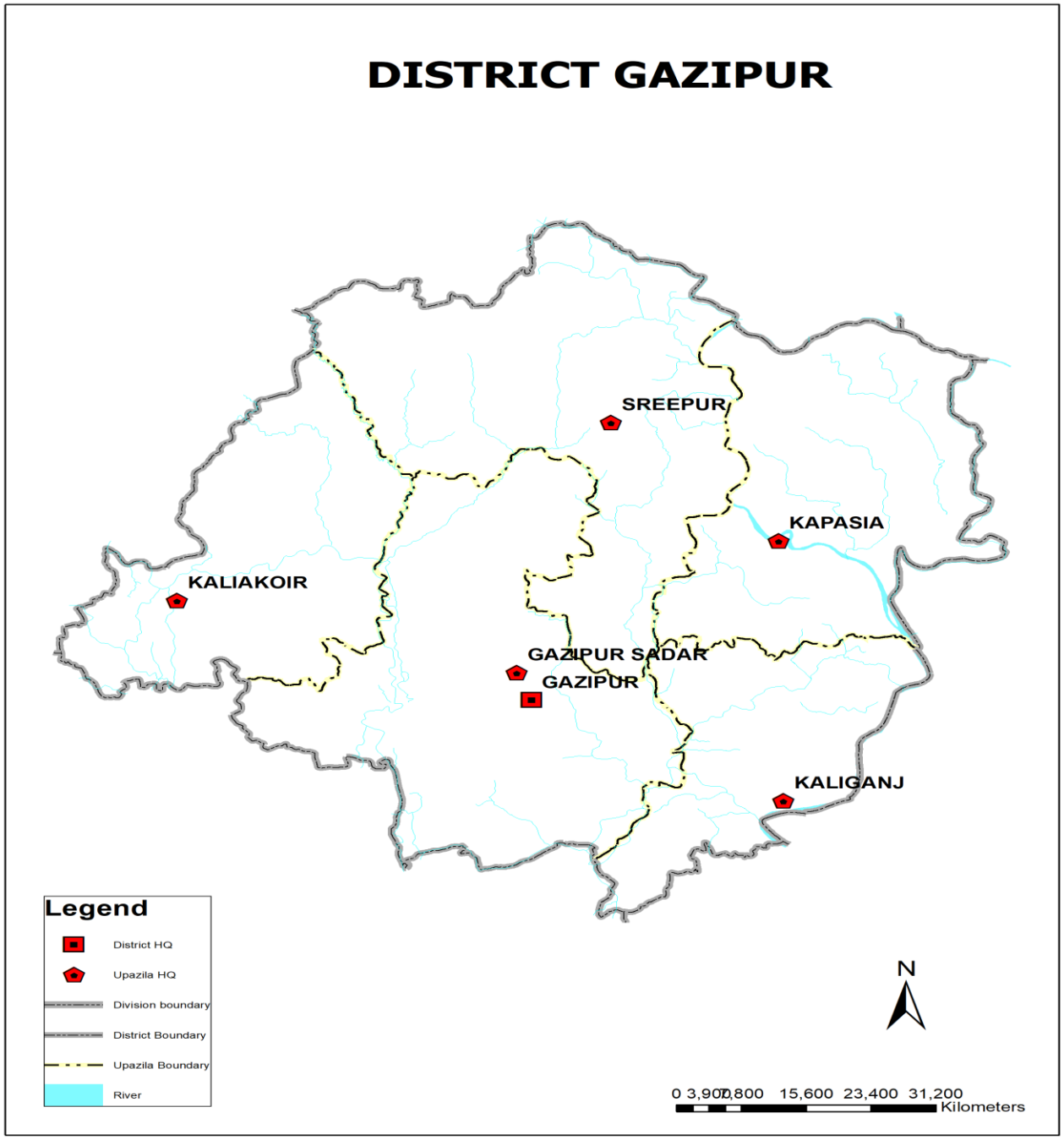


Figure 6: Map of Gazipur District

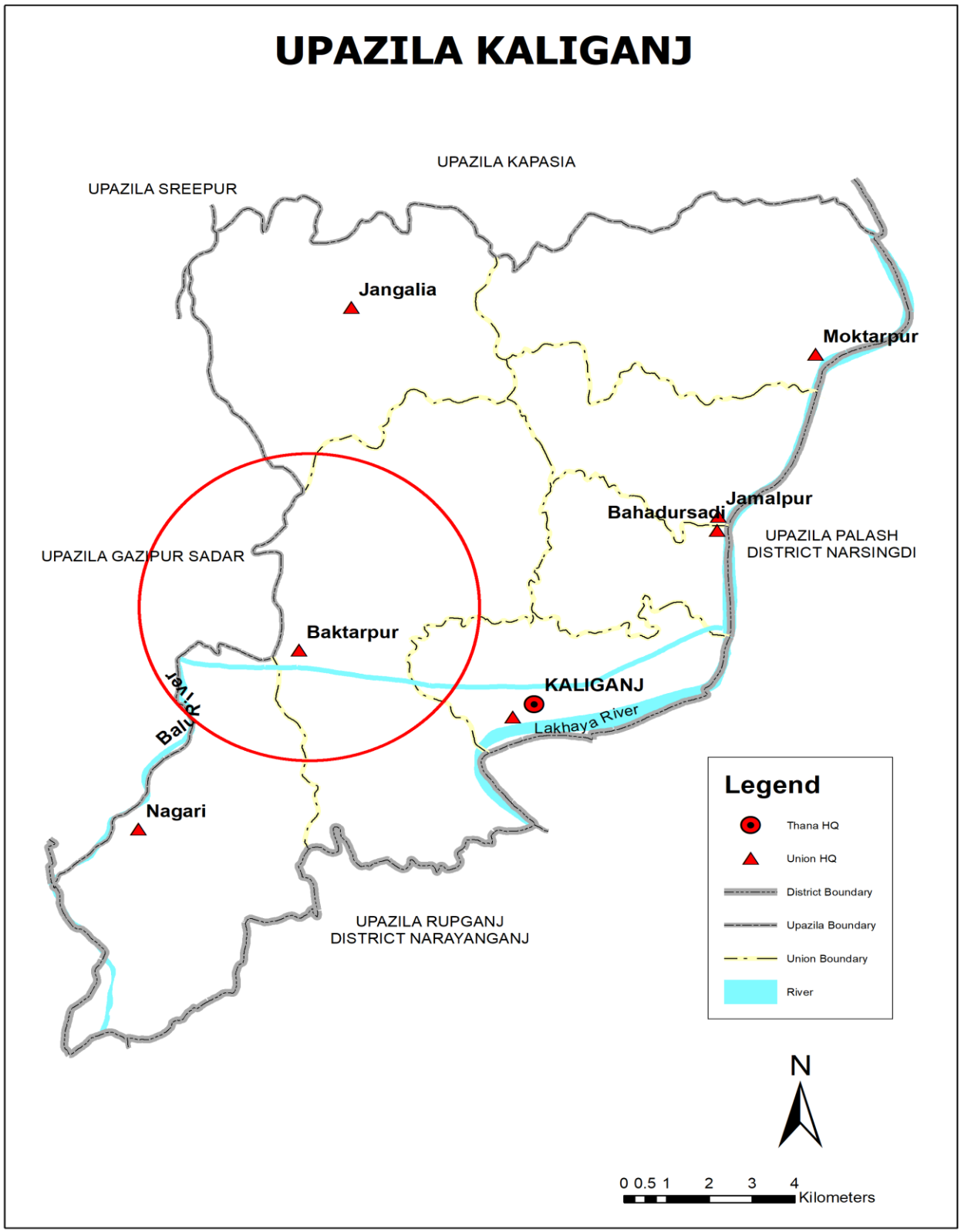


Figure 7: Map of Kaliganj Upazila (Gazipur)

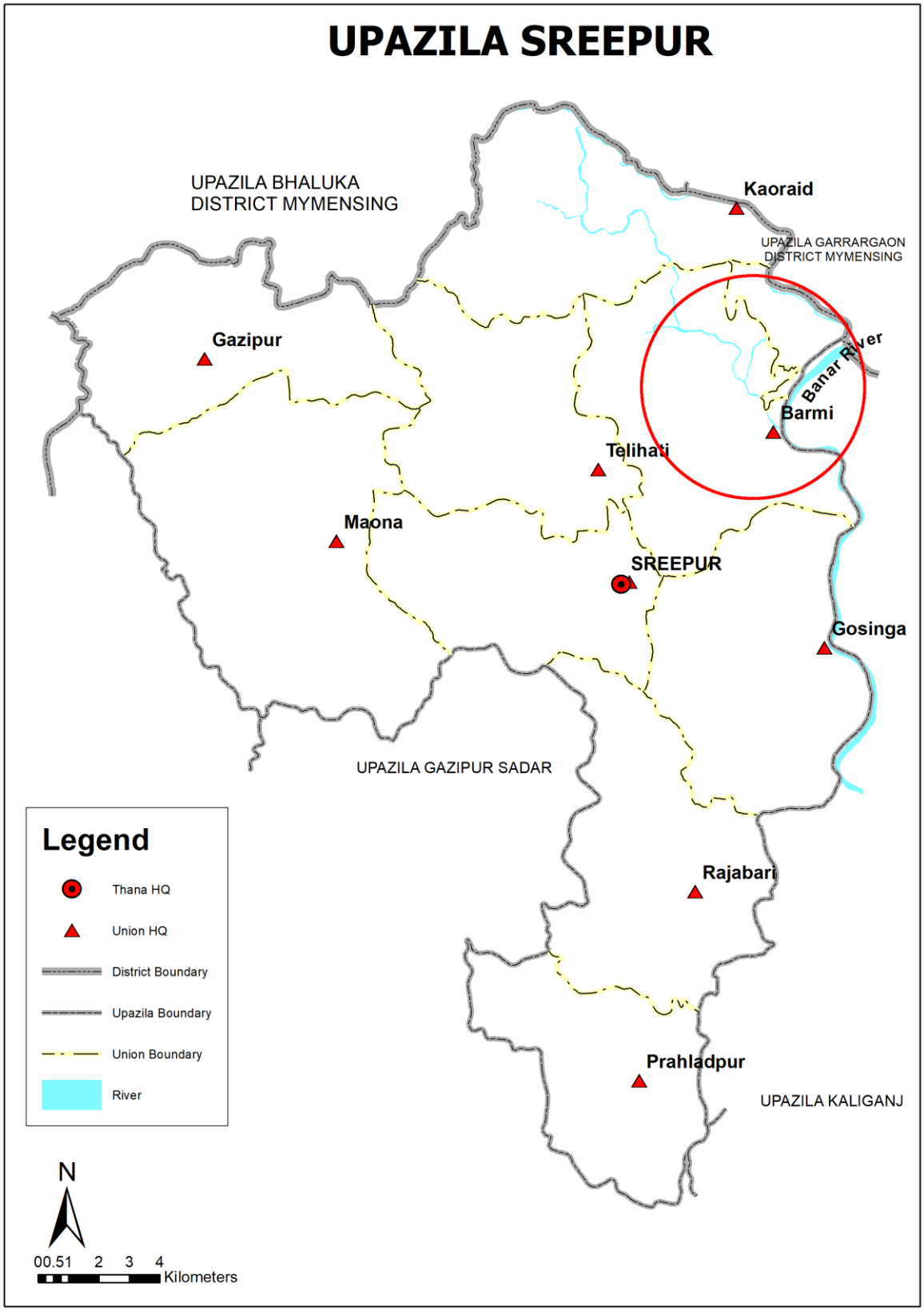


Figure 8: Map of Sreepur Upazila (Gazipur)

3.2.3 Annual Average Temperature and Rainfall

The annual average temperature of this district varies from a maximum 36°C to minimum 12.7°C. Annual rainfall is 2376 mm (Census, 2011).

3.2.4 Administration

There is a city corporation with 04 Municipalities in Gazipur District. They are Tongi, Sreepur, Kaliganj and Kaliakuir. Under Gazipur district there are 5 Upazilas that are Gazipur Sadar, Kaliakair, Kaligonj, Kapashia and Sreepur containing 44 Unions, 762 Mauzas and 1,114 Villages (Census, 2011).

3.2.5 Gazipur Town

Gazipur city is a very busy town which is consists of 9 wards and 31 mahallas. The area of the town is 49.32 sq. km with a population of 1,23,531. Among them, the male is 52.52% and the female is 47.48%. The population density is 2505 per sq. km. Many momentous institutions like Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Research Institute (BARI), CERDI, Seed Certifying Agency, The Security Printing Corporation (Bangladesh) Ltd, Machine Tools Factory, Bangladesh Ordnance Factory, Diesel Plant, BRAC Dairy Farm, Nova Poultry Limited, Cremation Ghat etc. are located in the Gazipur district. Dhaka University of Engineering and Technology (Previously known as BIT: Bangladesh Institute of Technology) is also situated in the city (Census, 2011).

3.2.6 Main Rivers

The Old Brahmaputra, Shitalakshya, Turag, Bangshi, Balu, Banar are main rivers of this district (Census, 2011).

3.2.7 Population

The total population of Gazipur district is 34,03,912. Among them male is 17, 75,310 and female is 16,28,602 and sex ratio 109:100. The population density of Gazipur district is 1884/Sq Km and the yearly growth rate is 5.21% (Census, 2011).

3.2.8 Literacy

The Literacy Rate of Gazipur district is 62.60%. Among them, the male is 66.00% and female is 58.90%. School attendance rate is 42.50% for 5 to 24 years age group (Census, 2011).

3.2.9 Main Crops

Paddy, jute, mustard seed, sugarcane, chilli, arum, turmeric, ginger etc. are the main crops of this district (Census, 2011).

3.2.10 Main Fruits

Jackfruit, pineapple, litchi, blackberry, guava, mango, papaya, kamranga, palm, boroi, karamcha, wood apple, tamarind etc. are main fruits of this district (Census, 2011).

3.2.11 Economic Situation

Agrarian economy dominates all over the district. Out of total 538,597 holdings, about 230,196 (42.74%) holdings are performing agricultural activities which produce varieties of crops, namely, local and HYV paddy, jute, pulses, vegetables, oilseeds and other minor crops, jackfruit, palm and wood trees add a bumper earning to well-to-do farmers. Non-farming economic activities have also a substantial share in revenue earnings and livelihood of rural people of the district (Census, 2011).

3.2.12 Soil

The conditions of the soil in the Bhawal Garh are assorted and often perplexing. A surprising range of soils is found, from red laterite soils at the extreme to almost undeveloped soils of raw Pleistocene clay at the other, with numerous intermediate stages developed between them and also with several kinds of soils occurring in the associated valleys (Census, 2011).

3.3 Research design

Designing is the early stages of a study in which the research topics and research problems are systematically identified and presented. Then the research objectives and methodology were set for data collection. Based on the research objectives questionnaires were designed and primary data collected through the survey. Secondary data were collected from BMD, BWDB, different published and unpublished journals, articles, newsletter, papers and e-papers which were tabulated, processed, collected, analyzed for reference to compare and contrast with the present research findings. After a brief review of the literature on the content, research methodology and previous research findings, a draft report was drafted to discuss and further refine the framework with the supervisors. Review of literature is done throughout the work. At the end, final report is submitted and paper is presented.

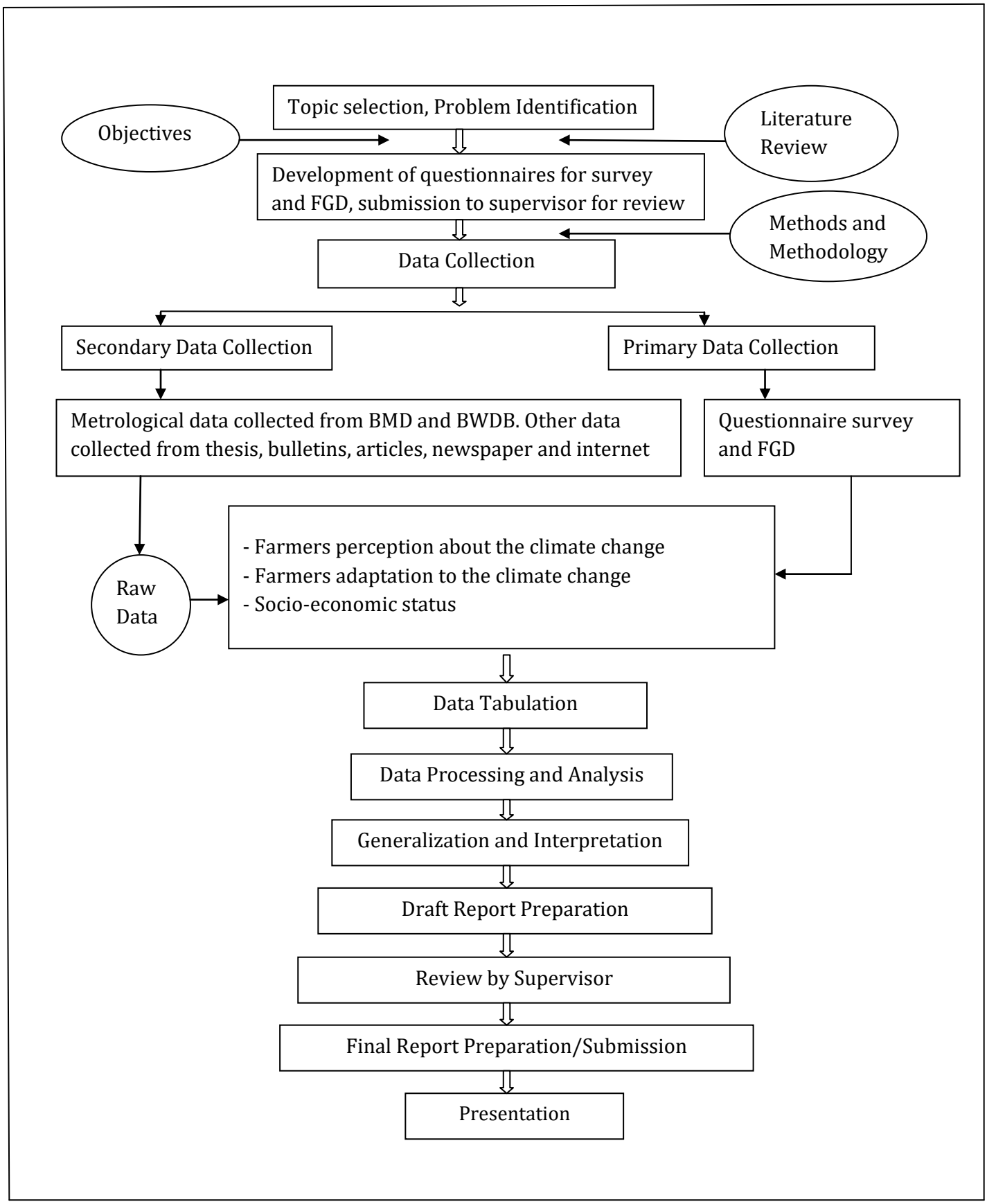


Figure 9: The research design of the research.

3.4 Research Methodologies

3.4.1 Sample size estimate

Total farmers of Gazipur district is 23,11,614. Assume that 50% of people are affected by climate change and confidence level is 95%. The estimated prevalence does not differ from the true prevalence by more than 0.05. The formula which is used to compute sample size is given as-

$$n_0 = \frac{z^2 pq}{d^2}$$

$$n_0 = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2}$$

= 384

n_0 = Desire sample size

z= Standard normal deviate usually set at 1.96, which corresponds to the confidence level

p= 50% farmers of Gazipur District are affected by climate change

d= 0.05 degree of accuracy desired in the estimated proportion

Again,

n_0 = 384

$$n = \frac{N n_0}{N + n_0}$$

$$n = \frac{231614 * 384}{231614 + 384}$$

= 383.36

Need total respondent for sample survey 384 from Gazipur district.

For the investigation took 2 Upazilas and 1 ward under city cooperation. So, each Upazila and ward needed 384/3=128 sample. The households selected randomly.

3.4.2 Methods of data collection

3.4.2.1 Primary data collection tools

To collect the data household questionnaire survey, focus group discussions (FGDs) and direct observations tools have been used.

The design of the questionnaire

The main objective of the questionnaire was to determine farmers' perception of climate change and evaluate how farmers were responding to climate change. Accordingly, a draft questionnaire was developed. The questions were directly related to the research objectives of this study. The questionnaire had four sections: households' socio-demographic characteristics, farm characteristics, farmers' perception of climate change, and farmers' adaptations strategies in the face of climate change.

Piloting the questionnaire

After preparing the questionnaire it is necessary to examine how respondents respond to the questions. The pilot survey conducted on 20 farmers in Gazipur district. The questionnaire was amended after the pilot survey. This procedure made the questionnaire unequivocal, suitable and acceptable to the final respondents.

Data coding, entry and cleaning

After culling the accomplished questionnaire, it was coded for data entry. Data from the completed questionnaires were entered into the Statistical Package for Social Sciences (SPSS; version 20) by the researcher. The SPSS is a useful software package for questionnaire surveys because of its flexibility, ease to use and its convertibility into other packages' files.

Once the data entry was completed, the data were then cleaned by producing frequency figures for each question and examining the outliers. Consequently, a large number of completed questionnaires were rechecked to avoid inconsistencies. At this stage, the data file was ready for final analysis.

3.4.2.2 Secondary data collection

There is no weather station in Gazipur district. The rainfall data of 50 years of Gazipur district had been collected from the BWDB (Bangladesh Water Development Board). To get the temperature data of Gazipur district, researcher averaged Tangail, Mymensing and Dhaka district's temperature data as Gazipur district is surrounded by those three districts. Temperature data would not be reliable if only consider the Dhaka station's temperature data as Gazipur district is under the Dhaka division.

3.4.2.3 Data analyzing methods

Data were analyzed by SPSS (20 version) and Excel 2007. Descriptive statistic and linear regression were employed to investigate the data. Those are given in below-

3.4.2.3.1 Descriptive statistics

Descriptive statistic (means, frequency, percentage) was used to identify farmer perceptions on climate changes and various adaptation measures being used by farmers, and barriers they face to adapt. SPSS version number 20 was the tool of analysis.

3.4.2.3.2 Linear regression model

"The linear regression line was fitted using the most common method of least squares. This method calculates the best fitting line for the observed data by minimizing the sum of the squares of the vertical deviations from each data point to the line. If a point lies exactly on the straight line then the algebraic sum of the residuals is zero. Residuals are defined as the

difference between an observation at a point in time and the value read from the trend line at that point in time. A point that lies far from the line has a large residual value and is known as an outlier or, an extreme value" (Roy et. al., 2015).

Regression analysis was done to see the trends in temperature and rainfall.

$$\mathbf{Y=ax+b}$$

Y= Dependent variable

x= Independent variable

a= Slope of the line

b= Constant (Y intercept where x=0)

3.4.2.3.3 Coefficient of determination

The coefficient of determination, R2, is employed to examine how the difference in one variable can be explained by a difference in a second variable. It is the most normal way to calculate the strength of the model. This can be given by the following formula-

Coefficient of determination, $\mathbf{R^2 = SSR/SST}$

$$=\frac{\sum(\widehat{\boldsymbol{Y}}_{\boldsymbol{i}} - \bar{\boldsymbol{Y}})^{\mathbf{2}}}{\sum(\boldsymbol{Y}_{\boldsymbol{i}} - \bar{\boldsymbol{Y}})^{\mathbf{2}}}$$

Where,

SSR is the Sum of Squared Regression also known as variation explained by the model

SST is Total variation in the data also known as sum of squared total

y_ i is the y value for observation i

y_bar is the mean of y value

y_bar_hat is the predicted value of y for observation

Chapter 4

Trend Analysis of the Temperature and Rainfall

4.1 Introduction

This chapter focuses on the first research objective, trend analysis of climatic parameters (temperature and rainfall) in Gazipur district. As there is no weather station in Gazipur district. To get the temperature data researcher averaged Tangail, Mymensing and Dhaka district's temperature as Gazipur district is surrounded by those districts and find weather stations only there. This chapter commence with the trend analysis of temperature and then investigate the trend of rainfall in Gazipur district as well as examine if there is any statistically significant relationship between two variables.

4.2 Trend analysis of the temperature

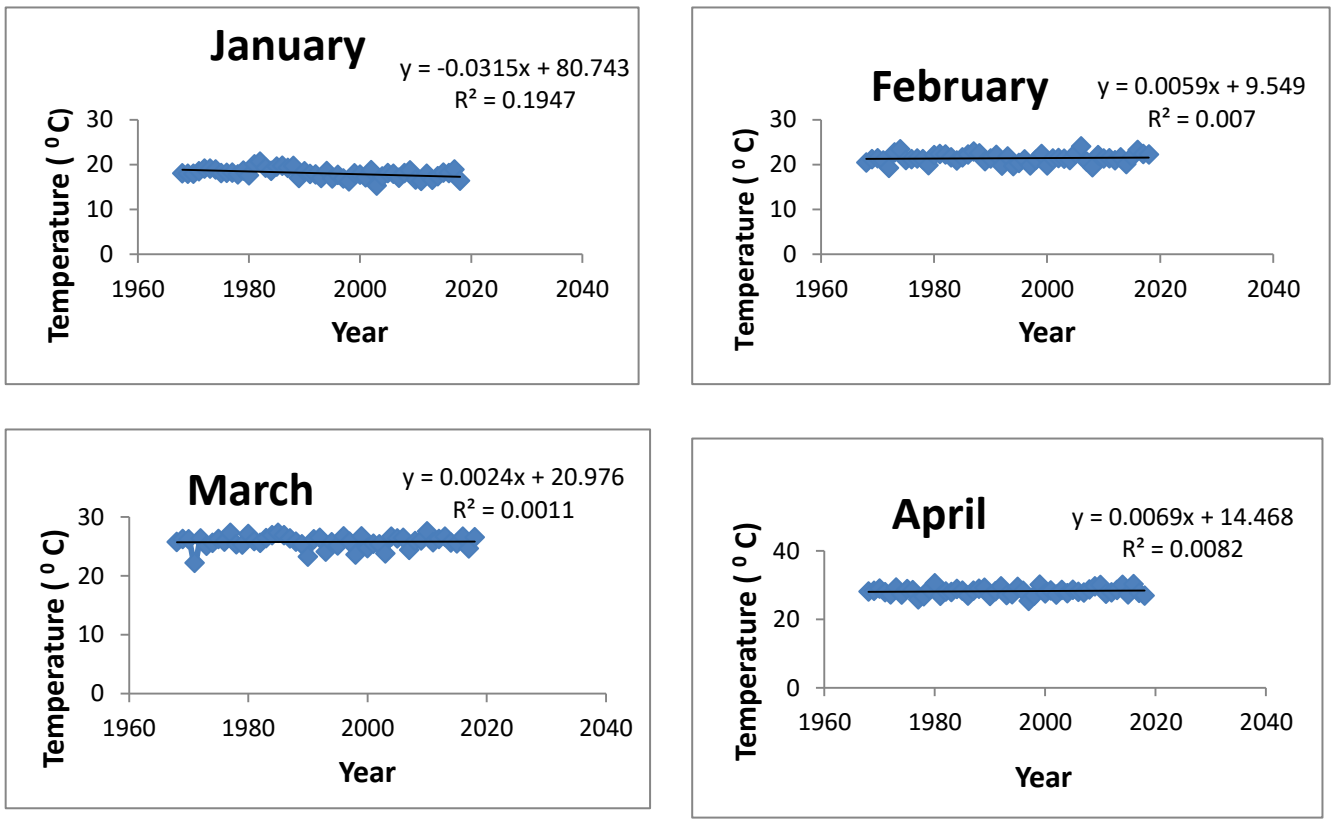


Figure 10: Trends of temperature of different months in Gazipur district.

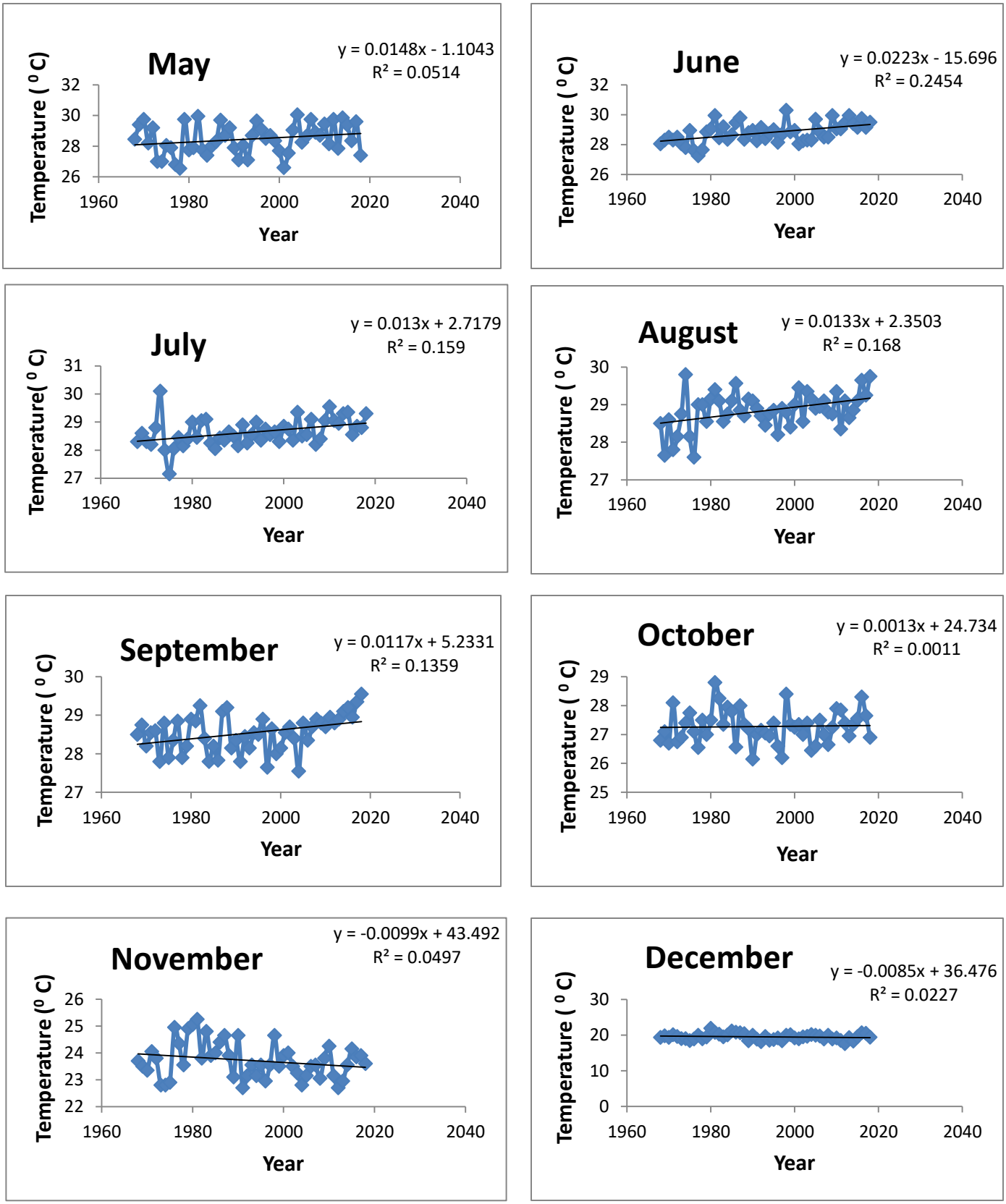


Figure 11: Trends of temperature of different months in Gazipur district.

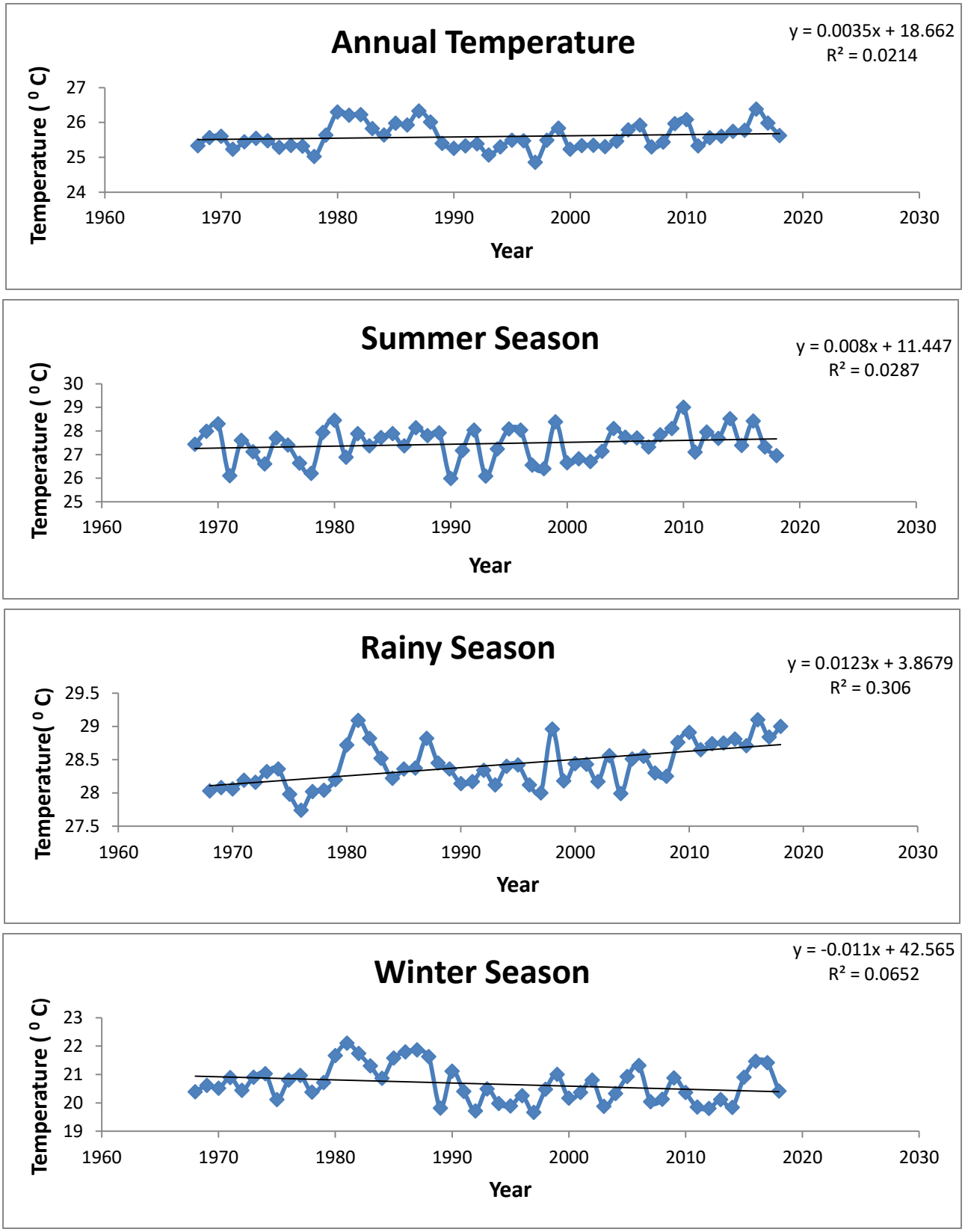


Figure 12: Trends of temperature of annual and different seasons in Gazipur district.

Table 4: Statistical result for the temperature of Gazipur district (^{0} C)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	Summer	Rainy	Winter
Pearson Correlation	-.441**	.084	.034	.091	.227	.495**	.399**	.410**	.369**	.033	-.223	-.151	.146	.170	.553**	-.255
Sig	.001	.559	.815	.526	.110	.000	.004	.003	.008	.816	.116	.291	.306	.234	.000	.070
Mean	18.04	21.39	25.78	28.17	28.45	28.79	28.64	28.84	28.54	27.27	23.72	19.51	25.60	27.47	28.42	20.67
Median	18.05	21.35	25.90	28.20	28.35	28.80	28.55	28.85	28.55	27.25	23.55	19.50	25.49	27.60	28.36	20.51
Mode	18[a]	21	25[a]	27	29[a]	28[a]	29	29	29[a]	27	24	20	25[a]	27[a]	28	20[a]
Standard deviation	1.060	1.054	1.067	1.125	.972	.670	.485	.482	.472	.568	.662	.839	.354	.705	.331	.640
Minimum (^{o}C)	15	19	22	25	27	27	27	28	28	26	23	18	25	26	28	20
Maximum (^{o}C)	21	24	28	31	30	30	30	30	30	29	25	22	26	29	29	22
R^2	0.1947	0.007	.0011	0.0082	0.0514	0.2454	0.159	0.168	0.13559	0.00011	0.04997	0.02027	.02 14	0.0214	0.306	0.0652
+/- (^{o}C)	-1.6065	+0.3009	+.1224	+0.3519	+0.7548	+1.1373	+0.663	+0.6783	+0.5967	+0.0663	+0.5049	-0.43 35	+.1785	+.408	+.6273	-0.561
N	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51

Correlation is significant at the 0.01 level (2-tailed),
Correlation is significant at the 0.05 level (2-tailed)
a Multiple mode exist. The smallest value is shown

January- A Pearson product-moment correlation was run to determine the relationship between temperature and time. There was a weak negative correlation between temperature and time, which was statistically significant (r=-0.441, n=51, p=0.001). In the January month temperature decreased 1.6065^0C and the $R^{2=}$0.1947 value indicated 19% variance in temperature explained by the time. The mean, median, mode and standard deviation were 18.04, 18.05, 18^a and 1.060 respectively. The minimum and maximum temperatures were 15^0C and 21^0C correspondingly (table 4).

February- In the February month temperature increased 0.3009^oC. The R^2 value was .007 which indicated 7% variance in temperature explained by the time. To evaluate the relationship between the Gazipur district's temperature and time a Pearson product-moment correlation coefficient was conducted. In February the trend of temperature for Gazipur district was increasing which indicated there was a highly weak positive linear relationship between temperature and time, r=0.084, n=51, p=0.559. It is not statistically significant. The mean, median, mode and standard deviation were 21.39, 21.35, 21 and 1.054 respectively. The minimum temperature was 19^0C and the maximum temperature was 24^0C correspondingly (table 4).

March- The temperature of the March month showed an increasing trend which was not statistically significant at the level of 0.815 and the correlation coefficient value was 0.034 that's mean there was positive weak relationship between temperature and time. In the Gazipur district from 1963 to 2013 (51 years) total annual temperature increased 0.1224^oC and the R^2 value was 0.0011 which refered 11% variance in the rainfall due to time. Respectively 25.78, 25.90, 25^a, 1.067 were the mean, median, mode and standard deviation of the temperature in the March month. 22^0 C was the minimum and 28^0 C was maximum temperatures of the March month (table 4).

April- The study exhibited an increasing trend in the temperature of April month with a correlation coefficient value of 0.091 that means there was a highly weak positive correlation between temperate and time which was not statistically significant (p= 0.526). The R^2 value was 0.0082 it indicated 82% variance in the temperature explained by the time. The total temperature increased by 0.3519^0 C from 1963 to 2013 (51 years) in the Gazipur district. The mean value was 28.17, the median was 28.20, the mode was

27 and the standard deviation was 1.125. In the April month, the minimum and maximum temperature was 25^0C and 31^0C respectively (table 4).

May- A Pearson product-moment correlation coefficient was computed to evaluate the relationship between the Gazipur district's temperature and time. There was a highly weak positive correlation between the two variables (r=0.227, n=51, p=0.110) and this was not statistically significant. The R^2 value of 0.0514 meant only 0.51% variation in temperature was explained by time. In the May month from 1963 to 2013 (51 years) temperature increased to 0.7548^0C. The Mean, Median, Mode and Standard deviation values were 28.45, 28.35, 29^a and 0.972 correspondingly. In this month the minimum and maximum temperatures were 27^0C and 30^0C respectively (table 4).

June- To establish the relationship between temperature and time a person product-moment correlation was run. There was a low positive relationship between temperature and time, which was statistically significant (r=.495, n=51, p=.000). In the June month temperature increased 1.1373^0C and the R^2 value was 0.2454 which pointed out 24% variance in temperature explained by time. The mean, median, mode and standard deviation were 28.79, 28.80, 28^a and 0.670. The minimum temperature was 27^0C and the maximum temperature was 30^0 C in this month (table 4).

July- Temperature had augmenting trend which had the correlation coefficient value of 0.399 that means there was a positive correlation between temperature and time as well as this trend was statistically significant at the level of 0.004. The mean, median, mode and standard deviation were 28.64, 28.55, 29 and 0.485 respectively. In this month 30^0C and 27^0C were the maximum and minimum temperature in that order. The R^2 value was 0.159 which pointed out a 15% variance in temperature explained by time. The temperature of the Gazipur district increased 0.663^0C in the July month (table 4).

August- Statistically significant increasing trend found for temperature in August month. A Pearson product-moment correlation was run to determine the relationship between temperature and time. There was a low positive correlation between temperature and time, which was statistically significant (r=0.410, n=51,p=0.003). In the August month temperature increased by 0.6783^0C. The R^2 value was 0.168 which

pointed out 16% variance in temperature which explained by time. The mean, median, mode and standard deviation were 28.84, 28.85, 29 and 0.482 respectively. The minimum and maximum temperatures were 28^0 C and 30^0 C correspondingly (table 4).

September- In the September month, the study found an increasing trend for temperature, having the correlation coefficient which was statistically significant (r=0.369, p=0.008, n=51). The correlation between two variables was a low positive relationship. 28.54, 28.55, 29[a] and 0.472 values were the mean, median, mode and standard deviation respectively. In the September month, the maximum and minimum temperatures were 30^0C and 28 ^{0}C respectively. In this month, the temperature of the Gazipur district increased by 0.5967^0C. The R^2 value was 0.1359 which pointed out 13% variance in the temperature explained by time (table 4).

October- Statistical significant increasing trend did not find in the temperature of October month. A Pearson product-moment correlation was run to determine the relationship between temperature and time. There was a low positive correlation between temperature and time, which was not statistically significant (r=0.033, n=51, p=0.816). In the October month temperature increased by 0.0663 ^{0}C. The R^2 value was 0.0011 which pointed out 11% variance in temperature explained by time. The mean, median, mode and standard deviation were 27.27, 27.25, 27 and 0.568 respectively. The minimum and maximum temperatures were 26^0 C and 29^0 C correspondingly (table 4).

November- The study demonstrated a decreasing trend in November month with a coefficient correlation value of -0.223 that means there was a low negative correlation between temperature and time which was not statistically significant at the level of p=0.116. The R^2 value was 0.0497 it indicated 49% variance in the temperature was explained by the time. The mean, median, mode and standard deviation were 23.72, 23.55, 24 and 0.662 respectively. The minimum and maximum temperatures were 23^0C and 25^0C correspondingly. In the November month temperature of Gazipur district decreased 0.5049^0C (table 4).

December- The analyzed data confirmed a declining trend with a coefficient correlation value of -0.151 which was not statistically significant at the level of 0.291. The mean, median, mode and standard deviation were 19.51, 19.50, 20 and 0.839 respectively. The minimum and maximum temperatures were 18^0C and 22^0C correspondingly. In the December month temperature decreased 0.4335^0C. The R^2 value was 0.0227 which pointed out 22% variance in temperature explained by time (table 4).

Annual Temperature- The study found an increasing trend for temperature, having the correlation coefficient of which was not statistically significant, (r=0.146, p=0.306, n=51). There was a low positive correlation between temperature and time. The total annual temperature increased by 0.1785^0C from 1968 to 2018. The R^2 value was 0.0214 which indicated 21% variance in temperature explained by time. The mean, median, mode and standard deviation were 25.60, 25.49, 25^a and 0.354 respectively. The minimum and maximum temperatures were 25^0C and 26^0C correspondingly (table 4).

Summer season- During the summer season, the total temperature showed a decreasing trend. A Pearson product-moment correlation was run to establish the relationship between temperature and time. There was a highly positive correlation between temperature and time, which was not statistically significant (r=0.170, n=51, p=0.234). The mean, median, mode and standard deviation were 27.47, 27.60, 27^a and 0.705 respectively. The minimum and maximum temperatures were 26^0C and 29^0C correspondingly. In the summer season temperature increased 0.408^0C. The R^2 value was 0.0214 which pointed out 21% variance in temperature explained by time (table 4).

Rainy season- Statistically significant increasing trend found in the rainy season. The temperature increased 0.6273^0 C in this year and R^2 value was 0.306 which pointed out 30% variance in temperature explained by time. A Pearson product-moment correlation was conducted to determine the relationship between temperature and time. There was a positive correlation between temperature and time, which was statistically significant (r=-0.553, n=51,p=.000). The mean, median, mode and standard deviation values were 28.42, 28.36, 28 and 0.331 respectively. The minimum and maximum temperatures were 28^0C and 29^0C correspondingly (table 4).

Winter season- A decreasing trend found for temperature in the winter season, having the correlation coefficient which was not statistically significant (r=-0.255, p=0.070, n=51). There was a negative correlation between temperature and time. In the winter season temperature decreased 0.561^0C. The R^2 value was 0.0652 which pointed out 65% variance in temperature explained by time. The mean, median, mode and standard deviation were 20.67, 20.51, 20^a and .640 respectively. The minimum and maximum temperatures were 20^0 C and 22^0 C correspondingly (table 4).

In conclusion, all over total temperature increased 0.146^0C in Gazipur district from 1968 to 2018. However, a statistically significant increased trend found in the month of June, July, August, September and the rainy season. On the other hand, the temperature increased in the month of February, March, April, May, and October which were not statistically significant. In addition, for the month of January found a significant decreasing trend. In contrast, the month of November, December and winter season observed decreasing trend of temperature which were not statistically significant (table 4).

4.3 Trends analysis of the rainfall

Rainfall is one of the elements that determine the climatic condition of an area. This section analysed monthly and seasonal rainfall changes from 1963 to 2013 in Gazipur district. Throughout the year and season, rainfall decreased in Gazipur district. The trend of seasonal rainfall for the period of 1963-2013 was shown in figure 13, 14 and 15. Statistical results have been displayed in Table 5.

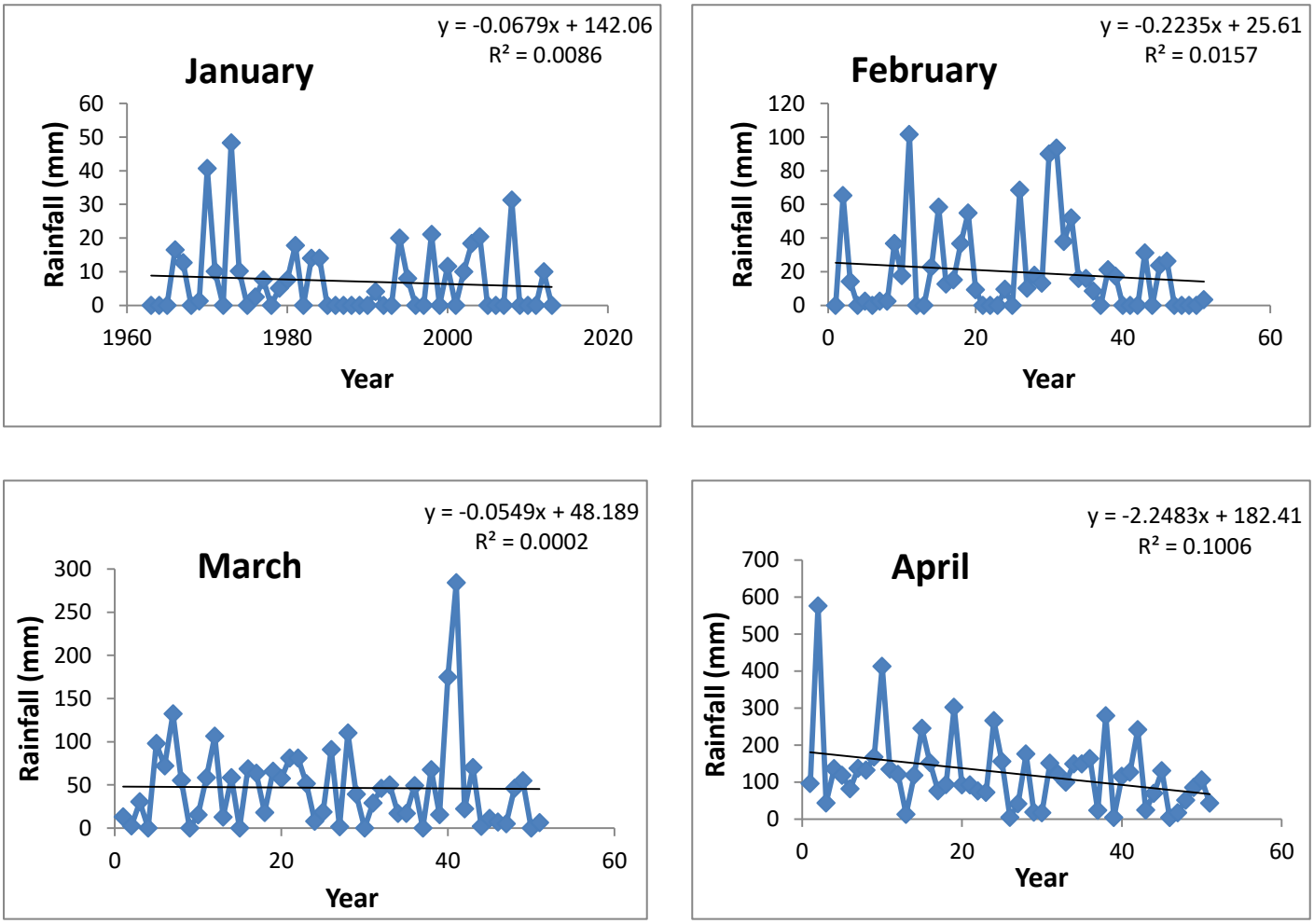


Figure 13: Trends of rainfall (mm) of different months in Gazipur district.

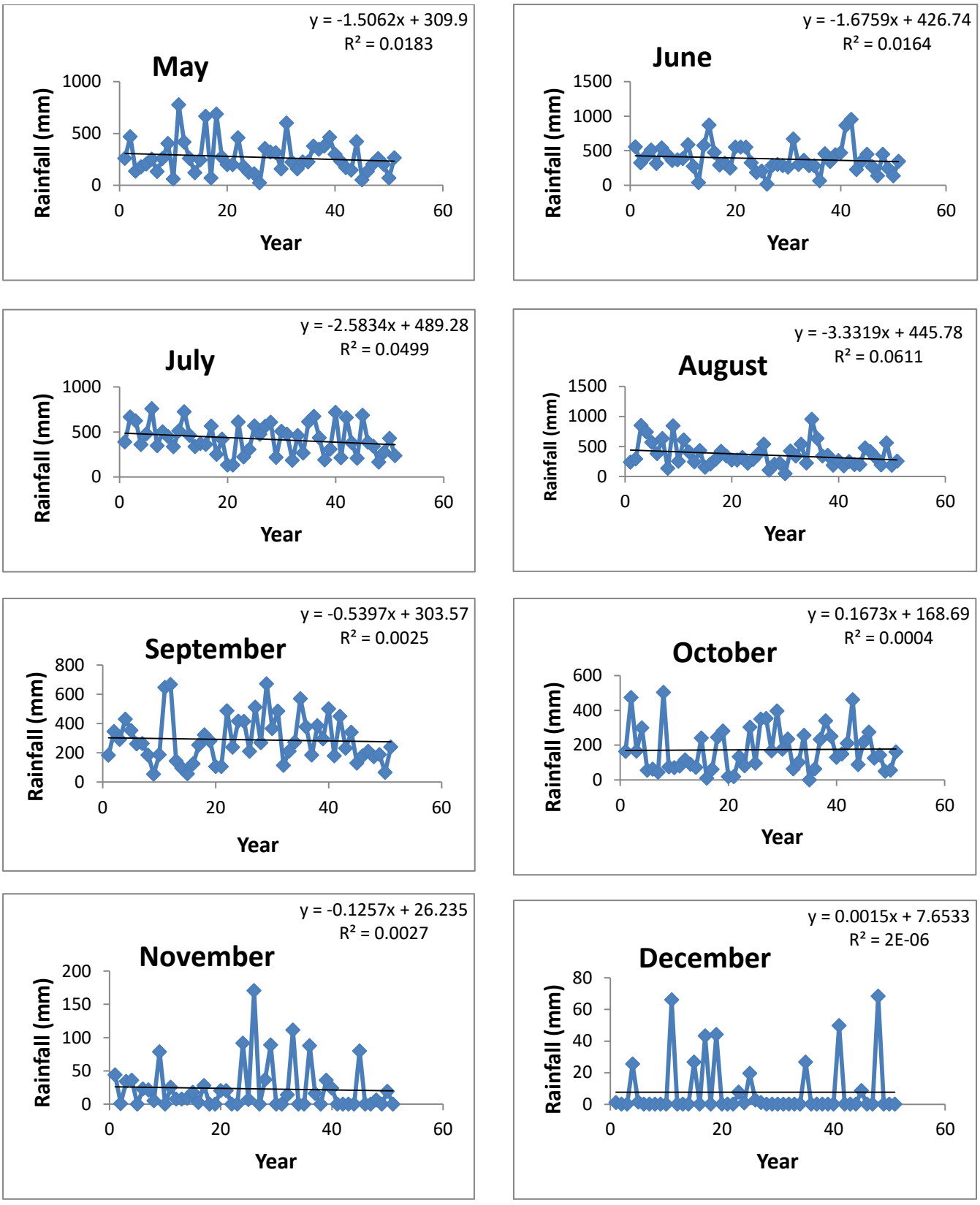
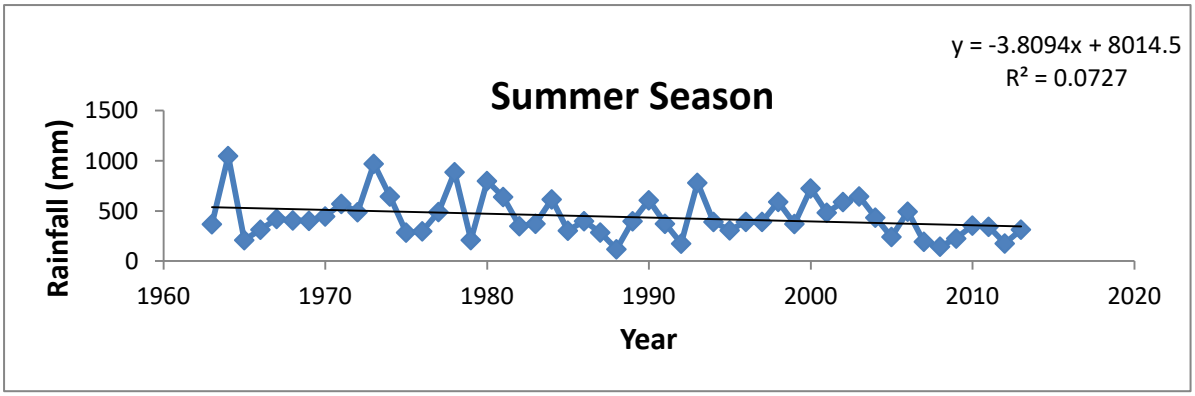
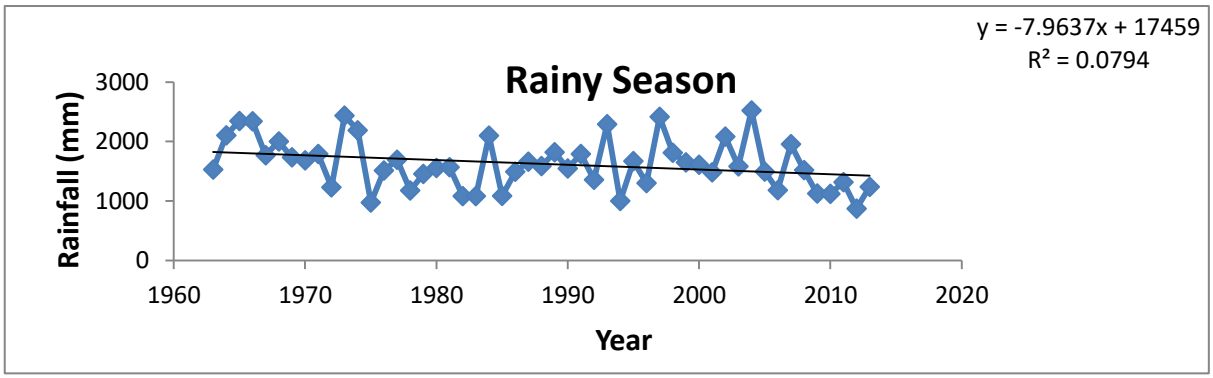
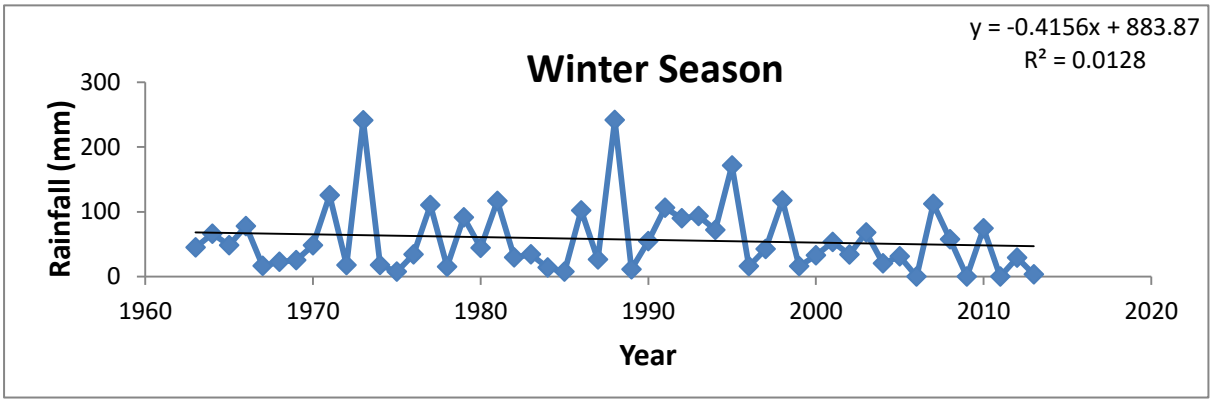


Figure 14: Trends of rainfall (mm) of different months of Gazipur district.







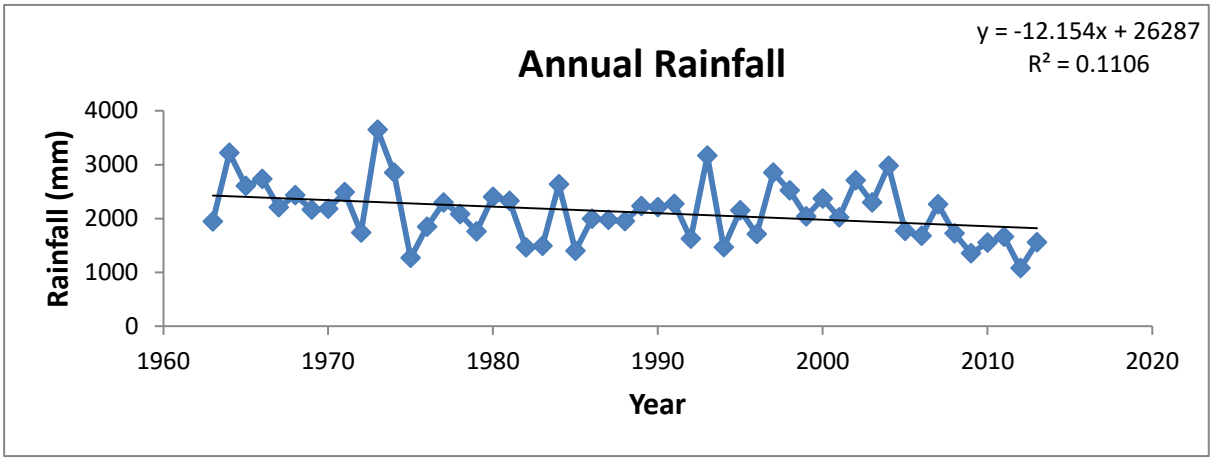


Figure 15: Trends of rainfall (mm) of different seasons and annual in Gazipur district.

Table 5: Statistical results of rainfall in Gazipur District (mm)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	Summer	Rainy	Winter
Pearson Correlation	-.098	-.128	-.016	-.317*	-.135	-.128	-.224	-.247	-.050	.020	-.054	.003	-.333*	-.270	-.282*	-.113
Sig	.495	.372	.911	.024	.344	.370	.115	.081	.726	.890	.709	.984	.017	.056	.045	.429
Mean	7.14	19.82	46.76	124	270.73	383.2	422.12	359.08	289.6	173.1	23.02	7.73	2124.14	441.45	1627.01	57.58
Median	0	10	39	116	235	347	420	292	261	143	8	0	2151	392.4	1583.2	42.6
Mode	0	0	0	4[a]	71[a]	449	132	186[a]	107[a]	19[a]	0	0	1078[a]	392	1083	0
Standard deviation	10.84	26.54	51.652	105.4	165.6	194.3	171.96	200.55	159.4	127.37	35.734	17.24	543.442	210.069	420.267	54.599
Maximum (mm)	48	102	52	576	778	954	758	952	673	504	171	68	3648	1048	2522	242
Minimum (mm)	0	0	0	4	24	16	132	46	55	0	0	0	1078	119	872	0
R^2	.0086	.0157	.0002	.1006	.0183	.0164	.0499	.0611	.0025	.0004	.0027	2E-06	.0727	.0794	.0128	.1106
+/-(mm)	-3.4629	-11.3985	-2.7999	-114.6633	-76.8162	-85.4709	-131.7534	-169.9269	-85.323	-8.5323	-6.4107	+0.0765	-619.854	-194.2794	-406.1487	-21.1956
N	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51

Correlation is significant at the 0.01 level (2-tailed)
Correlation is significant at the 0.05 level (2-tailed)
a Multiple mode exist. The smallest value is shown

January- A Pearson product-moment correlation coefficient was computed to assess the relationship between the Gazipur district's rainfall and time. There was a highly negative correlation between the two variables, r=-0.098, n=51, p=0.495 and this was not statistically significant. The R^2 value of 0.0086 means only 0.86% variation in rainfall was explained by time. In January from 1963 to 2013 (51 years) rainfall decreased 3.4629 mm. The Mean, Median, Mode and Standard deviation values were 7.14, 0, 0 and 10.84 correspondingly. In this month the maximum and minimum rainfalls were 48 mm and 0 mm respectively (table 5).

February- To evaluate the relationship between rainfalls and time a Pearson product-moment correlation coefficient was conducted. In February the rainfall trend for Gazipur was decreasing which indicated there was a highly negative linear relationship between rainfall and time, r= -0.128, n=51, p=0.372. It was not statistically significant. From 1963 to 2013 (51 years) total rainfall in February month has been reduced to 11.3985 mm. The R^2 value was 0.0157 which indicated that 15% variance in rainfall which was explained by the time. Respectively 19.82, 10, 0 and 26.54 values represented the mean, median, mode and standard deviation respectively. In the February month maximum and minimum rainfalls were 102 mm and 0 mm in order that (table 5).

March- The total rainfall of March month showed a decreasing trend which was not statistically significant. The correlation coefficient value was 0.016 which was not statistical significance at the level of 0.911. That represented a very weak positive correlation between two variables. In Gazipur district from 1963 to 2013 (51 years) total annual rainfall decreased 2.7999 mm and the R^2 value was 0.0002 which refered 2% variance in the rainfall due to time. The Mean, median, mode and standard deviation were 46.76, 39, 0, and 51.652 correspondingly. The maximum and minimum rainfalls in March month were 52 mm and 0 mm (table 5).

April- The study exhibited a decreasing trend of rainfall in the April month with a correlation coefficient value of -0.317 that meant there was a highly weak negative correlation between temperate and time which was statistically significant (p= .024). The R^2 value was 0.1006 it indicated a 10% variance in the rainfall explained by the time. Total rainfall decreased 114.6633 mm from 1963 to 2013 (51 years) in Gazipur district. The mean value was 124, the median was 116, the mode was 4^a and the standard deviation was 105.4. In the April month, maximum rainfall was 576 mm and minimum rainfalls were 4 mm correspondingly (table 5).

May- In the May month the total rainfall had a declining trend which had the correlation coefficient value of -0.135 and this trend was not statistically significant at the 0.344 level of significance. The mean, median, mode and standard deviations were 270.73, 235, 71^a, and 165.6 respectively. In this month maximum and minimum rainfalls were 778 mm and 24 mm and total rainfall reduced 76.8162 mm. The R^2 value was 0.0183 which indicated 18% variance in the rainfall was explained by the time (table 5).

June- The rainfall trend showed a negative correlation with the time which represented a decreasing trend. The Pearson coefficient correlation value for this trend was -0.128 and the significant value was 0.370 that meant it was not statistically significant. The mean was 383.2, the median was 347, the mode was 449 and the standard deviation was 194.3. In the June month, maximum and minimum rainfalls were 954 mm and 16 mm respectively and total rainfall decreased 85.4709 mm in Gazipur district. The R^2 value was 0.0164 it indicated 16% variance in the rainfall explained by the time (table 5).

July- The Rainfall had a reducing trend which had the correlation coefficient value of 0.224 and this trend was not statistically significant at the level of.115. The mean, median, mode and standard deviation were 422.12, 420, 132 and 171.96 respectively. In this month 758 mm and 132 mm were the maximum and minimum rainfall in that order. In the July month rainfall reduced 131.7534 mm from 1963 to 2013 (51 years) and the R2 was 0.0499 that meant 49% variance in the rainfall explained by the time/year (table 5).

August- The study found a decreasing trend for rainfall in August month having the correlation coefficient of -0.247 which was not statistically significant (p=.081). There was a highly negative relationship between two variables. The mean value was 359.08, the median was 292, the mode was 186[a] and the standard deviation was 200.55. In this month maximum and minimum rainfalls were 952 mm and 46 mm. From 1963 to 2013 (51 years) rainfall reduced 169.9269 mm and the R^2 was 0.0611 that meant 61% variance in the rainfall explained by the time/year (table 5).

September- A Pearson product-moment correlation coefficient was computed to evaluate the relationship between the Gazipur district's rainfall and time. There was a highly negative correlation between the two variables that's mean rainfall reduced (r=-0.050, n=51, p=.726) and this was not statistically significant. In the September month rainfall decreased 85.323 mm from 1963 to 2013(51 years) and the R^2 was 0.0025 that indicated 25% variance in the rainfall explained by the time. In the September month mean, median; mode and standard deviation were 289.6, 261, 107[a], and 159.4 correspondingly. The maximum rainfall was 673 mm and minimum rainfall was 55 mm (table 5).

October- In the October month, the study found an increasing trend for rainfall, having the correlation coefficient of which was not statistically significant (r=0.020, p=0.890,n=51). There was a highly positive relationship between two variables. 173.1, 143, 19[a] and 127.37 values were the mean, median, mode and standard deviation respectively. The maximum and minimum rainfalls were 504 mm and 0 mm correspondingly**.** In the October month rainfall reduced 8.5323 mm from 1963 to 2013 (51 years) and the R^2 was 0.0004 that meant 4% variance in the rainfall explained by the time (table 5).

November- The study demonstrated a decreasing trend in the November month with a coefficient correlation value of -0.054 which was not statistically significant at the level of 0.709 and R^2 value was 0.0027 it indicated 27% variance in the rainfall was explained by the time. The mean, median, mode and standard deviation were 23.02, 8, 0, and 35.734 respectively. The maximum and minimum rainfalls were 171 mm and 0 mm in order that.

In the November month rainfall reduced 6.4107 mm from 1963 to 2013 in the study area (table 5).

December- The analyzed data confirmed an augmenting trend with a coefficient correlation value of 0.003 which was not statistically significant at the level of 0.984. That represented a positive correlation between rainfall and time. The mean value was 7.73, the median was 0, the mode was 0 and the standard deviation was 17.24. The maximum and minimum rainfalls were 68 mm and 0 mm in order that. In the December month rainfall increased 0.0765 mm from 1963 to 2013 (51 years) and the R^2 was 2E-6 (.0006) that means 6% variance in the rainfall explained by the time/year (table 5).

Annual Rainfall- The study found an increasing trend for rainfall, having the correlation coefficient of which was statistically significant, (r=.333, p=.017,n=51). The mean value was 2124.14, the median was 2151, the mode was 1078[a] and the standard deviation was 543.442. The maximum and minimum rainfalls were 3648 mm and 1078 mm respectively. Annual rainfall reduced 619.854 mm from 1963 to 2013 (51 years) and the R^2 value was 0.0727 that meant 72% variance in the rainfall explained by the time (table 5).

Summer season- During the summer season, the total rainfall showed a decreasing trend. The correlation coefficient value was -0.270 which was no statistical significance at the level of .056. It indicated a highly negative relation between the two variables. The value of the mean, median, mode and standard deviation were 441.45, 392.4, 392 and 210.069 respectively. The maximum rainfall was 1048 mm and minimum rainfall was 119 mm. In the summer season rainfall reduced 194.2794 mm from 1963 to 2013 (51 years) and the R^2 value of 0.0794 means 79% variance in the rainfall explained by the time (table 5).

Rainy season-The study revealed in the rainy season total rainfall decreased to 406.1487 mm. The correlation coefficient value was -0.282 which was statistical significance at the level of .045 and it revealed a highly negative relationship between two variables. The R^2 value of 0.0128 means 12% variance in the rainfall explained by the time/year. The mean value was 1627.01, the median was 1583.2, the mode was 1083 and the standard deviation

was 420.267. 2522 mm and 872 mm were the maximum and minimum rainfall of the rainy season (table 5).

Winter- In the winter season, the total rainfall showed a decreasing trend. The correlation coefficient value was -0.113 which was not statistical significance at the level of .429**.** The mean, median, mode and standard deviation were 57.58, 42.6, 0 and 54.599. The maximum and minimum rainfalls were 242 mm and 0 mm. In the winter season rainfall reduced 21.1956 mm from 1963 to 2013 (51 years) and the R^2 was 0.1106 that means 11% variance in the rainfall explained by the time (table 5).

In conclusion, annual rainfall had been decreased 619.854 mm from 1963 to 2013 in Gazipur district and it was statistically significant. In addition, it is clear rainfall trend declined from January to November and increased trend found in the month of December. It observed a statistically significant decreasing trend only in the April month. However, rainfall reduced in summer and winter season but it is not statistically significant. On the other hand, in the rainy season statistically significant decreasing rainfall trend observed. So, it can say the change in rainfall happens in Gazipur district.

Chapter-5

Socio-Economic Status

5.1 Demographic Information

The total households sample (n=384) evenly divided among Sreepur Upazila (128 people) and Kaliganj Upazila (128 people) of Gazipur district as well as 30 no ward (128 people) under Gazipur city corporation. Among the respondents 98.96% was man and 1.04% was woman. Faced difficulties to take interview of women because their shyness and considered agricultural activities as household works. About 54% of the farmer's aged group from 41 to 60 years, while 36% farmer's aged group between 20 to 40 years, it implies that young generation has less tendency to engage in agricultural activities than older people (tables 6).

Table 6: Age classes of survey household heads (N=300)

Age Category	Count	Per cent
20-30	54	14
31-40	86	22
41-50	116	30
51-60	90	24
61-70	38	5
Total	384	100
Mean =45.99, SD =12.386, Minimum age =20 and Maximum age =70.		

The family size of the farmers was generally high with an average of 5.3 persons where the national average family size was 4.06 persons (BBS, 2016). About 24% of the respondents had family size was 4 persons and 21% had 5 persons and the standard deviation was 2.20. During FGD most of the respondents mentioned that having more family members were an advantage for them. Respondents believed the more children, the more labour and the more income. That is why; family size is comparatively high in the study area than national family size.

Of the household heads surveyed nearly one third (31%) of the farmers were illiterate and 30% had up to secondary education (eight passed) and 27% had primary education. The average income of the farmers was 20,823 taka per month and the standard deviation of income was 12125.478. Furthermore, the minimum and maximum incomes of the respondents were 2,000 taka and 66,666 taka per month correspondingly.

5.2 General characteristics of farm households

Exactly three quarter (75%) of the respondents confirmed they were the owner of the land and near one quarter (22.14%) of farmers worked as labour while a tiny amount of people do agriculture-based business. As overall, it is clear their economic condition is better.

Regarding involves in agriculture activities, on average farmers were engaged with the farming activities 24 years and the standard deviation of that was 11.50. The minimum and maximum years to involve in the farming sector were two years and fifty-five years respectively.

Crop production and livestock rearing are the major livelihood activities undertaken in the study areas. According to the survey, the dominantly cultivated crop was rice, hence, a large number (86.20%) of the farmers cultivated rice and one ten (11.72%) of the respondents planted wheat in Gazipur district. Besides they grew different types of seasonal fruits such as jackfruits, mango, guava, plum as well as different types of vegetables, for example, tomato, gourd, papaya, eggplant, spinach, kale etc. All the farmers mentioned that cultivate vegetables and fruits were more profitable than rice.

Livestock plays a decisive role in providing farmyard manure, fuel, and dietary supplements. About more than half (53%) of the farmers had hens, where a small portion (15%) had ducks. In contrast, near one fifth (19%) respondents claimed they had cow whereas a tiny portion (8% and 5%) mentioned they had calf and goat in that order. Poultry prevails among all the livestock.

With regard fish cultivation, near three fifths (58.1%) of the household participants revealed they did not cultivate fish, while two-fifths (20%) farmers disclosed during the rainy season they cultivated fish when low land covered with water.

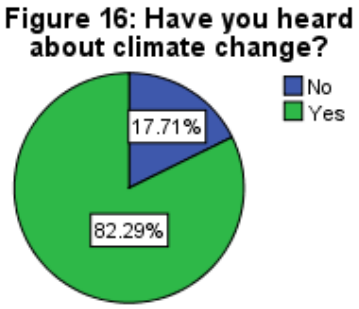
The cultivated vegetable was very common in the study area, about nine-tenths (91%) household respondents practised homestead garden and a very small amount of farmers did not cultivate vegetables.

According to farmers' opinion, the most profitable source of income was livestock (65.63%) then 2nd and 3rd lucrative sources were fishery (24.74%) and agriculture (9.64%). People are becoming unmotivated in agriculture practice due to high labour cost, the high price of seeds and irrigation. The production cost of 40kg paddy was 1000 taka where they sold that at taka of 700, even many farmers mentioned last year they did not harvest paddy from the field due to high labour cost. If it continues then in future Bangladesh may suffer food insecurity on account of farmers may stop to cultivate rice. More than two thirds (69.27%) of the household respondents pointed out that vegetables were the most profitable among all the crops, while one quater (24.48%) of the farmers confirmed rice was lucrative. A small amount (4.17% and 2.08%) of household participants mentioned wheat and others had advantageous.

Concerning irrigation facilities to the cultivated land, over three quarters (77.86%) of farmers had access to irrigation facilities while approximately one-quarter (22.14%) respondents claimed they did not have any irrigation opportunity in their field. More than half (52%) of the farmers confirmed they use the motor as irrigation whereas near one quarter (23.4%) respondents said they used deep tube well and a tiny portion (2.3%) used shallow tube well. On the other hand, 22.1% of people claimed they did not have any irrigation facilities because of lack of money.

Chapter 6

Farmers' Perception of climate change



The result revealed that majority of the farmers (82.29%) heard about the climate change that means farmers were aware and knowledgeable about climate change. On the other hand, near one fifth of the farmers had not heard (17.71%) about climate change (figure 16).

Figure 16: Heard about climate change. (Source: Author, 2019)

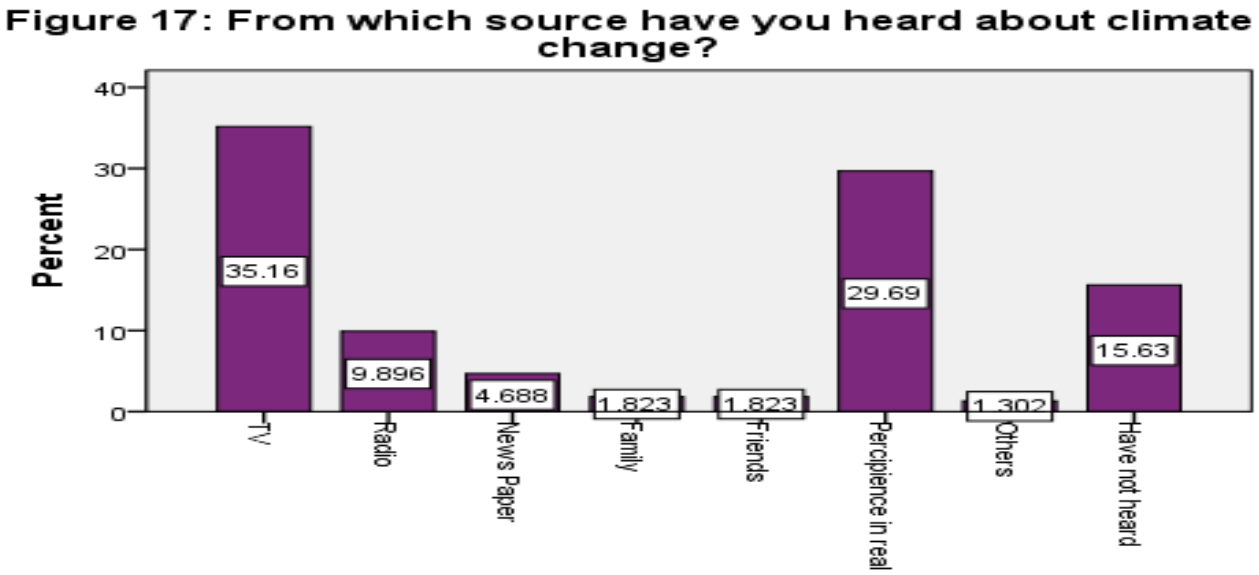


Figure 17: Source of knowledge. (Source: Author, 2019)

The diagram showed over one third (35.16%) of the farmers came to know about the climate change from the TV and almost three in tens (29.69%) of the respondents' response that they observed the climate change in reality. Third and fourth sources of the knowledge were radio (9.89%) and newspaper (4.68%) respectively. Few farmers came to know from friends and other sources (figure 17).

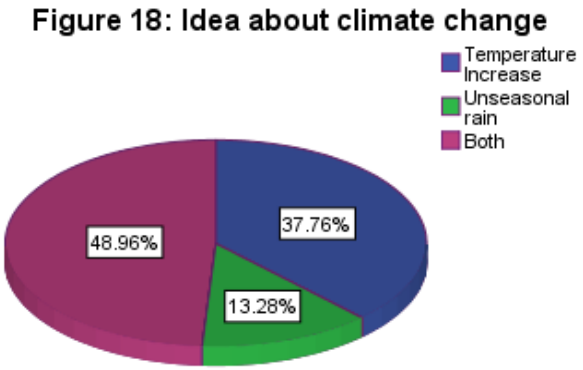


Figure 18: Idea about climate change. (Source: Author, 2019)

The pie chart sketched out that nearly half (48.96%) of the farmer's idea about climate change was both temperature increased and unseasonal rainfall. Well over one-third (37.76%) of the respondents understood climate change refers to temperature increase while above one in ten farmers idea was unseasonal rain (figure 18).

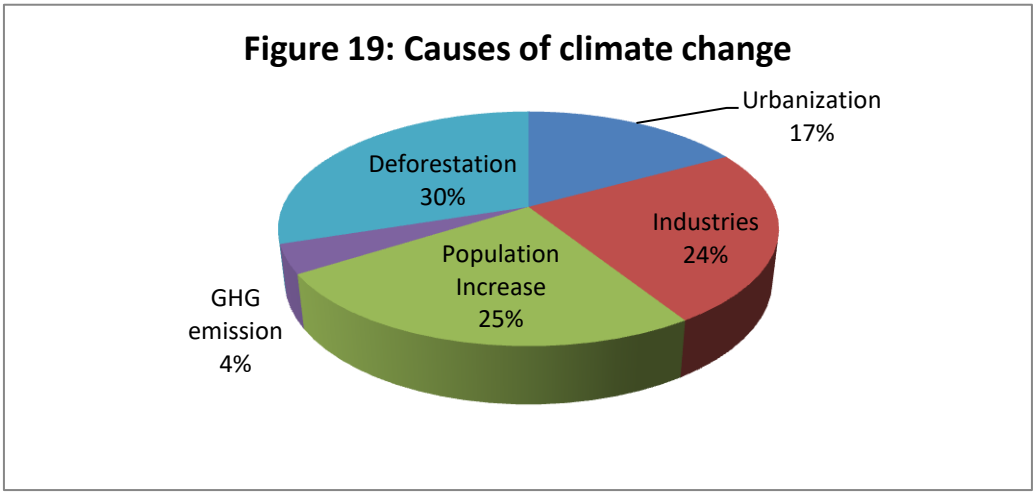


Figure 19: Causes of climate change. (Source: Author, 2019)

Exactly three tens (30%) of the farmers' responses the first cause of the climate change was deforestation while second, third and fourth causes were population increases (25%), industries (24%) and urbanization (17%). Oligo people mentioned GHG is one of the causes where 0% pointed out they don't know the reason (figure 19).

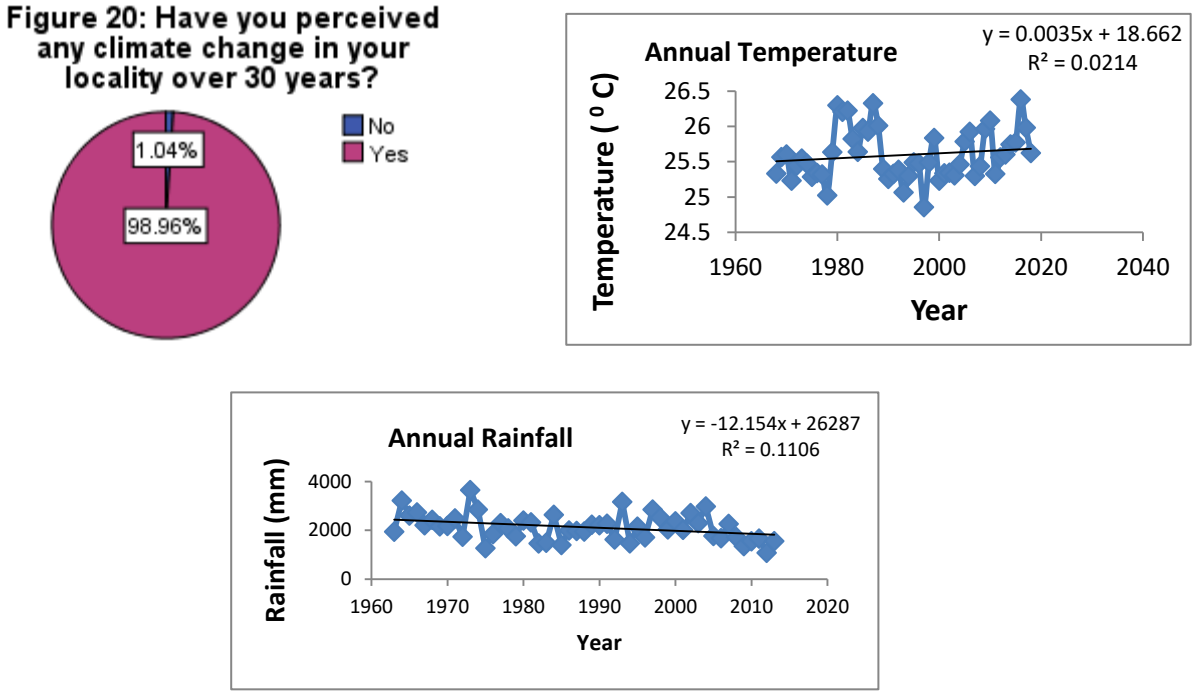


Figure 20: Perceive climate change in Gazipur district. (Source: Author, 2019)

The result indicated majority (98.96%) of the respondents' perceived climate change in Gazipur area over 30 years while very tiny portions (1.04%) observed no change in climate or they did not notice any climate change in their locality. The graphs of the annual temperature and annual rainfall also support the farmer's opinion. From 1968 to 2018 Gazipur district's annual temperature increased by 0.1785^{0}C and annual rainfall reduced 619.854 mm from 1963 to 2013 (figure 20).

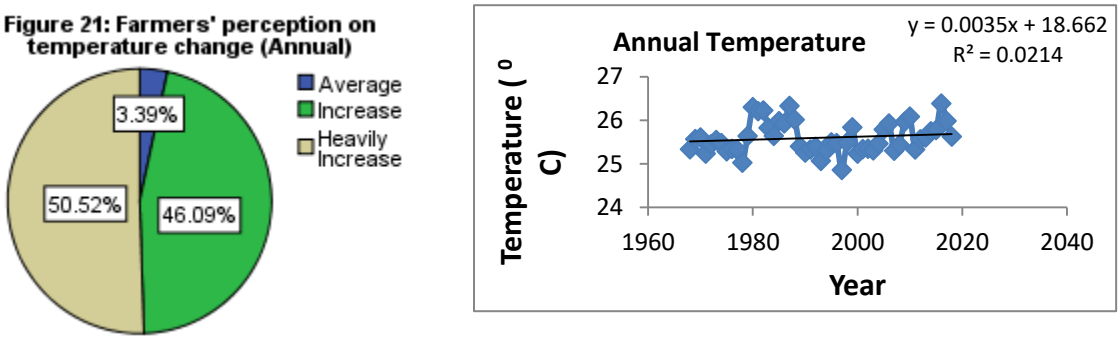
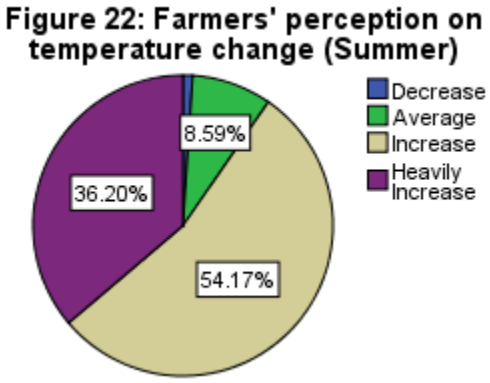


Figure 21: Farmers' perception on annual temperature change. (Source: Author, 2019)

Altogether the majority of the respondents (96.61%) confirmed temperature increased, among them half (50.52%) and nearly half (46.09%) of the participants perceived temperature increased and heavily increased respectively. Sundry people said the temperature was average. The graphs of the annual temperature (increased by 0.1785^{0}C) support the farmer's opinion (figure 21).



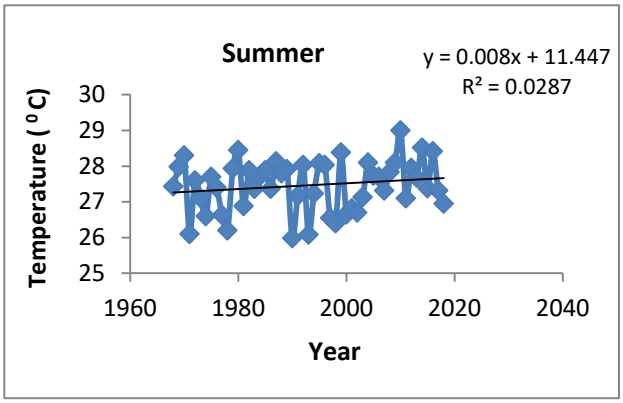


Figure 22: Farmers' perception on summer temperature change. (Source: Author, 2019)

The result indicated that the majority of the respondents (90.37%) felt summer's temperature augmented. Among them, more than half (54.17%) and nearly two fifths (36.20%) of the respondents noticed temperature increased and heavily increased respectively. Few farmers said temperature decreased and the temperature was average. The graph of the summer temperature confirmed that in the summer season temperature increased by 0.408^{0}C. Therefore, their opinion matches with the graph. During FGD many respondents shared the view that they noticed temperature increased dramatically that's why they could not work in the field for long times. Another respondent said excessive sweating made them weak, resulting they no longer stayed in the field. They felt burn in the skin and suffer severe headache during work (figure 22).

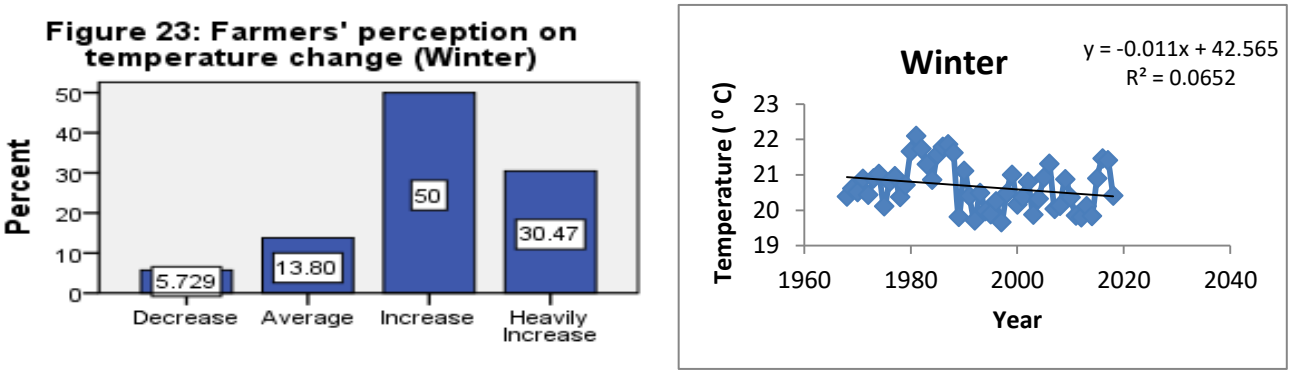


Figure 23: Farmers' perception on winter temperature change. (Source: Author, 2019)

The data suggested half (50%) of the respondents mentioned temperature increased and near one quarter (30.47%) of the respondents noticed winter's heavily increased, while a small portion (5.72%) perceived temperature decreased. Farmers' opinion did not match with the winter temperature's graph. It is showing the temperature decreased by 0.561^{0}C (figure 23).

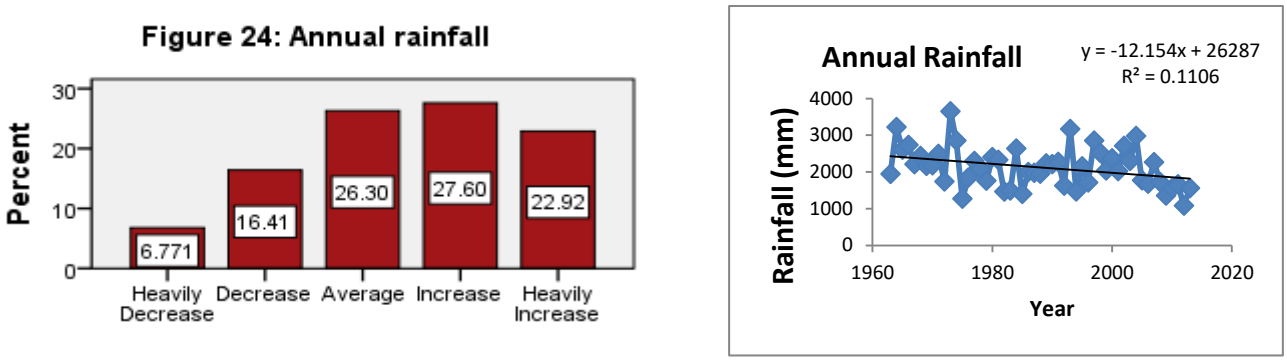


Figure 24: Farmers' perception on annual rainfall change. (Source: Author, 2019)

The finding indicated half (50.52%) of the respondents recognized the changes (increase 27.60% and heavily increase 22.92%) in annual rainfall amount, while around a quarter (23.18%) farmers noticed decrease trend (decrease 16.41% and heavily decrease 6.77%) in annual rainfall. Over one quarter said winter temperature was average. Most of the farmers' opinion did not go with the real rainfall data. Annual rainfall reduced 619.854 mm from 1963 to 2013 (51 years) (figure 24).

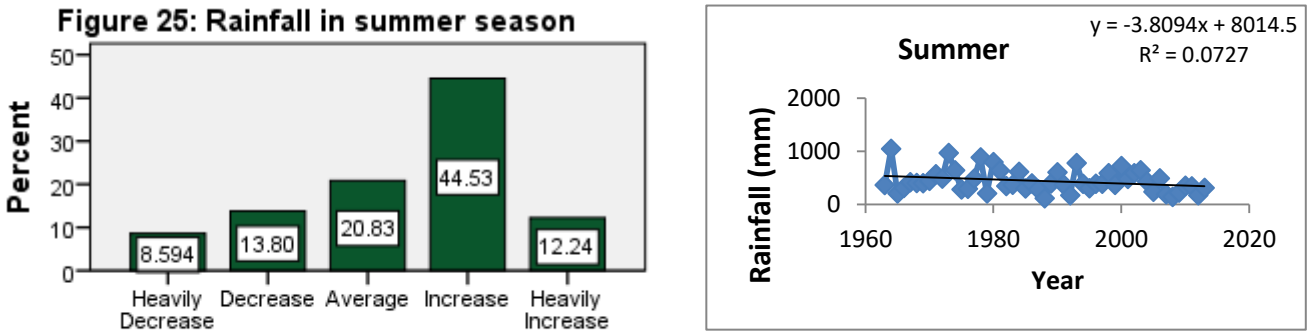


Figure 25: Farmers' perception on summer rainfall change. (Source: Author, 2019)

The result indicated that more than two-fifths (44.53%) respondents recognized rainfall increased in the summer season, while small minority (12.24%) farmers noticed summer rainfall heavily increased. Over one fifth (22.39%) of farmers perceived summer temperature decreased (decrease 13.80% and heavily decrease 8.594%). One fifth (20.83%) of the respondents noticed the summer season's rainfall was average. But in the summer season rainfall reduced 194.2794 mm from 1963 to 2013 (51 years) which did not match with farmers perception (figure 25).

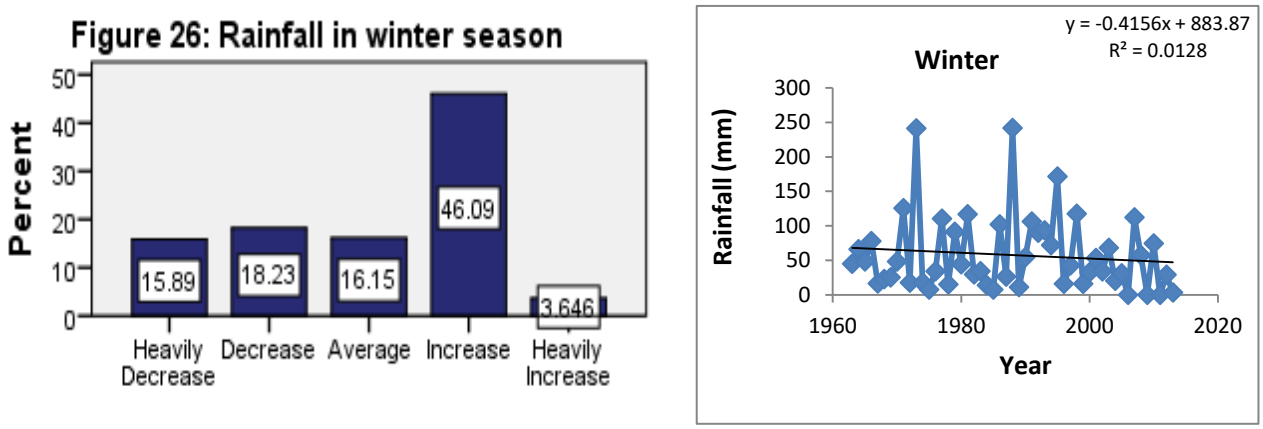


Figure 26: Farmers' perception on winter rainfall change. (Source: Author, 2019)

The result revealed that well over of two fifths (46.09%) of the respondents' perceived rainfall increased in the winter season, whereas a very tiny portion (3.648%) noticed winter rainfall heavily increased. Just over the one-third (34.12%) of respondents

perceived winter rainfall decreased (decrease 18.23% and heavily decrease 15.89%). Less than two-fifths of participants (16.15%) confirmed summer season's rainfall was average. In reality, the majority of farmers' view did not match with the statistical report. In the winter season rainfall reduced 21.1956 mm from 1963 to 2013 (51 years) (figure 26).

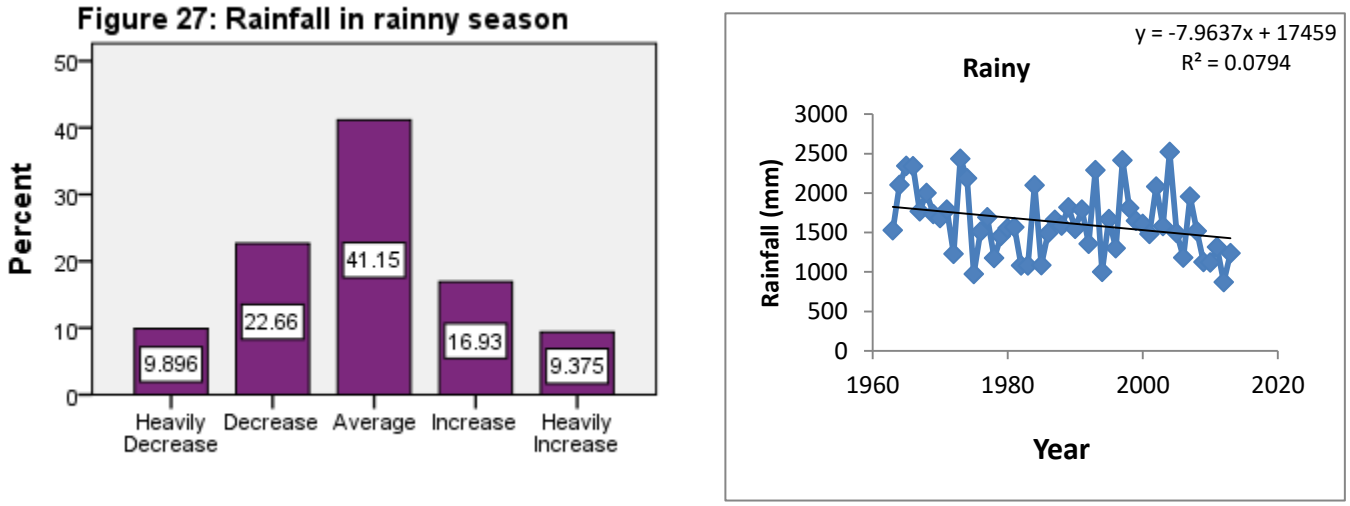
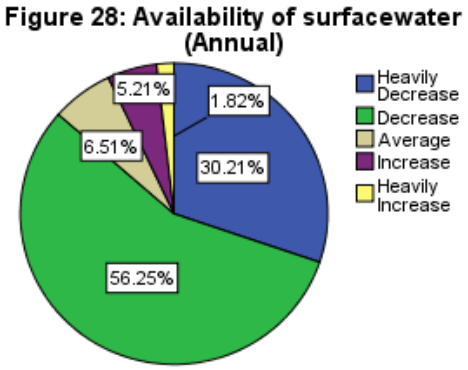


Figure 27: Farmers' perception on rainfall in the rainy season. (Source: Author, 2019)

The diagram revealed that just over two fifths (41.15%) of the participants noticed rainfall had not changed in the rainy season, it was average. Nearly a quarter (22.66%) and one in ten (9.896%) of the respondents observed rainfall decrease and heavily decrease respectively over the last 30 years in Gazipur area. Almost one-third of the respondents (32.55%) remarked rainfall decreased, whereas roughly one quarter (26.3%) observed rainfall increased in the rainy season. The study revealed in the rainy season annual rainfall decreased to 406.1487 mm which did not go with the majority's belief (figure 27).



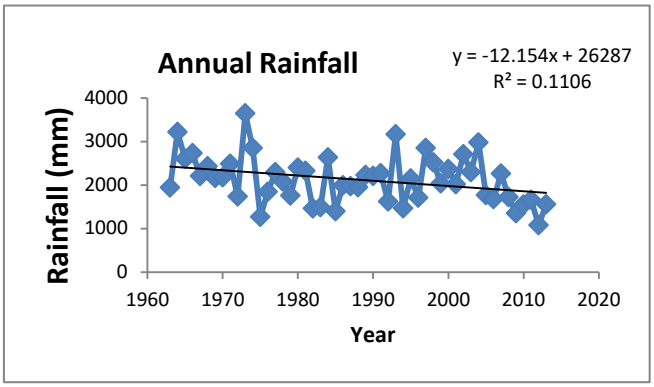
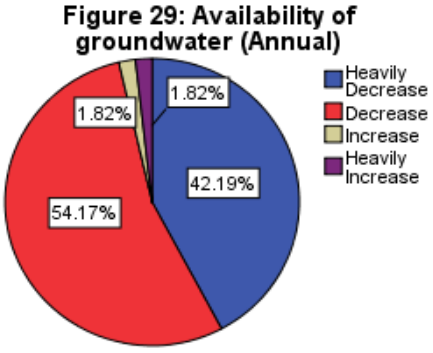


Figure 28: Farmers' perception on availability of surfacewater. (Source: Author, 2019)

The pie chart illustrated the majority of the participants (86.46%) revealed that the availability of surfacewater decreased which was supported by annual rainfall (619.854 mm reduced from 1963 to 2013). Among the well over half (56.25%) and nearly one third (30.21%) of the respondents remarked availability of surface water decreased and heavily decreased respectively, whereas very tiny proportion (7.03%) observed availability of groundwater increased (increased 5.21% and heavily increased 1.82%). Annual rainfall reduced 619.854 mm from 1963 to 2013 which supports the farmers opinion (figure 28).



(figure 28).

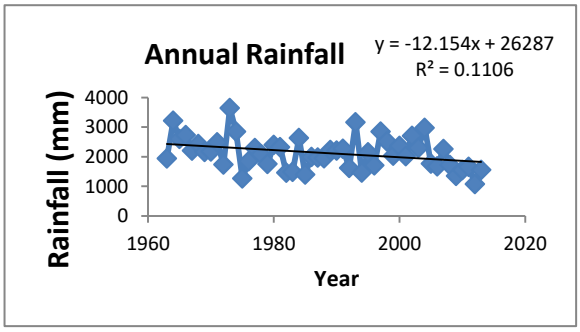


Figure 29: Farmers' perception on availability of groundwater. (Source: Author, 2019)

Majority of the participants which was 96.36% (decreased 54.17% and heavily decreased 42.19%) revealed that availability of groundwater decreased, whereas very tiny proportion 3.64% (increased 1.82% and heavily increased 1.82%) observed availability of groundwater increased. Annual rainfall (619.854 mm reduced from 1963 to 2013) completely supports farmers' view (figure 29).

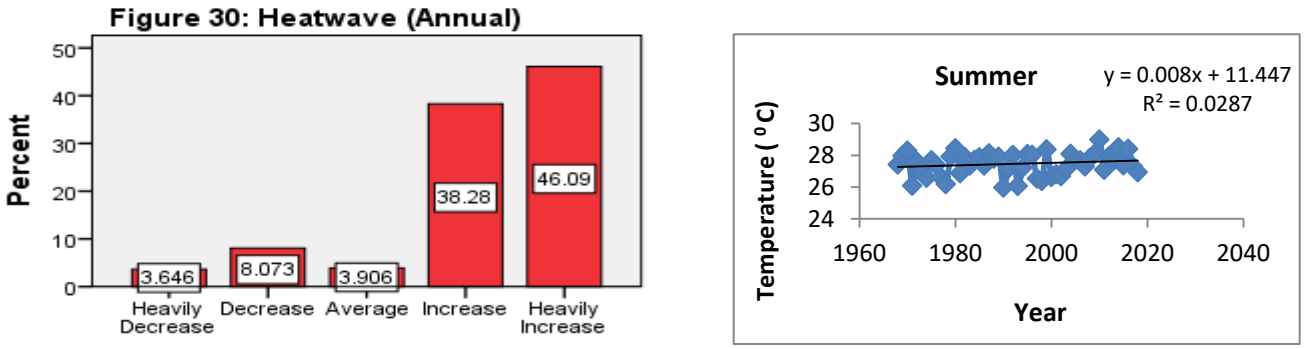


Figure 30: Farmers' perception on severity of heatwave (Annual). (Source: Author, 2019)

The diagram illustrated that most of the participants (84.37%) said the severity of heatwave increased (38.28% increased and 46.09% heavily increased) and a small portion (11.71%) said it decreased (3.64% decreased and 8.07% heavily decreased). In the summer season, the temperature increased by 0.408^{0}C which had a positive relationship with the farmers' perception regarding the severity of heatwave (figure 30).

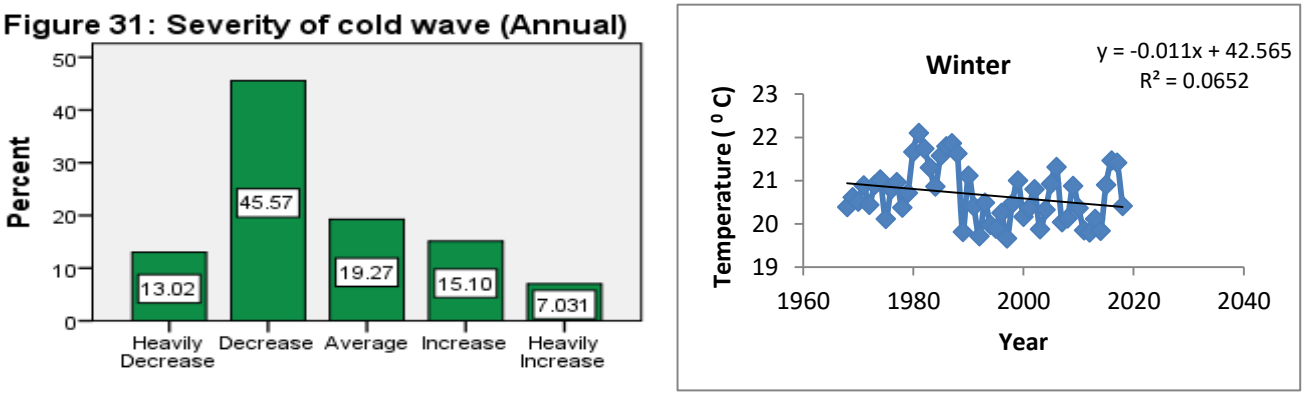


Figure 31: Farmers' perception on severity of cold wave (Annual). (Source: Author, 2019)

An overall view, half (58.59%) of the respondents said the severity of cold wave decreased and near a quarter (22.13%) of the participants mentioned it increased. Among them, more than two fifths (45.57%) and small portions (13.02%) of the respondents confirmed that the severity of the cold wave decreased and heavily decreased respectively. It showed temperature decreased by 0.561^{0}C. Hence, farmers' opinion matched with the winter temperature's statistical report (figure 31).

Over two fifths (45.57%) of respondents revealed annual summer period increased, while nearly one-third of farmers (31.77%) noticed summertime heavily increased over the last 30 years in the Gazipur area. More than three-quarters (77.34%) of the respondents perceived increased trend in the summer time. A small portion (15.62%) mentioned summer time period decreased (decrease by 12.5% and heavily decrease by 3.125%) (figure 32).

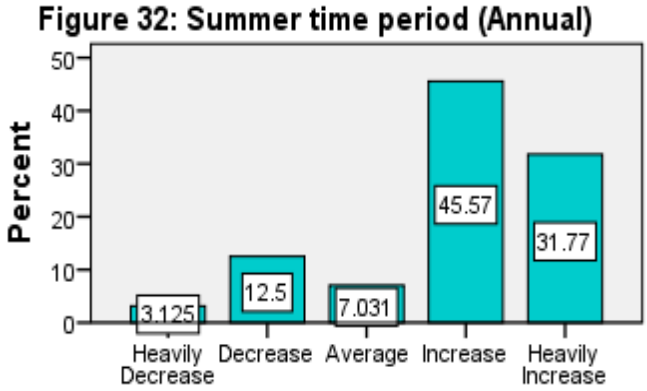


Figure 32: Farmers' perception on summer time period. (Source: Author, 2019)

Majority of the participants which was 84.90% revealed winter time period decreased. Among them, near two thirds (62.76%) mentioned winter time period decreased and near one quarter (22.14%) remarked it heavily decreased. A very small proportion (11.45%) observed winter time period increased (increased by 8.85% and heavily increased by 2.60%) (figure 33).

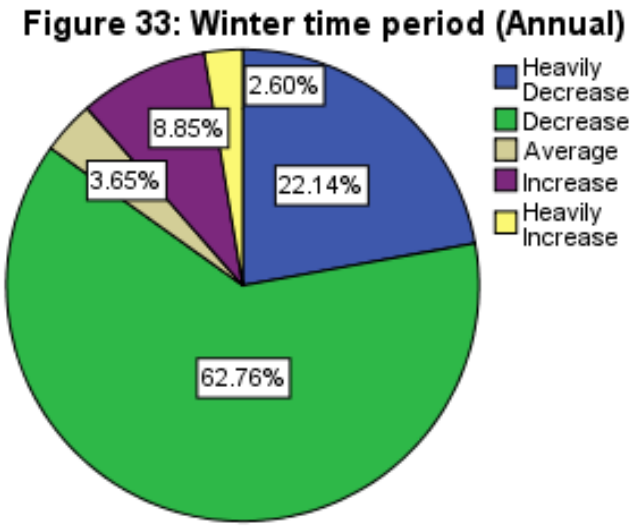


Figure 33: Farmers' perception on winter time period. (Source: Author, 2019)

More than two-fifths people (43.49%) of the respondents observed annual crops production increased and a small minority (14.84%) recognized crop production heavily increased. In total, more than half (58.33%) farmers thought annual crop production increased, while near a quarter respondents (22.65%) noticed crop production decreased (decreased by 19.01% and heavily decreased by 3.64%). A small minority of people gave opinion crops production was averaged (figure 34).

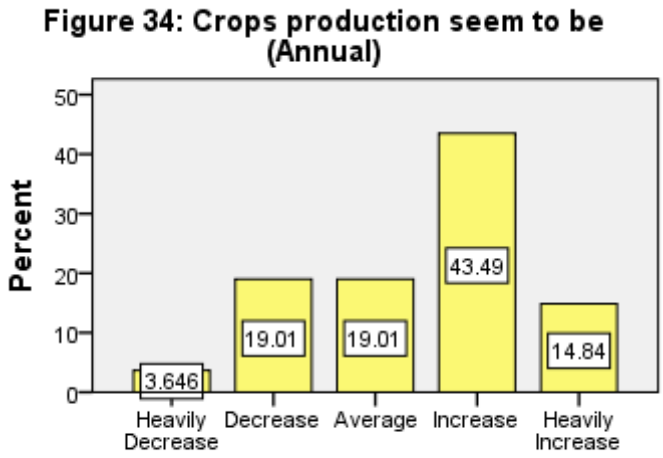


Figure 34: Farmers' perception on crops production. (Source: Author, 2019)

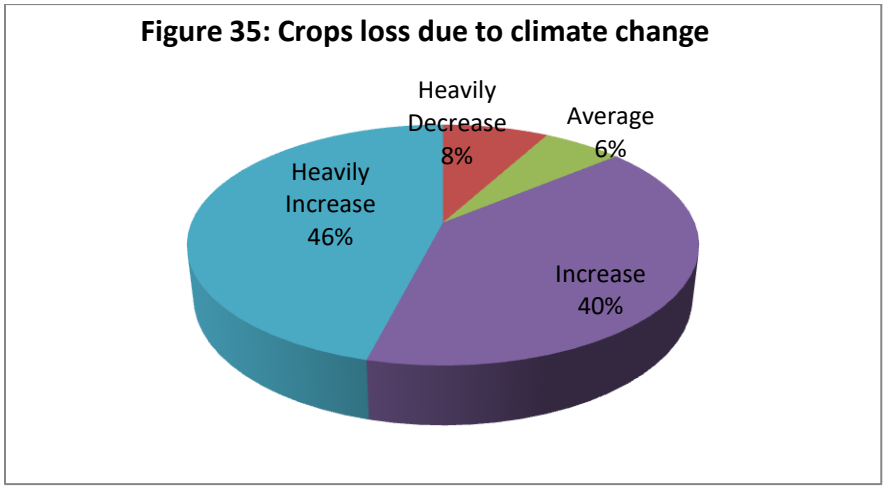


Figure 35: Farmers' perception on crops loss due to climate change. (Source: Author, 2019)

Well over four-fifths (86%) of the sample respondents mentioned crops losses increased, among them 46% and 40% confirmed it increased and heavily increased respectively. On the other hand, a very tiny portion answered crops loss decreased (figure 35).

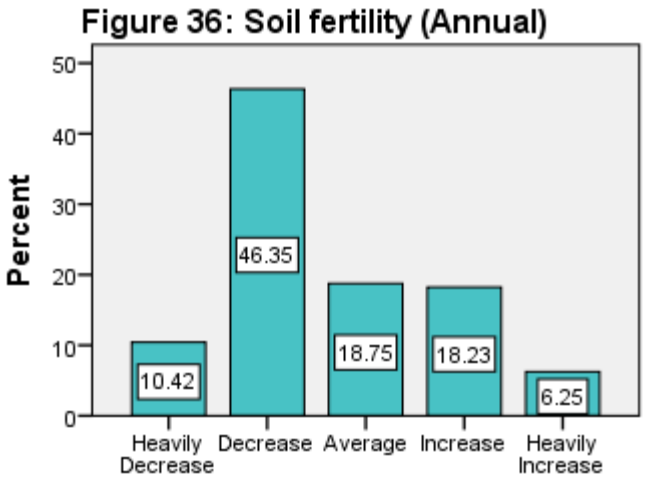


Figure 36: Farmers' perception on soil fertility. (Source: Author, 2019)

Above half of the participants (56.77%) revealed soil fertility decreased over the last 30 years. On the other hand around a quarter (24.48%), people mentioned soil fertility increased. More than two fifths (46.35%) people and a small portion (10.42%) respondent confirmed that soil fertility decreased and heavily decreased respectively. Less than one fifth (18.75%) of population verified soil fertility neither increased nor decreased that's mean it was average (figure 36).

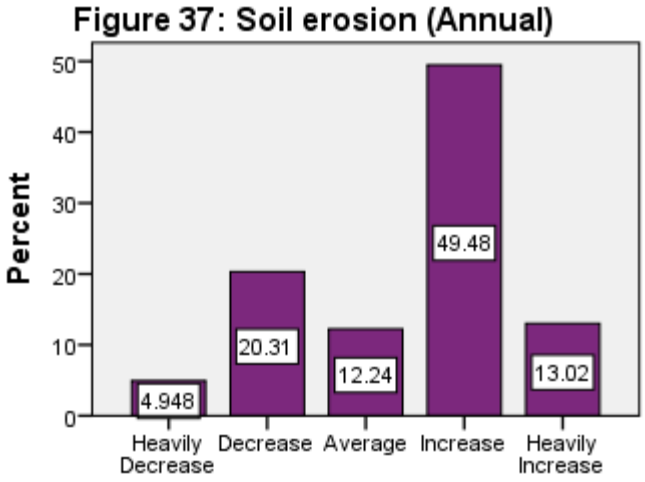
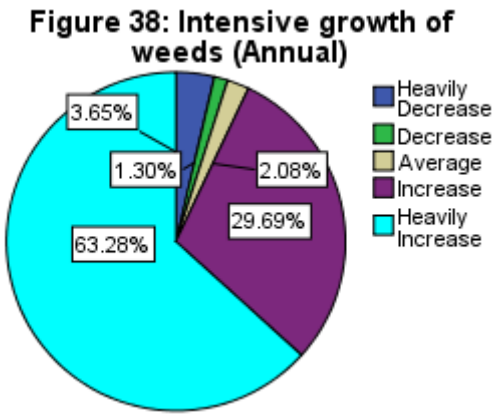


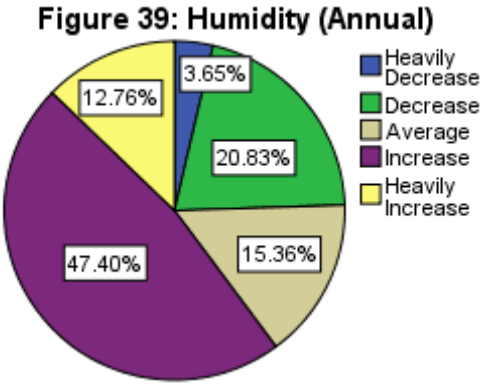
Figure 37: Farmers' perception on soil erosion. (Source: Author, 2019)

At a glance at the graphs revealed that almost half of the participants (49.48%) mentioned soil erosion increased whereas a small minority said it increased heavily. Altogether more than three fifths (62.50%) people confirmed soil erosion increased while a quarter (25.25%) respondents gave the opinion it decreased (figure 37).



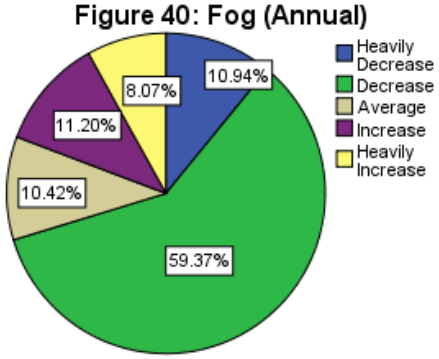
At the first glance, it is clear that maximum respondents (63.28%) noticed intensive growth of weeds heavily increased, whereas well over a quarter (29.69%) people mentioned intensive growth of weeds increased. A very tiny portion (4.95%) gave opinion intensive growth of weeds decreased (figure 38).

Figure 38: Farmers' perception on intensive growth of weeds. (Source: Author, 2019)



It is seen that humidity increased and heavily increased by nearly half (47.40%) and more than one ten (12.76%) correspondingly. All together three fifths (60.16%) farmers confirmed that humidity increased while near a quarter (24.48%) verified humidity decreased. A small minority mentioned humidity neither increased nor decreased (figure 39).

Figure 39: Farmers' perception on humidity. (Source: Author, 2019)



Three fifths (59.37a%) of the farmers perceived that fog decreased and one in ten (10.94%) participants confirmed fog decreased heavily. On contrast, near one fifth (19.27%) respondents confirmed that fog increased (figure 40).

Figure 40: Farmers' perception on fog. (Source: Author, 2019)

Half (50%) of the respondents observed that thunderstorm heavily increased and nearly a quarter (21.61%) farmers pointed out thunderstorm increased over 30 years in Gazipur area. Altogether the majority of the participants perceived that thunderstorm increased whereas a quarter (24.74%) respondents said that thunderstorm decreased (figure 41).

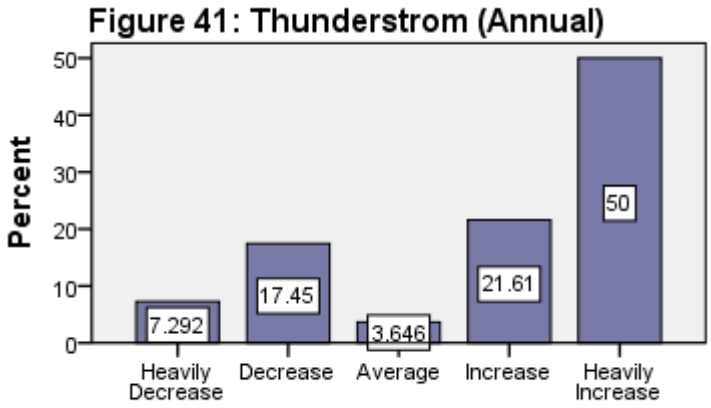


Figure 41: Farmers' perception on thunderstorm. (Source: Author, 2019)

The graph sketched out that more than two-fifths respondents (46.88%) confirmed that hail increased than previous time in Gazipur area where a quarter (25.26%) people perceived hail heavily increased. on the other hand; a quarter people observed hail decreased. A tiny portion revealed hail occurrence average in Gazipur area over 30 years (figure 42).

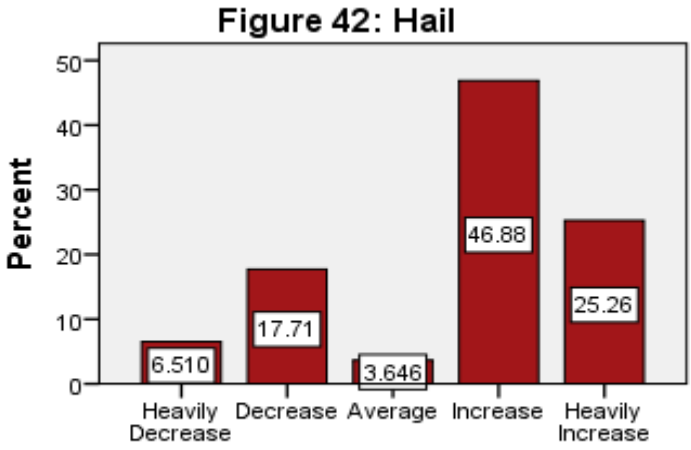
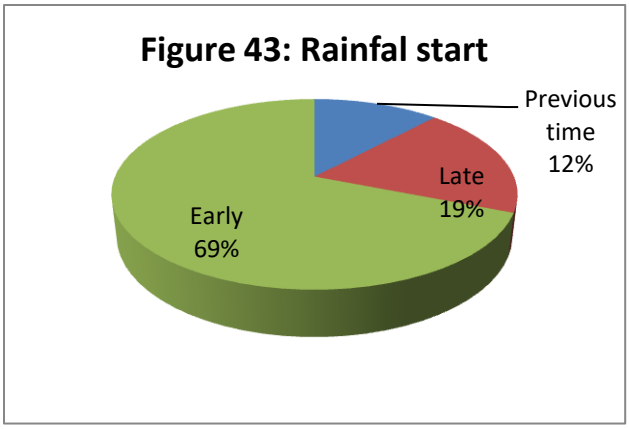
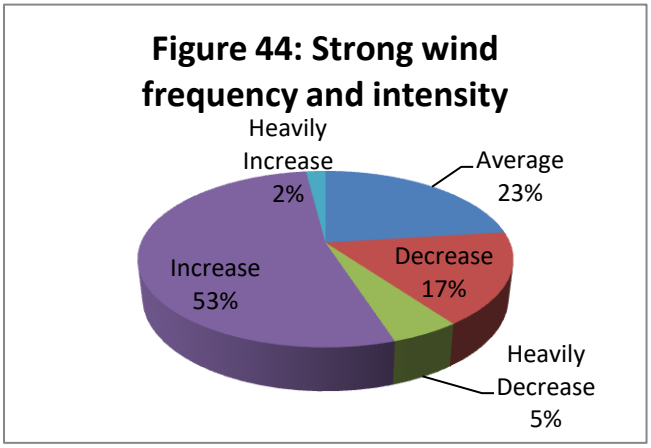


Figure 42: Farmers' perception on hail occurs. (Source: Author, 2019)



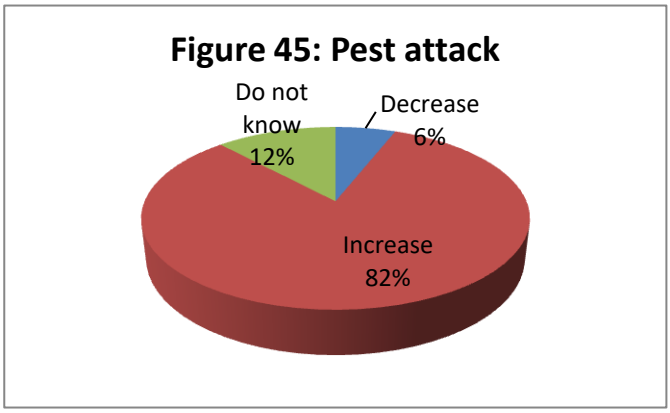
Well over two third (69%) of sample respondents observed now rainfall started early than the previous time. On the other hand, almost one-fifth (19%) of farmers confirmed rainfall started late (figure 43).

Figure 43: Farmers' perception on rainfall start. (Source: Author, 2019)



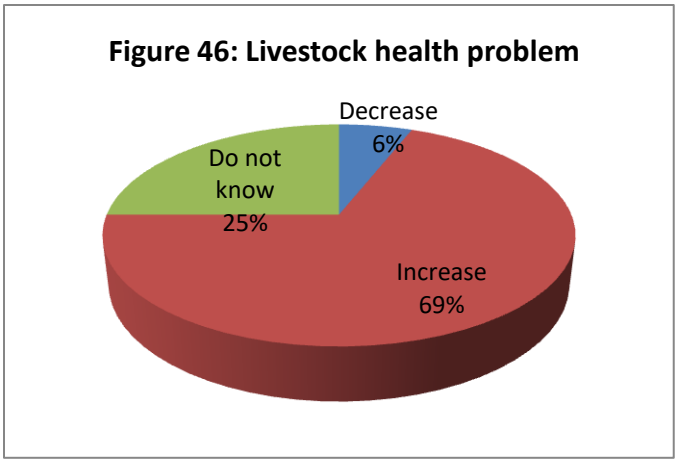
The graph sketched out that well over half (55%) of the participants confirmed strong wind frequency and intensity increased whereas near one quarter (22%) mentioned it decreased. Only 23% of respondents said the strong wind was average (figure 44).

Figure 44: Farmers' perception on strong wind frequency and intensity. (Source: Author, 2019)



At a glance, the graph revealed that over four fifths (82%) of the farmers noticed pest attack augmented and a tiny portion (6%) mentioned it declined over the last 30 years in Gazipur district. Over one-tenth (12%) answered they did not know about pest attack (figure 45).

Figure 45: Farmers' perception on pest attack. (Source: Author, 2019)



Well over two-thirds (69%) of the farmers recognized livestock health problem increased while a very tiny portion (6%) confirmed it decreased and exactly one quarter (25%) mentioned they did not know about livestock health problem (figure 46).

Figure 46: Farmers' perception on livestock health problem. (Source: Author, 2019)

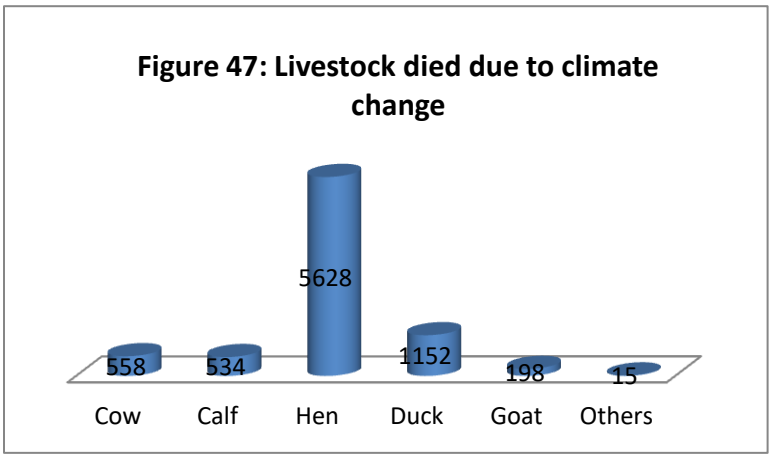


Figure 47: Farmers' perception on livestock dies due to climate change. (Source: Author, 2019)

The diagram illustrated among the livestock, hen died most 5628 while duck died 1152 over the last five years. Cow, calf and goat died 558, 534 and 198 correspondingly (figure 47)

Chapter 7

Farmers' Adaptation to Climate Change

7.1 Introduction

This chapter discusses different types of agricultural adaptation strategies that have been taken by the farmers of Gazipur district to reduce the impact of climate change. Two research questions have been investigated in this section those are a) what are the major adaptation strategies in the study area b) what are the barriers to effective adaptation to climate change.

7.2 Farmers' adaptation to climate change

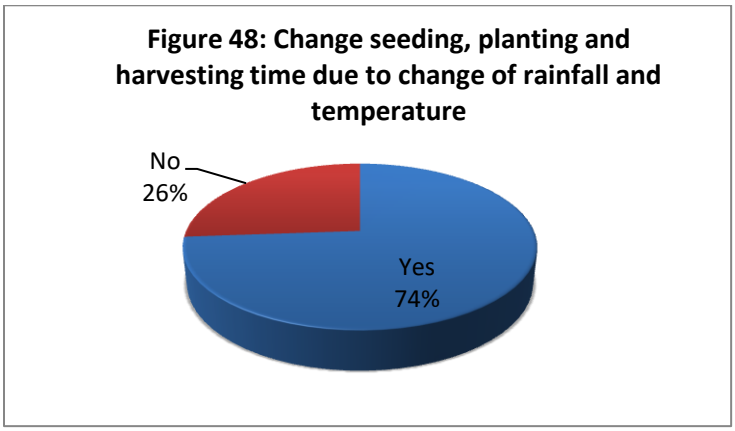
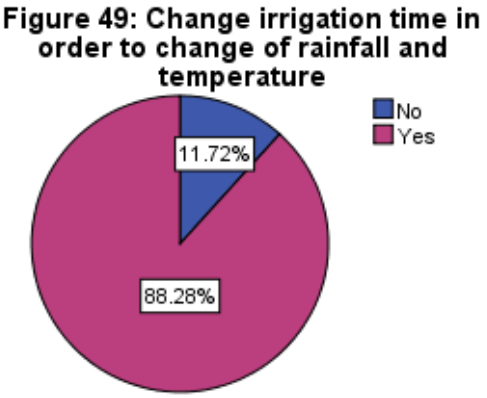


Figure 48: Change seeding, planting and harvesting time due to change of rainfall and temperature time. (Source: Author, 2019)

The result revealed near three quarter (74%) of the respondents changed their seeding, planting and harvesting time in order to change of rainfall and temperature's time while over one quarter (26%) of the farmers confirmed they did not change the time. The difference between change and not to change of seeding, planting and harvesting time due to climate change is 48%. They followed the previous time for seeding, planting and harvesting (figure 48).



Majority of the participants (88.28%) disclosed they changed irrigation time according to the change of rainfall and temperature's time. Just over one in ten (11.72%) people did not change their irrigation time. But during FGD time all the farmers mentioned if they got enough rainwater then they not need not irrigation (figure 49).

Figure 49: Change irrigation time in order to change of rainfall and temperature's time. (Source: Author, 2019)

Approximately three-quarters (77.083%) of the farmers reported they changed their fertilizer time in order to change of temperature and rainfall's time where near a quarter (22.92%) people pointed out they did not change the time. In the FGD time, they mentioned if they used fertilizer in the warm day then it burnt and that is harmful to the soil. Generally, they used fertilizer in the evening or comparatively cool day. Crop and soil get nitrogen from the rainwater because of rainwater contains with nitrogen that is why crop and soil do not need extra nitrogen from fertilizer during a rainy day (figure 50).

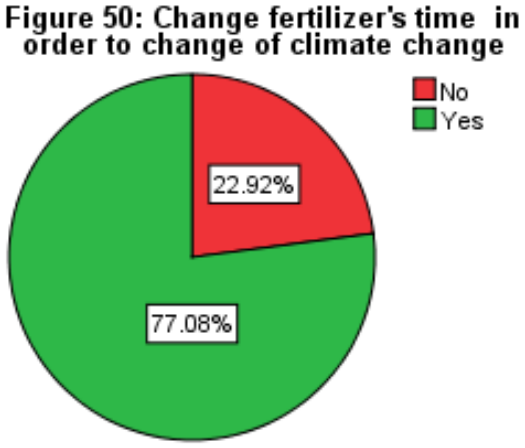


Figure 50: Change fertilizer's time in order to change of rainfall and temperature's time. (Source: Author, 2019)

The diagram sketched out well over three quarters (78.91%) of the respondents used herbicides for weeding while over one fifth (21.09%) did not use herbicides. They told for the period of FGD the growth rate of weeding was increasing dramatically. In the morning farmers pulled out weeds but they again found weeds in the evening or next day. That is why they had to do work hard and the extra hour on a warm day (figure 51).

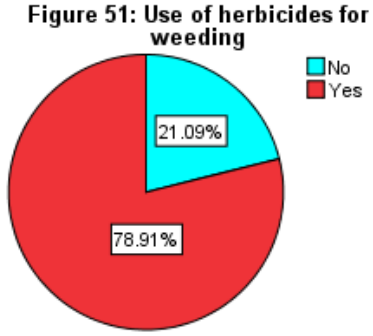
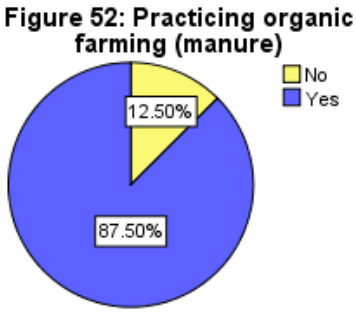


Figure 51: Use herbicides for weeding. (Source: Author, 2019)



A very large portion of respondents (87.50%) practiced organic farming (manure) and over one ten (12.50%) farmers confirmed they did not practise organic farming (figure 52).

Figure 52: Practicing organic farming. (Source: Author, 2019)

Momentous difference (almost 50%) found between the use of chemical medicine and not to use of chemical medicine. A significant proportion (75.26%) shared they used chemical medicine due to pest attack while almost a quarter (24.74%) farmers mentioned they did not use chemical medicine. At the time of FGD, many respondents shared the view that tremendous pest attack increased and even pests did not die after use of chemical medicine (figure 53).

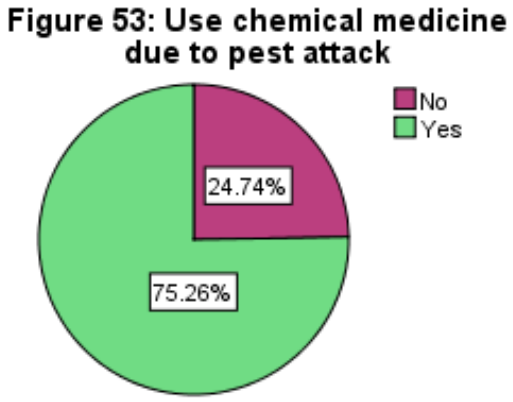


Figure 53: Use chemical medicine due to pest attack. (Source: Author, 2019)

The difference between growing and not growing numbers of different crops beside the main crop is almost 40%. A significant majority (70.05%) shared they grew several different crops beside the main crop. During FGD they informed they would not grow rice after 2/3 years because they were getting less profit from the rice. To grow vegetables and fruits are more profitable compared to rice (figure 54).

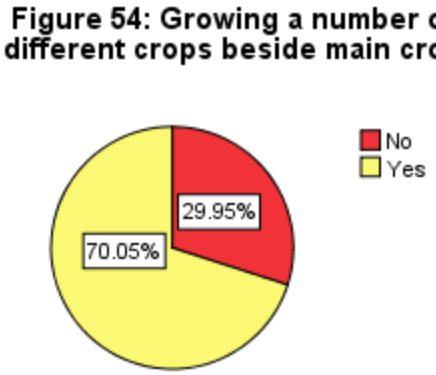


Figure 54: Growing a number of different crops beside main crops. (Source: Author, 2019)

The result revealed that more than half (54.95%) of the people used mulching and less than half of the people (45.05%) did not use mulching. During FGD they mentioned they covered the soil with leaves, wastes of rice to reduce soil erosion and hold on the soil moisture (figure 55).

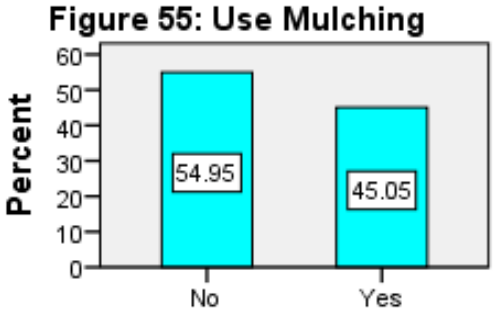


Figure 55: Use mulching. (Source: Author, 2019)

Two fifths (61.20%) of the surveyed households reported that they covered their crops. On the other picture, almost two fifths (38.80%) of the participants did not cover their crops (figure 56).

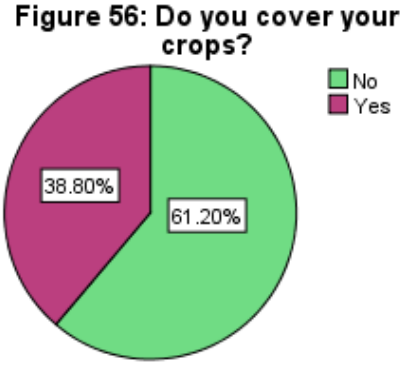
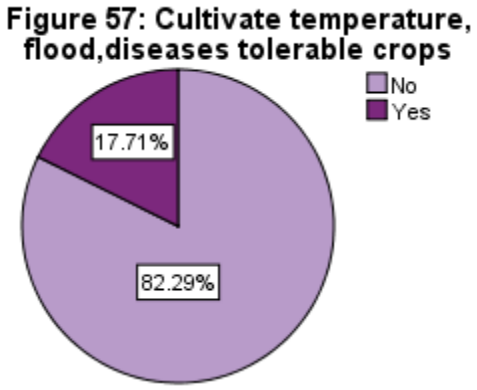
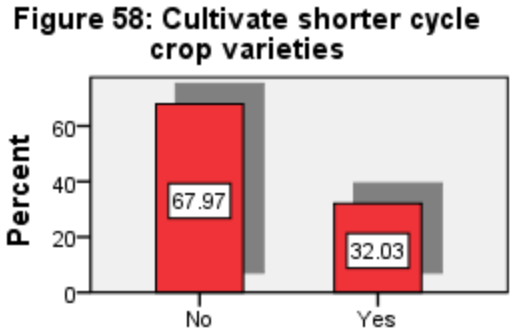


Figure 56: Cover crops. (Source: Author, 2019)



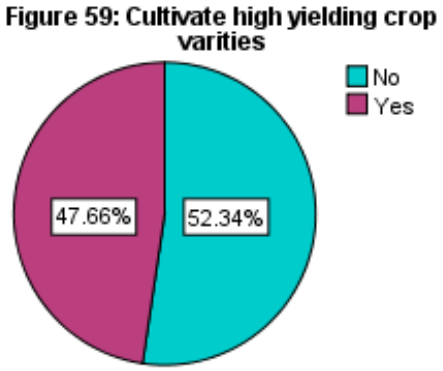
It is clearly seen that nearly four-fifths (82.29%) of the respondents do not cultivate temperature, flood and diseases tolerable crop whereas near one-fifth (17.71%) of the farmers cultivate temperature, flood and diseases tolerable crops. The distinction between "YES" and "NO" are very prominent at 64.58% (figure 57).

Figure 57: Cultivate temperature, flood and diseases tolerable crops. (Source: Author, 2019)



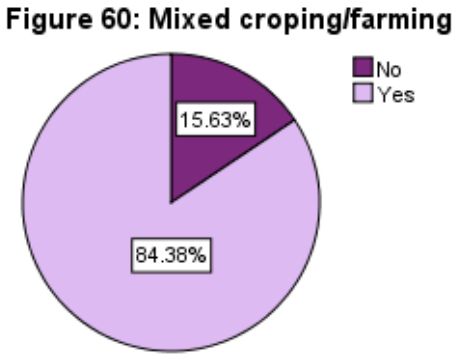
Almost one third (32.03%) surveyed respondent cultivated shorter cycle crop varieties whereas just over two-thirds (67.97%) people did not cultivate shorter cycle crop varieties. The difference between use and not to cultivate shorter cycle crop varieties is well over one third (35.94%)(figure 58).

Figure 58: Cultivate shorter cycle crop varieties. (Source: Author, 2019)



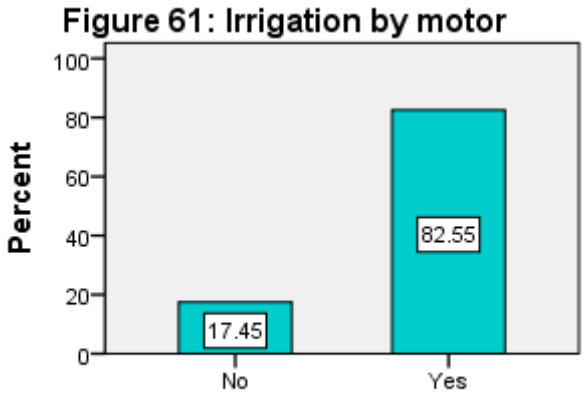
Over half (52.34%) of the participants confirmed they cultivated high yielding crop verities contrast just less than half (47.66%) of the respondents pointed out they did not cultivate high yielding crop verities. From the graph, it is clearly seen that the difference between YES and No is very less (figure 59).

Figure 59: Cultivate high yielding crop varieties. (Source: Author, 2019)



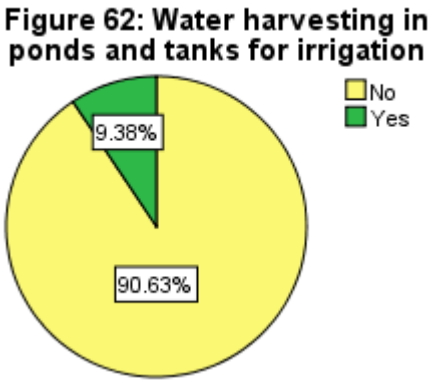
The difference between do mixed farming and not to do mixed farming is significant (68.75%). A very large proportion (84.38%) of farmers adopted mixed farming while a small minority did not adopt mixed farming (figure 60).

Figure 60: Mixed cropping/Farming. (Source: Author, 2019)



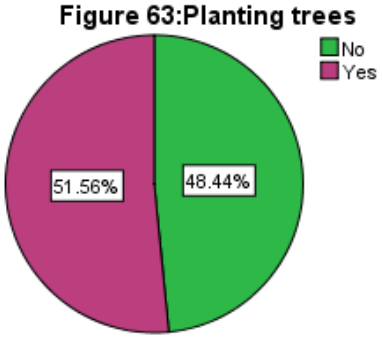
The graph showed the figure the majority of the respondents (82.55%) used motor for the irrigation. A very small portion (17.45%) did not use motor because of the lake of money. The disparity between use motor and not to use the motor is near two-third (65.1%) (figure 61).

Figure 61: Irrigation by motor. (Source: Author, 2019)



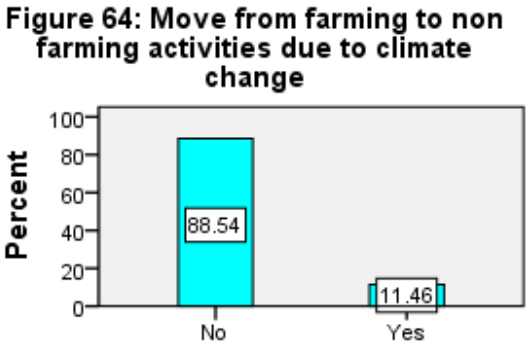
It is lucid very small portion (9.38%) of people harvest water in ponds and tanks for irrigation. A very large percentage (90.63%) expressed their opinion that they did not harvest water in ponds and tanks for irrigation. The difference is huge (81.25%) between Yes and No (figure 62).

Figure 62: Water harvesting in ponds and tanks for irrigation. (Source: Author, 2019)



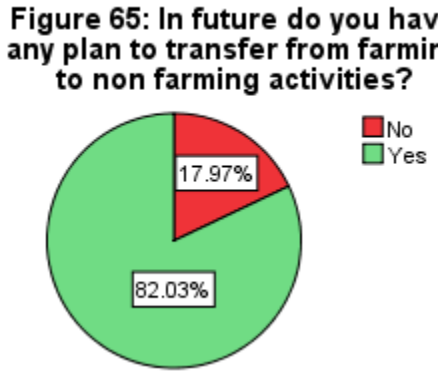
Over half of the respondents (51.56%) planted trees while near half of the population (48.44%) did not plant trees. During the time of FGD they mentioned through afforestation, it is possible to control climate change. They observed planting trees keep the weather cool and it boosts up rainfall (figure 63).

Figure 63: Planting trees. (Source: Author, 2019)



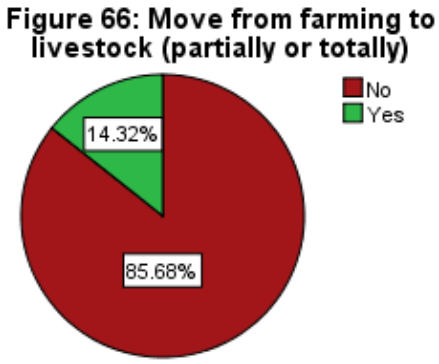
The graph sketched out a large percentage (88.54%) did not move from farming to non-farming activities due to climate change. A small portion (11.46%) moved from farming to non-farming activities. During FGD time they reported that in future they would move farming to non-farming activities because of losses (figure 64).

Figure 64: Move from farming to non farming activities due to climate change. (Source: Author, 2019)



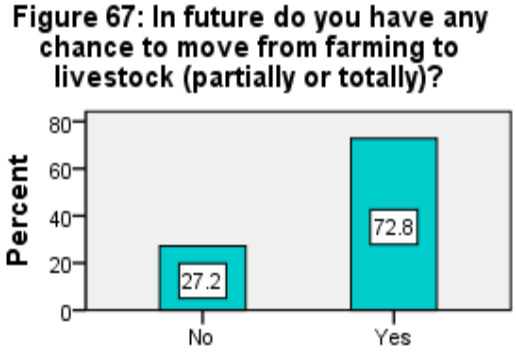
The bar chart illustrates a large amount (82.03%) of farmers confirmed in future they would move from farming to non-farming activities because of losses and a small portion(17.96%) participants would stay in their farming occupation (figure 65).

Figure 65: In future farmers have plan to transfer from farming to non farming activities. (Source: Author, 2019)



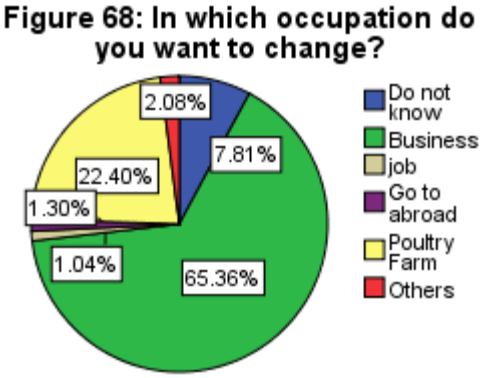
The bar chart indicated well over four-fifths (85.68%) of the respondents did not move from farming to livestock (partially or totally) on the other hand more than one ten (14.32%) of the surveyed participants mentioned they transferred from farming to livestock (figure 66).

Figure 66: Move from farming to livestock. (Source: Author, 2019)



Near three quarters (72.80%) of the respondents responded they had a chance to move from farming to livestock (partially or totally) while more than a quarter (27.20%) people would not transfer from farming to livestock (figure 67).

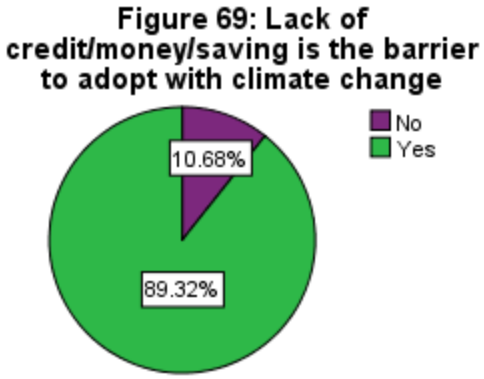
Figure 67: In future farmers have plan to transfer from farming to livestock. (Source: Author, 2019)



Owing to climate change, near two thirds (65.36%) of the farmers confirmed in future they will change their occupation from farming to business and over one fifth (22.40%) will change their occupation from farming to poultry farm. Less than one ten respondents do not know what they will do (figure 68).

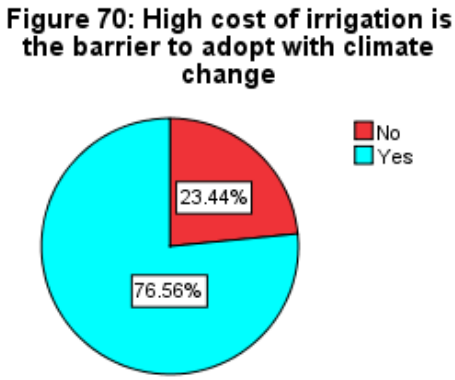
Figure 68: In future farmers will change their occupation. (Source: Author, 2019)

7.3 The barrier to adopting climate change



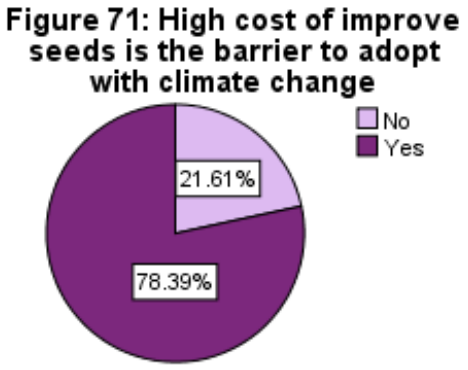
Majority of the farmers informed lake of credit, money and saving were the barrier to adopt with the change in the climate. During FGD they mentioned if they had enough money than they could buy heat tolerable, flood tolerable and short cycle paddy seeds more (figure 69).

Figure 69: Lake of credit, money and saving is the barrier to adopt with the climate change (Source: Author, 2019)



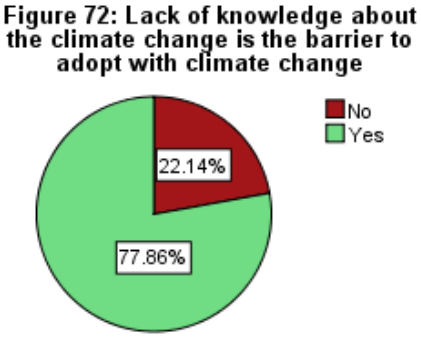
The pie chart illustrated near four-fifths (76.56%) of the population mentioned the high cost of irrigation was the impediment to adapt with the climate change while near a quarter (23.44%)of the farmers did not think the high cost of irrigation was the barrier to adopt with the climate change. The difference between Yes and No is more than half (53.12%) (figure 70).

Figure 70: High cost of irrigation is the barrier to adopt with the climate change. (Source: Author, 2019)



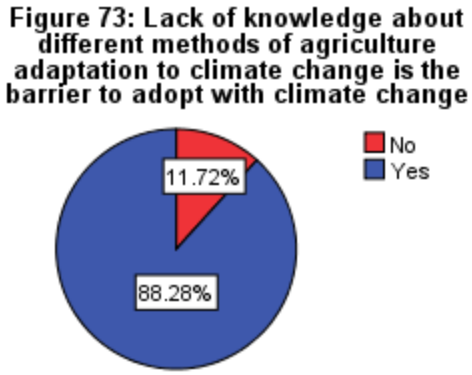
The pie chart depicted over three quarters (78.39%) of the farmers thought the high cost of improving seed was the obstacle to adapt with the climate change and just over one third (21.61%) of the people think it is no barrier to adopt with the change. The difference Yes and No is more than half (56.78%) (figure 71).

Figure 71: High cost of improve seeds are the barrier to adopt with the climate change. (Source: Author, 2019)



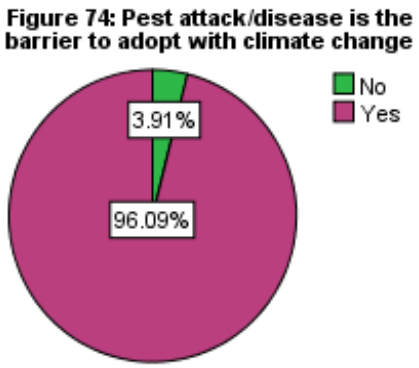
More than three quarters (77.86%) of the surveyed farmers thought lack of knowledge about the climate change was the hindrance to adapt with the climate change while less than a quarter of the respondents thought it was not any kind of barrier (figure 72).

Figure 72: Lack of knowledge about climate change is the barrier to adopt with the climate change. (Source: Author, 2019)



A very large percentage (88.28%) disclosed lack of knowledge about different methods of agriculture adaptation to climate change was the impediment to adopt with climate change and over than one ten (11.72%) pointed out it was not a barrier to adaptation (figure 73).

Figure 73: Lack of knowledge about different methods of agriculture adaptation to climate change is the barrier to adopt with the climate change. (Source: Author, 2019)



Except for a tiny percentage of the respondents and a large percentage of farmers believed that pest attack was the barrier to adopt with the climate change. Due to the pest attack, they were facing huge crops losses. Now pesticides are not working. They reported at the time of FGD had a connection between temperature increase and the birth of pest. They have not seen that much pest attack 10/15 years ago (figure 74).

Figure 74: Pest attack/disease is the barrier to adopt with the climate change. (Source: Author, 2019)

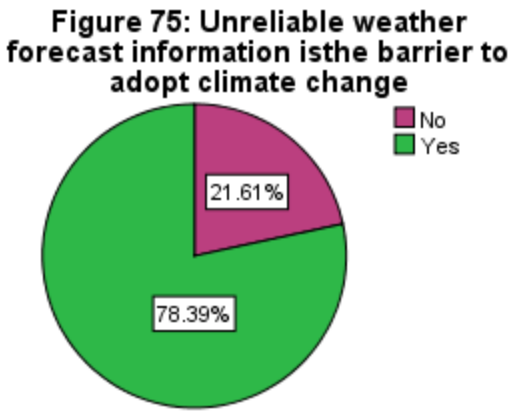


Figure 75: Unreliable weather forecast information is the barrier to adopt with the climate change. (Source: Author, 2019)

Less than four-fifths of the surveyed respondents (78.38%) informed that unreliable weather forecast information was the barrier to adopt with the change in climate and just over two-fifths of the farmers thought it was not any barrier (figure 75).

Chapter 8
Conclusion and Recommendation

8.1 Conclusion

This study explored Spatio-Temporal Analysis of the Climatic Parameter and Farmers' Perception, Adaptation to the Climate Change in Gazipur District. Based on the climatic parameter data (temperature and rainfall) and a micro dataset from surveying 384 farmers in Gazipur district, the analytical part of this study covered the four foremost areas:

a) analyzed the microclimatic parameters such as temperature and rainfall in Gazipur district.

b) examined farmers' perception regarding climate change.

c) analyzed different types of adaptation strategies/mechanisms that farmers adopt to adjust to climate change.

d) analyzed major constraints farmers faced adjusting their farming practices in the response of changing climate

Summary of findings

This segment briefly sketched out the major results to answer the three research questions of this study.

Research question 1: Are temperature and rainfall changing in Gazipur district?

The goal of the research question 1 was to analysis the microclimate of Gazipur district. By analysis, the climatic data of temperature and rainfall researcher tried to establish the hypothesis that climate of the study area had been changed. There are two parts of the research question 1. The first part focused on the temperature and second part spotlighted on rainfall.

Temperature- The analyzed data proved that annual temperature of Gazipur district increased by 0.1785^0C followed by the summer season 0.408^0C and in the rainy season 0.6273^0C but in winter season temperature declined by 0.561^0C from the year 1968 to 2018. Temperature augmented in the month of February, March, April, May, June, July, August, September, October and November by 0.3009^0C, 0.1224^0C, 0.3519^0C, 0.7548^0C, 1.1373^0C, 0.663^0C, 0.6783^0C, 0.5967^0C, 0.0663^0C and 0.5049^0C correspondingly. On the other hand, the temperature decreased by 1.6065^0 C and 0.4335^0 C in the month of January and December from the year 1968 to 2018. In the June month temperature increased most by 1.1373^0C and decreased most in the January month by 1.6065^0C. In contrast, season-wise temperature augmented most in the rainy season 0.6273^0C and reduced most in the winter season by 0.561^0 C from the year 1968 to 2018.

A statistically significant increased trend found in the month of June, July, August, September and in the rainy season. On the other hand, the temperature increased in the month of February, March, April, May, and October which were not statistically significant. In addition, for the month of January found a significant decreasing trend. In contrast, the month of November, December and winter season observed decreasing trend of temperature which were not statistically significant. It is proved that temperature has been changed in the Gazipur District.

Rainfall- Total Annual rainfall decreased 619.854 mm from the year of 1963 to 2013 (51 years). Rainfall also reduced 3.4629 mm, 11.3985mm, 2.7999mm, 114.6633mm, 76.8162 mm, 85.4709 mm, 131.7534 mm, 169.9269mm, 85.323 mm, 8.5323 mm, and 6.4107 mm in the month of January, February, March, April, May, June, July, August, September, October and November correspondingly. On the other hand, rainfall increased by 0.0765 mm in the month of December. In the summer season rainfall declined 194.2794 mm, in the rainy season 406.1487mm and the winter season 21.1956 mm. A statistically decreasing trend found annually and in the rainy season as well as in the month of April. All over, year wise and season wise rainfall reduced except December month. That proves the rainfall of Gazipur district has changed.

Research question 2: Are farmers aware of climate change? How do farmers perceive the indicators of climate change?

The objective of the research question 2 was to document farmers' perceptions regarding climate change. In the study area, the farmers' level of knowledge on climate change was comparatively high. From farmers perspective climate change means an increase of temperature and unseasonal rain both. The greater part of the farmers mentioned the main causes of climate change are deforestation, population increase and industries.

Most of the farmers understood and identified different types of indicators of climate change. According to their opinion temperature of annual, summer season, rainy season and winter season have been augmented than before and that matches with the real temperature data except for the winter season. However, it has been observed temperature increased in the summer season by 0.408^0C, in the winter season by 0.561^0C and annually by 0.1785^0C in Gazipur district over 50 years. On the other hand, the greater part of the farmers identified rainfall increased in the summer season, rainy season and the winter season, furthermore they noticed a change in annual rainfall over 50 years but in this case, real rainfall data of Gazipur district did not go with their opinion. Here, Rainfall declined by 194.2794 mm, 406.1487 mm, 21.1956 mm and 619.854 mm in the summer, rainy, winter season and annually respectively.

The severity of heatwaves, summer period, soil erosion, growth of the weeds, humidity, hail, thunderstorms, drought frequency and intensity, strong winds frequency and intensity, pest attack, livestock health problems, livestock die and crops loss due to climate change increased over 30 years in Gazipur district. On the other hand, availability of surface water, groundwater, winter period, soil fertility, fog decreased over 30 years in the study area.

Research question 3: What are the farmers' adaptation response/adoption mechanisms to climate change?

The foremost purpose of the research question 3 was to explore different farmers' adaptation strategies to face climate change. This study also based on 384 farmers' opinion. Farmers' perceptions regarding climate change exposed that temperature increased and rainfall became unpredictable over the last 30 years in Gazipur district. A simple graphical analysis of time series climatic data ensured farmers' perceptions. Farmers also took some adaptation strategies/mechanisms to adjust with the change.

To adapt to the climate change majority of the respondents change their seeding, planting and harvesting time (74%) as well as irrigation time (88.28%). Besides, they also increased using of herbicides for weeding (78.90%), chemical medicine for pest attack (75.26%), mulching for retaining soil moisture (54.95%) and motor for irrigation (82.55%). Moreover, they covered their crops (61.20%), grew a number of different crops beside the main crop (70.05%), planting trees (51.56%) as well as cultivated high yielding (52.34%) and shorter cycle crop (32.03%) verities, practiced organic farming (manure) (87.50%) in the field.

Small portion farmers adapt with the change of climate by moving from farming to non-farming activities (11.46%), using temperature, flood and diseases tolerable crop (17.71%) and harvest water in the ponds and tanks for irrigation (9.37%).

Research question 4: Analysis major constraints farmers faced to adjust their farming practices in the response of changing climate

Though some farmers were adapting with the local climate change, they pondered the adaption mechanisms were not adequate to lessen the shock of climate change. On the other hand, some respondents did not take any or took little initiatives to adjust with the change because of different constraint aspects. The main constraints farmers faced to

adjust with their farming practices in the response of changing climate were lacking of money,credit, savings (89.32%), high cost of irrigation (76.56%), high cost of improved seeds (78.38%), knowledge about the climate change (77.86%), knowledge about different methods of agriculture adaptation to climate change (88.28%), pest attack (96.06%), unreliable weather forecast information (78.38%) and help from the government (96.87%).

8.2 Recommendation

Effectual adaptation relies on technological improvements, organizational arrangements, accessibility of financing and information exchange. So, the following recommendations are presented as suggestions to take effective and sustainable adaptations to reduce the effect of climate change on agriculture.

1. The government should immediately ban eucalyptus and acacia from Bangladesh as it absorbs a huge quantity of water from the ground level that is why it is called water pump tree and take ample amount of oxygen from the environment than they produce. It also releases a chemical substance into the environment which stopped the growth of the other trees and kills near biodiversity as well as it destroys soil nutrition. The research found, if eucalyptuses are allowed to grow in the environment for about 10 years at a number of 10 per cent of total trees, the water level is expected to reduce by 20 per cent (The Daily Star, 2007). The researcher found enormous acacia and eucalyptus trees at the Gazipur district and farmers confirmed for the forestation they got these two trees from the government.

2. In the study area, all the fields remain underwater for six months. In this case, farmers can cultivate ‘‘Panifal” which is profitable. Government agencies and NGO can take initiative to introduce this among the farmers.

3. The government should take initiative to launch drought-tolerant livestock and poultry such as sheep, ducks and pigeons among farmers, particularly for the small and landless

farmers as the temperature is increasing and it will continue in future. Farmers confirmed that due to increasing temperature their livestock was facing different types of diseases. Sometimes they cannot find out the exact reason to die. So, the government should take the initiative as soon as possible to prevent livestock to die.

4. Most of the people are illiterate and poor that is why they have a little amount of access regarding weather information. During FGD, all the farmers demanded reliable weather forecast information from the agriculture office. If they come to know whether rainfall will come earlier or later then they can prepare their seedbeds, sowing and harvest. Then it will reduce crop loses and enhance crop production.

5. Government has to ensure every SAAO (Sub-Assistant Agricultural Officers) will visit each field and by doing soil test they will suggest farmers which crops will be suitable for that soil. SAAOs spend more time on field visits to assist in improving farmers' understanding.

6. Education plays a pivotal role in social improvement. Government and NGO together can lunch agricultural education policy to enhance farmers' knowledge as they can adapt to change and new technologies.

7. Farmers know about the climate change but that is not sufficient. To enhance knowledge, skills, capacity, and abilities regarding climate change government and NGO have to take initiative to arrange different types of training as they can adjust with the change very well. To create awareness arranges courtyard meeting, drama and video show.

8. Water availability one of the crises of Gazipur district. To eliminate this problem government and NGO can give training different type of techniques how they can harvest rainwater.

9. Though crop insurance has been introduced in some area as a pilot project by the government. That is now demanded of time to spread that through the whole country. The government should introduce livestock insurance to reduce losses.

10. Provide different types of non-farming training for men and women both such as vocational skills enhancement (*karchupi*/embroidery, computer operation, mobile repairing, block & batik, tailoring, electrician/beautician, etc.); small trading/grocery; women's cooperative for vegetable marketing as their livelihood do not depend completely on farming. Also, provide a certificate for that.

11. Create a volunteer team who will create awareness among the young and old farmers regarding climate change.

12. All the mobile tower should be removed from the agriculture field immediately. Because it's harmful radiation is reducing crops production.

13. As an industrial area of Gazipur, all the industry's toxic waste discharged into the rivers and farmers use this degraded water into the crops field which is not only harmful to the crops but also threaten for farmers' health. Fish died almost due to poisonous wastes. The government should take steps against river pollution to reduce pressure on the groundwater.

14. Being an industries area, the labour shortage is a common problem in Gazipur district. Due to the high labour cost for the last few years, farmers are not harvesting their paddy from the field. Near future farmers plan they will not grow rice in their field. In this case, the government should provide modern harvesting machines to the farmers at a cheap rate to avoid food insecurity near future.

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Appendix

The Questionnaire of Households Survey

Serial No-
Data collector's Name-

Dhaka University (M.Phil)

Geography and Environment

"Spatio-Temporal Analysis of Climatic Parameters and Farmers' Perception, Adaptation to the Climate Change in Gazipure"

SECTION A

Farmers' perceptions about climate change

A-1) Have you heard about climate change?

1. Yes 0. No

A-2) From which source have you heard about climate change? (Multiple answers are possible)

1. Television (TV) 2. Radio 3. Newspapers 4. Families 5. Friends
6. Government agencies/information 7. Perceive in real 8. Others

A-3) What is your idea about climate change?

1. Temperature increase 2.Unseasonla rainfall 3.Both

A-4) What do you think of the causes of climate change?

1. Natural Cause 2. Man-Made cause 3. Both natural cause and man-made cause
9. I do not know

A-5) If man-made causes are the reason for climate change then what the man-made causes are.

1. Deforestation 2. Green House Gases emission 3. Population increase

4. Rapid industrialization (more factories and industries zone)

5. Urbanization 6. Vehicles 7. Others 9. Do not know

A-6) Have you noticed/perceived any changing climate in your locality over the last 30 years?

a) Yes 0) No 9. Do not know

A-7) If yes, identify which of the environmental indicators and climatic variables you suppose have changed and described how they have changed over the last 30 years in Gazipur district.

Climate components	Time Period	Increased 4	Heavily increased 3	Average 2	Decrease 1	Heavily Decrease 0
1.Temperature	Annual					
	Summer					
	Winter					
2.Rainfall	Annual					
	Summer					
	Rainfall					
	Winter					
3. Availability of groundwater	Annual					
4. Availability of surface water(river,khal,bill,pond)	Annual					
5.Severity of heat wave/hot day	Annual					
6.Severity of cold wave	Annual					
7.Summer time period	Annual					
8.Winter time period	Annual					
9.Crops production seem to be	Annual					
10.Crops loss due to climate change	Annual					
11. Soil fertility	Annual					
12. Soil erosion	Annual					
13. Intensive growth of weeds	Annual					
14. Humidity						
15.Fog						
16.Thunderstorm						
17. Hail	Annual					
18. Pests and crop diseases	Annual					
19.Livestock health problem						
20. Drought frequency and						

intensity seem to be						
21. Strong wind frequency and intensity seem to be						

A-8) Has rain started late than normal? a) Early b) Late c) Normal

d) I do not know

SECTION B

Farmers' level of adaptation strategies

B-1) Have you made any changes to your farm operations due to changes in climate attributes (you have mentioned earlier) in order to reduce adverse impacts?

1. Yes 0. No

B-2) What adaptive measures (adjustments) do you practice to reduce crop loss?

Climate change adaptive measure	Yes (1)	No (0)
Group 1- Adjusting planning calendar		
1. Have you changed seeding, planting and harvesting time due to change of temperature and rainfall?		
Group -2- Adjusting planning techniques		
2. Have you changed irrigation time in order to change of temperature and rainfall?		
3. Have you changed timing of fertilizer (pesticides, herbicides)		
4. Have you changed timing of use chemical		
5. Have you used herbicides for weeding		
6. Practice organic farming (manure)		
7. Mulching		
8. Crop covering		
Group -3- Crop and variety diversification		
8. Growing a number of different crops		

9. Cultivate temperature, flood, diseases tolerable crops		
10. Mixed cropping/Farming		
11. Cultivate shorter cycle crop varieties		
12. Shift to higher-yielding crop varieties		
13. Shift to shorter cycle crop varieties		
Group -4- Water use management		
14.Irrigation by motor		
15.Water harvesting in ponds and tanks for irrigation		
Group -5- Reinforcing safety for humans and assets		
16. Planting trees		
17. Paying attention to the disaster warning system		
Group-6- Diversifying income source		
18. Changing from farming to non-farming activities		
19. If no, in future do you have any plan to transfer from framing to non-farming activities?		
20. Moving from farming to livestock (Partially or totally)		
22. If no, in future do you have any plan to transfer from framing to livestock?		
Group-7- Others Measure		
23. Migrate to another area		
24.Buying insurance		
25. Others		
26. No adaptation		

B-3) If you have planned to change your occupation then in which sector do you want to change?

1. Business 2. Job 3.Go to abroad 4.Poultry farm
5. Others 9. Do not know

B-4) What are your barriers in taking adaptive measures?

Barriers to adaptation	Please put tick marks
1. Lack of credit/money/saving	
2. High cost of irrigation facilities	
3. High cost of improved seeds	
4. Lack of education on climate change adaptation mechanisms	
5. Lack of knowledge about different methods of agriculture adaptation to climate change	
6. Pests, crop diseases and vermin	
7. Unreliable weather forecast information	

B-5) Have you received any agricultural technical support from the Government in implementing adaptation? 1. Yes 0.No

B-6) If yes, what kind of technical support do you received in your effort to reduce the impacts of

climate change and improve your farming system? Please list

i. ……
ii. ……
iii. ……
iv. ……

B-7) If no, what kind of support would you want to receive? Please list

i. ……

ii. ……

iii. ……

B-8) What do you suggest to be done to reduce the impacts of climate change in your Gazipur Area?

……
……

Household Questionnaire Survey

General information

Name of respondent: Mobile No-

Name of village/moholla/para: Ward

Name of Union: Name of Upazilla (sub-district):

Name of Zilla (district) :

SECTION C

Demographic information

C-1) Gender: - 1. Male- 2.Female- C-2) Age……..

C-3) Family Members: - 1. Male…….. 2.Female……..

Total……..

C-4) Education level:- 1) Primary 2) Eight Pass 3) SSC

4) HSC 5) University 0. Do know education

C-5) Family income 1) Form Farming …… 2. Other Sources……

Total……

C-6) Occupations- 1.Owner of the land 2.Labour 3. Business 4. Others

SECTION D

Land ownership for agriculture

D-1) How long have you been involved in farming (in years)?.....

D-2) Do you own any farm land? 1.Yes 0.No

D-3) What is the size of farm plot in acres……..?

D-4) a) Main crops are grown

a) …….. b) …….. c) …….. d) ……..

e) ……

D-5) Do your cultivable land has access to irrigation facilities? 1. Yes 0. No

D-6) If yes, what is the name of your service provider?

a) Deep tube well b) Own motor or shallow tube well c) Groundwater d) Surface Wate e) Others (Their name)

D-7) What percentage of your total cultivable land is under irrigation?

……%

D-8) What type of live stocks do you have?

Types of livestock headcount	**Number**
1. Oxen	
2. Calf	
3. Goats	
4. Sheep	
5. Donkey	
6. Poultry	
7. Beehives	
8.Others	

D-9) Do you practice fisheries? 1. Yes 0. No

D-10) Do you practice homestead? 1. Yes 0.No

D-11) Which sources are most profitable? 1. Agriculture 2.Fisharies 3.Rearing livestock

D-12) Which crops are most profitable? 1. Rice 2.Wheat 3.Vegetables 4.Others

Thanks for your time

সিরিয়াল নং-
তথ্য সংগ্রহকারীর নাম-
তথ্য সংগ্রহকারীর মোবাইল নং-

ঢাকা বিশ্ববিদ্যালয় (এম.ফিল)

"জলবায়ু উপাদানের স্থানিক, কালিক বিশ্লেষন এবং জলবায়ু পরিবর্তন সম্পর্কে গাজীপুরের কৃষকদের দৃস্টিভঙ্গি ও অভিযোজন প্রক্রিয়া"

সেকশন-ক জলবায়ু পরিবর্তন সম্পর্কে কৃষকের দৃস্টিভঙ্গি

ক-১) আপনি কি জলবায়ু পরিবর্তন সম্পর্কে শুনেছেন?

১. হ্যাঁ ০. না

ক-২) যদি শুনে থাকেন তাহলে কোথা থেকে শুনেছেন?

১. টিভি ২. রেডিও ৩.নিউজ পেপার ৪. পরিবার ৫. বন্ধু
৬. সরকারি প্রতিসঠন ৭.বাস্তবে দেখছেন ৮.অন্যান্য

ক-৩) জলবায়ু পরিবর্তন সম্পর্কে আপনার ধারনা কি?

১. তাপমাত্রা বৃদ্ধি ২. অসময়ে বৃস্টি ৩. উভয় ৪. অন্যান্য

ক-৪) বিগত ৩০ বছরে আপনার এলাকায় জলবায়ু (তাপমাত্রা,বৃস্টিপাত,আদ্রর্তা ইত্যাদি) পরিবর্তনের কোন চিহ্ন দেখতে পেরেছেন কি?

১. হ্যাঁ ০. না ৯. জানি না

ক-৫)উওর হ্যাঁ হলে, নিম্নের কোন কোন উপাদানের পরিবর্তন হয়েছে বলে আপনি মনে করেন?

জলবায়ুর উপাদান	সময়	খুব বেড়েছে ৪	বেড়েছে ৩	মাঝামাঝি ২	কমেছে ১	খুব কমেছে ০
১.৩০ বছরে তাপমাত্রার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	ক. বার্ষিক					
	খ. গ্রীস্ম					
	গ. শীত					
২.৩০ বছরে বৃষ্টিপাতের বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	ক. বার্ষিক					
	খ. গ্রীস্ম					
	গ. বর্ষা					
	ঘ. শীত					

৩. ৩০ বছরে ভূগর্ভের পানির প্রাপ্যতার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
জলবায়ুর উপাদান	সময়	খুব বেড়েছে ৪	বেড়েছে ৩	মাঝামাঝি ২	কমেছে **১**	খুব কমেছে ০
৪. ৩০ বছরে ভূপৃসঠের পানির প্রাপ্যতার(নদী,নালা,খালবিল) বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
৫.৩০ বছরে শৈত প্রবাহের তীব্রতার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
৬. ৩০ বছরে গরম তাপের প্রবাহের তীব্রতার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
৭. ৩০ বছরে শীতকালের মেয়াদ বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
৮.৩০ বছরে গ্রীষ্মকালের মেয়াদ বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?						
৯. ৩০ বছরে শষ্য এর উৎপাদন বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১০.৩০ বছরে অতিরিক্ত গরমে শষ্য নষ্ট হওয়ার প্রবণতা বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১১. ৩০ বছরে আগাছা বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১২.৩০ বছরে মাটির উর্বরতা বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১৩.৩০ বছরে মাটির ক্ষয় বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১৪.৩০ বছরে শীলা বৃস্টির পরিমান বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১৫.৩০ বছরে কুয়াশার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১৬.৩০ বছরে বাতাশের আর্দ্রতার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					
১৭.৩০ বছরে বজ্রপাতের বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?	বার্ষিক					

ক-৬) বজ্রপাতের কারনে কি আপনের এলাকার কেউ মারা গেছে? ১. হ্যাঁ ০. না ৯. জানি না

ক-৭) যদি হ্যাঁ হয়, তাহলে কতজন মারা গেছে?

ক-৮) বর্তমানে বৃষ্টিপাত (বর্ষাকাল) কখন শুরু হচ্ছে?**১.** সময়ের আগে **২.** সময়ের পরে ৩.আগের সময়

ক-৯) বর্তমানে বীজ বপনের সময় কখন শুরু হয়? **১.** সময়ের আগে **২.** সময়ের পরে ৩.আগের সময়

ক-১০) বর্তমানে গাছের ফুল আসার সময় কখন শুরু হয়? ১. সময়ের আগে **২.** সময়ের পরে ৩.আগের সময়

ক-১১) বর্তমানে ফসল কাটার সময় কখন শুরু হয়? **১.** সময়ের আগে **২.** সময়ের পরে ৩.আগের সময়

ক-১২)জলবায়ু পরিবর্তনের কারনে পশুপাখির রোগবালাই বৃদ্ধি পেয়েছে কী **?**

১.হ্যাঁ ০. না ৯. জানি না

ক-১৩)যদি হ্যাঁ হয়, তাহলে কি ধরনের রোগবালাই বৃদ্ধি পেয়েছে তার নাম লিখুন।

ক-১৪) গত ৩০ বছরে ফসলে পোকামাকড়ের আক্রমণ বেড়ে গিয়েছে কি**?**
১.হ্যাঁ ০. না ৯. জানি না

ক-১৫)যদি উওর হ্যাঁ হয়, তাহলে কি কি পোকামাকড়ের আক্রমণ বেড়ে গিয়েছে তার নাম নিম্নে লিখুন?

ক-১৬) টিক চিহ্ন দিন

	খুব বেড়েছে ৪	বেড়েছে ৩	মাঝামাঝি ২	কমেছে **১**	খুব কমেছে ০
১.৩০ বছরে জলাবদ্ধতা/বন্যার সংখ্যা বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?					
২.৩০ বছরে জলাবদ্ধতা/বন্যার তীব্রতা/ শাক্তি বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?					
৩.৩০ বছরে খরা বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?					
৪.৩০ বছরে খরার তীব্রতার বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?					
৫.৩০ বছরে শক্তিশালী বাতাশ প্রবাহের বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?					
৬.৩০ বছরে শক্তিশালী বাতাশ প্রবাহের তীব্রতা বৃদ্ধি বা কমার পরিমান/মাত্রা কেমন?					

ক-১৭) গত পাঁচ বছরে অতিরিক্ত গরম অথবা বন্যার কারনে কি আপনের কোন গৃহপালিত পশু মারা গেছে? মারা গেলে তার সংখ্যা কত?

ধরন	**সংখ্যায়**
১.গাভী	
২.বাছুর	
৩.মুরগী	
৪. হাস	
৫.ছাগল	
৬.অন্যান্য	

ক-**১৮**) জলবায়ু পরিবর্তনের কারনে ফসল উৎপাদনে নিম্নের কোনটি প্রধান বাধা মনে করেন **(**বহু উত্তর হতে পারে**)**

ফসল উৎপাদনে বাধা	
১. বন্যা	
২.অনিয়মিত বৃষ্টি	
৩. খরা	
৪.মাটি ক্ষয়	
৫.পোকামাকড়ের আক্রমণ	
৬.আগাছা বৃদ্ধি	
৭.উন্নত বীজের অভাব	

ক-১৯) জলবায়ু পরিবর্তনের কারনে কি আপনি আর্থিকভাবে ক্ষতিগ্রস্ত হচ্ছেন? ১.হ্যাঁ ০.না

ক-২০) আপনি কি মনে করেন ভবিষ্যৎ এ জলবায়ু পরিবর্তনের মাত্রা বাড়বে? ১.হ্যাঁ ০.না

ক-২১**)** জলবায়ু পরিবর্তনের কারন কি কি **? (**বহু উত্তর হতে পারে**)**

১**)** প্রাকৃতিক কারন ২**)** মানুষ সৃস্টি কারন ৩**)** উভয় ৪) অন্যান্য

০**)** জানি না

** যদি মানুষ সৃস্টি এবং উভয় হলে তাহলে নিম্নের প্রশ্ন জিজ্ঞাস করুন

ক-২২) মানুষ সৃস্টি কারনগুল কি কি?

১**)** বন কেটে ফেলা ২**)** গ্রিন হাউস গ্যাস নির্গমন ৩**)** জনসংখ্যা বৃদ্ধি

৪**)** কলকারখানা ৫**)** নগরায়ন ৬**)** গাড়ী ৭**.** অন্যান্য ৯**)** জানি না

ক-২৩)দূর্যোগ পূর্বাভাসের খবর কোথা থেকে পান?

১. রেডিও ২. টিভি ৩.নিউজ পেপার ৪. মোবাইল ৫.অন্যান্য

সেকশন-খ **কৃষকদের অভিযোজনের(খাপ খাওয়ানোর) নানা কৌশল**

খ-১) জলবায়ু পরিবর্তনের সাথে খাপ খাওয়াতে নিম্নের কোন পদধতি অবলম্বন করেছেন**?**

জলবায়ু পরিবর্তনের সাথে অভিযোজনের পরিমাপ	হ্যাঁ	না
১.বৃষ্টিপাত/তাপমাত্রার উপর নির্ভর করে কি আপনি বর্তমানে বীজ বোপণ অথবা ফসল সংগ্রহ করেন?		
২. বর্তমানে বৃষ্টিপাত/তাপমাত্রার উপর নির্ভর করে কি আপনি জলসেচের সময় পরিবর্তন করেছেন?		
৩. বর্তমানে বৃষ্টিপাত/তাপমাত্রার উপর নির্ভর করে কি আপনি সার দেবার সময় পরিবর্তন করেছেন?		
৪. আগাছা নাশক ওষুধ ব্যবহার করেন কি		
৫.গাছের চারপাশে ভিজা খড়/পাতা/কচুরি পানা দিয়ে কি আপনি ঢেকে রাখেন?		
৬. বর্তমানে তাপমাত্রা, বৃষ্টিপাত ও পোকামাকড়ের আক্রমণের হাত থেকে রক্ষা করার জন্য কি আপনি শস্য বা ফসল ঢেকে রাখেন?		
৭. পোকামাকড়ের আক্রমণের হাত থেকে রক্ষা করার জন্য রাসায়নিক ঔষূধ ব্যবহার করেন কি?		
৮. ভসমান বাগান পদ্ধতিতে কি চাষাআবাদ করেন?		
৯.প্রধান ফসলের পাশাপাশি অন্যান্য ধরনের শস্য বা ফসল আবাদ করেন ?		
১০. তাপমাত্রা,বন্যা, রোগবালাই সহনশীল শস্য বা ফসল আবাদ করেন কি? যদি হ্যাঁ হয় তাহলে তার নাম লিখুন (ধান,গম ও অন্যান্যর জাতের নাম নিখুন)		
১১.মিশ্র আবাদ করেন কি? (একই সাথে কৃষিকাজ এবং পশুপালন করা)		
১২.স্বল্প সময়ে পরিপক্ক হয় এমন শস্য বা ফসল আবাদ করেন কি?		
১৩. উচ্চ ফলনশীল ফসলের আবাদ করেন কি? যদি হ্যাঁ হয় তাহলে তার নাম লিখুন (ধান,গম ও অন্যান্যর জাতের নাম লিখুন)		
১৪. বর্তমানে মোটরের মাধ্যমে কি জলসেচের ব্যবস্থা করছেন?		
১৫. বৃষ্টির পানি পুকুর এবং ট্যাঁকে সংরক্ষণ করেন কি?		
১৬.জলবায়ু পরিবর্তনের সাথে খাপ খাওয়াতে গাছপালা লাগান কি ?		
১৭. জৈব সার ব্যবহার করেন কি?		
১৮. দুর্যোগ পূর্বাভাস পর্যবেক্ষণ করেন কি?		
১৯.জলবায়ু পরিবর্তনের কারনে কি স্থান পরিবর্তন করেছেন?		
২০.কৃষি ইনসুরেন্স কিনেছেন কি?		
২১.জলবায়ু পরিবর্তনের সাথে (অভিযোজন) খাপ খাওয়াননি		
২২. অন্যান্য		

খ-২). সঠিক সময়ে বৃষ্টিপাত না আসা এবং তাপমাত্রা বৃদ্ধির জন্য আপনে কি **আপনের পেশা (অংশিক/পুরাপুরি) কৃষি কাজ থেকে অকৃষি পেশায় পরিবর্তন করেছেন?**

১.হ্যাঁ ০.না

খ-৩)যদি না করে থাকেন, তাহলে কি ভবিষ্যৎ এ আপনি আপনের পেশা কৃষিকাজ থেকে অকৃষি কাজে পরিবর্তন করার চিন্তাভাবনা করছেন?

১.হ্যাঁ ০.না

খ-৪) উত্তর যদি হ্যাঁ হয়, তাহলে কোন পেশায় পরিবর্তন করবেন?

খ-৫) জলবায়ু পরিবর্তনের কারনে কি **আপনের পেশা (অংশিক/পুরাপুরি) কৃষি কাজ থেকে পশুপালন পেশায় পরিবর্তন করেছেন?**

১.হ্যাঁ ০.না

খ-৬) যদি না করে থাকেন, ভবিষ্যৎ এ কি আপনি আপনের পেশা কৃষিকাজ থেকে পশুপালন কাজে পরিবর্তন করার চিন্তাভাবনা করছেন?

১.হ্যাঁ ০.না

খ-৭)যখন শীত সময়ের আগে অথবা দেরি করে আসে তখন জমিতে কি ফসল আবাদ করেন**?**

খ-৮) জলবায়ু পরিবর্তনের সাথে খাপ খাওয়ানোর জন্য আপনি নিম্নের কোনটিকে বাঁধা মনে করেন?

অভিযোজনের ক্ষেত্রে বাঁধা	টিক চিহ্ন দিন
১. টাকা**/**ঋন**/**জমানো টাকার অভাব কি জলবায়ু পরিবর্তনের সাথে খাপ খাওয়ানোর জন্য বাঁধা মনে করেন?	
২.সেচ ব্যবস্থার উচ্চ খরচ কি জলবায়ু পরিবর্তনের সাথে খাপ খাওয়ানোর জন্য বাঁধা মনে করেন?	
৩. উন্নত শস্যের উচ্চ খরচ কি জলবায়ু পরিবর্তনের সাথে খাপ খাওয়ানোর জন্য বাঁধা মনে করেন?	
৪. জলবায়ু পরিবর্তন সম্পর্কে কম ধারণাকে কি বাঁধা মনে করেন**?**	
৫.জলবায়ু পরিবর্তনের সাথে খাপ খাওয়ানোর বিভিন্ন পদ্ধতি সম্পর্কে কম ধারনাকে কি বাঁধা মনে করেন?	
৬.পোকামাকড়**,**গাছের রোগ এবং ক্ষতিকর পোকামাকড়ের আক্রমন কি বাধা মনে করেন	
৭.আবহাওয়া পূর্বাভাসের উপর অনাস্থাকে কি জলবায়ু পরিবর্তনের সাথে খাপ খাওয়াতে বাঁধা মনে করেন?	

খ-৯) জলবায়ু পরিবর্তনের সাথে খাপ খাওয়ানোর জন্য সরকারের কাছ থেকে কি কোন সহযোগিতা পেয়েছেন**?**

১. হ্যাঁ ০.না

খ-১০) যদি হ্যাঁ হয় **,**তাহলে কৃষি ক্ষেত্রে জলবায়ু পরিবর্তনের প্রভাব কমানোর জন্য কী ধরনের সহযোগিতা পেয়েছে?

খ-১১) যদি না হয়, তাহলে কি ধরনের সহযোগিতা আশা করেন**?** নিম্নে তা লিপিবদ্ধ করুন**?**

খ-১২)আপনের মতে গাজীপুরের জলবায়ু পরিবর্তনের প্রভাব কমানোর জন্য কী কী পদক্ষেপ নেওয়া যেতে পার

সেকশন- গ

সাধারন তথ্য

নাম- মোবাইল নং-

পৌরসভা- গ্রাম/পাড়া/মহল্লা-

ওয়ার্ড- ইউনিয়ন-

বাড়ি নং- উপজেলা-

জনসংখ্যা বিষয়ক তথ্য (নিম্নে টিক চিহ্ন দিন)

গ-১) লিঙ্গ: - ১.পুরুষ ২. নারী

গ-২) বয়স .....বছর

গ-৩)পরিবারের সদস্য- ১. পুরুষ ..... জন ২. নারী .....জন মোট-.....জন

গ-৪)শিক্ষাগত যোগ্যতা: ১.প্রাইমারি ২.এইট পাশ ৩.এস.এস.সি ৪.এইচ.এস.সি

৫.ইউনিভার্সিটি ৬. নাম লিখতে পারে ০. পড়াশুনা জানে না

গ-৫) পরিবারের মোট আয় -- ১. কৃষি..... টাকা

২. অন্যান্য উৎস .....টাকা

মোট-.....টাকা

গ-৬)পেশা (কৃষি কাজের ধরন)- ১. জমির মালিক ২. শ্রমিক ৩. ব্যবসা ৪. অন্যান্য

সেকশন-ঘ

ঘ-১) আপনি কৃষি কাজের সাথে কত বছর ধরে জড়িত- .....বছর

ঘ-২) আপনের কি নিজস্ব কোন জমি আছে? ১. হ্যাঁ ০. না

ঘ-৩)যদি হ্যাঁ হয়, তাহলে মোট কৃষি জমির পরিমান কত- .....একর।

ঘ-৪)প্রধান শস্য- ১. ধান ২. গম ৩. আলু ৪. আখ ৫. হলুদ ৬. আদা ৭. মরিচ

৮.নারিকেল ৯. ডাল ১০.সরিষা ১১.অন্যান্য

প্রধান ফল- ১.কাঠাল ২. আম ৩. লিচু ৪. আনারস ৫.পেয়ারা ৬.কামরাঙ্গা

৭.বড়ই ৮. লেবু ৯.করমচা ৯. অন্যান্য

শাক সবজি- ১. আলু ২. লাউ ৩. পেপে ৪. পাতা কপি ৫. ফুল কপি ৬.টমেটো ৭.গাজর ৮.বেগুন ৯. শাক ১০. ধুন্দুল ১১. অন্যান্য

ঘ-৫) আপনের জমিতে সেচের ব্যবস্থা কি আছে? ১.হ্যাঁ ০. না

ঘ-৬) **(**যদি উত্তর হ্যাঁ হয়**)** তাহলে কি ধরনের সেচ ব্যবস্থা রয়েছে**?**

১. গভীর নলকূপ ২. অগভীর নলকূপ

৪. দোল ঝুড়ী ৫. দোন ৬.অন্যান্য

ঘ-৭) কী ধরনের গৃহপালিত পশুপাখি পালন করেন**?**

ধরন	**সংখ্যা**
১.গরু/গাভী	
২.বাছুর	
৩.ছাগল	
৪.ভেড়া	
৫.মুরগী	
৬. হাস	
৭.মৌমাছি	
৮.অন্যান্য	

ঘ-৮) আপনি কি মৎস চাস করেন কি? ১. হ্যাঁ ০. না

ঘ-৯) বাড়ীর আশপাশে কি শাক সবজি লাগান কি? ১. হ্যাঁ ০. না

ঘ-১০)কোন উৎস থেকে বেশী লাভবান হন? ১. কৃষি কাজ ২.মৎস চাষ ৩.পশুপালন

ঘ-১১)কৃষিকাজের পাশাপাশি আর কি কি কাজ করেন?

ঘ-১২)কোনটি চাষ করলে বেশী লাভবান হন? ১. ধান ২.গম ৩. শাক সবজি ৪.অন্যান্য

ধন্যবাদ আপনের মূল্যবান সময়ের জন্য