EFFECTS OF CLIMATE CHANGE ON FARMERS' FOOD AND NUTRITION SECURITY

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This is to certify that the thesis entitled, **"EFFECTS OF CLIMATE CHANGE ON FARMERS' FOOD AND NUTRITION SECURITY"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **Master of Science (MS) in Agricultural Extension**, embodies the result of a piece of bona-fide research work conducted by **MD. SHAJINUR RAHMAN, Registration no. 18-09214** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this study has been dully acknowledgement by him.

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THIS THESIS IS LOVINGLY DEDICATED TO MY PARENTS AND ELDER BROTHER FOR THEIR ENDLESS SUPPORTS, ENCOURAGEMENT THROUGHOUT MY LIFE

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ABBREVIATION AND ACRONYMS

Abbreviation	Full word
Ag. Ext. Ed.	Agricultural Extension Education
B	Multiple regression
BBS	Bangladesh Bureau of Statistics
BER	Bangladesh Economic Review
CEGIS	Centre for Environmental and Geographic Information Services
DAE	Department of Agricultural Extension
DoE	Department of Environment
et al.	All Others
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FPMU	Food Planning and Monitoring Unit
GDP	Gross Domestic Product
GHI	Global Hunger Index
GOB	Government of Bangladesh
HIES	Household income and expenditure survey
HKI	Helen Keller International
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
MEA	Millennium Ecosystem Assessment
MoA	Ministry of Agriculture
MOEF	Ministry of Environment and Forest
MoYS	Ministry of Youth and Sports
NAPA	National Adaptation Programme of Action
NDA	Nutrition and Allergies
OLS	Ordinary Least Squares
SD	Standard Deviation
SPSS	Statistical Package for Social Science
UN CESCR	UN Committee on Economic, Social and Cultural Rights
UNFCCC	United Nation Framework for Climate Change Conference
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WB	World Bank
WFS	World Food Summit
WHO	World Health Organization

EFFECTS OF CLIMATE CHANGE ON FARMERS' FOOD AND NUTRITION SECURITY

MD. SHAJINUR RAHMAN

ABSTRACT

Bangladesh is one of the most exposed countries to climate change and continuously effects on rural farmers and their food and nutrition security. The study examined effects of climate change on farmers' food and nutrition security. The study carried out in Tangail sadar upazila under Tangail district. The methods of the study is a qualitative methods based on data collection. The objectives of the research were to describe the selected characteristics of the farmers, assess the effects of climate change among study and control group respondents and the contribution of the selected characteristics of the study group farmers on their food and nutrition security. Descriptive statistics, multiple regression analysis, independent two sample t-test were used for data analysis with different categories and t-test value taking both study and control group with the minimizing spillover effects. Data were collected from the 100 test respondents selected from the intervention area (4 study villages) considering those who were affected to climate change. On the other hand, data were collected from 33 control respondents selected from the two control villages in purposive random sampling method considering those who were not affected to the climate change effects. Data showed that majority of the farmers in the study area were in under low category for food availability, food stock ability, nutrition uptake and household dietary diversity. There was a significant negative (-2.66) effects of climate change on farmers' food and nutrition security comparing the study and control group means. Findings also reveal that among the variables namely agricultural training experience, annual family income, Body Mass Index (BMI), agricultural extension media contact and knowledge on climate change had significant contribution to the farmers' food and nutrition security in the study group respondents. It may be enlightened that climate change has played commencing role in the study group respondents on food and nutrition security. Based on the findings, it is recommended that respective authorities should implement and popularize farmers' food and nutrition based projects on a massive scale for achieving food and nutrition security of the farmers.

Key words: Climate change, Food security, Nutrition security

CHAPTER I

INTRODUCTION

1.1 General Background

Climate change refers to the variation in the earth's global climate or in regional climates over time. It is the change of climate which attributed directly or indirectly to human activity that alters the composition of the global atmosphere (UNFCC, 2001). Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization resulting variations in solar energy, temperature and precipitation (Upreti, 1999). Climate change is an emerging environmental challenge to date is a natural process and has been considered through increased variability and uncertainty of precipitation. Greenhouse gases (GHGs) mainly CO_2, N_2O and CH_4 majorly emitted from the energy sector are the major contributing agents of climate change. Emission of Carbon Dioxide (CO_2) is the major element, which forms more than 80% of the total GHG. GHGs have created a greenhouse effect, which subsequently altered precipitation patterns and global temperatures. Several basic indicators in our surroundings, such as steady rise in temperatures, increasing concentration of greenhouse gases in the atmosphere, and growing weather or climatic uncertainties, show the aggregate effects of these changes. IPCC (1995) reported that the global mean surface air temperature has increased in Bangladesh. Climate change affects agriculture in a variety of ways. Temperature, solar radiation, rainfall, soil moisture and CO_2 concentration are all important variables that determine agricultural productivity and their relationships are not simply linear. The interaction of temperature increase and changing precipitation patterns determines the availability of soil moisture. With rising temperatures, both evaporation and precipitation are expected to increase. The resulting net effects on water availability makes agriculture and livelihood of the people more vulnerable. Effects of climate change on agriculture are very vague that climate change may have increased productivity in some region while it to be decreased in another region (Pathak, 2003). This will put greater number of people at risk when agriculture is affected due to climate variability and uncertainty (Dahal and Khanal, 2010).

Bangladesh is one of the most exposed countries to climate change because of geographic exposure, population density, low income and greater dependency on

climate sensitive sectors, particularly agriculture. The livelihood of the Bangladeshi residents depends on mostly agriculture for which reason, Bangladesh is identified as a highly vulnerable country to Climate Change (Silwal, 2009). The agriculture in Bangladesh is vulnerable for two reasons. First, the existing system of food production is highly climate sensitive because of its low level of capital investment and adoption of modern technological options. Second, agriculture is the main source of livelihoods for a majority of the population i.e. 80% population depends on agriculture (BBS, 2019). People, exposed to the most severe climate-related hazards are often least able to cope with the associated impacts due to their limited adaptive capacity and are expected to become more susceptible in future (Islam *et al.*, 2010a).

The climate of Bangladesh can be characterized by high temperatures, heavy rainfall, high humidity, and fairly marked three seasonal variations like hot summer, shrinking winter and medium to heavy rains during the rainy season. Climate change has already affected the life and livelihoods of the people in the coastal areas and in the arid and semi-arid regions of Bangladesh (Garai, 2014). The agricultural sector is most likely to face significant yield reduction in future due to climate variability (Islam *et al.*, 2010b). Most importantly, crop agriculture is the most vulnerable to climate change among different sectors of the Bangladesh economy. One major determinant of fluctuations in crop yield is year-to year changes in climatic variables (Hazell, 1984; Anderson &Hazell, 1989). Over the last several decades, global warming has been observed on local, regional, and global scales. The Inter-governmental Panel on Climate Change report presents a detailed evaluation of long term worldwide observations on climate change and a sound physical analysis of the potential trends of change in climate (IPCC, 2007). The report concludes that global climate is very likely to get warmer in the near future. As scientific evidence becomes more convincing that increasing concentrations of greenhouse gases will warm the planet. It has become ever more important to understand the impacts of global warming. The impacts on agriculture are among the largest and the best documented. Bosello and Zhang (2005) stated that the relationships between climate change and agriculture are complex and manifold. They involve climatic and environmental aspects, social and economic responses.

Agricultural development provides food and nutrition security for the people of a nation. One of the fundamental rights of the citizens stipulated in the constitution of Bangladesh is food security for all. The key elements of food security are: a) availability

of enough food from domestic production or imports to meet the demand b) access of the food to all people at all times through enough incomes and affordable prices c) proper hygiene and sanitary practices and safe water for utilization of food to have optimum impact on health and nutrition d) a regulatory framework in place and its proper implementation for controlling contamination to ensure food safety. Food security is the state achieved when food systems operate such that all the people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2008). The unprecedented impacts of climate change along with other environmental and geomorphologic changes make more concerns over food security especially, for the poor and marginal population (Gregory & Ingram, 2000; Parry *et al.*, 2007; Rosegran & Cline, 2003). Later definitions added demand and access issues to the definition. The final report of the World Food Summit (1996) states that food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Shaw, 2007). Individuals who are food secure do not live in hunger or fear of starvation (FAO, 2013). Food insecurity, on the other hand, is a situation of limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways (USDA, 2016). Food preference also plays an important role in the determination of nutritional status of people. Nutrient content of food is generally considered as objective characteristics. Subjective characteristics comprise a wide of range of attributes such as taste, size, shape, volume, color, aroma etc. The social value attached to consumption also falls within the range of subjective characteristics. If people, out of their preference for quality or subjective characteristics, pay more for the same quantity or in other words buy less nutrients for the same money, the phenomenon leads to leakage of some point of view. From consumers' point of view, it may lead to lesser food security and reduced nutritional welfare (Talukder *et al.*, 2015). Food security incorporates a measure of resilience to future disruption or unavailability of critical food supply due to various risk factors including droughts, shipping disruptions, fuel shortages, economic instability, and wars (Boeing, 2016). In the years (2020), an estimated 690 million people worldwide go to bed hungry each night (Global hunger index, 2020). The United Nations (UN) recognized the Right to Food in the Declaration of Human Rights in 1948, and has since noted that it is vital for the enjoyment of all other rights (UNCESCR, 2016). In view of

repeated experience of severe hunger and famine, food security in Bangladesh has long been synonymous with achieving self-sufficiency in rice, the dominant staple food. Bangladesh economy has made respectable progress in rice, tripping production from 11 million tons in 1971 to 36 million in 2012 (BBS, 2014).

Bangladesh remains highly food insecure in spite of important economic progress. About 60 million people consume less than the minimum daily recommended amount of food (HIES, 2010). According to International Food Policy Research Institute (IFPRI, 2010) Global Hunger Index-which is a combined measure of the proportion of undernourishment, child malnutrition and child mortality- food security has improved in Bangladesh since 1990, with country moving from an extremely alarming to an alarming level of hunger. Despite this progress, Bangladesh's food security is still fragile and major challenges remain as well. The farmers of Bangladesh mainly depend on agriculture and agriculture related activities. Opportunities for off-farm activities are marginal. As a result of river erosion, cultivable land, crops and homestead are often damaged or devoured by rivers regularly. Development of farmers' livelihood, knowing of position of food security of farmers is essential where a major portion is secured by a landless people. People have experienced frequent natural and human induced disasters including sea level rise, cyclones, storm surge, flooding, land erosion, water logging, and salinity intrusion in soil and water because of extreme variability of climate change which cause loss of life, damage the infrastructure and economic assets, decrease of income, social security, inadequate of food and adversely effects the livelihoods of rural people especially the farmers, vulnerable and destitute living in environmentally fragile areas. The combination of a high level of poverty, and a depleted ecological system increase the country's vulnerability to the impacts of climate change (Khan *et al.,* 2010). For this reason, it was deemed necessary to undertake this study. If food and nutrition insecurity is revealed, careful and need-based interventions may possibly be taken properly to mitigate the crises. The researcher intended to take an attempt to understand the status of farmers' food and nutrition security and measurement of climate change effects of the climatic vulnerable and non vulnerable farmers' at Tangail districts of Bangladesh. Appreciating and analyzing the previously mentioned conditions the researcher has become interested in undertaking a research entitled, "Effects of climate change on farmers' Food and nutrition Security".

1.2 Statement of the Problem

Food, in the hierarchy of needs, is the most basic need for sustenance of life and is the perennial problem issue for healthy and active life of humankind. Food security is not just an economic problem but also a social and political issue in as much as food insecurity is a factor to create social and political instability in the country. Food security is a basic factor for development of human capital and starter for overall development of the society. Right to adequate and stable supply of safe nutritious food is a constitutional right of the people for nutrition security in Bangladesh. The Government of Bangladesh is strongly committed to the progressive realization of the right to food. Food security, as put by FAO, involves four dimensions: availability, accessibility, food utilization and stability of components of food security. Nutrition, food safety and quality have attained considerable importance recently in Bangladesh. Ensuring food and nutrition security for all is one of the major challenges that Bangladesh faces today. Despite significant achievements in food grain production and food availability, food security at national, household and individual levels remains a matter of major concern for the country. Since independence, Bangladesh has made significant progress in increasing domestic production of food grains. This, to a large extent, helped in overcoming the constraints of insufficient national food availability. Adequate food availability however was not a sufficient condition for ensuring national food security. Ensuring food and nutrition security for all reportedly require a major effort at enhancing access to nutritious food and subsequent utilization of food by the poor and distressed households. Though hunger is the number one issue, malnutrition has become emerging problem for treatment. Along with underweight, overweight including obesity has become another problem of health related to nutrition intake. In this situation, providing adequate, stable, safe and nutritious balanced food to all becomes a challenging task in the way of development ahead, and there is a serious need to develop a road map to achieve this visionary goal for a healthy society.

In the context of the above circumstances, the researcher intended to find out the answers of the following research questions

- What are the extent of effects of climate change on farmers' food and nutrition security?
- What are the socio economic profiles of the farmers?

- What are the contribution of selected characteristics of the farmers on their food and nutrition security?

In order to get a clear view of the above questions the researcher undertook a study entitled ‘‘Effects of Climate Change on farmers’ food and nutrition security”.

1.3 Specific Objectives of the Study

In order to answer the above the questions the following specific objectives were formulated that supposed to provide proper direction and to the study:

a) To describe the socio-economic profile of the climate change affected farmers; the characteristics were as follows:

a) Age
b) Level of education
c) Family size
d) Effective farm size
e) Agricultural training experience
f) Amount of agricultural credit
g) Annual family income
h) Body Mass Index (BMI)
i) Agricultural extension media contact
j) Knowledge on climate change

b) To ascertain the effects of climate change on farmers’ food and nutrition security.

c) To explore the contribution of the selected characteristics of the farmers on their food and nutrition security.

1.4 Scope of the Study

The present study was designed to have an understanding the effects of climate change on farmers’ food and nutrition security and to explore its contribution with farmers selected characteristics.

- The findings of the study will in particular be applicable to the study area at Tangail sadar upazila of Tangail district. The findings may also be applicable to other locale of Bangladesh where socio-cultural, psychological and economic circumstance do not differ much than those of the study areas.

- ❖ The findings of the study may also be subsidiary to the field worker of extension service to enhance their action strategies on managing effects of climate change on farmers food and nutrition security.
- ❖ The findings of the study will be conducive to accelerate the improvement in agriculture activities, farmers food and nutrition supports, farmers logistic supports, information needs and the way of dissemination especially tuned to key role players in the society as well as effects of climate change on farmers food and nutrition security. The outcomes might also be helpful to the planners and policy makers, extension workers and beneficiaries of the farmers.
- ❖ To the academicians, it may help in the further conceptualization of the systems model for analyzing the effects of climate change on farmers food and nutrition security. In addition, the findings of this study may have other empirical evidence to all aspects of effects of climate change on farmers' food and nutrition security, which may be used to build a theory of effects of climate change aspects.

1.5 Justification of the Study

Bangladesh is a major victim of climate change. Agricultures are facing barriers and constraints due to the changing climate. The focus of the study is to ascertain the effects of climate change on farmers' food and nutrition security. Climate change is forcing people to take diversified occupation to maintain their livelihood, income and production. Bangladesh is continuously fighting with the climate change effects. Extreme weather events not only limit agricultural persuasion during the event but also have the potential to erode household assets, like destruction of house, trees and even it may kill people or injure them. The household assets including human health and motivation, houses, trees, other physical assets, livelihood tools and equipment are destroyed in the extreme weather events and thus reducing capitals to pursue livelihoods and accordingly reducing resilience to extreme conditions.

The study will have great importance to the farmers conditions and their food and nutrition security status. Therefore, the researcher needs to enquire about the effects of climate change on farmers' food and nutrition security. The findings of the study are therefore, expected to be conducive to the researchers, academicians and policy makers who are concerned with effects of climate change. Keeping the above facts in view, a study undertook entitled 'Effects of climate change on farmers' food and nutrition security'.

1.6 Assumptions of the Study

An assumption is the supposition that an apparent fact or principle is true in the light of available evidence (Goode and Hatt, 1952). The researcher had considered the following assumptions while undertaking the study:

- The respondents were capable of furnishing proper answers to the questions contained in the interview schedule.
- The data were collected free from any bias and respondents were normally distributed.
- The responses provided by the respondents were valid, acceptable and reliable.
- Information sought by the researcher generate the real situation was the representative of the whole population of the study area to gratify the objectives of the study.
- The researcher was capable to adjust with the social and cultural environment of the study area. So, the respondents could provide their information correctly and bias free.

1.7 Limitations of the Study

Considering the time, respondents, communication facilities and other necessary resources available to the researcher and to make study meaningful, it became necessary to impose certain limitations as mentioned bellow:

- The study was confined to the four villages of Kakua union and two villages of Danya union of Tangail sadar upazila under Tangail district which may fail to represent the actual scenario of the whole situation as people develop their strategies according to concrete situation they face.
- It is difficult to get exact information on effects of climate change on farmers' food and nutrition security indicator from the farmers' as many of them are illiterate.
- Characteristics of the farmers were many and varied, but only ten characteristics were selected for the research study.
- There were embarrassing situations at the time of data collection. Therefore, the researcher had to manage proper rapport with the respondents to collect maximum proper information.
- Several methods, scales and statistical tests have been utilized in this study over a relatively short period.

1.8 Definition of Key Terms

Food

For people, food is what they eat. For policy makers, food is any substance intended for human consumption.

Food security

Food security is a measure of the availability of food and individuals ability to access it. According the United Nations' Committee on World Food Security, food security is defined as the means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life.

Nutrition security

Food security is defined as the availability and the access of food to all people; whereas nutrition security demands the intake of a wide range of foods, which provides the essential needed nutrients.

Climate change

Climate change is the global phenomenon of climate transformation characterized by the changes in the usual climate of the planet (regarding temperature, precipitation, and wind) that are especially caused by human activities. As a result of unbalancing the weather of Earth, the sustainability of the planet's ecosystems is under threat, as well as the future of humankind and the stability of the global economy. NASA's definition of climate change says it is "a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gases to Earth's atmosphere. These phenomena include the increased temperature trends described by global warming, but also encompass changes such as sea-level rise, ice mass loss in Greenland, Antarctica, the Arctic, mountain glaciers worldwide, shifts in flower or plant blooming and extreme weather events."

Balanced diet

A balanced diet is a diet that provides energy and all essential nutrients for growth and a healthy and active life, since few foods contain all the nutrients required to permit the normal growth, maintenance and functioning of the human body. A variety of food is needed to cover a person's macro and micronutrient needs. Any combination of foods

that provides the correct amount of dietary energy and all essential nutrients in optimal amounts and proportions is a balanced diet.

Nutrients

Nutrients are the substances and chemical elements and compounds that food contains. They make us grow, maintain our bodies in good repair, give us energy and keep us healthy. Those that are required in large quantities are classified as macronutrients (carbohydrates, fats and protein) and those required in only very small amounts but being essential as micronutrients (vitamins, minerals and trace elements). All foods contain at least one of the macronutrients, and most, though not all foods contain at least a few micronutrients. Essential micronutrients need to be consumed as the body cannot produce them on its own. For all nutrients, recommendations for daily intake and safe levels of intake exist.

Nutrition

Nutrition is the consequence of the intake of food and the utilization of nutrients by the body. Good nutrition produces a healthy physical and physiological condition. It is secured when food intake, absorption and utilization provide all essential nutrients in required amounts. Poor nutrition produces an unhealthy physiological condition and is caused by lack of physical, economic, social or physiological access to the right amounts of dietary energy and nutrients. Consequences of poor nutrition can be impaired physical and mental development, reduced immunity, increased susceptibility to disease, decreased ability to do work and reduced productivity. Since parasites, poor hygiene and diseases can compromise a person's ability to absorb and biologically utilize the nutrients consumed, a safe food supply, clean drinking water, a sanitary environment, adequate health, education and care are essential for good nutrition, along with a balanced diet. Optimal nutrition supports development to obtain each individual’s full genetic potential.

Dietary energy

Dietary energy is supplied by all the macronutrients (carbohydrates, fats and protein) and is measured in terms of calories, kilocalories or joules. It is essential to life because the body requires energy to perform basic involuntary functions, as well as to carry out willed activity, be it work that is necessary for survival or activity that is undertaken for

pleasure. When the quantity of dietary energy consumed is insufficient, people lose weight and when it is excessive, they gain weight.

Hunger

Nutritionists have estimated the amount of dietary energy that people of different ages and sex with different activity levels in different cultures require to maintain a healthy and active life. When people do not have access to the amount of dietary energy needed for their normal level of activity, they feel hungry. If the situation persists over a longer time, it leads to undernutrition. Chronic energy deficiency can lead to a reduction in physical activity, weight loss or both. In severe forms, chronic energy deficiency can lead to wasting and eventually death. Hunger is not synonymous with malnutrition or undernutrition, but there are overlaps between these two.

Malnutrition

Malnutrition is defined as nutritional disorder in all its forms and includes both undernutrition and over nutrition. It relates to imbalances in energy, and specific macro and micronutrients- as well as in dietary patterns. Conventionally, the emphasis has been in relation to inadequacy, but it also applies to both excess and imbalanced intakes. Malnutrition occurs when the intake of essential macro- and micronutrients does not meet or exceeds the metabolic demands for those nutrients.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to review the past studies and opinions of experts and social scientists having relevance to this investigation based on the major objectives of the study. Attempts have been made in this chapter to review that finding of past researches having relevance to the present study. But unfortunately, very few studies have been obtained which were directly related with "Effects of climate change on farmers' food and nutrition security" status in general or which explain the factors that influence the farmers food and nutrition security in the study part of Bangladesh. The researcher, therefore, made comprehensive effort to review the previous research works directly or indirectly related to the present study by different researcher in home and abroad. However, many studies could be found on food and nutrition security problem confrontation, the result of which were indirectly related to the present study and which focuses climate change effects. This chapter comprises with several sections. A few of these studies relevant to this research are briefly discussed in this chapter under the following six sections:

Section 1: Impacts of Climate Change in Bangladesh

Section 2: Induced Climate Change Effects

Section 3: Effects of Climate Change on Food Security

Section 4: Effects of Climate Change on Nutrition Security

Section 5: Research Gap

Section 6: Conceptual Framework of the Study

Section 7: A Schematic Diagram of the Study

2.1 Impacts of Climate Change in Bangladesh

The Inter-governmental Panel on Climate Change (IPCC, 2007a) defines climate change as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use". The United Nations Framework

Convention on Climate Change (UNFCCC) defines climate change as "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 time periods" (Bodansky, 2010).

Bangladesh is one of the most vulnerable country in the world. The main reasons for its vulnerability are due to (i) its location in the tropics, (ii) the dominance of floodplains, (iii) its low elevation from sea level and (iv) its high population density. (MOEF, 2005; DOE, 2007; Shahid and Behrawan, 2008; Pouliotte *et al.,* 2009; Hossain and Deb, 2011). The geographical location of the country has made the people largely depended on the environment and vulnerable to natural disasters. According to IPCC (2007b), sea level in the coastal region of Bangladesh has been predicted to rise up to 80 cm by 2100. As people of Bangladesh will be affected by climate change directly or indirectly in all regions. Climate change is the biggest global health threat of the 21st century and increasingly recognized as a public health priority (WHO, 2008; Lancet, 2011, Young *et al.,* 2002; Yongyut *et al.,* 2009). Changes in climate generally involve changes in two major climatic variables: temperature and rainfall. It leads to increased temperatures, changing rainfall patterns and amounts, and a higher frequency and intensity of extreme climate events such as floods, cyclone, droughts, and heat wave (IPCC, 2007c; Tirado *et al.,* 2010). According to the International Panel for Climate Change (2007d), an increase in the average global temperature will lead to changes in precipitation and atmospheric moisture, sea level rise due to the changes in atmospheric circulation, and increases in evaporation, water vapor.

The effects of climate change are heterogeneous and region specific. For example, a rise in temperature with reduced and more variable rainfall has already affected the natural and physical ecosystems of Bangladesh, predominantly the northwest with its recurrent droughts and the southwest with rising soil salinity (Ahsan *et al.,* 2011a). Consequence of climate change, agricultural sector of northern districts is suffering from increased spikelet sterility, higher infestation of pests and diseases, deficiency of water and soil moisture due to increase rate of evapo-transpiration and hampering the agricultural productions (rice, wheat, pulses, rape seed and coconut). On the other hand, southern coastal belt will be inundated and vulnerable for salinity intrusion causing to reduce the existing crop productions. The 700 km long coastline of Bangladesh covers 2.5 million ha area in coastal area is supporting to 35 million people as their home and

daily livelihood and expected to be reached to 40-50 million by 2050 (Agrawala *et al.,* 2003; Ahmed, 2006). But 0.83 million hectare land within these areas are vulnerable to sea level rise, suffering from salinity intrusion varying from 0 to 20 ppt deteriorating agro-resources and the distribution is gradually increasing (Uddin *et al.,* 2011). Consequently, agricultural production is decreasing (0.3 m rise will cause a net reduction of 0.5 million metric tons) due to shortage of fresh water, soil degradation and terminative energy and germination rate of some plants (Krishnamurthy *et al.,* 2014). A recent research showed within 8.3 million ha there is 4.2 million ha of lands are droughts prone with different intensities. At present, 30 million tons food are producing yearly from irrigated agriculture (56.0%) in which 80.0% areas are irrigated from groundwater due to terrible shortage of surface and ground waters where eastern part will be suffered from loss of 14,000 tons grain production alone in 2030 and 252,000 tons by 2075 (Islam *et al.,* 1999; Minar *et al.,* 2013). The recent studies found that climate change causing the change in rainfall pattern would decrease 30.0% crop production in 2100 and 28.0% for rice and 68.0% for wheat respectively (Karim *et al.,* 2012). Furthermore, 1 meter sea level rise will lose up 15.0% of total land area that will create up to 30 million environmental refugees and national GDP will decline between 27.0-57.0% (Agrawala *et al.,* 2003a; Harasawa, 2006). The tropical cyclone of 2007 caused loss of valuable mangroves, social and physical resources and livelihood bases that post-disaster recovery has not yet been possible in Bangladesh (Mallick *et al.,* 2011). Changing frequency of cyclonic wind and storm surges and inundation of coastal agriculture and domestic fisheries and open fishing have been highly affected which are significant livelihoods sources to majority coastal people. Salinity level is slowly increasing over the time and causing serious threats to traditional agriculture farming and mangrove ecosystems (Moniruzzaman, 2012). Seasonal variations have also diverse influence on fishing, hatchery operations, fish production and livelihoods of a wide range of people (Haque, 2007). Climate change and its effects on farmers' food production, economy and food consumption arises as vital issue to the Bangladeshi farmers since last two decades. As a result, a limited number of similar researches have so far been conducted by the researcher. Systematic and comprehensive study is yet to be conducted. It is therefore, the researcher has been taken into consider for further study this piece of research.

2.2 Induced Climate Change Effects

The effects of climate change are heterogeneous and region specific. For example, a rise in temperature with reduced and more variable rainfall has already affected the natural and physical ecosystems of Bangladesh, predominantly the northwest with its recurrent droughts and the southwest with rising soil salinity (Ahsan *et al.,* 2011b). The effects of temperature on agriculture is complex due to a number of interplaying factors: while higher Carbon-dioxide levels and solar radiation theoretically can increase food production, heat stress, shorter growing seasons and higher evapo-transpiration resulting in soil moisture levels being lowered counteract the former influences leading to overall lower production of most foodstuffs such as most varieties of rice, wheat and potato. Reductions in yield could potentially be as high as a 1728% decline for rice and 31-68% decline in wheat production (Karim *et al.,* 1999a). So, 8% smaller rice harvests and a 32% smaller wheat harvests by 2050 now look likely (IPCC, 2007d). A holistic perspective on changing rainfall driven flood risk is provided for the late 20th and early 21st centuries (Kundzewicz *et al.,* 2014).

The temperature is rising all over the world due to global warming as a result of gas emission and anthropogenic activities. The ice-sheets of the Antarctica and glaciers of the Himalayas are melting quickly due to increased temperature. Being situated at the base of the Himalayas, Bangladesh suffers from various natural calamities, which affected negatively on fish and fisheries of the country (Rahman, 2008). Global average temperature has warmed and cooled many times in the twentieth century and is likely to rise constantly in the future mainly due to an increased concentration of Green House Gas (GHG) in the atmosphere. Without GHGs, the earth surface temperature was raised by 0.740 and 0.180 (1.33± 6.0F) during 20th century and scientists estimated that it could increase as much as 6.40C average in the 21th century (UNFCC, 2007). Edward H. Allison (2004) predicted that during the next 50 years, temperatures in Bangladesh are predicted to increase by 1.1° C during the flood season and by 1.8° C during the dry season. The effect of temperature on agriculture is complex due to a number of interplaying factors: reductions in yield could potentially be as high as a 17-28% decline for rice and 31-68% decline in wheat production (Karim *et al.,* 1999b). So 8% smaller rice harvests and a 32% smaller wheat harvests by 2050 now look likely (Reid *et al.,* 2007).

Alam *et al.* (2009) found that the highest monthly rainfall (362.4mm) was occurred in July 2007 and no rain in December 2006 in the Basantapur beel under Natore district. The highest rainy day was recorded in 26th July, 2007. According to Quadir (2003) the annual profile of monsoon precipitation occurs during July and August. Sylhet shows very high precipitation and Rajshahi a relatively monsoon precipitation compared to the other stations. It was clear that the northeastern and southeastern part of Bangladesh gets high precipitation than other western part. Changes in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. The IPCC predicts that precipitation will increase in high latitudes, and decrease in most subtropical land regions some by as much as about 20 percent. (IPCC, 2007e). A holistic perspective on changing rainfall driven flood risk is provided for the late 20th and early 21st centuries (Kundzewicz *et al.,* 2014).

Sea levels continue to rise due to climate change. It has already been observed that the mean annual water level in the south-west region is increasing by 5.5 millimetres per year (Rahman *et al.,* 2011). The effects of sea level rise go beyond the gradual inundation of coastal land areas to include the intrusion of saline water into freshwater rivers and aquifers and the intensification of impacts from cyclones and storm surges. As sea levels rise, saline water will intrude directly into rivers and streams, advancing not only as a function of the water level but also according to changes in river discharge that may result from climate change (Islam, 2004). About 10 to 25 millimeters of sea-level rise was observed over the 20th century and models predict continued rise in a range of anywhere from 20 to 90 centimeters within the 21st century (IPCC, 2013a). In Khulna, Bagerhat and Satkhira districts of southwest region of Bangladesh found that the suitable area for transplanted Aman rice cultivation would reduce from 88% to 60% with 32 cm rise in sea level and 12% with an 88 cm rise in sea level (CEGIS, 2005). The inundation of land areas through sea-level rise and increased precipitation is not the only worrisome effect of global climate change.

In the final decades of the 20th century roughly 2.7 million ha of land in Bangladesh alone were vulnerable to annual drought with a 10% probability that 41%–50% of the country experiencing drought in a given year and those figures are forecast to increase in both geographic scope and event intensity (IPCC, 2013b). Agrawala *et al.* (2003b) studied Development and Climate Change in Bangladesh and they observed south-west and north-west regions were particularly susceptible to drought. *Islam et al.* (2002)

described that ascent and descent of severity of drought mostly depended on fluctuation in rainfall distribution. Higher fluctuation was responsible for higher drought; while less varied distribution causes somewhat lower drought. Rice is the main crop in Bangladesh covering 80% of the total cultivated area of the country and is important both in terms of the nutrition and in terms of income it gives to the people of Bangladesh. However, drought can affect the rice crop in three different seasons: Firstly Pre-Karif droughts in March and April prevent land preparation and ploughing, delaying the planting of crops during the monsoon season; secondly Karif droughts in July and August delay the transplantation of aman rice in highland and medium high areas, as well as in Modhupur Tract and western Rajshahi Division, while Karif droughts in September and October reduce yields of both broadcast and transplanted aman rice and delay sowing of pulses and potatoes in the west of Rajshahi Division and along major rivers. Meanwhile Rabi droughts in winter months affect boro rice, wheat and other crops grown in the dry season, most severely in the Barind Tract and west of Khulna division, severely in areas of the Chittagong Hilltracts, southern Sylhet Division and other parts of Rajshahi Division and slightly in remaining areas of western, northern and central Bangladesh (Selvaraju *et al.,* 2006; CIMMYT, 2005).

Flooding is a regular occurrence in Bangladesh. On average, nearly one quarter of Bangladesh is flooded each year (Ahmed and Mirza, 2000). Bangladesh experiences four types of floods: flash floods, rain floods (due to poor drainage), monsoon floods, and coastal floods (IPCC, 2012). Das (2009) conducted an analysis on the adverse effects of flood. He concluded that, floods can cause enormous damage, destroying standing crops, houses, lives and livestock. Floods also deposit layers of sand on existing crops, which can cause irreversible harm. Climate change is believed to affect Bangladesh river system badly as the melting of Himalayan glaciers will result in higher flow of water in the river, which in turn will result into flood and water logging in huge urban areas (Daily Star, 2011). Food supply will be another problem caused by river floods; for the 1998 flood reduced agricultural production by 45% (Ahmed, 2006). It will also effect on rural incomes, where agriculture still employs 70% of the population. High-yielding aman rice varieties are very easily destroyed by floods as they 34 are unable to grow fast enough to keep up with the increasing depth of flood water and if the flood water rises faster than 4-5cm deep per day other rice varieties will also be lost. Monsoon vegetables also die when under water (Karim *et al.,* 1999c). The quality of

floodwater may also be reducing, threatening rice production, including the bumper harvests of boro rice after flooding. For instead of depositing silt, that boosts soil fertility, floods are now carrying more sands, which often cover whole fields making them useless for agriculture (Chowdhury, 2002).

Bangladesh's vulnerability to cyclones is exacerbated by the shape of the coastline and low, flat terrain combined with high population density and poorly built infrastructure (World Bank, 2000a). In fact, 60 percent of the cyclone-related deaths that occurred worldwide between 1980 and 2000 were in Bangladesh (Nicholls *et al.*, 2007). In 1991, a devastating cyclone hit the coastal region, accompanied by a tidal bore, which was between five and eight meters high with winds of up to 240 kilometers per hour (Paul, 2009). Ali (2003) showed that Bangladesh currently has extreme vulnerability to cyclones, both on account of its somewhat unique location and topography (that creates an inverted funnel effect), and because of the low (though growing) capacity of its society and institutions to cope with such extreme events. A cyclone in 1970 resulted in close to 300,000 deaths, and another, in 1991 led to the loss of 138,000 lives, although in recent years greater success in disaster management has significantly reduced the lives lost (World Bank, 2000b).

FAO (2008) reported that fisheries, aquaculture and fish habitats are at risk in the developing world. For example, saltwater intrusion into the Mekong delta from sea level rise and reduced flows threatens the viability of the aquaculture industry for catfish in the delta, which currently produces 1 million tons valued at $1 billion a year and provides over 150,000 livelihood opportunities for mostly rural women, unless saltwater tolerant strains can be developed. About 6.0 million people are already exposed to high salinity (>5 ppt), but due to climate change this is expected to increase to 13.6 million in year 2050 and 14.8 million in 2080 and the population in Khulna, Satkhira and Bagerhat will be most affected (Mohal and Hossain, 2007). This will be due to the boundary to the area of high salinity and the salinity front moving gradually north by 40 km (Mohal *et al.*, 2006) to 60 km (NAPA, 2005) inland from the coast by 2100. But as well as making household water supply problematic, salinity negatively affects agricultural production. Above all issues has been taken in consideration that massive effect on rural communities. Because they are highly depends on nature for agricultural activities. But last two decades, climate change has been hampered their agricultural production and its greatly influenced their food and nutrition security.

2.3 Effects of Climate Change on Food Security

Food security encompasses three elements: availability, accessibility and utilization (USAID, 1996). Food availability refers to the physical presence of food at various levels from household to national level, be that from own production or through markets. Food access refers to the ability to obtain an appropriate and nutritious diet and is in particular linked to resources at the household level. Food utilization refers to the proper use of food, which includes the existence of proper food processing and storage practices, adequate knowledge and application of nutrition and childcare and adequate health and sanitation services (FANTA, 2006). Food security is a concept used to describe access to and availability of food supply at different levels. Numerous definitions, with slight variations depending upon the source, have been established to describe food security and insecurity. As a working definition, food security a situation that exists when all the people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (WFS, 1996). Food insecurity is limited or uncertain access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The World Food Summit of 1996 defines food security as existing "at the individual, household, national, regional and global levels". However, the concept has evolved; during 1970s, the concern was regarding national and global food supplies while since the 1980s the focus shifted to the household and individual levels such shift was caused by Amartya Sen's entitlement theory (Maxwell & Smith, 1992). Food security is built on: 1) food availability, defined as having sufficient quantities of food available on a consistent basis; 2) food access, defined as having sufficient resources to obtain appropriate foods for a nutritious diet; and 3) food use, defined as appropriate use based on knowledge of basic nutrition and care (FAO, 2013a). In their review, Maxwell and Smith (1992) found four core concepts that are similar to the above-described pillars: sufficiency of food- similar to food availability; access to food- comparable to food access; security defined as the balance between vulnerability, risk and insurance; and time.

The past half-century has seen marked growth in food production, allowing for a dramatic decrease in the proportion of the world's people that are hungry, despite a doubling of the total population (FAOSTAT, 2009 and World Bank, 2008). Nevertheless, more than one in seven people today still do not have access to sufficient

protein and energy from their diet, and even more suffer from some form of micronutrient malnourishment (FAO, 2013b). The world is now facing a new set of intersecting challenges (Evans, 2009). The global population will continue to grow, yet it is likely to plateau at some 9 billion people by roughly the middle of this century. A major correlate of this deceleration in population growth is increased wealth, and with higher purchasing power comes higher consumption and a greater demand for processed food, meat, dairy, and fish, all of which add pressure to the food supply system. At the same time, food producers are experiencing greater competition for land, water and energy. Need to curb the many negative effects of food production on the environment is becoming increasingly clear (Tilmanet *et al.*, 2001 and MEA, 2005). Overarching all of these issues is the threat of the effects of substantial climate change and concerns about how mitigation and adaptation measures may affect the food system (Parry *et al.,* 2007).

Patterns in global food prices are indicators of trends in the availability of food, at least for those who can afford it and have access to world markets. Over the past century, gross food prices have generally fallen, leveling off in the past three decades but punctuated by price spikes such as that caused by the 1970s-oil crisis. In mid-2008, there was an unexpected rapid rise in food prices, the cause of which is still being debated, that subsided when the world economy went into recession (Piesse and Thirtle, 2009). However, many (but not all) commentators have predicted that this spike heralds a period of rising and more volatile food prices driven primarily by increased demand from rapidly developing countries, as well as by competition for resources from first-generation bio fuels production (Royal Society, 2008a). Increased food prices will stimulate greater investment in food production but the critical importance of food to human well-being and also to social and political stability makes it likely that governments and other organizations will want to encourage food production beyond that driven by simple market mechanisms (Skidelsky, 2009). The long-term nature of returns on investment for many aspects of food production and the importance of policies that promote sustainability and equity also argue against purely relying on market solutions. Recent studies suggest that the world will need 70 to 100% more food by 2050 ((Royal Society, 2008b and World Bank, 2008). A limited number of researches both farmers' food and nutrition security have so far been conducted by the

researcher. Systematic and comprehensive study is yet to be conducted. It is therefore, the researcher has been taken into consider for further study this piece of research.

2.4 Effects of Climate Change on Nutrition Security

Nutrition is the science that interprets the nutrients and other substances in food in relation to maintenance, growth, reproduction, health and disease of an organism. It includes ingestion, absorption, assimilation, biosynthesis, catabolism and excretion (NDA, 2011). The diet of an organism is what it eats, which is largely determined by the availability and palatability of foods. For humans, a healthy diet includes preparation of food and storage methods that preserve nutrients from oxidation, heat or leaching, and that reduces risk of foodborne illnesses. The seven major classes of human nutrients are carbohydrates, fats, fiber, minerals, proteins, vitamins, and water.

This is largely attributable to the increased wealth of consumers everywhere and most recently in countries such as China and India. Well-balanced diets rich in grains and other vegetable products are considered to be more healthful than those containing a high proportion of meat (especially red meat) and dairy products. As developing countries consume more meat in combination with high-sugar and -fat foods, they may find themselves having to deal with obesity before they have overcome under nutrition, leading to an increase in spending on health that could otherwise be used to alleviate poverty. Livestock production is also a major source of methane, a very powerful greenhouse gas, though this can be partially offset by the use of animal manure to replace synthetic nitrogen fertilizer. Of the five strategies, we discuss here, assessing the value of decreasing the fraction of meat in our diets is the most difficult and needs to be better understood.

Food grain production has more than doubled since independence in 1971, Nutrition insecurity both in national and household level remains a matter of concern for the government. About half of the population cannot reach the minimum dietary energy requirement (2122 kcal/capita/day) and one quarter of them subsist in extreme shortage of energy consuming less than 1800 kcal/capita/day (GOB, 2000a). Apart from the prevailing deficit in total calorie intake, the normal diet of Bangladeshi people is seriously imbalanced, with inadequate shares of fat, oil and protein (GOB, 2000b). Dietary imbalance and unavailability of micronutrients are among the major factors responsible for poor nutritional outcomes. High consumption of cereals, but low intake

of edible oils, vegetables and fish result in a low level of absorption of micronutrients and a high level of anemia and other ailments. About 70% of the total calorie comes from cereal of which rice alone contributes 62 % (HIES, 2010). Contributions of other food groups to calorie are edible oil (7.9%), vegetables (3.8%), potato (2.8%) and spices (2.9%). The share of rice in total calorie intake was substantially higher in rural (65%) than in urban (53%) area which is consistent with higher rice consumption of the rural people. Although the share of cereal in the total calorie intake decreased from 73% in 2005 to 70% in 2010, according to nutritional norm the share should not exceed 60% (FPMU, 2014). Women and children are especially vulnerable due to their limited access to food. This dietary imbalance reflects insufficient domestic production of non-cereal foods (pulses, oilseeds, fruits, meat, milk and eggs), low incomes, food preferences and lack of nutrition knowledge. Past studies suggest that consumed cereal diets meet nutritional demand in terms of energy needs as well as protein requirements (Mehta, 1982). Indeed, many vitamins and mineral deficiencies would also be reduced if sufficient calories were consumed (Greer and Thorbecke, 1986). The cereals, particularly rice (currently over 470 gm/person/day) in the diet is so high that their contribution to total dietary energy nears about 75-80% in Bangladesh (Yusuf, 1997). And over the period, the supply of cereals (mainly rice) increased (despite consumption of cereals even in excess of the set amount of 454 gm/person/day (Hossain *et al.*, 2005), but the country suffers sufficient consumption of balanced food which indicates the inadequateness of diet from nutritional point of view. Also, due to the low yield of production and lack of access to food turn the country to the problem of balanced diet alone with sufficient amount of calorie intake from cereals and non-cereals. Therefore, insufficient calories, energy and protein intake, which can be supplemented by cereals, and non-cereals intake are also a problem in Bangladesh. The food consumption and diet patterns should have emphasized on farmers' nutrition.

2.5 Research Gap

There are many researches on climate change issue but very few researches had so far been done to merely assess the effects of climate change on farmers' food and nutrition security. Moreover, among the limited studies on effects of climate change on farmers' food and nutrition security, only a few researchers followed systematic method to assess the effects of climate change on farmers' food and nutrition security. This was one of the research gaps of the study. Hence, the researcher carried out the present study to

assess the effects of climate change on farmers' food and nutrition security in Tangail district following the method which is important to be able to identify and understand the research approach suitable for any given study because the selection of a research approach influences the methods chosen, the statistical analyses used, the inferences made and the ultimate goal of the research (Creswell, 1994).

There has been yet to be conducted study to assess the effects of climate change on farmers' food and nutrition security compared with study and controls group farmers in the described area. This was also a significant research gap of the study. The methodology of the present work was unique in this regard. Therefore, the researcher implemented the research program following the methodology as mentioned. Additionally, no research was carried out taking the indicators of effects of climate change on farmers' food and nutrition security, which were carried out by the researcher in the present study. This is another research gap of the present work. Hence, the researcher followed the current research program using those indicators to assess the effects of climate change on farmers' food and nutrition security. Lastly, very few researches were conducted to assess the effects of climate change on farmers' food and nutrition security taking the variables that were used in the present study. This is also a research gap of the present research.

2.6 Conceptual Framework of the Study

In scientific research, selection and measurement of variables constitute an important task. Studies on individual, group and society revealed that acceptance of modern technologies is conditional upon many factors. The conceptual framework of Rosenberg and Hovland (1960) was kept in mind while framing the structural arrangement for the dependent and independent variables of the study. The hypothesis of a research while constructed properly consist at least two important elements i.e.: a dependent variable and an independent variable. Variables together are the causes and the phenomenon is effect and thus, there is cause effect relationship everywhere in the universe for a specific events or issues.

This study is concerned with the 'effects of climate change on farmers' food and nutrition security'. Thus, climate change effects on farmers' food and nutrition security was the dependent variable and eleven selected characteristics of the farmers were considered as the independent variables under the study. Effects of climate change on

farmers' food and nutrition security may be affected through interacting forces of many independent variables. It is not possible to deal with all of the independent variables in a single study. It was therefore, necessary to limit the independent variables, which were age, level of education, family size, effective farm size, agricultural training experience, amount of agricultural credit, annual family income, Body Mass Index (BMI), agricultural extension media contact and knowledge on climate change for this study. Considering the above-mentioned situation and discussion, a conceptual framework has been developed for this study figure 2.1, which is diagrammatically presented in the following Figure 2.2.

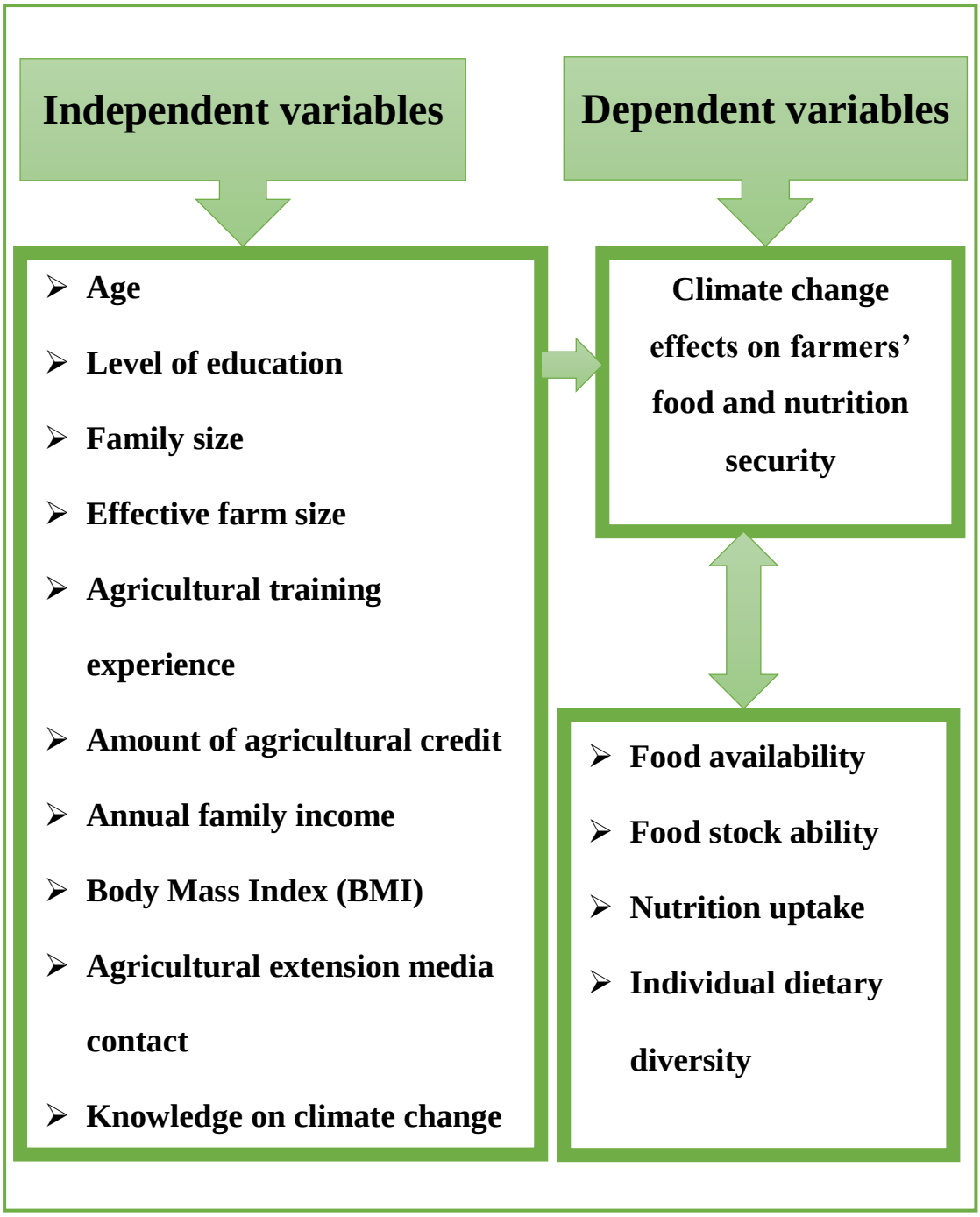

Figure 2.1 Conceptual Framework of the Study

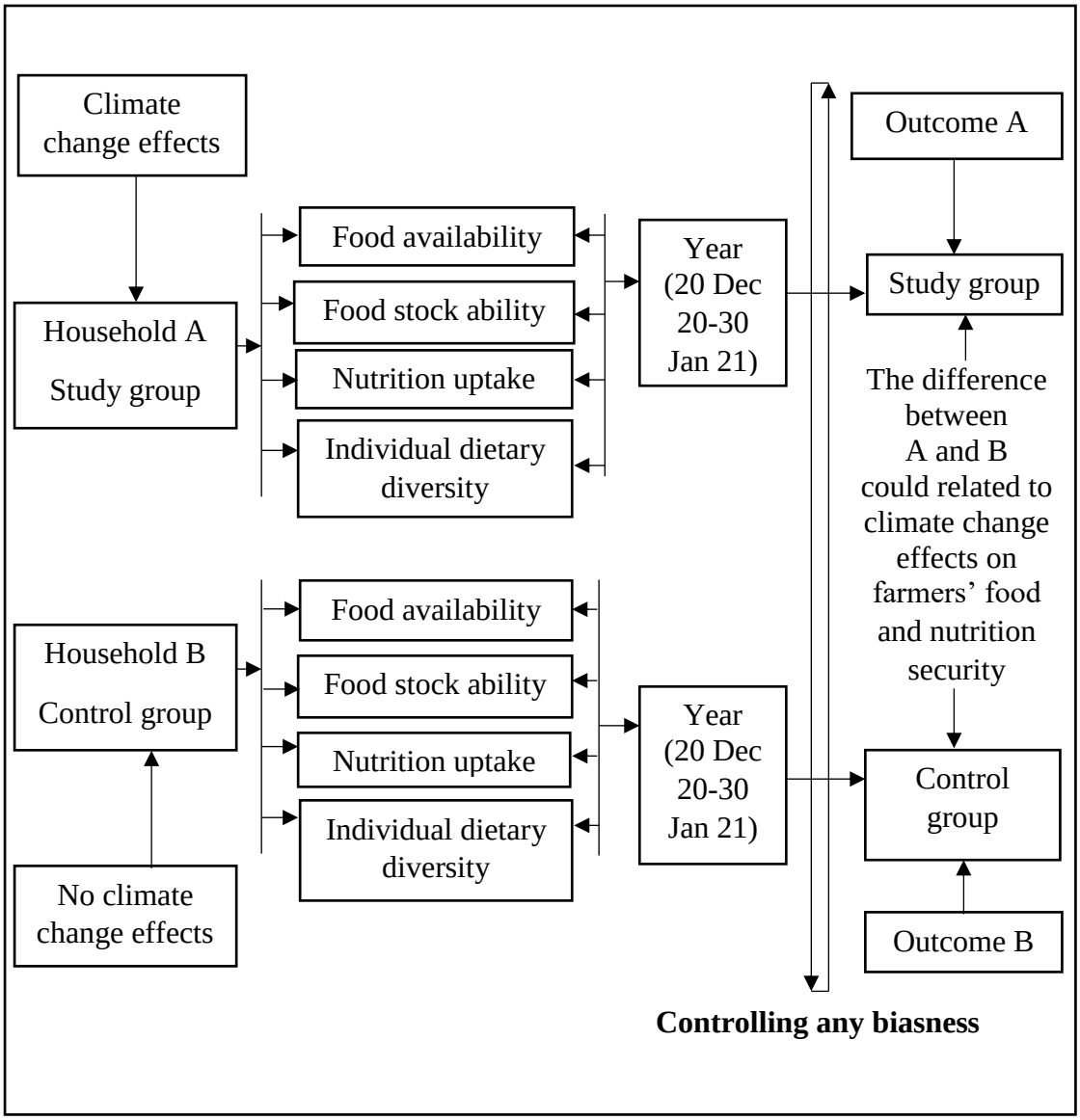

Figure 2.2 A schematic diagram of the proposed study: Effects of Climate Change on Farmers' Food and Nutrition Security

CHAPTER III

MATERIALS AND METHODS

The materials and methods used in conducting any research play a critically important role and deserve careful consideration by the researcher. Methodology gives clear direction to a researcher about the works and activities during the whole period of the study. According to Mingers (2001), research method is a structured set of guidelines or activities to generate valid and reliable research results. Appropriate procedures for collecting data were taken by the researcher to collect valid and reliable information. Methods of analysis were appropriate to arrive at correct conclusion. Various methods, tools and techniques were used during different stages of this research work and compilation of data. The purpose of this chapter was to describe the setting, methods and procedures used in conducting this study.

3.1 Research Design

A research design is a detailed plan of exploration. It is the diagram of the detailed procedure of testing the hypothesis and analysis of the obtained data. The research design followed in this study was ex-post facto, because of uncontrollable and non-manipulating variables. This is absolute descriptive and diagnostic research design. A descriptive research design is used for fact-findings with adequate interpretation. Diagnostic research design, on the other hand, is concerned with testing the hypothesis for specifying and interpreting the relationship of variables.

3.2 Locale of the Study

The study was conducted at Tangail sadar upazila under Tangail district of Bangladesh where people were affected by climate change. Climate change affected people were considered as a study group and climate change non-affected people were considered as a control group. Two unions of Tangail sadar upazila namely Kakua was selected as study group and Danya was selected as control group through purposively. Four villages were finally selected through random technique from the selected unions for study group. Similarly, two villages were finally selected through random technique from the selected unions for control group. A purposive sampling technique was followed to selected one district from all over the Bangladesh. A map of Tangail district showing the Sadar upazilla and a map of Tangail sadar upazila showing the union of the research area are presented in Fig. 3.1 & Fig. 3.2.

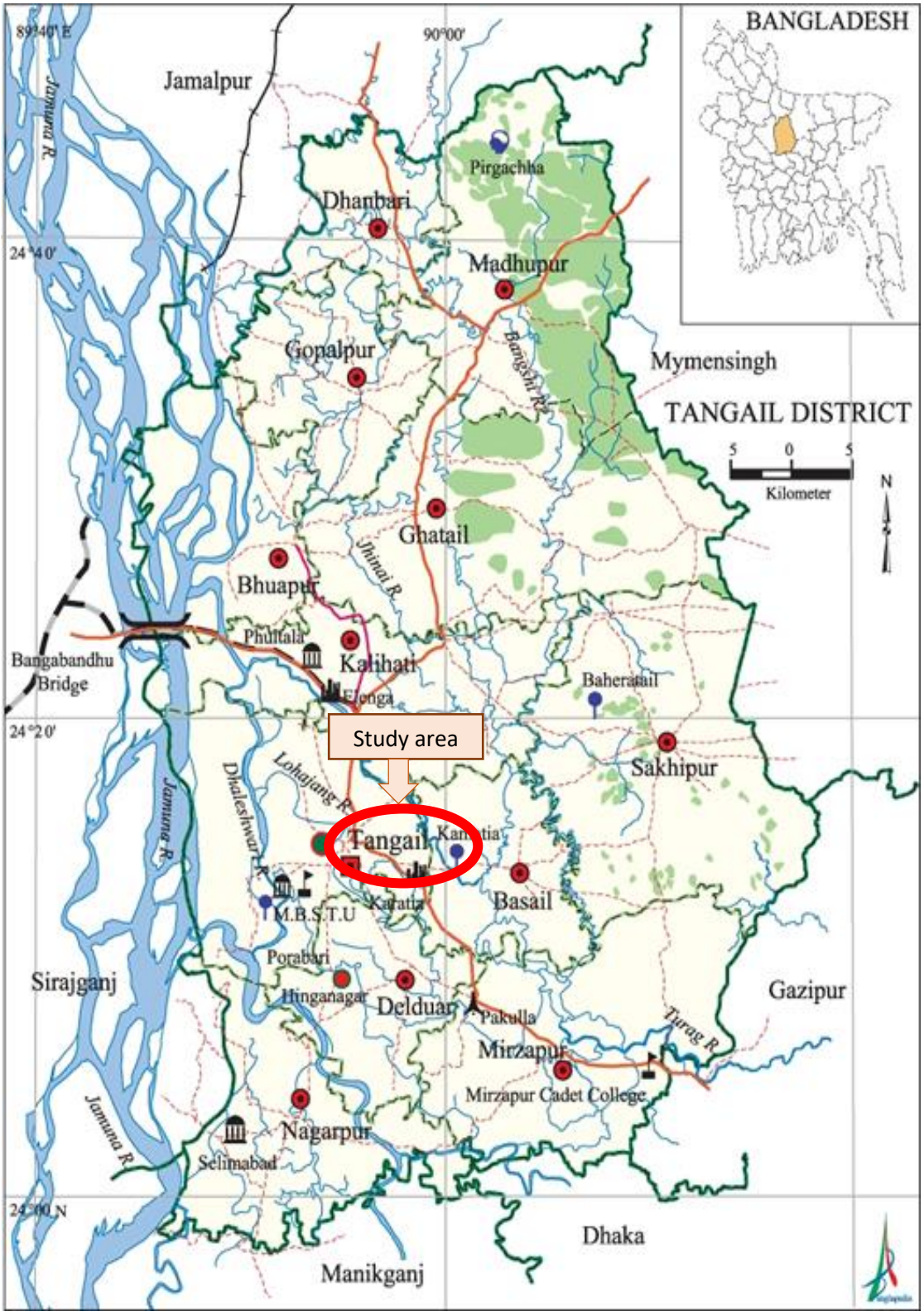

Figure 3.1 Map of Tangail District

Figure 3.2 Map of Tangail Sadar Upazilla

3.3 Population and Sampling Procedure

People who engaged farming activities and permanently reside in the selected villages of Kakua union constituted the active population of this study. As all population of the study area could not possible to measure, head of the farm families of Kakua, Kali keutil, Jawgara and Rangachira villages of Kakua union under Tangail sadar upazila were selected as the population of the study. However, representative sample from the population were taken for collection of data following random sampling technique. One farmer from each of the farm families was considered as the respondent. Updated lists of all the farmers of the selected villages were prepared with the help of SAAO and

local leader. A purposive sampling procedure was followed to select the study group. The total number of four village farmers in Kakua union are 1007; where 202 from Kakua village, 301 from Kali keutil village, 72 from jawgara village and 432 from Rangachira village under the Kakua union which constituted the population of the study. Control group farmers were selected in two villages from Daniya union. The total number of two village farmers in Daniya union are 260; where 150 from Sapua and 110 from Sreephaliata.

3.3.1 Determination of sample size

Total 1007 populations, the farmers comprising 100 (10% of total population) farmers' constituted the sample size as a study group. Thus the sample size for Kakua, Kali keutil, Jawgara and Rangachira were 20, 30, 7 and 43 respectively. The respondents' size of the control group was 33 farmers, which calculated as one-third of the sampling population number. The sample size for Sapua and Sreephaliata were 19 and 14 respectively.

3.3.2 Distribution of the population of sample size

A reserve list of ten percent both study group (10 farmers) and control group (3 farmers) were also prepared so that the farmers of this list could be used for interview if the farmers included in the original sample were not available at the time of conduction of interview. After determining both of the sample sizes for each of the group, a semi-structured questionnaire was developed and printed for conducting one to one interview. To reduce information distortion, one farmer from each of the farming family was included in the survey. Furthermore, to ensure similar socio-economic conditions for both the control and test groups, a two-way stratified random sampling technique was used (Wencong, 2015), in which education and farm size were considered as two individual strata (Rashid, 2014). Education was categorized into three groups: group 1 (denoted E_1), respondents are illiterate or can sign only; group 2 (denoted E_2), respondents have primary education, and group 3 (denoted E_3), respondents have secondary or higher education. Farm size was also categorized into three groups: group 1 (denoted F_1), small farm group (farm size up to 0.5 hectors); group 2 (denoted F_2), medium-farm group (farm size 0.51 to 1.0 hector), and group 3 (denoted F_3), large farm group (farm size above 1.0 hector). The two-way stratified random table is given as Table 3.2.The distribution of the population, sample size along

with the reserve list both study and control group farmers are given in the following Table 3.1.

Table 3.1 Distribution of population, sample and reserve list for the study

Selected Upazila	Group	Selected Union	Selected Villages	Population	Sample Size	Reserve List
Tangail Sadar Upazila	Study Group	Kakua	Jawgara	72	7	1
			Kakua	202	20	2
			Kali keutil	301	30	3
			Rangachira	432	43	4
	Sub total			1007	100	10
	Control Group	Danya	Sapua	150	19	2
			Sreephaliata	110	14	1
	Sub total			260	30	3
	Grand total			1267	133	13

Table 3.2 Two-way stratified random data of the study group and control group respondents based on their level of education and effective farm size as strata

Category	% of respondents	No. of respondents from study group	No. of respondents from control group (one-third of the study group)
$E_1 \times F_1$	3	3	1
$E_1 \times F_2$	18	18	6
$E_1 \times F_3$	3	3	1
$E_2 \times F_1$	15	15	5
$E_2 \times F_2$	27	27	9
$E_2 \times F_3$	6	6	2
$E_3 \times F_1$	13	13	4
$E_3 \times F_2$	8	8	3
$E_3 \times F_3$	7	7	2
Total	100	100	33

3.4 Minimizing Spill-over Effects

The study used a quasi-experimental survey design to resolve the problems of endogeneity at both location level and participant level. To overcome the transmission or contamination of information or knowledge from affected to non affected population, i.e. diffusion of treatment, and to avoid downward bias, all control respondents were selected from those villages where farmers' had not faced any major climatic threats. The study areas exclusively surveyed these selected villages, where no organizations implemented a similar program within the villages, or even outside the villages within a considerable surrounding area. Moreover, a large distance (about 3–5 km) was

maintained between the study and control group villages within the block (Hulme, 2000).

3.5 Data Collection Methods and Tools

3.5.1 Data collection methods

The survey method was used to collect quantitative data that allow to answer the research questions framed and to gain an understanding of the determinants of effects of climate change on Farmers' food and nutrition security. Individual interviews were used in the survey and were conducted in a face-to-face situation by the researcher. This method is useful to get unanticipated answers and to allow respondents to describe the world as they really see it rather than as the researcher does (Bryman, 2001).

3.5.2 Data collection instrument

A semi-structured interview schedule was prepared keeping in mind the objectives of the study. Direct questions and different scales were kept in the questionnaire to get the desired information. After preparation of data collection instrument pretest was conducted on 15% of the sample i.e. 20 respondents (15 climate change affected farmers and 5 climate change non-affected farmers) from the population but excluded from the sample. Necessary correction, addition and alternation were made in the interview schedule based on the pre-test. After correction, the interview schedule was finalized for the data collection.

3.5.3 Data collection

Data were collected personally by the researchers themselves through interview schedule from the sampled farm families of the selected areas. Before starting the collection of data, the researchers met the respective Upazila Agriculture Officer (UAO), Agriculture Extension Officer (AEO), Upazila Food Program Officer (UFPO), Assistant Health Inspector (AHI) and the concerned SAAOs. The researchers also discussed the objectives of the present study with the respondents and above mentioned officers and requested them to provide actual information. A rapport was established with the rural people so that they feel easy to answer the questions. The researchers took all possible care to establish rapport with the respondents so that they would not feel any indecision while starting the interview. A very good cooperation was obtained from the field extension workers and the local leaders. No serious difficulty was faced by the researchers during the collection of data. The interviews were made individually

in the houses of respondents. Questions were asked in different ways so that the respondents could easily understand the questions. Whenever a respondent faced difficulties in understanding any questions, care was taken to explain the same clearly with a view to enabling him/ her to answer it properly. Before going to the respondents home for interviewing they were informed verbally to ensure their availability at home as per schedule date and time. In the case of failure to collect information from the respondents due to their other business, a revisit was made with prior to appointments. If any respondent failed to understand any question, the researchers took great care to explain the issue. If the respondents could not clear about what was wanted to know then supplementary questions were asked for further clarification. The researcher received full cooperation from the respondents during the time of interview. The data were collected from December 20, 2020 to January 30, 2021.

3.6 Variables and Measurement Techniques

In a descriptive social research, selection and measurement of the variable is an important task. A variable is any characteristics that can assume varying or different values are successive individuals cases (Ezekiel and Fox, 1959). An organized research usually contains at least two identical elements i.e. independent and dependent variable. An independent variable is a factor, which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable is a factor, which appears, disappears or varies as the experimenter introduces, removes or varies the independent variables (Townsend, 1953). According to the relevance of the research area, the researcher selected 10 characteristics of the climate change affected farmers as the independent variables (e.g. age, level of education, family size, effective farm size, agricultural training experience, amount of agricultural credit, annual family income, body mass index, agricultural extension media contact and knowledge on climate change). On the other hand, the dependent variable was treated as climate change effects on farmers' food and nutrition security of this study. The methods and procedures in measuring the variables of this study are presented below:

3.6.1 Measurement of Independent Variables

For conducting the study in accordance with the objectives, it was necessary to measure the independent variables. The independent variables of the study were age, level of education, family size, effective farm size, agricultural training experience, amount of

agricultural credit, annual family income, body mass index, agricultural extension media contact and knowledge on climate change. The procedure followed in measuring the independent variables have been discussed in the subsequent sections bellow:

3.6.1.1 Age

Age of the farmers was measured in terms of actual years from their birth to the time of the interview, which was found on the basis of the verbal response of the rural people. A score of one (1) was assigned for each year of one's age. This variable appears in item number 1(1) in the interview schedule as presented in Appendix-I for study group. Based on the available information cited by the farmers, they were classified into three categories (MoYS, 2012).

Categories	Years
Young age	≤ 35
Middle age	36 to 50
Old age	≥ 50

3.6.1.2 Level of education

The education level of a rural farmer was measured by the number of years of schooling completed in an educational institution. A score of one (1) was given for each year of schooling completed. If a rural farmer didn't know how to read and write, his education score was zero, while a score of 0.5 was given to a rural farmer who could sign his name only. If a farmer did not go to school but took non-formal education, his educational qualification was determined as the equivalent to a formal school student. This variable appears in item number 1(2) in the interview schedule as presented in Appendix-I for study group and 1(1) in Appendix-II for control group. According to Reza (2007) the level of education of a respondent were classified as:

Category	Education (year of schooling)
Illiterate	(0)
Can sign only	.5
Primary education	1-5
Secondary education	6-10
Above secondary	>10

3.6.1.3 Family size

The family size of the respondents was measured by the total number of members in the family of a respondent. The family members included the respondent himself/herself, his/her spouse, children and other dependents who jointly live and eat together during interview time. It was measured by computing total number of member in the family. One score was given for each family member. This variable appears in item number 1(3) in the interview schedule as presented in Appendix-I. According to Haque (2002) based on their total family size, the respondents were classified into three categories:

Categories	Family members
Small family	1-4
Medium family	5-8
Large family	Above 8

3.6.1.4 Effective farm size

Farm size of a farmer referred to the total area of land on which his/her family carried out the farming operation, the area being in terms of full benefit to the family. The term refers to the cultivated area either owned by the farmer or cultivated on sharecropping, lease or taking from other including homestead area and measured using the following formula (Rashid, 2014):

$$FS = A + B + \frac{1}{2}(C + D) + E$$

Where,

FS = Farm size

A = Homestead area

B = Own land under own cultivation

C = Land taken from others as borga

D = Land given to other as borga

E = Land taken from others on lease

The data was first recorded in terms of local measurement unit i.e. bigha, or decimal and then converted into hectare. The total area, thus, obtained is considered as his farm size score (assigning a score of one for each hectare of land). This variable appears in item number 1(4) in the interview schedule as presented in Appendix-I. Based on their

total farm size, the farmers were classified into five categories according to Department of Agricultural Extension (DAE, 1999). This variable appears in item number 1(4) in the interview schedule as presented in Appendix-I for study group. This variable appears in item number 1(2) in the interview schedule as presented in Appendix-II for control group. According to DAE (1999) the level of education of a respondent were classified as:

Category	Area (hectare)
Landless	≤ 0.020
Marginal farmer	0.021 to 0.20
Small farmer	0.21 to 1.00
Medium farmer	1.01 to 3.00
Large farmer	>3.00

3.6.1.5 Agricultural training experience

Agricultural training exposure of a respondent was measured by the total number of days for which a respondent attended in different training programs on agriculture. If a respondent takes training for 5 days, he will get scores of 5. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely low, medium and high training exposure. This variable appears in item number 1(5) in the interview schedule as presented in Appendix-I.

3.6.1.6 Amount of agricultural credit

Access to agricultural credit of a respondent was measured on the basis of the farmers taken of amount of credit of selected four items such as Bank, microfinance or others training organization, credit from person(s) and friends. It was expressed in Taka. One score was given for 1000 taka. Based on their access to agricultural credit, the respondents were classified into three categories (Mean ± Standard Deviation) as low, medium and high access. This variable appears in item number 1(6) in the interview schedule as presented in Appendix-I.

3.6.1.7 Annual family income

Annual family income of a respondent were measured by taking sum of income amount in taka earned by a respondent and other member of the family in a year from sources such as: crop sector, livestock and fisheries sector and non-agricultural sector. On the basis of annual family income, the farmers were classified into three categories (national standard) namely low, medium and high annual family income. This variable appears in item number 1(7) in the interview schedule as presented in Appendix-I.

3.6.1.8 Body Mass Index (BMI)

Body mass index (BMI) is a measure of body fat based on height and weight that applies to adult men and women. The body mass index (BMI) is a statistic developed by Adolphe Quetelet in the 1900's for evaluating body mass (Eknoyan, 2007). It is not related to gender and age. It uses the same formula for men as for women and children. The body mass index is calculated based on the following formula (Bodyweight in kilograms divided by height in meters squared):

BMI = x KG / (y M × y M)

Where:

x = bodyweight in kilogram (KG)

y = height in meter (M)

Example for 175 cm height and 70 kg weight:

BMI = 70 / (1.75 × 1.75) = 22.86 and that result was counted score for every respondents. This variable appears in item number 1.8 in the interview schedule as presented in Appendix-I. The WHO regards a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI equal to or greater than 25 is considered overweight and above 30 is considered obese. Based on the available information cited by the farmers, they were classified into four categories according to (WHO, 2006) i.e. Underweight (<18.5), Normal weight (18.5–24.9), Overweight (25–29.9) and Obesity (BMI of 30 or greater). This variable appears in item number 1(8) in the interview schedule as presented in Appendix-I.

3.6.1.9 Agricultural extension media contact

Respondents were asked to indicate how frequently they have contact with 10 selected information sources to be replied as not at all, rarely, occasionally and regularly. Weights were assigned as 0 for not at all, 1 for rarely, 2 for sometimes and 3 for regularly contact. Thus the possible range of agricultural extension media contact score were 0 to 40. The farmers were classified into three categories on the basis of their exposure to farm information through communication exposure scores and distribution of the three categories (Mean ± SD) namely low, medium and high extension media contact. This variable appears in item number 1(9) in the interview schedule as presented in Appendix-I.

3.6.1.10 Knowledge on climate change

Knowledge of the farmers towards climate change was measured on 10 basic open-ended questions. Each question contains 2 marks. Knowledge of rural farmers was determined by summing up the weights for their responses to all the ten statements. Thus knowledge of the farmers towards climate change score of the respondents could range from 0 to 20, where zero (0) indicating no knowledge and 20 indicate sound knowledge Based on the knowledge on climate change scores, the farmers were classified into three categories (Mean ± SD) namely poor, moderate and sound knowledge on climate change. This variable appears in item number 1(10) in the interview schedule as presented in Appendix-I.

3.6.2 Measurement of Dependent Variable

The dependent variable was treated as climate change effects on farmers' food and nutrition security. Many researcher and research organization conducted research paper to measure the farmers' food and nutrition security conditions by selecting various indicators. In this paper, researcher selected two dimension of the dependent variable as a) farmers' food security and b) farmers' nutrition security. Farmers' food security had two selected sub dimension as i) food availability and ii) food stock ability. Farmers' nutrition security had two selected sub dimension as i) nutrition uptake and ii) individual dietary diversity to analysis the effects of climate change on farmers' food and nutrition security. The procedure followed in measuring the dependent variables have been discussed in the subsequent sections bellow:

3.6.2.1 Food availability

It was defined as farmers' available and variation of food. Food availability of a farmer was measured by asking him nine type of foods. Score on the basis of their availability of foods among their family members. Each respondents was asked to indicate his/her types of food availability with four alternative responses, like sufficient, less than sufficient, less available and always with shortage and score of four, three, two and one were assigned for those alternative responses, respectively. For unit free, scores were assigned for 1 to 9 foods (1), 10 to 18 foods (2), 19 to 26 foods (3) and above 26 foods (4). This variable appears in item number 2(a) (i) in the interview schedule as presented in Appendix-I for study group and Appendix-II for control group. Based on the

information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely low, medium and high food availability.

3.6.2.2 Food stock ability

The total number of meal stocked at his/her family determined food stock ability of a farmers' family. The measurement of food stock ability was followed by up to one day (up to 3 meals), up to one week (4 to 21 meals), up to one month (22 to 90 meals) and more than one month (>90 meals). The scoring was made by the 1 for each meal stock ability. For example, if a farmer had one-month food stock ability, his score was given as (90). For unit free, scores were assigned for up to 3 meals (1), 4 to 21 meals (2), 22 to 90 meals (3) and above 90 meals (4). This variable appears in item number 2(a) (ii) in the interview schedule as presented in Appendix-I for study group and Appendix-II for control group. Based on the information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely low, medium and high food stock ability of the farmers' family.

3.6.2.3 Nutrition uptake

It was measured based on calculated nutritive value of the daily food habit of the respondents. What type of food and how many times they are up taking? It was measured under the mentioned amount gm for each time breakfast, lunch, and dinner and other. The total daily average intake per person per day was converted into to nutritive value Kilocalorie following a standard chart. Score (1), were given each calorie of nutritive value. For unit free, scores were assigned for up to 800 calories (1), 801 to 1600 calories (2), 1601 to 2400 calories (3) and above 2400 calories (4). According to daily nutrition consumption, the nutrition security of the respondents was classified into three categories (Mean ± Standard Deviation) namely low, medium and high nutrition security. This variable appears in item number 2(b) (i) in the interview schedule as presented in Appendix-I for study group and Appendix-II for control group.

3.6.2.4 Individual dietary diversity

It was measured to examine the amount of balance diet taken against the essential food elements as carbohydrate, protein, fats and oils, vitamins and minerals. According to National institute of nutrition (2011) as referred the perfect balance diet for a person per day mentioned as those diet having fiber rich carbohydrate (25%), Protein (25%), Fat (10%), vitamin and minerals (40%). Farmers were asked to what extent they

maintain their diet to make it balance. Score (1), were given each percentage of elements they mentioned. For unit free, scores were assigned for up to 25% (1), 26% to 50% (2), 51% to 75% (3) and above 75% (4). For example if they mentioned their diet were as rich as having carbohydrates 25% then they obtained score against carbohydrates were 25. According to the farmers dietary diversity, the respondents was classified into three categories namely low balanced, partially balanced and completely balanced. This variable appears in item number 2(b) (ii) in the interview schedule as presented in Appendix-I for study group and Appendix-II for control group.

3.7 Hypothesis of the Study

According to Kerlinger (1973), a hypothesis is a conjectural statement of the relation between two or more variables. Hypothesis are always in declarative sentence form and they are related, either generally or specifically from variables to variables. In broad sense hypotheses are divided into two categories: (a) Research hypothesis and (b) Null hypothesis.

3.7.1 Research hypothesis

Based on review of literature and development of conceptual framework, the following research hypothesis was formulated: "Each of the 10 selected characteristics (age, level of education, family size, effective farm size, agricultural training experience, amount of agricultural credit, annual family income, Body Mass Index (BMI), agricultural extension media contact and knowledge on climate change) of the farmers has significant contribution to farmers' food and nutrition security."

3.7.2 Null hypothesis

A null hypothesis states that there is no contribution between the concerned variables. The following null hypothesis was formulated to explore the contribution of the selected characteristics of the farmers. Hence, in order to conduct tests, the earlier research hypothesis was converted into null form as follows: "There is no contribution of the selected characteristics (age, level of education, family size, effective farm size, agricultural training experience, amount of agricultural credit, annual family income, Body Mass Index (BMI), agricultural extension media contact and knowledge on climate change) to farmers' food and nutrition security".

3.8 Data Processing and Analysis

Bogdan and Biklen (2006) insist that data analysis is an on-going part of data collection. Initially, all collected data were carefully entered in Access, exported to Microsoft Excel. Exported data were checked randomly against original completed interview schedule. Errors were detected and necessary corrections were made accordingly after exporting. Further consultation with research assistants and in some cases with the community people were required. Finally, data were exported from the program Microsoft Excel to SPSS version 26.0, which offered statistical tools applied to social sciences. Qualitative data were converted into quantitative numbers, if required, after processing, scaling and indexing of the necessary and relevant variables to perform subsequent statistical analysis for drawing inferences. As outlined earlier, many different forms and methods can be used to analyze both quantitative and qualitative data in accordance with the objectives of the study. Both descriptive and analytical methods were employed in order to analyze the data. Descriptive techniques have been used to illustrate current situations, describe different variables separately and construct tables and graphs presented in results. These included: frequency distribution, percentage, range, mean, median and standard deviation. The sample sizes in the two groups (study group and control group) were not equal and were therefore, estimated separately. Independent two sample t-test were used to assess differences between means and measure the effects in this study. In most cases the opinions of respondents were grouped in broader categories. Analytical techniques have been utilized to investigate the contribution of the selected characteristics of farmers' food and nutrition security. Statistical test like multiple regression analysis was used in this study. Each statistical technique is used under specific conditions and depends on measurement scale of different variables.

3.8.1 Regression Analysis

Regression analysis was used to identify the linear combination between independent variables used collectively to predict the dependent variables (Miles and Shevlin, 2001). Regression analysis helps us understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Ordinary Least Squares (OLS) is used most extensively for estimation of regression functions. In short, the method chooses a regression where the sum of residuals, ΣUi is as small as possible (Gujarati, 1995). The

overall quality of fit of the model has been tested by ANOVA specifically F and R^2 test. The data were analyzed in accordance with the objectives of the proposed research work. Independent two sample t-test were used to assess the effects of climate change among study and control group farmers'. The factors that contribute to farmers' food and nutrition security were analyzed using a regression model, multiple regression analysis (β) was used. Throughout the study, five (0.05) percent level of significance were used as the basis for rejecting any null hypothesis. If the computed value of (β) was equal to or greater than the designated level of significance (p), the null hypothesis was rejected and it was concluded that there was a significant contribution between the concerned variable. Whenever the computed value of (β) was found to be smaller at the designated level of significance (p), the null hypothesis could not be rejected. It was concluded that there was no contribution of the concerned variables. The model used for this analysis can be explained as follows:

$$Y_i = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + b_{10}x_{10} + e$$

(i=1, 2, 3, 4)

Where,

$Y_{i=1}$ is the farmers' food security

$Y_{i=2}$ is the farmers' nutrition security

$Y_{i=3}$ is the farmers' food and nutrition security

Of the independent variables, x_1 is the age of farmer, x_2 is level of education, x_3 is family size, x_4 is effective farm size, x_5 is agricultural training experience, x_6 is amount of agricultural credit, x_7 is annual family income, x_8 is Body Mass Index (BMI), x_9 is agricultural extension media contact and x_{10} is knowledge on climate change. On the other hand, b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9 and b_{10} are regression coefficients of the corresponding independent variables, (e) is random error, which is normally and independently distributed with zero mean and constant variance and (a) is constant value of the regression equation.

CHAPTER IV

RESULTS AND DISCUSSION

The recorded observations in accordance with the objective of the study were presented and probable discussion was made of the findings with probable, justifiable and relevant interpretation under this chapter. The findings of the study and their interpretation have been presented in this chapter. These are presented in three sections according to the objectives of the study. The first section deals with the selected characteristics of the farmers, while the second section deals with the climate change effects on farmers' food and nutrition security. The third section deals with Contribution of selected characteristics of the farmers on their food and nutrition security.

4.1 Selected Characteristics of the Respondents

Reactions of an individual is determined to a large extent by one's personal characteristics. There were various characteristics of the farmers that might have consequence to fight against climate change. But in this study, eleven characteristics of them were selected as independent variables, which included their age, level of education, family size, effective farm size, agricultural training experience, amount of agricultural credit, annual family income, body mass index, agricultural extension media contact, knowledge on climate change that might be greatly influenced the farmers food and nutrition security. The findings of the ten selected characteristics of the respondents have been discussed in ten subsections. A brief summary of the characteristic profile of the respondents like measuring unit, categories, and distribution, mean, standard deviation have been presented as follows in Table 4.1.

Table 4.1 Characteristics profile of the respondents

Sl. No.	Characteristics	Measuring Unit	Range		Mean	Standard Deviation
			Possible	Observed	Study group	Study group
1.	Age	Year	-	30-65	45.16	9.21
2.	Level of education	Year of Schooling	-	0-12	4.23	3.55
3.	Family size	Score	-	3-11	5.95	2.27
4.	Effective farm size	ha.	-	0.07-3.20	1.09	0.85
5.	Agricultural training experience	no. of days	-	1-6	2.34	1.20
6.	Amount of agricultural credit	'000' taka	-	10-80	25.45	19.07
7.	Annual family income	'000' taka	-	40-200	87.15	45.86
8.	Body Mass Index	kg/m^2	-	16.55-25.12	20.49	2.33
9.	Agricultural extension media contact	Score	0-40	16-34	22.36	4.30
10.	Knowledge on climate change	Score	0-20	7-15	10.62	1.857

4.1.1 Age

Age of the farmers ranged from 30 to 65 years with a mean of 45.16 years and standard deviation of 9.21. Considering the recorded age farmers were classified into three categories namely young, middle and old aged following MoYS (2012). The distributions of the farmers in accordance of their age is presented in Table 4.2.

Table 4.2 Distribution of the farmers according to their age

Category	Basis of categorization (years)	Observed range (years)	Farmers		Mean	SD
			Number	Percent		
Young age	≤ 35	30-65	17	17	45.16	9.21
Middle age	36-50		57	57		
Old age	> 50		26	26		
Total			100	100		

Data furnished in the Table 4.2 shows that the middle aged respondents group was higher than old aged and young aged group. It was found that 57 percent of the respondents were middle-aged, 26 percent of the respondents were old and rest 17 percent were young (Table 4.2). Nasreen *et al.* (2013) in different study area where young aged respondents group was higher than the middle and old aged respondents

groups observed different result. It seems that climate change effects decrease young and old farmers for non- farming, but middle aged may be indicated that middle aged farmers can carry challenges more as they have comparatively more energy and have experienced.

4.1.2 Level of education

The level of educational scores of the farmers ranged from 0 to 12 with a mean and standard deviation of 4.23 and 3.55, respectively. Based on the educational scores, the farmers were classified into five categories. The distributions of farmers according to their level of education is presented in Table 4.3.

Table 4.3 Distribution of the respondents according to their education

Category	Basis of categorization (Score)	Observed range (Score)	Farmers		Mean	SD
			Number	Percent		
Illiterate	0	0-12	6	6	4.23	3.55
Can sign only	.5		21	21		
Primary education	1-5		38	38		
Secondary education	6-10		31	31		
Higher secondary education	>10		4	4		
Total			100	100		

Results presented that highest number of the respondents were in primary education level where lowest number of the respondents were higher secondary level. Nasreen *et al.* (2013) observed similar result where the highest number of respondents were completed up to primary education level. However, Reza (2007) observed contradictory result where highest number of respondents were educated up to secondary level education. It seems that due to lack of available support from family they were unable to continue their secondary and higher study.

4.1.3 Family size

Family size of the farmers ranged from 3 to 11 with the mean and standard deviation of 5.95 and 2.27, respectively. According to family size the farmers were classified into three categories (Mean ± Standard Deviation) viz. ‘small’, ‘medium’ and ‘large’ family. The distribution of the farmers according to their family size is presented in Table 4.4.

Table 4.4 Distribution of the respondents according to their family

Category	Basis of Categorization (years)	Observed range (Score)	Farmers		Mean	SD
			Number	Percent		
Small family	≤ 3 (Mean-1SD)	3-11	12	12	5.95	2.27
Medium family	4-8 (Mean ± SD)		73	73		
Large family	> 8 (Mean+1SD)		15	15		
Total			100	100		

Data presented in table 4.4 indicated that 73 percent of the farmers had medium family size, while 12 percent of the farmers were small family and 15 percent had large family size. The findings indicated that average family size of the study area was bigger than the national average that is 4.85 (BBS, 2014). It seems that the family size is bigger than the national average might be due to laggardness of size control progress, lack of enjoyment facilities and lack of awareness in their daily life.

4.1.4 Effective farm size

The effective farm size of the farmers ranged from .07 ha to 3.20 ha. with a mean and standard deviation of 1.09 and .85, respectively. Based on their farm size, the farmers were classified into five categories following the categorization according to DAE (1999). The distribution of the farmers according to their farm size is presented in Table 4.5.

Table 4.5 Distribution of the farmers according to their effective farm size

Category	Basis of categorization (ha.)	Observed range (ha.)	Farmers		Mean	SD
			Number	Percent		
Landless	(≤.02)	0.07-3.20	0	0	1.09	0.85
Marginal	(0.021-0.20)		16	16		
Small	(0.21-1.00)		39	39		
Medium	(1.01-3.0)		41	41		
Large	(>3)		4	4		
Total			100	100		

Results presented in Table 4.5 indicate that 39 percent of the farmers had small farm size, while 41 percent of the farmers had medium, 16 percent had small farm size and 4 percent had large farm size. Data presented in the Table 4.5 indicate that most of the respondents had medium farm size where small marginal and large farm size was lower than medium farm size. There were no farmers with marginal farm. Similar result was

observed Nasreen *et al.* (2013) highest respondents were small farm sized. It seemed that most of the farmers in the study area were faced riverbank erosion and flood due to the effect of climate change.

4.1.5 Agricultural training experience

Training experience score of the farmers ranged from 1 to 6 with a mean and standard deviation of 2.34 and 1.20 respectively. Based on the training experience score, the farmers were classified into three categories (Mean ± Standard Deviation) viz namely 'low', 'medium' and 'high' training experience. The distribution of the farmers according to their training experience is presented in Table 4.6.

Table 4.6 Distribution of the farmers according to their training experience

Category	Basis of categorization (no. of days)	Observed range (no. of days)	Farmers		Mean	SD
			Number	Percent		
Low training	≤2 (Mean-1SD)	1-6	64	64	2.34	1.20
Medium training	2-4 (Mean ± SD)		29	29		
High training	> 4 (Mean+1SD)		7	7		
Total			100	100		

Results presented in Table 4.5 indicate 64 percent respondents had low experience while 29 percent respondents had low experience and 7 percent had high experience. Information furnished in the Table 4.6 amplify that the respondent having lower training experience were higher than the respondents having medium and high training experience respectively. Similar result was observed by Poddar (2015) where highest number of respondents were in low training experience. It seems that farmers were not interested in training experience due to lack of proper organizational support, lack of proper communication channel and unconsciousness.

4.1.6 Amount of agricultural credit

The score of amount of agricultural credit of the farmers ranged from 10 to 80 thousand (BDT) with a mean and standard deviation of 25.45 and 19.07, respectively. Haque (2002) classified the access to finance into three categories as low, medium and high. The distribution of the farmers according to their amount of agricultural credit is presented in Table 4.7.

Table 4.7 Distribution of the farmers according to their amount of agricultural credit

Category	Basis of categorization (‘000’ Taka)	Observed range (‘000’ Taka)	Farmers		Mean	SD
			Number	Percent		
Low amount	≤24	10-80	69	69	25.45	19.07
Medium amount	25-45		18	14		
High amount	> 45		13	17		
Total			100	100		

Results presented in Table 4.7 indicate 69 percent respondents had to get low amount while 18 percent respondents had to get medium amount and 13 percent had to get high amount. But contradictory result was observed Haque (2002) revealed that the majority (49.6%) of the farmers had medium amount to finance as compared to 33.3% and 17.1% having high and low amount to finance respectively. It seems that farmers are involved in taking low amount of agricultural credit or lack of proper organizational facilities.

4.1.7 Annual family income

The score of annual family income of the farmers ranged from 40 to 200 thousand (BDT) with a mean and standard deviation of 87.15 and 45.86, respectively. On the basis of annual family income, the farmers were classified into three categories (national standard) namely low, medium and high annual family income. The distribution of the farmers according to their annual family income is presented in Table 4.8.

Table 4.8 Distribution of the farmers according to their annual family income

Category	Basis of categorization (‘000’ Taka)	Observed range (‘000’ Taka)	Farmers		Mean	SD
			Number	Percent		
Low income	≤80	40-200	60	60	87.15	45.86
Medium income	81-160		30	30		
High income	> 160		10	10		
Total			100	100		

Data presented in the Table 4.8 shows that 60 percent respondent had low income, 30 percent had medium income and 10 percent had high income. However, Reza (2007) observed contradictory result found the highest number of respondents were medium

annul income. It seems that the results might have due to the climate changing effects on their farming production and economy at the study area.

4.1.8 Body Mass Index (BMI)

Body Mass Index (BMI) score of the farmers ranged from 16.55 to 25.12 with a mean and standard deviation of 20.49 and 2.32, respectively. Based on the Body Mass Index (BMI) score, the farmers were classified into four categories according to (WHO, 2006). The distribution of the farmers according to their Body Mass Index (BMI) is presented in Table 4.9.

Table 4.9 Distribution of the farmers according to their Body Mass Index

Category	Basis of categorization (kg/m^2)	Observed range (kg/m^2)	Farmers		Mean	SD
			Number	Percent		
Underweight	≤18.5	16.55-25.12	17	17	20.49	2.32
Normal weight	18.5–24.99		74	74		
Overweight	25–29.99		9	9		
Obesity	≥30		0	0		
Total			100	100		

Table 4.9 indicates that the highest proportion 74 percent of the farmers had normal weight compared to 17 percent in underweight and 9 percent in overweight. No farmers were found in obesity category. Noman (2016) observed similar result where highest number of respondents were in normal weight category. It seems that the supply of daily food in the farmers' family and their daily hard works keep them in normal weight.

4.1.9 Agricultural extension media contact

The observed score of agricultural extension media contact of the farmers ranged from 16 to 34. The mean score of the farmers' extension media contact was 22.36 with a standard deviation 4.30. The farmers were classified into three categories on the basis of their exposure to farm information through communication exposure scores and distribution of the three categories (Mean ± SD) namely low, medium and high extension media contact as shown in Table 4.10.

Table 4.10 Distribution of the respondents according to their extension media contact

Category	Basis of categorization (Score)	Observed range (Score)	Farmers		Mean	SD
			Number	Percent		
Low contact	≤21 (Mean-1SD)	16-34	44	44	22.36	4.30
Medium contact	22-26 (Mean ± SD)		38	38		
High contact	> 26 (Mean+1SD)		18	18		
Total			100	100		

Table 4.10 indicates that the highest proportion 44 percent of the farmers had low extension media contact, 38 percent of farmers had medium extension media contact and 18 percent were felt under low extension media contact. Similar result was observed by Poddar (2015) where maximum number of respondents were in low media contact. It seems that low extension media contact might be the reason of having low educational background of the farmers.

4.1.10 Knowledge on climate change

Knowledge on climate change scores of the farmers ranged from 7 to 15. The average score and standard deviation were 10.62 and 1.85 respectively. Based on the knowledge on climate change scores, the farmers were classified into three categories (Mean ± SD) namely poor, moderate and sound knowledge on climate change is presented in Table 4.11.

Table 4.11 Distribution of the respondents according to knowledge on climate change

Category	Basis of categorization (Score)	Observed range (Score)	Farmers		Mean	SD
			Number	Percent		
Poor knowledge	≤8 (Mean-1SD)	7-15	14	14	10.62	1.85
Moderate Knowledge	9-12 (Mean ± SD)		68	68		
Sound Knowledge	> 13 (Mean+1SD)		18	18		
Total			100	100		

Results presented in the Table 4.11 indicates that 68 percent respondents having moderate knowledge which were higher where 14 percent and 18 percent respondents

had poor knowledge and good knowledge respectively. Similar result was observed by Poddar (2015) where maximum number of respondents were kept moderate knowledge on climate change. It may be indicated that most of the farmers in the study area had primary level of education and they might be faced different types of climatic vulnerability that's why they had moderate knowledge on climate change.

4.2 Climate Change Effects on Farmers' Food and Nutrition Security

Climate change effects on farmers' food and nutrition security had two-selected dimension as a) farmers' food security and b) farmers' nutrition security. Farmers' food security had two-selected sub dimension viz. i) Food availability ii) Food stock ability. Farmers' nutrition security had two selected sub dimension viz. i) Nutrition uptake ii) Individual dietary diversity. The result of different sub dimension were presented in bellow:

4.2.1 Farmers' Food Security

4.2.1.1 Food availability

Food availability scores of the farmers ranged from 15 to 31. The average score and standard deviation were 20.63 and 4.29 respectively. Based on the scores, the farmers were classified into three categories (Mean ± SD) namely low, medium and high food availability. Distribution of the farmers according to their food availability is presented in Table 4.12.

Table 4.12 Distribution of the farmers according to their food availability

Category	Basis of categorization (Score)	Observed range (Score)	Farmers		Mean	SD
			Number	Percent		
Low food availability	≤19 (Mean-1SD)	15-31	46	46	20.63	4.29
Medium food availability	20-25 (Mean ± SD)		38	38		
High food availability	> 25 (Mean+1SD)		16	16		
Total			100	100		

Results presented in the Table 4.12 reveals that the food availability of the farmers were highest in low level, it was 46 percent and medium food availability was closer to the low food availability as 38 percent. Noman (2018) observed different findings where maximum number of the respondents were in medium food availability category. The

high food availability category constituted by 16 percent farmers. It seems that high climate change consequences, lower economic status and lack of good agricultural production that's why most of the farmers had low and medium food availability status.

4.2.1.2 Food stock ability

Food stock ability scores of the farmers ranged from 21 to 180 and the average score and standard deviation were 66.64 and 42.61, respectively. Based on the number of days, the farmers were classified into three categories (Mean ± SD) namely low, medium and high food stock ability. Distribution of the farmers according to their food stock ability is presented in Table 4.13.

Table 4.13 Distribution of the farmers according to their food stock ability

Category	Basis of categorization (no. of days)	Observed range (no. of days)	Farmers		Mean	SD
			Number	Percent		
Low stock ability	≤59 (Mean-1SD)	21-180	50	50	66.64	42.61
Medium stock ability	60-110 (Mean ± SD)		30	30		
High stock ability	> 110 (Mean+1SD)		20	20		
Total			100	100		

Results presented in the Table 4.13 reveals that the food stock ability of the farmers were highest in low level, it was 50 percent. Medium food stock ability and high food stock ability category constituted by 30 and 20 percent farmers respectively. Similar result was observed by Kisar (2018) but different result was observed by Noman (2016) where medium stock ability was higher. It seems that climate change effects on their economic status, food production and migrant them to non-farming activity that's why most of the farmers had the low food stock ability.

4.2.2 Farmers' Nutrition Security

4.2.2.1 Nutrition uptake

Nutrition uptake scores of the farmers ranged from 16 to 25.15 and the average score and standard deviation were 19.18 and 2.57 respectively. Based on the number of days, the farmers were classified into three categories (Mean ± SD) namely low, medium and high nutrition uptake is presented in Table 4.14.

Table 4.14 Distribution of the farmers according to their nutritional uptake

Category	Basis of categorization (‘00’ kcal.)	Observed range (‘00’ kcal.)	Farmers		Mean	SD
			Number	Percent		
Lower uptake	≤18.99 (Mean-1SD)	16-25.15	59	59	19.18	2.57
Medium uptake	19-21 (Mean ± SD)		23	23		
High uptake	> 21 (Mean+1SD)		18	18		
Total			100	100		

Results presented in the Table 4.14 reveals that the changes in nutrition uptake of the respondents were highest in lower level uptake as 59 percentage. Medium nutrition uptake and high nutrition uptake category constituted by 23 and 18 percent farmers respectively. Different result was observed Kisar (2018) and Noman (2016) where highest number of the respondents were in medium nutrition uptake category. It seems that the most of the respondents were poor in nutrition consumption. It might be due to climate change effects on food production and economy of the respondents.

4.2.2.2 Individual dietary diversity

Dietary diversity of the farmers ranged from 40 to 100 with a mean and standard deviation of 56.60 and 14.44 respectively. Based on farmers dietary diversity, the daily dietary of farmers’ were classified in according to National institute of nutrition (2011). The distribution of the farmers according to their dietary diversity is presented in Table 4.15.

Table 4.15 Distribution of the farmers according to their dietary diversity

Category	Basis of categorization (‘%’ nutrients)	Observed range (‘%’ nutrients)	Farmers		Mean	SD
			Number	Percent		
Low balanced	≤59	40-100	62	62	56.60	14.44
Partially balanced	60-80		31	31		
Completely balanced	> 80		7	7		
Total			100	100		

Results presented in the Table 4.15 reveals that the dietary diversity of the respondents were highest in low balanced as 62 percentage. Partially balanced and completely balanced dietary diversity category constituted by 31 and 7 percent farmers respectively. It seems that the most of the respondents were poor and having poor knowledge on balance diet. It might be due to climate change effects on food production and economy of the respondents.

4.2.3 Effects of Climate Change on Study Group Farmers' vs Control Group Farmers'

A comparison between study group and control group was done to find out the effects of climate change on farmers' food and nutrition security. Study group farmers were considered them who faced the climate change effects and control group farmers were considered them who did not face the climate change effects. Climate change had mentionable negative effects on study area farmers' in the Jamuna river side areas of Tangail sadar upazila. Study group mean score was found 11.79 while the control group gained 14.45. The distributions of climate change effects on farmers' food and nutrition security with respect to study group and control group respondents are shown in table 4.16.

Table 4.16 Distribution of study group and control group respondents level of climate change effects on food and nutrition security based on their mean value differences

Farmers' food and nutrition security indicators	Study group mean value	Control group mean value	t-test value
Food availability	3.03	3.39	-3.20**
Food stock ability	3.06	3.79	-6.197**
Nutrition uptake	2.85	3.42	-6.590**
Individual dietary diversity	2.85	3.85	-9.381**
Sum	11.79	14.45	-9.493**

** Significant at .000-.009 (1% level) * Significant at .010-.049 (5% level)

Effects of climate change on farmers' food and nutrition security

= Mean score of study group farmers - Mean score of control group farmers

= 11.79 – 14.45

= -2.66

The score of effects of climate change on farmer' food and nutrition security was found -2.66. So, there was a significant negative effects of climate change on farmer' food and nutrition security in the study area. Beside the score value, it was also found the significant negative effects of study group farmers' as well as the effects of climate change on food and nutrition security at 1% significance value from t-test compared with control group farmers' where they did not face the climate change effects. In addition, significant negative effects of climate change on study group respondents were observed by Poddar (2015 and value was -1.86, but study area was different. It concluded that climate change effects on study area and it makes different from study group to control group farmers for food and nutrition security. The policy should be concerned on the effects of climate change on farmers' and their food and nutrition security. It's may be recommended that the government should take serious steps and make sustainable development along with NGOs, international organizations and others donor organizations for climate change effects on farmers'.

4.3 Contribution of Selected Characteristics of the Farmers on Food and Nutrition Security

In order to assess the Contribution of selected characteristics of the farmers' on food and nutrition security, multiple regression analysis was conducted.

4.3.1 Contributing characteristics related to farmers' food security

Table 4.17 shows that there is a significant contribution of agricultural training experience, annual family income, body mass index and knowledge on climate change. Of these, annual family income was the most important contributing factors (significant at the 1% level of significance). Agricultural training experience, body mass index and knowledge on climate change (significant at the 5% level of significance) was also important contributing while coefficients of other selected variables don't have any significant contribution on farmers' food security.

Table 4.17 Multiple regression coefficients of contributing variables related to farmers' food security

Dependent Variable	Independent variables	β	*P*	R^2	Adj. R^2	F
Farmers' food security	Age	.045	.577	.643	.599	14.43
	Level of education	-.022	.792			
	Family size	.049	.469			
	Effective farm size	.138	.284			
	Agricultural training experience	.142	.050*			
	Amount of agricultural credit	.053	.499			
	Annual family income	.523	.000**			
	Body mass index	.165	.026*			
	Agricultural extension media contact	.101	.220			
	Knowledge on climate change	.221	.012*			

** Significant at .000-.009 (1% level) * Significant at .010-.049 (5% level)

The value R^2 (0.643) means that independent variables accounts for 64% of the variation in farmers' food security. Therefore, the adjusted R^2 value (0.599) tells us how much variance in Y (Farmers' food security) would be accounted if the model has been deprived from the populations from which the sample was taken. Adjusted R-square value (0.599) also indicates the addition of future predictors in the model and shows the variance in food security of the respondents and the models were suitable. The F ratio is 14.43 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable. All significant predictors have positive β-values indicates if values of predictors increases so do the extent of change in farmers' food security as vice-versa. Therefore, the β-value of annual family income, Body Mass Index (BMI), agricultural training experience and knowledge on climate change is positive value of 0.523, 0.165, 0.523 and 0.221. Therefore, it can be stated that as annual family income, Body Mass Index (BMI), agricultural training experience and knowledge on climate change increase by one unit, increased in farmers' food security by 0.523, 0.165 and 0.221 units respectively. In summary, the models suggest that the NGOs, DAE and other organizations should consider farmers' agricultural training exposure, annual family income, body mass index and knowledge on climate change while offering and implementing any sustainable agricultural development program or policy associate with farmers' food security.

4.3.2 Contributing characteristics related to farmers' nutrition security

Table 4.18 shows that there is a significant contribution of agricultural training experience, annual family income, agricultural extension media contact and knowledge on climate change. Of these, agricultural extension media contact was the most important contributing factors (significant at the 1% level of significance). Agricultural training experience, annual family income and knowledge on climate change (significant at the 5% level of significance) was also important contributing while coefficients of other selected variables don't have any significant contribution on farmers' nutrition security.

Table 4.18 Multiple regression coefficients of contributing variables related to farmers' nutrition security

Dependent Variable	Independent variables	β	*P*	R^2	Adj. R^2	F
Farmers' nutrition security	Age	.052	.567	.545	.489	9.59
	Level of education	.009	.926			
	Family size	.100	.190			
	Effective farm size	-.213	.144			
	Agricultural training experience	.171	.037*			
	Amount of agricultural credit	.053	.552			
	Annual family income	.337	.029*			
	Body mass index	.143	.086			
	Agricultural extension media contact	.512	.000**			
	Knowledge on climate change	.226	.022*			

** Significant at .000-.009 (1% level) * Significant at .010-.049 (5% level)

The value of R^2 (0.545) means that independent variables accounts for 54% of the variation in farmers' nutrition security. Therefore, the adjusted R^2 value (0.489) tells us how much variance in Y (Farmers' nutrition security) would be accounted if the model has been deprived from the populations from which the sample was taken. Adjusted R-square value (0.489) also indicates the addition of future predictors in the model and shows the variance in nutrition security of the respondents and the models were suitable. The F ratio is 9.59 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable. All significant predictors have positive β-values indicates if values of predictors increases so do the extent of change in farmers' nutrition security as vice-versa. Therefore, it can be stated that as annual family income, agricultural extension media

contact and knowledge on climate change increase by one unit, increased in farmers' nutrition security by 0.337, 0.512, 0.171 and 0.226 units respectively. In summary, the models suggest that the NGOs, DAE and other organizations should consider farmers' agricultural training experience, annual family income, agricultural extension media contact and knowledge on climate change while offering and implementing any sustainable agricultural development program or policy associate with farmers' nutrition security.

4.3.3 Contributing characteristics related to farmers' food and nutrition security

Table 4.19 shows that there is a significant contribution of agricultural training experience, annual family income, body mass index, agricultural extension media contact and knowledge on climate change. All the five significant variables were the most important contributing factors (significant at the 1% level of significance). While coefficients of other selected variables do not have any significant contribution on farmers' food and nutrition security.

Table 4.19 Multiple regression coefficients of contributing variables related to farmers' food and nutrition security

Dependent Variable	Independent variables	β	*P*	R^2	Adj. R^2	F
Farmers' food and nutrition security	Age	.056	.434	.718	.683	20.41
	Level of education	-.012	.876			
	Family size	.081	.178			
	Effective farm size	-.001	.996			
	Agricultural training experience	.180	.006**			
	Amount of agricultural credit	.062	.373			
	Annual family income	.528	.000**			
	Body mass index	.184	.006**			
	Agricultural extension media contact	.309	.000**			
	Knowledge on climate change	.262	.001**			

** Significant at .000-.009 (1% level) * Significant at .010-.049 (5% level)

The value of R^2 (0.718) means that independent variables accounts for 71% of the variation in farmers' food and nutrition security. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted R^2 value (0.683) tells us how much variance in Y (Farmers' food and nutrition security) would be accounted if the model has been deprived from the populations from which the sample was taken.

Adjusted R-square value (0.683) also indicates the addition of future predictors in the model and shows the variance in food security of the respondents and the models were suitable. The F ratio is 20.41 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable. All significant predictors have positive β-values indicates if values of predictors increases so do the extent of change in farmers' food and nutrition security as vice-versa. Therefore, it can be stated that as annual family income, Body Mass Index (BMI), agricultural extension media contact, agricultural training experience and knowledge on climate change increase by one unit, increased in farmers' food and nutrition security by 0.528, 0.184, 0.309, 0.180 and 0.262 units respectively. In summary, the models suggest that the NGOs, DAE and other organizations should consider farmers' agricultural training experience, annual family income, body mass index, agricultural extension media contact and knowledge on climate change while offering and implementing any sustainable agricultural development program or policy associate with farmers' food and nutrition security.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The study was conducted in the Kakua and Daniya union of Tangail sadar upazila to find out the effect of climate change on farmers' food and nutrition security. Total 100 farmers were selected from Kakua union as the study group where they faced climate change effects and 33 respondents from Daniya as Control Group farmers where they did not face the climate change effects. A semi-structured interview schedule was developed based on objectives of the study for collecting information. The independent variables were: age, level of education, family size, effective farm size, agricultural training experience, amount of agricultural credit, annual family income, body mass index, agricultural extension media contact and knowledge on climate change. The dependent variable of this study was the climate change effects on farmers' food and nutrition security. Data collection was started from 20 December, 2020 and completed in 30 January, 2021. Various statistical measures such as frequency counts, percentage distribution, average, and standard deviation were used in describing data. In order to estimate the effects and contribution of the selected characteristics of farmers' on food and nutrition security, independent two sample t-test and multiple regression analysis (B) was used. The major findings of the study are summarized below:

5.1 Summary of Findings

The major findings of the study are summarized below:

5.1.1 Selected Characteristics of the Farmers

Findings in respect of the 10 selected characteristics of the farmers are summarized below:

Age: The middle-aged farmers comprised the highest proportion (57%) and the lowest proportion by young aged category (17%).

Level of education: The highest proportion of the respondents was in primary education level (38%) followed by secondary education level (31%) and can sign only (21%). The lowest number of the respondents was higher secondary education level (4%) followed by who had no education level (6%).

Family size: The majority of the respondents were medium sized family (73%) compared to the respondents having small (12%) and large sized family (15%) respectively.

Effective farm size: Most of the respondents had medium farm size (41%) followed by marginal (16%), small (39%), and large farm size (4%) respectively.

Agricultural training experience: The respondents having low training experience (64%) and medium training experience (29%) were higher than the respondents having high training experience (7%) respectively.

Amount of agricultural credit: The highest proportion (69%) of the respondents had low access as compared to (18%) and (13%) having medium and high access to credit respectively.

Annual family income: The respondents having low annual family income (60%) were higher than respondents having medium family annual income (30%) and high family annual income (10%).

Body Mass Index (BMI): The highest proportion (74%) of the farmers had normal weight compared to (17%) in underweight and (9%) in overweight. No farmers were found in obesity category.

Agricultural extension media contact: The respondents having low use of agricultural extension media contact (44%) were higher than the respondents having medium (38%) and high use of agricultural extension media contact (18%) respectively.

Knowledge on climate change: The respondents having moderate knowledge on climate change (68%) were higher than the respondents having poor (14%) and sound knowledge on climate change (18%) respectively.

5.1.2 Climate Change Effects on Farmers' Food and Nutrition Security

5.1.2.1 Farmers' food security

i) Food availability: The respondents having low food availability (46 %) was higher than medium food availability (38 %) and high food availability (16%).

ii) Food stock ability: The respondents having low food stock ability (50%) was higher than medium food stock ability (30%) and high food stock ability (20%).

5.1.2.2 Farmers' nutrition Security

i) Nutrition uptake: The respondents having lower nutrition uptake (59%) was higher than medium nutrition uptake (23%) and high nutrition uptake (18%).

ii) Dietary diversity: The respondents having low balanced (62%) was higher than partially balanced (31%) and completely balanced (7%).

5.1.2.3 Effects of climate change on study group farmers' vs control group farmers'

Study group mean score was found 11.79 while the control group gained 14.45. The score of effects of climate change on farmers' food and nutrition security found -2.66. So, there was a negative effects of climate change on farmers' food and nutrition security.

5.1.3 Contribution of Selected Characteristics of the Farmers on Food and Nutrition Security

- There was a significant contribution of the farmers' agricultural training experience, annual family income, Body Mass Index (BMI) and knowledge on climate change to play significant role to change in farmers' food security through R^2 (0.643), adjusted R^2 (0.599) and F (14.43) variation attributed.
- There was a significant contribution of the farmer agricultural training experience, annual family income, agricultural extension media contact and knowledge on climate change to play significant role to change in farmers' nutrition security through R^2 (0.545), adjusted R^2 (0.489) and F (9.59) variation attributed.
- There was a highly significant (1% level) contribution of the respondent agricultural training experience, annual family income, body mass index, agricultural extension media contact and knowledge on climate change to play significant role to change in farmer' food and nutrition security through R^2 (0.718), adjusted R^2 (0.683) and F (20.41) variation attributed.

5.2 Conclusions

The findings and relevant facts of research work prompted the researcher to draw following conclusions.

- Findings reveal that respondents having low food availability (46%) and medium food availability (38%) was higher and high food availability (16%) category

constituted by lower number of farmers due to climate change effects on farmers' food availability.

- ❖ Findings reveal that the respondents having low food stock ability (50%) and medium food stock ability (30%) was higher and high food stock ability (20%) category constituted by the lower number of farmers due to climate change effects on farmers' food stock ability.
- ❖ Findings reveal that the respondents having low consumption (59%) and medium consumption (23%) was higher and high consumption (18%) category constituted by the lower number of farmers due to climate change effects on farmers' nutrition uptake capacity.
- ❖ Findings reveal that the respondents having low balanced (62%) and partially balanced (31%) was higher and completely balanced (7%) category constituted by the lower number of farmers due to climate change effects on farmers' household dietary diversity.
- ❖ Findings reveal that study group and control group farmers showed significant negative t-test value and mean value differences for measuring effects of climate change in farmers food availability, food stock ability, nutrition uptake and household dietary diversity. Therefore, it is concluded that needs to minimize effects on climate change affected farmers.
- ❖ Findings reveal that the farmers' agricultural training exposure, annual family income, Body Mass Index (BMI) and knowledge on climate change to play significant role to influence in food security of the farmers in the study group. It may be concluded that the food security of farmers' is likely to be influenced by the farmers agricultural training experience, annual family income, Body Mass Index (BMI) and knowledge on climate change to achieve food security.
- ❖ Findings indicate that the farmers agricultural training experience, annual family income, agricultural extension media contact and knowledge on climate change to play significant role to influence in nutrition security of the farmers in the study group. It may be concluded that the nutrition security of the farmers is likely to be influenced by the farmers agricultural training experience, annual family income, agricultural extension media contact and knowledge on climate change to achieve nutrition security.
- ❖ Findings reveal that agricultural training experience, annual family income, Body Mass Index (BMI), agricultural extension media contact and knowledge on climate

change to play significant role to influence in food and nutritional security of the farmers in the study group. It may be concluded that the changes in food and nutrition security of farmers' due to climate change is likely to be influenced by the farmers agricultural training experience, annual family income, Body Mass Index (BMI), agricultural extension media contact and knowledge on climate change.

5.3 Recommendations

5.3.1 Recommendations for policy

On the basis of the findings and conclusion of the research some recommendations have been formulated. These are following-

- The study findings indicate that most of the farmers enabled them to their food availability, food stock ability, nutrition uptake and household dietary diversity as low category in aspect of food and nutrition security dimension. To uplift their food and nutrition security condition, the government should take more initiatives through increasing facilities and awareness of the farmers about convenience of the food and nutrition security so that they can lead their life safely from adverse future effects.
- The findings of the research indicate that the different indicators of food security including the dimensions of the food security were attributed to the farmers agricultural training experience, annual family income, Body Mass Index (BMI) and knowledge on climate change had significant contribution to the food security of the farmers. It may be recommended that the government along with NGOs should consider the farmers mentioned characteristics during providing any program or training facilities for the farmers so that they can get the opportunities to promote their food security status.
- The research findings indicate that the agricultural training experience, annual family income, agricultural extension media contact and knowledge on climate change had significant contribution to the nutrition security of the farmers. It may be recommended that the government along with NGOs should provide facilities to the farmers of villages so that they can get more knowledge on food nutrition to uplift their nutrition security status.
- The research findings indicate that agricultural training experience, annual family income, Body Mass Index (BMI), agricultural extension media contact and

knowledge on climate change had highly significant contribution of the farmers food and nutrition security. So, it may be recommended that the government should arrange more training through different GO & NGO organization such as Department of Agricultural Extension (DAE) and intergovernmental panel on climate change (IPCC) on improving the income generating activities, so that all farmers can get the facilities to apply their knowledge to increase their income generating activities with a view to achieving improved food and nutrition security status and all farmers can get the facilities to apply their knowledge in climate change situation.

5.3.2 Recommendation for further research

- The present research was undertaken Kakua and Daniya union in the sadar upazila of Tangail district. The findings of its recommended that similar studies should be conducted in other areas of Bangladesh.
- The present research was undertaken to measure the effects of climate change were considered as the farmers food and nutrition security in this study. Further research should be conducted to assess the effects of specific climate change indicators.
- The present study was conducted on the basis of the recall data furnished by the respondents. Further research should be carried out without using recall data.
- The present research was carried out considering unequal number of respondents in study and control group. Further research should be conducted taking similar number of respondents in study and control group.
- Contribution of only ten selected characteristics of the respondents to the farmers food and nutrition security. It may be recommended for further research to examine the contribution of other socio-economic characteristics of the farmers to the effects of climate change.
- The present research was carried out four indicators to measure the effects of climate change. Further research undertaking should be carried out to measure the effects of climate change with different indicators.
- The study was based on the effects of climate change on farmers' food and nutrition security. Further studies may be conducted in respect of other effects on farmers.

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APPENDIX-I

ENGLISH VERSION OF THE INTERVIEW SCHEDULE (For study group respondents)

Department of Agricultural Extension and Information System

Sher-e-Bangla Agricultural University, Dhaka-1207

An Interview Schedule for the Study Entitled

"EFFECTS OF CLIMATE CHANGE ON FARMERS' FOOD SECURITY AND NUTRITION"

Name of the respondent: ……Serial No……...

Village: …….……...Contact No. …….....

Union:…….Upazila:…….....

(Please provide the following information. Your information will be kept confidential and will be used for research purpose only)

1.1 Age

How old are you? _____Years.

1.2 Level of education

Please mention your level of education

a) I can't read and write ☐

b) I can sign only ☐

c) I have passed……class.

d) I took non-formal education that equivalent to...……weeks/months/years

1.3 Family size

Please mention the number of your family member

a) Male….....

b) Female……Total…….

1.4 Effective farm Size: Please mention the area of your land possession

SI. No.	Use of land	Land possession	
		Local unit	Hectare
1.	Homestead area (A)		
2.	Own land own cultivation (B)		
3.	Land taken from others on Borga system(C)		
4.	Land given to others on Borga system (D)		
5.	Land taken from others on lease (E)		
Total=A+B+$\frac{1}{2}$(C+D)+E			

1.5 Agricultural training experience

Have you attended any agricultural training programme? 1) Yes…….. 2) No…….. If yes, please mention the following information:

SI. No.	Name of the training course	Organization	Days
1.			
2.			
3.			
4.			
5.			

1.6 Amount of Agricultural credit: Please indicate your opinion on the following statements

SI. No.	Sources of credit	Amount(Taka)
1.	Bank	
2.	Microfinance /other financing organization	
3.	Credit from person (s)	
4.	Friends	

1.7 Annual family income: Please mention your annual family income from the following sources

a) Agriculture	Amount (TK.)	b) Non- agriculture	Amount (TK.)	Total (a+b)TK.
Field crop		labor		
Homestead crop		Service		
Fruit tree		Business		
Timber tree		Foreign remittance		
Nuts				
Bamboo				
Livestock				
Fisheries				
Poultry				
Grand total		**Grand total**		

1.8 Body Mass Index (BMI)

Sl. No.	Person's weight (kg)	Person's Height (m)	BMI= Person's Weight (kg)/ Person's Height (m^2)
1.			

1.9 Agricultural extension media contact

SI. No.	Communication media	Extent of contact			
		Regularly (4)	Sometimes (3)	Rarely (2)	Not at all (1)
1.	Meet with contact growers/model Farmers				
2.	Meet with agricultural input (seed/fertilizer/pesticide/fish feed/poultry feed/equipment) dealers				
3.	Meet with SAAOs				
4.	Meet with social worker				
5.	Meet with NGO worker				
6.	Meet with Agriculture Extension officer/UAO				
7.	Agricultural program through electronic media (radio/TV)				
8.	Agricultural features in Printing media (Daily Newspaper, krishi biplob, krishikotha, leaflet, booklet, Magazine etc.)				
9.	Participation in FINA/ Problem census(PC)/FGD				
10.	Participation in agricultural result demonstration program/Field day				

1.10 Knowledge on climate change: Please answer the following questions

SI. No.	Questions	Full Marks	Marks obtained
1.	What is your idea about climate change?	2	
2.	What are the elements of climate change?	2	
3.	Which month does the temperature highest and lowest?	2	
4.	What are the effects of temperature?	2	
5.	Which month do we call the rainy season?	2	
6.	When does the rain fall highest?	2	
7.	What is river erosion?	2	
8.	What are the effects of flood?	2	
9.	When do we call drought?	2	
10.	What are the effects of drought?	2	
Total		**20**	

2. Climate Change Effects on Farmers' food and Nutrition Security

a) Farmers' Food Security

i) Food availability

Please mention the availability of food among your family members

SI. No.	Types of food	Availability of Food			
		Sufficient (4)	Less than sufficient (3)	Less available (2)	Always with shortage (1)
1.	Cereals				
2.	Vegetables				
3.	Fruits				
4.	Meat				
5.	Eggs				
6.	Fish				
7.	Pulses				
8.	Milk and milk products				
9.	Oils and fats				

ii) Food stock ability

How many meals do you have in your stock?

Sl. No.	Time period	No. of Meals
1.	Up to one day (up to 3 meals)	
2.	Up to one week (4 to 21 meals)	
3.	Up to one month (22 to 90 meals)	
4.	More than one month (>90 meals)	

b) Farmers' Nutrition Security

i) Nutrition uptake (Calorie intake)

Please state daily average food consumption/person, among your family members

Sl. No.	Name of Meal	Menu and amount (gm)	Nutrition value (calorie)
1.	Breakfast		
2.	Lunch		
3.	Supper/dinner		
4.	Others (if any)		
Total			

ii) Individual dietary diversity

Please mention the percentage of essential nutrients intake per meal in terms of balance diet by your family members

Essential nutrients	Amount (gm)	Nutrition value (calorie)	Percentage (%)
Carbohydrates (25%)			
Proteins (25%)			
Fats and oils (10%)			
Vitamins and (40%) minerals			

Thank you for your kind co-operations

_____

Signature of the interviewer

APPENDIX-II

ENGLISH VERSION OF THE INTERVIEW SCHEDULE (For control group respondents)

Department of Agricultural Extension and Information System

Sher-e-Bangla Agricultural University, Dhaka-1207

An Interview Schedule for the Study Entitled

"EFFECTS OF CLIMATE CHANGE ON FARMERS' FOOD SECURITY AND NUTRITION"

Name of the respondent: ……Serial No……...

Village: ……..……...Contact No. …….....

Union:…….Upazila:…….....

(Please provide the following information. Your information will be kept confidential and will be used for research purpose only)

1.1 Level of education

Please mention your level of education

a) I cannot read and write ☐

b) I can sign only ☐

c) I have passed……class.

d) I took non-formal education that equivalent to...……weeks/months/years

1.2 Effective farm Size

Please mention the area of your land possession

SI. No.	Use of land	Land possession	
		Local unit	Hectare
1.	Homestead area (A)		
2.	Own land own cultivation (B)		
3.	Land taken from others on Borga system(C)		
4.	Land given to others on Borga system (D)		
5.	Land taken from others on lease (E)		
Total=A+B+$\frac{1}{2}$(C+D)+E			

2. Climate Change Effects on Farmers' Food and Nutrition Security

a) Farmers' Food Security

i) Food availability

Please mention the availability of food among your family members

SI. No	Types of food	Availability of Food			
		Sufficient (4)	Less than sufficient (3)	Less available (2)	Always with shortage (1)
1.	Cereals				
2.	Vegetables				
3.	Fruits				
4.	Meat				
5.	Eggs				
6.	Fish				
7.	Pulses				
8.	Milk and milk products				
9.	Oils and fats				

ii) Food stock ability

How many meals do you have in your stock?

Sl. No.	Time period	No. of Meals
1.	Up to one day (up to 3 meals)	
2.	Up to one week (4 to 21 meals)	
3.	Up to one month (22 to 90 meals)	
4.	More than one month (>90 meals)	

b) Farmers' Nutrition Security

i) Nutrition uptake (Calorie intake)

Please state daily average food consumption/person, among your family members

Sl. No.	Name of Meal	Menu and amount (gm)	Nutrition value (calorie)
1.	Breakfast		
2.	Lunch		
3.	Supper/dinner		
4.	Others (if any)		
Total			

ii) Individual dietary diversity

Please mention the percentage of essential nutrients intake per meal in terms of balance diet by your family members

Essential nutrients	Amount (gm)	Nutrition value (calorie)	Percentage (%)
Carbohydrates (25%)			
Proteins (25%)			
Fats and oils (10%)			
Vitamins and (40%) minerals			

Thank you for your kind co-operations

_____

Signature of the interviewer

APPENDIX-III

Food items	Calorie (Kcal/Kg)	Food items	Calorie (Kcal/Kg)
Carbohydrates		**Proteins**	
Rice	3,490	Fish	1,360
Wheat	3,410	Egg	1,730
Tuber	970	Meat	1,090
Vitamins and minerals		Pulse	3430
Vegetables	430	**Fats and oils**	
Fruit	200	Edible Oil	9,000
		Milk	670
		Soyabean oil	8,840
		mustard oil	8,840

Source: Dr. Shin Imai (2003), Livelihood Survey Forms, SPFS, FAO

Breakfast items	Amount(Per 100 gm)	Calorie(Kcal/Kg)
Muri	1 cup	50
Chanachur	28gm	144
Mixed vegetables	1 cup	27
Partha	1 piece(79 gm)	238
Tea with sugar and milk	1 cup	37
Biscuit	1 piece	116

Source: National Institute of Nutrition (2011), India