EFFECT OF CLIMATE CHANGE ON AGRICULTURE IN THE SALINE PRONE AREAS OF BANGLADESH

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SHER-E-BANGLA NAGAR, DHAKA-1207

JUNE, 2016

EFFECT OF CLIMATE CHANGE ON AGRICULTURE IN THE SALINE PRONE AREAS OF BANGLADESH

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A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE (MS)

IN

AGRICULTURAL EXTENSION

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF CLIMATE CHANGE ON AGRICULTURE IN THE SALINE PRONE AREAS OF BANGLADESH"** submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment 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 carried out by **Md. Ekramul Hosen**, Registration No. 10-04140, 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 sources of information, as has been availed of during the course of investigation have been duly acknowledged.

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LOVINGLY DEDICATED TO MY BELOVED PARENTS AND RESPECTED TEACHERS OF SHER-E-BANGLA AGRICULTURAL UNIVERSITY

ACKNOWLEDGEMENTS

All praises, thanks and gratitude are due to the the Almighty Allah for His grace bestowed upon the author for accomplishing this research study. With boundless love and appreciation, the researcher would like to extend his heartfelt gratitude and appreciation to all who helped him bring this study into reality.

In particular, the researcher takes the opportunity to express thanks to his respectable supervisor **Md. Wali Ahad Setu**, Assistant Professor, Department of Agricultural Extension and Information System, Sher-e-Bangla Agricultural University, for his noble guidance, constructive criticism, constant stimulation and encouragement through supervision during the course of preparation of this thesis, without which this work would not have been possible. For his unwavering support, I am truly grateful. His insight and practical skill have left a distinct mark on this work.

The researcher also wishes to express sincere appreciation and heartfelt gratitude to his co-supervisor **Dr. Mohummed Shofi Ullah Mazumder,** Department of Agricultural Extension and Information System, Sher-e-Bangla Agricultural University, for his valuable suggestions, constant cooperation, inspirations and sincere advice to improve the quality of the thesis throughout the period of this research program.

The researcher also wishes to express sincere appreciation and heartfelt gratitude to all teachers, Department of Agricultural Extension and Information System, Sher-e-Bangla Agricultural University, for their valuable advice to improve the quality of the thesis throughout the period of this research program.

Heartfelt thanks and appreciations are also expressed to the Upazila Agriculture Officer and SAAO of Assasuni upazila of Satkhira district in the study area for their benevolent help and cooperation in data collection period. The researcher is especially grateful to all the respondents in the study area for their cooperation and help in accomplishing the objectives of this research work.

Last but not the least, the author expresses his immense indebtedness, deepest senses of gratitude to his beloved mother, elder brother and sisters who sacrificed all their happiness during the whole study period especially during his MS study. The wishes, heartfelt thanks and gratitude to extend to all his relatives, well-wishers especially friends for their inspiration, blessing, cooperation and encouragement in all phases of this academic pursuit from the very beginning to the end.

June, 2016 **The Researcher**

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ABBREVIATION AND GLOSSARY

Abbreviation	Full word
Ag. Ext. Ed.	Agricultural Extension Education
Ag. Ext. and Info. Sys.	Agricultural Extension and Information System
AIS	Agriculture Information Service
ANOVA	Analysis of Variance
B	Multiple regression
BBS	Bangladesh Bureau of Statistics
BEC	Bangladesh Economic Census
CH_4	Methane
CO_2	Carbon dioxide
DAE	Department of Agricultural Extension
et. al	All Others
GHGs	Green House Gases
IPCC	International Panel for Climate Change
HKI	Helen Keller International
MoYS	Ministry of Youth and Sports
OLS	Ordinary Least Squares
SAAO	Sub Assistant Agriculture Officer
SPSS	Statistical Package for Social Science
UNFCCC	United Nation Framework for Climate Change Conference

EFFECT OF CLIMATE CHANGE ON AGRICULTURE IN THE SALINE PRONE AREAS OF BANGLADESH

ABSTRACT

The study examined effect of climate change on agriculture in the saline prone areas, and estimate the level of contribution of the selected characteristics of the farmers to the effect of climate change on agriculture. The methods of the study is an integration of quantitative and qualitative methods based on data collection. Data were collected from 88 farmers under study group and 30 farmers under control group from 16 March, 2017 to 15 April, 2017. Descriptive statistics, multiple regression, t-test were used for data analysis. There was a negative effect of climate change on agriculture comparing the study and control group changed score from 2015 to 2017. In case of study group, 61.4 percent of the farmers had medium effect, 17.0 percent had low effect and 21.6 percent of the farmers had high Effect of climate change on agriculture. Among the variables: age, level of education, annual family income, farming experience, training exposure, agricultural knowledge and knowledge on climate change had significant contribution to the effect of climate change on agriculture in the saline prone areas. It is concluded that climate change may play a significant role in decreasing the yield of cereal crops, yield of vegetables, yield of pulses and increasing number of adopted new varieties of agricultural crops by the farmers. It is recommended that the Bangladesh government should take initiative for reducing effect of climate change on agriculture for a sustainable agricultural development.

Key words: Effect, climate change, agriculture;

CHAPTER I

INTRODUCTION

1.1 General Background

Bangladesh is a densely populated (around 152.51 million people lives in its 1, 47,570 square kilometer of land; BBS, 2014) and agro-based (47.5% of the total manpower is involved in agriculture) developing country. About 76% of the people live in rural areas. In Bangladesh, agriculture contributes 18.82% of the gross domestic product (GDP) of the country in the year of 2014-2015 (BEC, 2016). Most of the rural people are dependent for their livelihood mainly on agricultural activities. Any extent of change in climatic variables therefore directly affects agriculture performance. However, change in climatic variability and uncertainty has been posing increasing threats on agriculture.

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 (Upreti, 1999) resulting variations in solar energy, temperature and precipitation. 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 effect on water availability makes agriculture and livelihood of the people more vulnerable. The livelihood of the Bangladeshi 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. 48% population depends on agriculture (BBS, 2016). This will put greater number of people at risk when agriculture is effected due to climate variability and uncertainty (Dahal and Khanal, 2010). Effect of climate change s 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).

The effects of climate change in Bangladesh, most cultivable land area is depended on water and therefore productivity is dependent on form, intensity, distribution and timing of precipitation through rain or other any artificial forms. Agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall but also by shifts in the timing of the monsoon rain. The current irrigation facilities may not have sufficient water during dry seasons in the future due to climate change. This change in climate has been shifting the cropping calendar. Summer rainfall accounts for almost 80% of the total annual rainfall over Bangladesh and is crucial to Bangladeshi agriculture. Increase in temperature and increasing number of events of erratic rainfall directly affect agriculture and food supply through their effects on crops. Insufficient rain and increasing temperature cause drought whereas intense rain in short period reduces ground water recharge by accelerating runoff resulting floods. Both these situations induce negative effects in agriculture. The climate change also causes disruption in normal weather pattern, intensity and duration of monsoon. The effect of climate change as witnessed in recent times has adversely affected agriculture in a variety of ways. Any change in rainfall patterns or the increasing the salinity of land in the coastal area of Bangladesh pose a serious threat to agriculture, and thereby national economy and rural livelihood. The major districts which are affected by the high level of salinity are: Bagerhat, Barguna, Barisal, Bhola, Cox's Bazar, Noakhali, Khulna, Patuakhali, Pirojpur and Satkhira. Effect of climate change s lives and livelihoods, particularly of economically poor and climatically, sensitive countries like Bangladesh.

During the wet monsoon, the severity of salt injury is reduced due to dilution of the salt in the root zone of the standing crop. The dominant crops grown in the saline areas are local transplanted Aman rice with poor yields. Salinity problem received little attention in the past but due to increased demand for growing more food to feed the booming population for the country, it has become imperative to explore the potentials of these lands for crop production. Although, climate change has an enormous effect on agriculture in the saline area of Bangladesh, little research has been conducted regarding the effect of climate change on agriculture in the saline prone areas particularly in Bangladesh. Hence, on the basis of above considerations the research regarding this topic entitled 'Effect of Climate Change on Agriculture in the Saline Prone Areas of Bangladesh' was taken into consideration.

1.2 Statement of the Problem

One of the major problems in the coastal zone of Bangladesh is salinity intrusion. It is increasing alarming due to natural and anthropogenic reasons. About 53% of coastal areas are affected by salinity. Salinity is causing decline in soil productivity and crop yield which results in severe degradation of bio-environment and ecology. In order to formulate suitable strategic measures for the effect of climate change on agriculture in the saline prone areas of Bangladesh, this research focuses on socio-economic characteristics of farmers and their existing situation and examines the effect of climate change on agriculture. This was finished by looking for answers to accompanying queries:

- What was the extent of effect of climate change on agriculture?
- What were the characteristics of the farmers?
- What were the contribution of selected characteristics of the farmers to the effect of climate change on agriculture?

In order to get a clear view of the above questions the investigator undertook a study entitled 'Effect of Climate Change on Agriculture in the Saline Prone Areas of Bangladesh'.

1.3 Objectives of the Study

The focal point of the research work was to explore the effect of climate change on agriculture. This is why the following objectives were structured out in order to provide an appropriate track to the research work:

i. To assess the extent of effect of climate change on agriculture;

ii. To describe the following selected characteristics of the farmers:
   - Age
   - Level of education
   - Family size
   - Effective farm size
   - Annual family income
   - Farming experience
   - Training exposure
   - Extension media contact
   - Organizational participation
   - Agricultural knowledge and
   - Knowledge on climate change;

iii. To explore the contribution of the farmers' selected characteristics to the effect of climate change on agriculture;

1.4 Scope or rationale of the study

The present study was designed to have an understanding the effect of climate change on agriculture in the saline prone areas of Bangladesh and to explore its contribution with farmers selected characteristics.

i. The findings of the study will, in particular, be applicable to the study area at Assasuni upazila of Satkhira 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.

ii. The findings of the study may also be subsidiary to the field worker of extension service to enhance their action strategies on effect of climate change on agriculture in the saline prone areas of Bangladesh.

iii. The findings of the study will be conducive to accelerate the improvement in agriculture, farmers' logistic supports, information needs and the way of dissemination especially tuned to key role players in the society as well as effect of climate change on agriculture in the saline prone areas of Bangladesh. The outcomes might also be helpful to the planners and policy makers, extension workers and beneficiaries of the agriculture.

iv. To the academicians, it may help in the further conceptualization of the systems model for analyzing the effect of climate change on agriculture in the saline prone areas of Bangladesh. In addition, the findings of this study may have other empirical evidence to all aspects of effect of climate change on agriculture in the saline prone areas of Bangladesh which may be used to build a theory of effect of climate change aspects.

1.5 Justification of the study

Bangladesh is a major victim country of climate change. Coastal agricultures are facing barriers and constraints due to the changing climate. The main focus of the study is to ascertain the effect of climate change on agriculture in the saline prone areas of Bangladesh**.** Climate change is forcing people to take diversified occupation to maintain their livelihood, income and production. Bangladesh is continuously fighting with effect of climate change on agriculture. Extreme weather events not only limit agricultural persuasion during the event but also have the potential to erode crops 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 findings of the study will have great importance to the agricultural condition of the coastal and saline prone areas of Bangladesh. Therefore, the researcher needs to enquire about the effect of climate change on agriculture. So, it is logical to investigate about the effect of climate change on agriculture in the saline prone areas of Bangladesh. The findings of the study are therefore, expected to be conducive to the researchers, academicians and policy makers who are concerned with effect of climate change. Keeping the above facts in view, a study undertook entitled 'Effect of climate change on Agriculture in the Saline Prone Areas of Bangladesh'.

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:

i. The respondents were capable of furnishing proper answers to the questions contained in the interview schedule.

ii. The data collected were free from any bias and normally distributed.

iii. The responses answered were valid, acceptable and reliable.

iv. Information sought by the researcher elicited the real situation was the representative of the whole population of the study area to gratify the objectives of the study.

v. The researcher was well adjusted to himself with the social contiguous of the study area. Hence, the collected data were free from favoritism.

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:

i. The study was confined to the 8 villages of Asasuni upazila under Satkhira district which may fail to represent the actual scenario of the whole situation as people develop their strategies according to concrete situation they face.

ii. It is difficult to get exact information on effect of climate change on agriculture indicator from the farmers as many of them are illiterate.

iii. Characteristics of the farmers were many and varied, but only eleven characteristics were selected for the research study.

iv. There were embarrassing situations at the time of data collection. So, the researcher had to manage proper rapport with the respondents to collect maximum proper information.

v. Several methods, scales and statistical tests have been utilized in this study over a relatively short period of time.

CHAPTER II

REVIEW OF LITERATURE

Review of literature gives the clear and concise direction of the researcher for conducting the experiment. In this chapter, review of literatures relevant to the objectives of this study was presented. This was mainly concerned with 'effect of climate change on agriculture'. There was serious dearth of literature with respect to research studies on this aspect. So, the directly related literatures were not readily available for this study. Some researchers addressed various aspects of the effect of climate change on agriculture and its effect on client group and suggesting strategies for their emancipation from socio-economic deprivations. A few of these studies relevant to this research are briefly discussed in this chapter under the following six sections:

Section 1: Climate change and its components

Section 2: Effect of climate change s through natural hazards

Section 3: Climate change and agriculture

Section 4: The level of contribution of the farmers' characteristics to the effect of climate change on agriculture

Section 5: Research gap of the study

Section 6: Conceptual framework of the study

2.1 Climate change and its components

2.1.1 Climate change

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 very much depended on the environment and vulnerable to natural disasters. According to IPCC (2007), 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 2007; Tirado *et al*. 2010). According to the International Panel for Climate Change (2007), 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.

2.1.2 Temperature

IS92a, a scenario developed by IPCC predicted the GHGs and total radioactive force continues to increase through simulation period of 1990-2100. During it CO_2 increases as 6GtC to 36GtC, CH_4 as 540-1170 Tg per year, NOx as 14-19 Tg per year. This scenario assumes 2°C rise in global mean surface temperature between 1990-2100 (IPCC, 2001b).

The global temperature has increased by 0.74° C during the period of 1906 to 2005. It is also recorded that 1990s was the warmest decade of the global surface temperature since 1850. The studies further reveal that the global temperature will rise between 1.5°Cto 4.5°C by sometime in the 21st Century. In addition, it has been suggested that warming of more than 2.5°C could reduce global food supplies and contribute to higher food prices (UNEP & UNFCCC, 2002). World Bank, 2007 showed the average increase in mean annual temperature of earth surface between 1977 and 1994 was by 0.06°C annually. Cline, 2008 in his study with climate models under IPCC's scenario A23, predicted CO_2 concentration would increase to 735ppm by 2085 from current level of 380 ppm and global temperature would rise by 3.3°C. Land area would become warmer than the ocean. 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 effected 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 6.4^{0}C average in the 21th century (UNFCC, 2007). Edward (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.

2.1.3 Rainfall

IPCC, 2007 projects that there will be a general increase in the intensity of heavy rainfall events in the future, and an overall decrease as many as 15 days in number of rainy days over large part of South Asia. This will cause significant warming particularly at higher elevations, leading to reduction in snow and ice coverage, increased frequency of extreme events like flood, drought, and increased precipitation. Moench, 2010 has reported that annual variation in precipitation has increased so far that has increased flooding and erosion and affecting agriculture.

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, 2007).

2.2 Effect of climate change s on natural hazards

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*., 2011). The effect of temperature on agriculture is complex due to a number of interplaying factors: However, 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.*, 1999). So, 8% smaller rice harvests and a 32% smaller wheat harvests by 2050 now look likely (IPCC, 2007). 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 millimeters 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 effects 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, 2013). In Khulna, Bagerhat and Satkhira districts of southwest region of Bangladesh found that the suitable area for transplanted Aman rice cultivation will 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, 2013).

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: 254). 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). 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, 2000). 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 year greater success in disaster management has significantly reduced lives lost (World Bank, 2000). 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 ‘the salinity front’ moving gradually north by 40 km (Mohal *et. al.*, 2006) to 60 km (NAPA, 2005a) inland from the coast by 2100. But as well as making household water supply problematic, salinity negatively affects agricultural production.

2.3 Climate change and agriculture

2.3.1 Effect of climate change on agriculture

Agriculture is an economic activity that is highly dependent upon weather and climate in order to produce the food and fiber necessary to sustain human life. Not surprisingly, agriculture is deemed to be an economic activity that is expected to be vulnerable to climate variability and change. It involves natural processes that frequently require fixed proportions of nutrients, temperatures, precipitation, and other conditions (Vuren *et. al.*, 2009). Agriculture represents less than 2 percent of GDP in high-income countries, and 2.9 percent for the world as a whole. It is more important for low-income countries, contributing large GDP (Ackerman and Stanton, 2013). Climate change affects agriculture in a number of ways; including through changes in average temperatures; rainfall and climate extremes with an important effect on soil erosion (i.e. floods, drought, etc): changes in pests and diseases, changes in atmospheric carbon dioxide, changes in the nutritional quality of some foods, changes in growing season, and changes in sea level (World Bank, 2008). Crop yields show a strong correlation with temperature change and with the duration of heat or cold waves, and differ based on plant maturity stages during extreme weather events (Hoffmann, 2013). Modified precipitation patterns will enhance water scarcity and associated drought stress for crops and alter irrigation water supplies. They also reduce the predictability for farmers' planning (OECD, 2014). In an indirect way, a change in temperature and moisture levels may lead to a change in the absorption rate of fertilizers and other minerals, which determine yield output. In short, the rise in temperature along with the reduction in rainfall reduces agricultural productivity if both are beyond the threshold that is suitable for crop production (Tirado and Cotter, 2010). Climate change currently decreases yield of maize, rice, wheat and vegetables and continue to reduce seriously by 2050 globally (Cabral *et. al.*, 2007). Climate change is also likely to affect the livestock sector both by affecting the quantity and quality of feed and by affecting the frequency and severity of extreme climate events. There is a limited body of literature that deals with effect of climate change s on livestock, but livestock sector may be particularly vulnerable to the effects of climate change (Hoffmann, 2013). Climate change regional effects are likely to be substantial and variable, with some regions benefiting from an altered climate and other regions adversely affected. Generally, food production is likely to decline in most critical regions (e.g. subtropical and tropical areas), whereas agriculture in developed countries may actually benefit where technology is more available and if appropriate adaptive adjustments are employed (Ignaciuk and Mason-D'Croz, 2014).

In relation, crop productivity is projected to increase slightly at mid to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase risk of hunger (OECD, 2015). Warmer weather was expected to bring longer growing seasons in northern areas, and plants everywhere were expected to benefit from carbon fertilization (Vuren *et al.,* 2009). Agriculture is central to the survival of millions of people in many countries of sub-Saharan Africa (SSA). It is the number one provider of employment and livelihood in developing countries (IPCC, 2007b). The effects of climate change on agriculture have significant consequences on livelihoods, food production, and the overall economy of countries, particularly those with agriculture-based economies in the developing world because agriculture contributing 29 percent of developing countries' GDP and 65 percent of developing countries' populations (Campbell *et. al.*, 2011). As Lobell *et al.*(2008) study in 12 food-insecure regions of the world reported that climate change could significantly effect agricultural production and food security up to 2030 particularly for sub-Saharan Africa and South Asia due to both changes in mean temperatures and rainfall as well as increased variability associated with both.

The study from Nigeria done by Okoloye *et. al.*(2013) shows that in recent years the climatic elements are extremely changed and flood and drought frequency are increasing. According to Guiteras (2009), climate change is likely to impose significant costs on the Indian economy by affecting crop yield. From African countries, Ethiopia is one of the most at risk from effect of climate change s on agricultural productivity and food security (Evangelista, 2013). Gebreegziabher *et. al.* (2011) reported that its low adaptive capacity, geographical location and topography make the country highly vulnerable to the adverse effects of climate change. In addition, dependency of most population on climate sensitive sectors for livelihood i.e. worsens Ethiopia's vulnerability to the effects of climate change (UNEP, 2011). Over the last decades, the temperature in Ethiopia increased at about 0.2°C per decade, on the other hand, precipitation remained fairly stable over the last 50 years when averaged over the country. However, the spatial and temporal variability of precipitation is high (IPCC, 2007c). MacDonald and Simon (2011) also reported that farmers living in Ethiopia's semi-arid and arid lowlands that have less diversified assets and are heavily reliant on rain-fed agriculture are, along with their livestock, particularly vulnerable to climate change. It is estimated that the 1984-85 climate induced drought reduced Ethiopia's agricultural production by 21 percent, which led to a 9.7 percent fall in the GDP (World Bank, 2006). Bezabih *et. al.* (2014) also point out that climate variability and change in Ethiopia has significant effect in different crop yield.

2.3.2 The contribution of agricultural activities to climate change

According to Thornton and Lipper (2013), agriculture contributes 30-40% of anthropogenic GHG emissions. Three-quarters of agricultural GHG emissions occur in developing countries, and this share may rise above 80% by 2050 (Smith *et. al.,* 2007a). According to FAO (2014a) report in developing countries there is a significant increase in GHGs emission from 2001-2011 (14%), the increase occurred, due to an expansion of total agricultural outputs. In Ethiopia particularly, a GHG emission from agriculture accounts about 80% (Marius, 2009). As the global population and the demand for food continue to grow, total GHG emissions from the agricultural sector are projected to increase over time (IPCC, 2014). Agriculture creates both direct and indirect emissions. Direct emissions come from fertilized agricultural soils and livestock manure. While indirect emissions come from runoff and leaching of fertilizers, emission from land-use changes, use of fossil fuels for mechanization, transport and agro-chemical and fertilizer production (David and Lal, 2013; Smith *et. al.,* 2007a). The most significant indirect emissions are changes in natural vegetation and traditional land use, including deforestation and soil degradation. Yibekal *et. al.* (2013) found that deforestation (for agricultural expansion and fuel wood) is the main cause of climate change in Ethiopia. Intensive tillage is also one of traditional land use practices which involve disturb the land. This practice increases CO_2 emissions by causing decomposition of SOM and soil erosion (Busari *et al.,* 2015). According to the World Bank (2008b), agriculture contributes about half of the global emissions of two of the most potent non-CO_2 GHG: nitrous oxide (N_2O) and methane (CH4). These non-carbon GHGs have powerful greenhouse effects and have greater longevity than CO_2.

Globally, agriculture contributes to 58 percent of total N_2O emission (Smith *et. al.,* 2007a, IPCC, 2007d). It creates 4.5 million tons of nitrous oxide annually (Denman, 2007). Various management practices in the agricultural land can lead to production and emission of nitrous oxide, range from fertilizer application to methods of irrigation, tillage and cattle and feedlots. The use of synthetic fertilizer for agriculture is a major source of nitrous oxide emissions. Apart from this, large quantities of natural gas are used to make synthetic fertilizers because it is the main ingredient. The production process also takes a lot of energy so their effect on climate change is actually larger when we factor this in. Industrialized farming practices have worsened this loss and the result has been increased emissions. Continuous cropping may result in using of large chemical fertilizer (World Bank, 2008b). According to Amdu (2010), Study from Ethiopia reported that farmers widely used huge amount of chemical fertilizer to boost their product and considered as one of the main activities to adapt CC. And the study also reported that the farmers consider the negative effect of agro-chemicals only for their crops. This indicates that the farmers only care about their crop and select suitable condition to apply not environmental side effect of fertilizers. Because of this all, agriculture is the most important human source of nitrous oxide emissions. As earlier mentioned, methane is another non-CO_2 GHG which have large contribution in agriculture GHGs emission. Livestock, especially cattle, produce methane as part of their digestion. This process is called enteric fermentation. The sector is responsible for 47 percent of the world’s methane emissions. The way in which manure is managed contributes largely. When the manure of livestock is not used as a fertilizer or left in fields during grazing. Many of these systems create conditions that are favorable for nitrous oxide producing bacteria (David and Lal, 2013).

2.3.3 Agriculture as a solution for climate change

The agricultural sector holds significant climate change mitigation potential through reductions of GHG emissions and enhancement of agricultural sequestration (Vuren *et. al.,* 2009). In addition, it also has significant role to adapt climate change. Adaptation alone is not enough to offset the effects of climate change, and thus still need to be supplemented by concerted mitigation efforts (Ackerman and Stanton, 2013). Mostly, when we implement adaptation measure, we enhance mitigation capacity of particular area such as practicing different land use managements (soil and water conservation measure, manure and fertilizer management) in the agricultural field will help us to sequester substantial amount of carbon in the field and reduce emission of methane and nitrous oxide which are the main GHG emission means. The management activities are interrelated and help us to adapt and mitigate climate change. Agricultural activities are relatively affordable form of mitigation option, for which many technical options are already readily available (FAO, 2009). Global adoption of organic agriculture (OA) has the potential to sequester up to the equivalent of 32% of all current man-made GHG emissions (Robert *et al.,* 2009). OA is a production system that sustains the health of soils, ecosystems and people. In OA, soil fertility is maintained mainly through farm internal inputs (organic manures, legume production, wide crop rotations etc.); energy-demanding synthetic fertilizers and plant protection agents are rejected; and there is less or no use of fossil fuel (IPCC, 2007b). In relation, improved cropland management (lower use of synthetic fertilizers, reduced tillage etc.), Reducing industrial livestock production and improving feeding and grazing land management, Restoration of organic soils and degraded lands to increase soil carbon sinks, Improved water and rice management, Land-use change and agro-forestry, Increasing efficiency in fertilizer production and behavioral changes of food consumers (reducing the meat content) could also be main climate change mitigation measures in agriculture sector (Paul *et al.*, 2009). As earlier mentioned, the agricultural sector has also a potential to adapt to climate change in many areas. Climate change adaptation is a continuous process requiring location-specific response. Adaptation should enable agricultural systems to be more resilient to the consequences of climate change (FAO, 2011). Farming systems and farmers will differ enormously in their capacities to respond to climate change. Differentiated adaptation strategies and enhanced climate risk management support to agriculture and farming households are critical to counter the effects of climate change (Campbell *et. al.,* 2011). These adaptation measures could include in particular the choice and change of species and varieties, the adaptation of the field works to the calendar (more flexibility), the adaptation of plant production practices (i.e. fertilization, plant protection, irrigation, etc.) or the adoption of plant production practices that increase the soil organic matter content or the soil coverage by plants, manure management and agro forestry practices. Some of them discussed below how these practices serve as adaptation means:

2.3.3.1 Change crop variety

It involves switching from one crop variety to another in response to climatic stresses and changes. Study done by Komba and Muchapondwa (2015), in Tanzania explained that Tanzania’s farmers try to adapt climate change by using drought resistance crops. Introducing Avena species (Ingedo) species in Ethiopia as fodder crop and through time it replaces the dominant stable crop i.e., barley in the highland and serve as one means to adapt CC (Amdu, 2010).

2.3.3.2 Change in cropping pattern

Application of changes in how crops are cycled within a season. Farmers in the drought-prone semi-arid areas of Brazil have realized that several varieties of a single crop species can occupy a common land area, incorporating several bean varieties, maize and sorghum, among others, to increase harvest potential arid climate stresses (Action Aid, 2008).

2.3.3.3 Change in cropping calendar

It is another common adaptation to climate change at the farm level, which largely involves altering the timing of farm activities to suit climatic variations or changes. In Philippines, farmers adapt to the early onset of rainy season through early cultivation of upland farms, which results in high agricultural production for the season and higher household income from farm activities (Lasco and Pulhin, 2009).

2.3.3.4 Farm management practices

Change in current farm management practices such as OA practice focus on maintaining diverse farming systems (i.e. planting different crop species) also helps diversify potential sources of income for farmers, making the farming household more resilient to adverse effects of climate on agricultural production (Muller, 2009). According to Rhodes *et. al.* (2014), also crop residue management practice is considered one of the best climate smart actions. Ditch and check dam constructions are the major soil and water conservation (SWC) practice that helps to adapt CC.

2.3.4 Effect of climate change on agriculture in Bangladesh

Unfortunately, literature relating to the effects of climate change on agriculture in Bangladesh is sparse and decidedly qualitative. A number of papers on Bangladesh's risk, vulnerability and adaptations to climate change (Agrawala *et. al.*, 2003; Ali, 1999) have been policy focused and have lacked quantitative techniques to isolate the effect of climate change on agricultural productivity from other confounding factors. 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.*, 1999). Agrawala *et. al*. (2003) studied

Development and Climate Change in Bangladesh and they observed south-west and north-west regions were particularly susceptible to drought. Islam *et. al.* (1999) 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.

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; Agricultural Research Council, 2005). The effects of climate change are inherently region specific, inciting the need for region-based research on climate change. Ruttan (2002) noted this, saying rainfall and sunlight could potentially alter agricultural productivity but the gross effect was largely region-specific. Specifically discussing Bangladesh, Rashid and Islam (2007) identified droughts, floods, salinity and cyclones as the major extreme climatic events to which Bangladeshi agriculture is most vulnerable. Additionally, they identified a series of structural adaptations necessary to mitigate potential effects of climate change on agriculture, including: crop diversification away from those most vulnerable to climatic changes; improving water efficiency; improving crop production strategies; investing in measures to mitigate the effect of cyclones and other natural disasters; reclaiming soil salinity by investing in cultivating Boro rice and sweet water shrimp; and investing in machinery to expedite farming operations. Previous studies based on scientific models in Bangladesh have employed the CERES[1]-Rice and DSSAT[2] models (Basak *et. al.*, 2010; Mahmood, 1998; Karim *et. al.*, 1996) to assess climate change influence on agriculture. These models simulated the effects of rising temperature and CO2 concentration on rice.

Karim *et. al.* (1996) conducted a series of simulations using the CERES-Rice and Wheat models for Aus, Aman and Boro rice, and wheat. They tested the sensitivity of the crops to three different levels of atmospheric carbon dioxide concentration (330, 580, and 660 parts per million) and two levels of temperature increases (2 and 4 degrees Celsius). They found that while higher concentrations of CO_2 increased yields with temperature unchanged, higher temperatures adversely affected yields even with higher CO_2 concentrations. Basak *et. al.* (2010) concluded that climate change was likely to have predominately adverse effects on the yield of Boro rice. They found that if climate change was to result in increased temperatures, this would cause grain sterility during the growing season and hence a reduced yield. They also found that while changes to the level of atmospheric carbon dioxide and solar radiation might offset the effect of increased temperatures to some degree, that it would not be sufficient to mitigate it altogether.

Mahmood *et al.* (2004) observed that since rain-fed rice constitutes over 50% of total rice production in Bangladesh, production of this crop is extremely vulnerable to volatility in the supply of water. Early monsoon arrival can cause flood damage to rice seedlings in early growth stages, whilst late monsoon arrival can lead to water stress. Their application of the CERES-Rice model found that high water stress could lead to yield losses as high as 70% to rice plants in both flowering and maturing stages, suggesting potentially disastrous effects for rice production from changes to seasonal monsoon occurrence caused by CC. Sarker *et al.* (2012) performed time series analysis to assess this question for three major rice crops (Aus, Aman and Boro) in Bangladesh at the aggregate level using both Ordinary Least Squares and median quantile regression. However, this study did not account for regional variations and unobserved heterogeneity. The authors use maximum and minimum temperature and rainfall as climate variables and found a significant relationship between climate change and agricultural productivity. They found that minimum temperature was significant only for the Aman and Boro varieties, with a negative effect on output in the former case and a positive effect in the latter. Maximum temperature was found to be significant for all varieties, with a positive effect on output of Aus and Aman and a negative effect on Boro output. Finally, rainfall was found to be significant only for Aus and Aman, with a positive effect on output for both varieties.

2.4 The level of contribution of the farmers' characteristics to the effect of climate change on agriculture

There was found a very little or no review about the contribution or relationship of the farmers selected characteristics (age, level of education, family size, effective farm size, annual family income, farming experience, training exposure, extension media contact, organizational participation, agricultural knowledge and knowledge on climate change) to the effect of climate change on agriculture.

2.5 Research gap of the study

There are lots of researches on climate change issue but very few researches had so far been done to solely assess the effect of climate change on agriculture in the saline prone areas of Bangladesh. Moreover, among the limited studies on effect of climate change on agriculture, only a few researchers followed systematic method to assess the effect of climate change on agriculture in the saline prone areas of Bangladesh. This was one of the research gaps of the study. Hence, the researcher carried out the present study to assess the effect of climate change on agriculture in the saline prone areas of Bangladesh in Satkhira 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 yet to be study that conducted to assess effect of climate change compared with controls. This was also a significant research gap of the study. The methodology of the present work was very unique in this regard. So, the researcher implemented the research program following the methodology as mentioned.

Additionally, no research was carried out taking the indicators of effect of climate change on agriculture in the saline prone areas of Bangladesh 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 effect of climate change on agriculture in the saline prone areas of Bangladesh. Lastly, very few researches were conducted to assess the effect of climate change on agriculture in the saline prone areas of Bangladesh taking the variables which 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 modem technologies is conditional upon many factors. Some of these are social, personal, economical and situational factors and the behavior of rice cultivators are influenced by these characteristics. The hypothesis of a research while constructed properly consist at least two important elements i.e.: a dependent variable and an independent variable. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variables (Townsend, 1953). An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. 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 ‘effect of climate change on agriculture in the saline prone areas of Bangladesh’. Thus, effect of climate change on agriculture was the dependent variable and 11 selected characteristics of the farmers were considered as the independent variables under the study. Effect of climate change on agriculture in the saline prone areas 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, annual family income, farming experience, training exposure, extension media contact, organizational participation, agricultural knowledge and knowledge on climate change for this study.

Considering the above-mentioned situation and discussion, a conceptual framework has been developed for this study, which is diagrammatically presented in the following Figure 2.1.

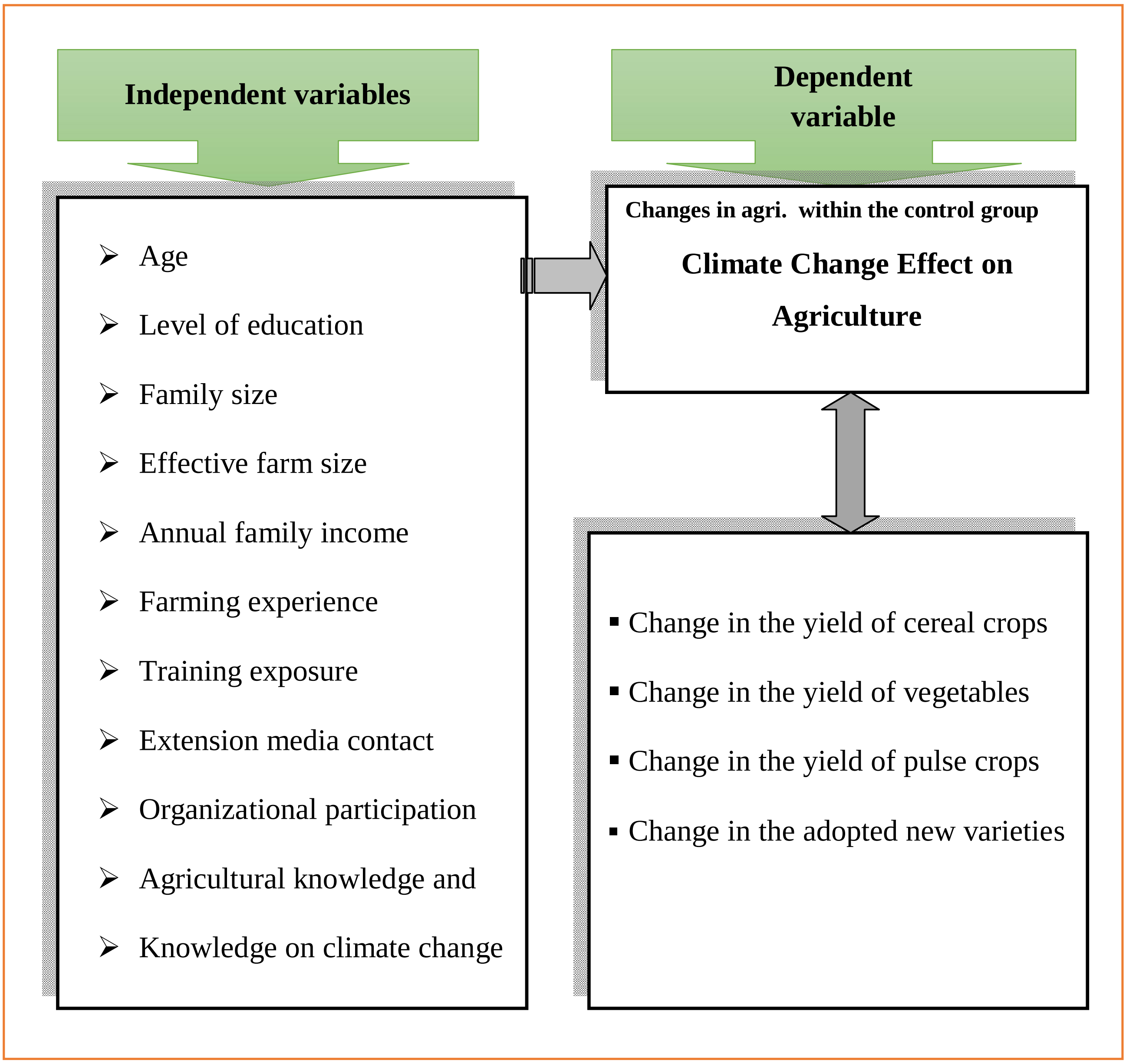

Figure 2.1 The conceptual framework of the study

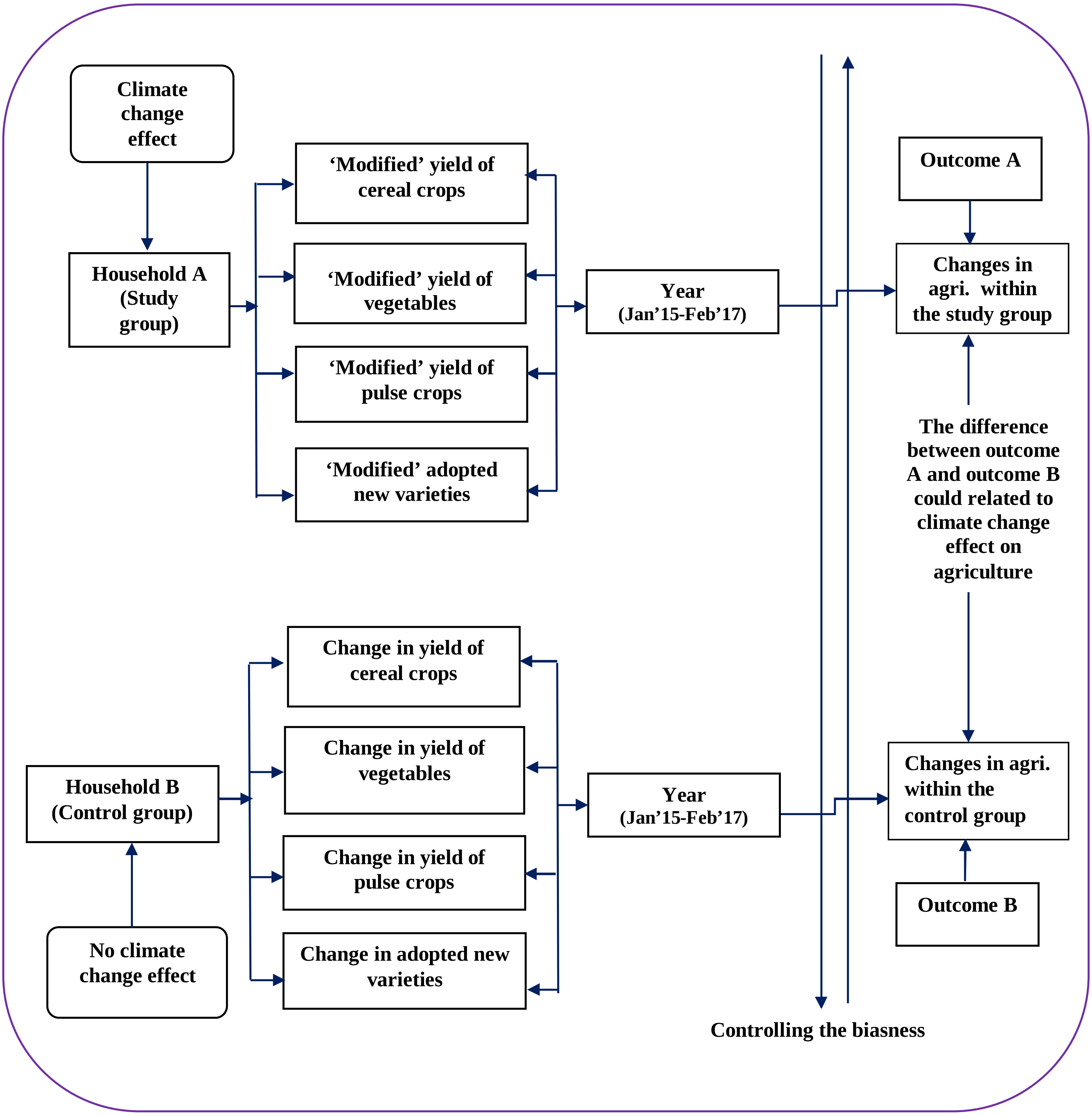

Figure 2.2 A schematic diagram of the proposed study: effect of climate change on agriculture

CHAPTER III

MATERIALS AND METHODS

Methods play an important role in a scientific research. To fulfill the objectives of the study, a researcher should be very careful while formulating methods and procedures in conducting the research. According to Mingers (2001), research method is a structured set of guidelines or activities to generate valid and reliable research results. This chapter of the thesis illustrates the research methods and procedures used to collect and analyze the data for answering the research questions and attaining the purposes. The methods and operational procedures followed in conducting the study e.g. selection of study area, sampling procedures, instrumentation, categorization of variables, collection of data, measurement of the variables and statistical measurements. A chronological description of the methods followed in conducting this research work has been presented in this chapter.

3.1 Research Design

A research design is a detailed plan of investigation. It is the blueprint 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.

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3.2 Locale of the study

The study was conducted in the Assasuni upazila of Satkhira district. The area of Assasuni upazila (Satkhira district) is 402.36 sq km, located in between 22°21' and 22°40' north latitudes and in between 89°03' and 89°17' east longitudes. It is bounded by Satkhira sadar and Tala upazilas on the north, Shyamnagar upazila on the south, Paikgachha and Koyra upazilas on the east and Kaliganj and Debhata upazilas on the west. The features of the farmers and agriculture at Assasuni upazila are like- main sources of income: agriculture 63.11%; ownership of agricultural land: landowner 58.34%, landless 41.66%; agricultural landowner: urban 39.56% and rural 59.08%; main crops paddy, jute, potato, wheat, pulses, sugarcane, vegetables. Assasuni upazila has several unions in which Protapnagar union was selected randomly as the study area.

The present study was conducted at Protapnagar union of Assasuni upazila based on the population size in the selected area. The farmers of the study area are involved in farming activities. The number of farmers who involves in farming activities in the study area is 1001.

The map of the Satkhira district has been presented in Figure 3.2. and specific study location namely Assasuni upazila have also been shown in Figure 3.3.

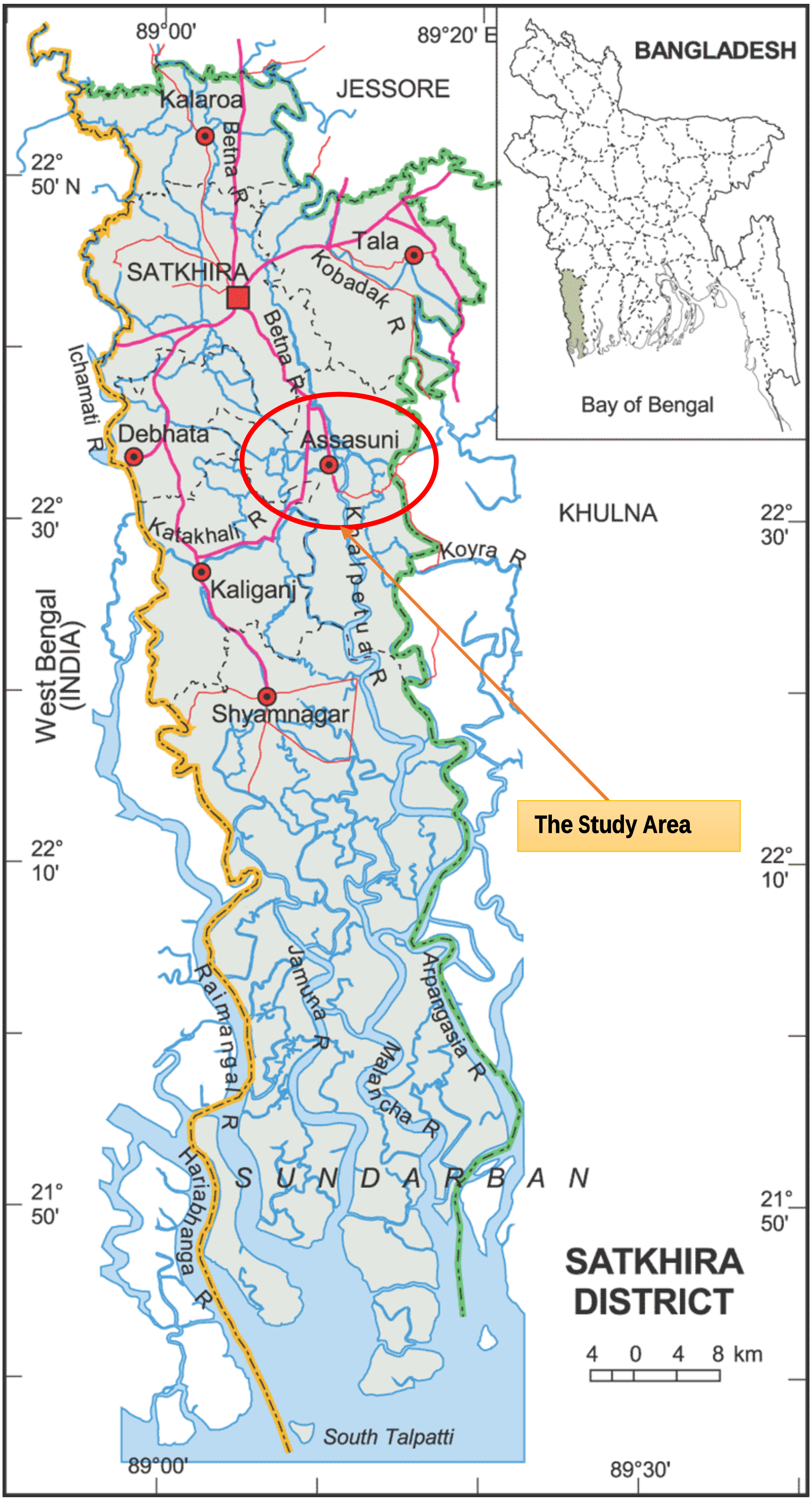

Figure 3.1 Map of Satkhira district showing the study area Assasuni

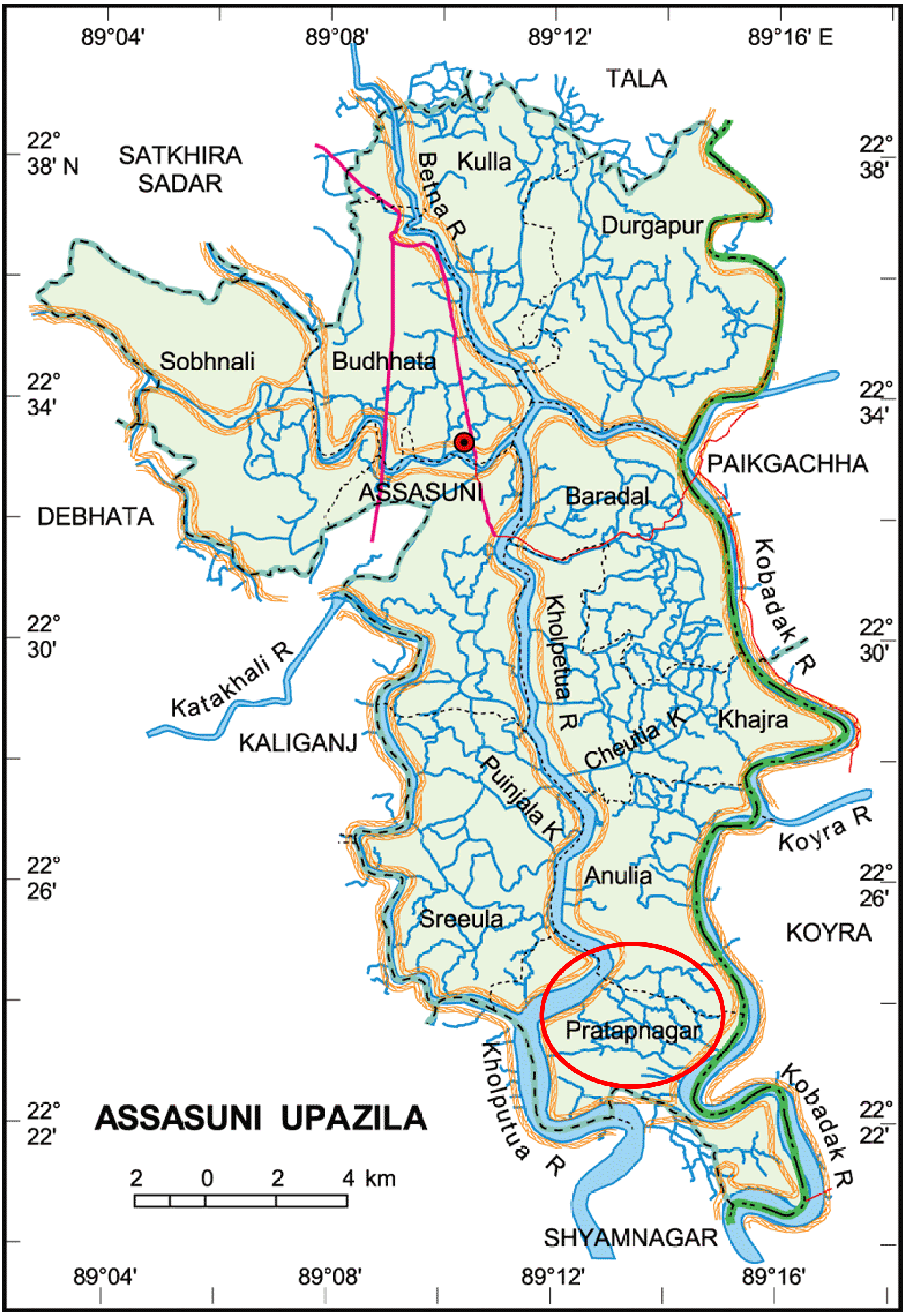

Figure 3.2 Map of Assasuni upazila showing the study area Protapnagar union

3.3 Population and sample of the study group respondents

People who engaged farming activities and permanently reside in the selected villages of Protapnagar 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 Protapnagar, Kallayanpur, Nakna, Kuribahunia, Khajra and Kola villages of Protapnagar union under Assasuni upazila were 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 farmers in Protapnagar union are 1001; where 156 from Protapnagar village, 178 from Kallayanpur village, 145 from Nakna village, 187 from Kuribahunia village, 164 from Khajra village and 171 from Kola village under the Protapnagar union which constituted the population of the study. Thus, 1001 farmers constituted population of study which is shown in following Table 3.1.

Table 3.1 Population of the study area

Name of the selected upazila	Name of the selected union	Name of the selected villages	Number of the population
Assasuni	Protapnagar	Protapnagar	156
		Kallayanpur	178
		Nakna	145
		Kurikahunia	187
		Khajra	164
		Kola	171
Total			1001

3.3.1 Determination of sample size of the study group

There are several methods for determining the sample size; here, the researcher used Yamane's (1967) formula for study group:

$$n = \frac{z^2 P(1-P)N}{z^2 P(1-P)+N\,(e)^2}$$

Where, n = Sample size;

N, Population size = 1001;

e, The level of precision = 10%;

z = the value of the standard normal variable given the chosen confidence level (e.g., z = 1.96 with a confidence level of 95 %) and

P, The proportion or degree of variability = 50%;

The sample size (n) is 88.

3.3.2 Distribution of the population, sample size of study group and Reserve list

According to Yamane's formula, the respondents comprised of 88 farmers. A reserve list of 11 farmers (ten percent of the sample size) 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. The farmers of the villages were measured according to the proportionate of the total sample size (88) which was calculated using Yamane's (1967) formula. The distribution of the population, sample size along with the reserve list is given in the following Table 3.2.

Table 3.2 Distribution of the farmers according to population and reserve list

Selected upazila	Selected union	Selected villages	Population	Sample size	Reserve list
Assasuni	Protapnagar	Protapnagar	156	14	1
		Kallayanpur	178	16	2
		Nakna	145	12	1
		Kurikahunia	187	16	2
		Khajra	164	15	1
		Kola	171	15	2
Total			1001	88	9

3.3.3 Control group selection

The respondents' size of the control group was 30 farmers which calculated as one-third of the sampling population number. Sampling selected as 88 respondents who involved farming activities from the study area and 30 respondents as controls far away from the study area from the farmers. To ensure similar socio-economic conditions for both the control and test groups, a two-way stratified random sampling technique was used (Mazumder and 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 3.3.

Table 3.3 Two-way stratified random sampling of respondents based on their Level of education and farm size

Category	% of respondents	Study Group	Control Group (one-third of the study group)
$E_1 \times F_1$	4.5	4	1
$E_1 \times F_2$	20.5	18	6
$E_1 \times F_3$	3.4	3	1
$E_2 \times F_1$	17.1	15	5
$E_2 \times F_2$	29.5	26	9
$E_2 \times F_3$	2.3	2	1
$E_3 \times F_1$	13.6	12	4
$E_3 \times F_2$	5.7	5	2
$E_3 \times F_3$	3.4	3	1
Total	100	88	30

With the help of the two-way stratified random sampling procedure, homogeneous/ similar categories of control and testing group respondents were selected, and then the proportionate random sampling technique was used to select either study or control group respondents from each village/group. To ensure the same respondents for the interviews, 5% extra respondents were interviewed to fill in the gaps in case of any interviewed respondent unavailable.

3.4 Data collection methods and tools

3.4.1 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 effect of climate change on agriculture in the saline prone areas of Bangladesh. Individual interviews were used in the survey and were conducted in a face-to-face (Bryman, 2001) 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).

3.4.2 Data collection tools

A semi-structured interview schedules were prepared with open and closed questions to reach the objectives of the study. The open questions allowed for the respondents to give answers using their own language and categories (Casley and Kumar, 1998). The questions in this schedule were formulated in a simple and unambiguous way and arranged in a logical order to make it more attractive and comprehensive. The instruments were first developed in English and then translated into Bengali. The survey tools were initially constructed based on an extensive literature reviews and pre-tested. The schedule was pre-tested with 15 randomly selected farmers in the study area. The pre-test was helpful in identifying faulty questions and statements in the draft schedule. Thus, necessary additions, deletions, modifications and adjustments were made in the schedule on the basis of experiences gained from pre-test. The questionnaires were also checked for validity by supervisor and educational experts at Sher-e-Bangla Agricultural University (SAU). Finally, based on background information, an expert appraisal and the pre-test, the interview schedule was finalized. Data was gathered by the researcher personally. During data collection, necessary cooperation was obtained from field staff of different GOs and NGOs and local leader. The primary data were collected from 10 March to 15 March, 2017. Books, journals, reports and internet documents were used as secondary sources of data supporting or supplementing the empirical findings of the study. The final data collection was started from 16 March and completed in 15 April, 2017.

3.5 Variables and their measurement techniques

The variable is a characteristic, which can assume varying, or different values in successive individual cases. A research work usually contains at least two important variables viz. independent and dependent variables. An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variable (Townsend, 1953). In the scientific research, the selection and measurement of variable constitute a significant task. Following this conception, the researcher reviewed literature to widen this understanding about the natures and scopes of the variables relevant to this research. At last it was selected 11 independent variables and one dependent variable. The independent variables were: age, level of education, family size, effective farm size, annual family income, experience in farming, training exposure, extension media contact, organizational participation, agricultural knowledge and knowledge on climate change. The dependent variable of this study was the ‘effect of climate change on agriculture in the saline prone areas of Bangladesh’. The methods and procedures in measuring the variables of this study are presented below:

3.5.1 Measurement of independent variables

The 11 characteristics of the farmers mentioned above constitute the independent variables of this study. The following procedures were followed for measuring the independent variables.

3.5.1.1 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 (Rashid, 2014). A score of one (1) was assigned for each year of one's age. This variable appears in item number 1 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (MoYS, 2012).

Category	Years
Young aged	≤ 35
Middle aged	36 to 50
Old aged	≥ 51

3.5.1.2 Level of Education

Education was measured by assigning score against successful years of schooling by a farmer. One score was given for passing each level in an educational institution (Rashid, 2014). For example, if a farmer passed the final examination of class five or equivalent examination, his/her education score has given five (5). Each farmer of can't read & write has given a score of zero (0). A person not knowing reading or writing but being able to sign only has given a score of 0.5. If a farmer did not go to school but took non-formal education, his educational status was determined as the equivalent to a formal school student. This variable appears in item number 2 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into five categories.

Category	Education (year of schooling)
Can’t read & write	0
Can sign only	0.5
Primary education	1 to 5
Secondary education	6 to 10
Above secondary	> 10

3.5.1.3 Family size

Family size of a farmer was determined by the total number of members in his/her family including him/her, children and other dependents. The scoring was made by the actual number of family members expressed by the numbers. For example, if a farmer have five members in his/her family, his/her score was given as 5. This variable appears in item number 3 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely ‘small’, ‘medium’ and ‘large’ family.

3.5.1.4 Effective farm size

Effective 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):

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

Where, EFS = Effective Farm size

A = Homestead area including garden and pond

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. kani 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 four (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).

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
Large farmer	>3

3.5.1.5 Annual family income

The term annual income refers to the annual gross income of farmer and the members of his family from different sources. It was expressed in taka. In measuring this variable, total earning taka of an individual farmer was converted into score. A score of one was given for every one thousand taka. The method of ascertaining income involved three phases. Firstly, the income from agricultural crops in the preceding year was noted and converted into taka. Secondly, income from animals and fish resources and thirdly, other source income included earning form small business, service, other family members' income, day laborer, fishing and others if any. This variable appears in item number 5 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' annual family income.

3.5.1.6 Farming experience

Farming experience of a farmer was determined by the total number of year involved in farming activities. A score of one (1) was assigned for each year farming activities. This variable appears in item number 6 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'little', 'medium' and 'high' farming experience.

3.5.1.7 Training exposure

Training exposure of a farmer was determined by the total number of agricultural training received regarding farming activities. A score of one (1) was assigned for each type of training attended. This variable appears in item number seven (7) in the interview schedule as presented in Appendix-I. 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.

3.5.1.8 Extension media contact

It was defined as one's extent of exposure to different communication media related to agricultural production. Extension media contact of a farmer was measured by computing extension media contact score on the basis of their nature of contact with eight extension media. Each farmer was asked to indicate his nature of contact with five alternative responses, like regularly, frequently, sometimes, rarely and not at all basis to each of the eight media and score of four, three, two, one and zero were assigned for those alternative responses, respectively. Logical frequencies were assigned for each of the five-alternative nature of contact. Extension media contact of the farmers was measured by adding the scores of eight selected source of information. Thus, extension media contact score of a farmer could range from 0 to 32, where zero indicated no extension media contact and thirty-two indicated highest level of extension media contact. This variable appears in item number 8 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' extension media contact.

3.5.1.9 Organizational participation

Organizational participation of a respondent was computed on the basis of his/her participation in different organizations. This variable appears in item number nine (9) in the interview schedule as presented in Appendix-I. Scoring of the organizational participation was done using the following formula and in the following way:

$OP = P_{om} + P_{em} + P_{eo}$

Where, OP = Organizational participation score,

P_{om} = Participation as ordinary committee member,

P_{em} = Participation as executive committee member and

P_{eo} = Participation as executive committee officer (president/secretary).

Nature of participation	Score assigned
No participation	0
Participation as ordinary member	1
Participation as executive member	2
Participation as secretary/ president	3

For example, if a respondent participated as an executive committee member of school committee, an ordinary member at NGO organized society and no participation in other organizations, that respondent would have a total score 3. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'less', 'medium' and 'high' organizational participation.

3.5.1.10 Agricultural knowledge

Agricultural knowledge of a farmer was measured by asking him/her 12 questions related to different components of agricultural production. It was measured assigning weight two for each question. So, the total assigned scores for all the questions became twenty. The score was given according to response at the time of interview. Answering a question correctly an individual could obtain full score while for wrong answer or no answer he obtained zero (0) score. Partial score was assigned for partially correct answer. Thus, the agricultural knowledge score of a farmer could range from zero (0) to twenty-four (24), where zero indicates very low knowledge and twenty-four indicates highest knowledge on agricultural production technologies. This variable appears in item number ten (10) in the interview schedule as presented in Appendix-I. Based on the information cited by farmers, they were classified into three categories (Mean ± Standard Deviation) namely ‘poor’, ‘moderate’, ‘sound’ agricultural knowledge.

3.5.1.11 Knowledge on climate change

Climate change knowledge of a farmer was measured by asking him/her 10 questions related to different components of climate change. It was measured assigning weight three of each question. So, the total assigned scores for all the questions became thirty. The score was given according to response at the time of interview. Answering a question correctly an individual could obtain full score while for wrong answer or no answer he obtained zero (0) score. Partial score was assigned for partially correct answer. Thus, the knowledge on climate change score of a farmer could range from zero (0) to thirty (30), where zero indicates no knowledge and thirty indicates highest knowledge on climate change. This variable appears in item number eleven (11) in the interview schedule as presented in Appendix-I. Based on the information cited by farmers, they were classified into three categories (Mean ± Standard Deviation) namely ‘poor’, ‘moderate’, ‘sound’ knowledge on climate change.

3.5.2 Measurement of dependent variable: effect of climate change on agriculture

Effect of climate change on agriculture is the dependent variable. To reveal this effect of climate change on agriculture, the researcher considered four (04) components: change in the yield of cereal crops, change in the yield of vegetables, change in the yield of pulse crops and change in the adopted new varieties. All the major components were measured with the help of identified subcomponents. Each subcomponent was measured against the identified items, collected through the process of review of relevant literature, focused discussion with the officials, experts and experienced farmers. Effect of Climate Change (ECC) on agriculture was calculated by using the formula:

$$ECC = CYCC + CYV + CYPC + CANV$$

Where,

ECC = Effect Climate Change on agriculture
CYCC= Change in the yield of cereal crops

CYV= Change in the yield of vegetables

CYPC= Change in the yield of pulse crops

CANV= Change in the adopted new varieties

In each case, the effect was measured in difference-in-difference method. In this study, the difference between 2015 and 2017 was measured both for study and control group respondents. Finally, the study group was compared with the control group based on difference between 2015 and 2017 data record (Mazumder and Lu, 2015).

By the following table the observed score was further categorized and data were analyzed combinedly.

Categories	Basis
High negative effect	≥ -3
Moderate negative effect	-2
Low negative effect	-1
No effect	0
Low positive effect	1
Moderate positive effect	2
High positive effect	≥ 3

3.5.2.1 Change in the yield of cereal crops

In case of cereal crops majority of the respondents practiced only Boro rice, wheat, maize as their cereal crop. The change in the yield/decimal of cereal crops of the respondents was measured in difference-in-difference method. The change value was computed considering the changes in the yield/decimal of cereal crops from 2015 to 2017 and then comparing with control group. Score 1 was assigned for each 100kg change in the yield of cereal crops.

3.5.2.2 Changes in the yield of vegetables

The changes in the yield/decimal of vegetables of the respondents were measured in difference-in-difference method. Some specific vegetables like cauliflower, cucumber, brinjal, bottle gourd, tomato, amaranth and sweet gourd were considered for measuring changes in the yield/decimal of vegetables where the average yield/decimal of the seven vegetables was measured. The change value was computed considering the changes in the yield/decimal of vegetables from 2015 to 2017 and then comparing with control group. Score 1 was assigned for each 40kg change in the yield of vegetables.

3.5.2.3 Changes in the yield of pulse crops

The changes in the yield/decimal of pulse crops of the respondents were measured in difference-in-difference method. Some specific vegetables like cauliflower, cucumber, brinjal, bottle gourd, tomato, amaranth and sweet gourd were considered for measuring changes in the yield/decimal of vegetables where the average yield/decimal of the seven vegetables was measured. The change value was computed considering the changes in the yield/decimal of pulse crops from 2015 to 2017 and then comparing with control group. Score 1 was assigned for each 40kg change in the yield of pulse crops.

3.5.2.4 Change in the adopted new varieties

The change value was computed considering the changes in number of adopted new varieties of agricultural crops from 2015 to 2017 and also comparing with the control group. The new varieties of agricultural crops- rice, vegetables and fruits released within five years of the respective year were considered as new varieties of agricultural crops for adoption in the respective year. Score 1 was assigned for each change in adopted new varieties.

3.6 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.

3.6.1 Research hypothesis

Based on review of literature and development of conceptual framework, the following research hypothesis was formulated:

"Each of the 11 selected characteristics (age, level of education, family size, effective farm size, annual family income, farming experience, training exposure, extension media contact, organizational participation, agricultural knowledge, knowledge on climate change) of the farmers has significant contribution to the effect of climate change on agriculture."

3.6.2 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 to the effect of climate change on agriculture. 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, annual family income, farming experience, training exposure, extension media contact, organizational participation, agricultural knowledge, knowledge on climate change) of farmers to the effect of climate change on agriculture".

3.7 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/windows version 22.0, 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, there are many different forms and methods that 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.

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 the farmers to their effect of climate change on agriculture in the saline prone areas of Bangladesh. Statistical test like regression was used in this study. Each statistical technique is used under specific conditions and depends on measurement scale of different variables.

3.8 Statistical 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^2test.

The data were analyzed in accordance with the objectives of the proposed research work. The factors that contribute to the effect of climate change on agriculture in the saline prone areas of Bangladesh are analyzed using a regression model, multiple regression analysis (B) 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 (B) 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 (B) 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:

$$Y_i = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + b_{10}x_{10} + b_{11}x_{11} + e \quad (i=1, 2, 3, 4)$$

Where,

$Y_{i=1}$ is the change in yield of cereal crops

$Y_{i=2}$ is the change in yield of vegetables

$Y_{i=3}$ is the change in yield of pulse crops

$Y_{i=4}$ is the change in adopted new varieties

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 annual family income, x_6 is farming experience, x_7 is training exposure, x_8 is extension media contact, x_9 is organizational participation, x_{10} is agricultural knowledge and x_{11} 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, b_{10} and b_{11} are regression coefficients of the corresponding independent variables, and 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 objective of the study. The first section deals with the selected characteristics of the farmers, while the second section deals with the effect of climate change on agriculture. The third section deals with contribution of the farmers' selected characteristics to the effect of climate change on agriculture.

4.1 Characteristics of the farmers

Behavior 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, annual family income, farming experience, training exposure, extension media contact, organizational participation, agricultural knowledge, knowledge on climate change that might be greatly influenced the effect of climate change on agriculture are presented below:

4.1.1 Age

The age of the farmers has been varied from 27 to 65 years with a mean and standard deviation of 45.61 and 9.38 respectively. 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 are presented in Table 4.1.

Table 4.1 Distribution of the farmers according to their age

Category	Basis of categorization (years)	Observed range (years)	Farmers		Mean	SD
			Number	Percent		
Young aged	≤ 35	27-65	14	15.9	45.61	9.38
Middle aged	36-50		40	45.5		
Old aged	> 50		34	38.6		
Total			88	100.0		

Table 4.1 reveals that the middle-aged farmers comprised the highest proportion (45.5 percent) followed by old aged category (38.6 percent) and the lowest proportion were made by the young aged category (15.9 percent). Data also indicates that the middle and old aged category constitute 84.1 percent of total farmers. From the table, it can be stated that the middle and old aged farmers were generally more involved in farm activities than the young aged farmers. The researcher thinks that the results might be due to the inherited traits at the study area.

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 4.83 and 3.25, respectively. Based on the educational scores, the farmers were classified into five categories. The distributions of farmers according to their level of education are presented in Table 4.2.

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

Category	Basis of categorization (score)	Observed range (score)	Farmers		Mean	SD
			Number	Percent		
Can't read and sign	0	0-12	4	4.5	4.83	3.25
Can sign only	0.5		11	12.5		
Primary education	1-5		41	46.6		
Secondary education	6-10		31	35.2		
Above secondary	>10		1	1.1		
Total			88	100.0		

Table 4.2 shows that farmers under primary education category constitute the highest proportion (46.6 percent) followed by secondary education (35.2 percent). Other hands, the lowest 1.1 percent in above secondary education category followed by can't read and sign category (4.5 percent) and 12.5 percent farmers were above can sign only category. The researcher thinks that the results might have due to the lack of torchbearer's effect at the study area.

4.1.3 Family size

Family size of the farmers ranged from 3 to 7 with the mean and standard deviation of 4.65 and 1.22, 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 4.3.

Table 4.3 Distribution of the farmers according to their family size

Category	Basis of categorization (score)	Observed range (score)	Farmers		Mean	SD
			Number	Percent		
Small family	≤ 3 (Mean-1SD)	3-7	7	8.0	4.65	1.22
Medium family	4-6 (Mean ± SD)		18	20.5		
Large family	> 6 (Mean+1SD)		63	71.6		
Total			88	100.0		

Table 4.3 indicates that the large size family constitute the highest proportion (71.6 percent) followed by the medium size family (20.5 percent). Only 8.0 percent farmers had small family size. Such finding is quite normal as per the situation of Bangladesh. The findings indicated that average family size of the study area was smaller than the national average which is 4.85 (BBS, 2014). The researcher thinks that the trend of nuclear family has been rising in the study area and subsequently the family member becoming smaller than the extended family.

4.1.4 Effective farm size

The effective farm size of the farmers ranged from 0.12 ha to 5.35 ha with a mean and standard deviation of 1.39 and 1.10, respectively. Based on their farm size, the farmers were classified into five categories following the categorization according to DAE. The distribution of the farmers according to their farm size is presented in Table 4.4.

Table 4.4 Distribution of the farmers according to their farm size

Category	Basis of categorization (ha)	Observed range (ha)	Farmers		Mean	SD
			Number	Percent		
Landless	≤ 0.02	0.12-5.35	0	0	1.39	1.10
Marginal	0.021-0.20		3	3.4		
Small	0.21-1.00		32	36.4		
Medium	1.01-3.0		45	51.1		
Large	>3		8	9.1		
Total			88	100.0		

Table 4.4 indicates that the medium farm holder constitutes the highest proportion (51.1 percent) followed by small farm holder (36.4 percent). The large sized farm holder constituted by the 9.1 percent farmers. The marginal sized farm holder constituted by the 3.4 percent farmers where no farmers found were found in landless category. The findings of the study reveal that most of the farmers were marginal to small sized farm holder. The average farm size of the farmers of the study area (1.39 ha) was higher than that of national average (0.60 ha) of Bangladesh (BBS, 2014). The researcher thinks that due to the enhancing the economic status of the farmers, farmers is likely to motivate to buy land.

4.1.5 Annual family income

The score of annual family income of the farmers ranged from 60 to 540 thousand (BDT) with a mean and standard deviation of 197.75 and 127.30, 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 4.5.

Table 4.5 Distribution of the farmers according to their annual family income

Category	Basis of categorization ('000' Tk.)	Observed range ('000' Tk.)	Farmers		Mean	SD
			Number	Percent		
Low income	≤ 120	60-540	32	36.4	197.75	127.30
Medium income	121-250		34	38.6		
High income	> 250		22	25.0		
Total			88	100.00		

Table 4.5 reveals that the farmers having medium annual income constituted the highest proportion (38.6 percent), while the lowest proportion was high income (25.0 percent) and low annual family income constituted by 36.4 percent farmers. Overwhelming majority (75. 0 percent) farmers have low to medium level annual family income. The researcher thinks that the results might have due to the climate changing effects on their farming production at the study area.

4.1.6 Farming experience

Score of farming experience of farmers could range from 7 to 36 with mean and standard deviation of 19.82 and 7.03, respectively. On the basis of farming experience scores, the farmers were classified into three categories (Mean ± Standard Deviation) namely 'little, 'medium' and 'high' experience in cultivation. The distribution of the farmers according to their farming experience is presented in Table 4.6.

Table 4.6 Distribution of the farmers according to their farming experience

Category	Basis of categorization (year)	Observed range (year)	Farmers		Mean	SD
			Number	Percent		
Little experience	≤ 12 (Mean-1SD)	7-36	17	19.3	19.82	7.03
Medium experience	13-27 (Mean ±SD)		57	64.8		
High experience	> 27 (Mean+1SD)		14	15.9		
Total			88	100.0		

Table 4.6 reveals that the majority (64.8 percent) of the farmer fell under medium farming experience category, whereas only 19.3 percent in little farming experience category followed by 15.9 percent in high farming experience category. The findings of the present study reveal that around 84.1 percent of the farmers in the study area had low to medium farming experience.

4.1.7 Training exposure

Training exposure score of the farmers ranged from 0 to 15 with a mean and standard deviation of 5.94 and 3.16 respectively. Based on the training exposure score, the farmers were classified into four categories namely 'no training', 'low', 'medium' and 'high' training exposure. The distribution of the farmers according to their training exposure is presented in Table 4.7.

Table 4.7 Distribution of the farmers according to their training exposure

Category	Basis of categorization (score)	Observed range (score)	farmers		Mean	SD
			Number	Percent		
Low training	≤2 (Mean-1SD)	0-15	6	6.8	5.94	3.16
Medium training	3-9 (Mean ± SD)		69	78.4		
High training	> 9 (Mean+1SD)		13	14.8		
Total			88	100.0		

Table 4.7 indicates that the highest proportion (78.4 percent) of the farmers had medium training exposure compared to 14.8 percent in high training exposure and 6.8 percent in low training exposure category, respectively. Training makes the farmers skilled and helps them to acquire deep knowledge about the respected aspects. Trained farmers can face any kind of challenges about the adverse situation in their cultivation. So, they show favorable behavior towards positive attitude in cultivation. The researcher thinks that the results might have due to the materialization of training program by different organizations at the study area.

4.1.8 Extension media contact

The observed score of extension media contact of the farmers ranged from 20 to 28 against a possible range of 0 to 32. The average score of the farmers' extension media contact was 23.97 with a standard deviation 1.94 (Table 4.8). 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 ± Standard Deviation) namely 'low', 'medium' and 'high' extension media contact.

Table 4.8 Distribution of farmers according to their extension media contact

Category	Basis of categorization (score)	Observed range (score)	Farmers		Mean	SD
			Number	Percent		
Low contact	≤ 21 (Mean -1SD)	20-28	10	11.4	23.97	1.94
Medium contact	22-26 (Mean ± SD)		70	79.5		
High contact	> 26 (Mean +1SD)		8	9.1		
Total			88	100.0		

Data shows that the highest proportion (79.5 percent) of the farmers had medium extension media contact and 9.1 percent of farmers had high extension media contact and 11.4 percent were felt under low extension media contact. Table revels that majority of the farmers had medium extension media contact. Finding also reveals that 11.4 percent of the farmers had low extension media contact which demands for strengthening and improving the communication strategy. The researcher thinks that low extension contact might be the reason of having low educational background of the farmers.

4.1.9 Organizational participation

Organizational participation score of the farmers ranged from 0 to 7 with a mean and standard deviation of 1.89 and 1.38. Based on organizational participation score, the farmers were classified into four categories namely 'no', 'low', 'medium' and 'high' organizational participation. The distribution of the farmers as per their organizational participation is presented in Table 4.9.

Table 4.9 Distribution of the farmers according to their organizational participation

Category	Basis of categorization (score)	Observed range (score)	Farmers		Mean	SD
			Number	Percent		
No participation	0	0-7	12	13.6	1.89	1.38
Low participation	1 (Mean-1SD)		27	30.7		
Medium participation	2-4 (Mean ± SD)		44	50.0		
High participation	> 4 (Mean+1SD)		5	5.7		
Total			88	100.0		

Data reveals that the highest proportion (50.0 percent) of the farmers had medium organizational participation, while 30.7 percent farmers had low organizational participation, 13.6 percent farmers had low organizational participation and the lowest 5.7 percent farmers had high organizational participation. The researcher thinks that the results might be logical because the farmers of the study area were busier in income generating activities. Hence, the high organizational participation in the study area was low.

4.1.10 Agricultural knowledge

Agricultural knowledge scores of the farmers ranged from 13 to 21 against possible score of 0 to 24. The average score and standard deviation were 17.95 and 1.70 respectively. Based on the agricultural knowledge scores, the farmers were classified into three categories (Mean ± Standard Deviation) namely poro, moderate and sound agricultural knowledge.

Table 4.10 Distribution of farmers according to their agricultural knowledge

Category	Basis of categorization (score)	Observed range (score)	farmers		Mean	SD
			Number	Percent		
Poor knowledge	≤ 16 (Mean-1SD)	13-21	18	20.5	17.95	1.70
Moderate knowledge	17-20 (Mean ± SD)		65	73.9		
Sound knowledge	> 20 (Mean+1SD)		5	5.7		
Total			88	100.0		

Table 4.10 reveals that 73.9 percent of the farmers had moderate agricultural knowledge, 20.5 percent had poor knowledge and the lowest 5.7 percent had sound agricultural knowledge. Overwhelming majority (55.0 %) of farmers had moderate agricultural knowledge.

4.1.11 Knowledge on climate change

Knowledge on climate change scores of the farmers ranged from 14 to 21 against possible score of 0 to 30. The average score and standard deviation were 18.57 and 1.67, respectively. Based on the knowledge on climate change scores, the farmers were classified into three categories (Mean ± Standard Deviation) namely poor, moderate and sound knowledge on climate change.

Table 4.11 Distribution of the farmers according to their knowledge on climate change

Category	Basis of categorization (score)	Observed range (score)	farmers		Mean	SD
			Number	Percent		
Poor knowledge	≤ 16 (Mean-1SD)	14-21	14	15.9	18.57	1.67
Moderate knowledge	17-20 (Mean ±SD)		66	75.0		
Sound knowledge	> 20 (Mean+1SD)		8	9.1		
Total			88	100.0		

Table 4.11 reveals that 75.0 percent of the farmers had moderate knowledge on climate change, 15.9 percent had poor knowledge and 9.1 percent had sound knowledge on climate change. Thus, majority (75.0 %) of the farmers had moderate knowledge on climate change. The researcher thinks that the results might be due to the having primary level of education among the farmers.

4.2 Effect of climate change on agriculture in the saline prone areas

It was found from the finding of the study that the effect of climate change on agriculture had some significant role in the agricultural production. In order to measure the effect of climate change on agriculture, the agricultural production of the farmers of study group was compared with the control group. Negative significant production of the farmers of the study group was observed which might be attributed to effect of climate change on agriculture. Effect of climate change on agriculture was measured in four dimensions: a) change in the yield of cereal crops, b) changes in the yield of vegetables, c) changes in the yield of pulse crops and d) changes in the adopted new varieties. In this study, the difference between 2015 and 2017 was measured both for study and control group respondents. Finally, the study group was compared with the control group based on difference between 2015 and 2017 data record (Mazumder and Lu, 2015). The changes result for the study is presented in bellow:

4.2.1 Effect of climate change on study group vs control group

A comparison between study group and control group was done to find out the effect of climate change on agriculture. Study group farmers were considered them who cultivated field crops where they faced the climatic hazards and control group farmers were considered them who cultivated field crops where they did not face the climatic hazards. Climate change had mentionable negative effect on agriculture in the saline prone areas of Bangladesh. Study group changed mean score of agricultural production was found -4.62 while the control group gained only -3.89. The distributions of changed effect of climate change on agriculture with respect to study group and control group respondents are shown in table 4.12.

Table 4.12 Distribution of study group and control group respondents' level of agricultural production based on their changed value

Sl. No.	Agriculture indicators	Study Group (changed mean value differences)	Control Group (changed mean value differences)	t-test
1.	Yield of cereal crops	-2.23	-1.86	-12.03**
2.	Yield of vegetables	-0.56	-0.50	-6.18 **
3.	Yield of pulse crops	-0.73	-0.73	-9.80 **
4.	Adopted new varieties	-1.10	-0.80	-9.01**
Total		-4.62	-3.89	-15.73 **

** t-value at 1% significant level

Effect of climate change on agriculture

= Mean score of study group agricultural production - Mean score of control group agricultural production

= -4.62 - (-3.89)

= -0.73

The score of effect of climate change on agriculture found -0.73. So, there was a negative effect of effect of climate change on agriculture. Beside the score value, it was also found the significant negative effect of study group as well as the effect of climate change on agriculture at 1% significance value from t-test compared with control group who cultivated field crops where they did not face the climatic hazards.

4.2.2 Effect of climate change on agriculture in the saline prone areas

Effect of climate change on agriculture in the saline prone areas ranged from -12 to12. The average and standard deviation were -1.55 and -4.43 respectively. On the basis of effect of climate change observed range on agriculture in the saline prone areas, the respondents were categorized into three categories namely negative, no and positive effect as shown in table 4.13.

Table 4.13 Distribution of the respondents according to effect of climate change on agriculture

Category	Basis of categorization (score)	Observed range (score)	Farmers		Mean	SD
			Number	Percent		
Negative effect	-12 to -1	12 to -12	58	65.9	-1.55	- 4.43
No effect	0		0	0		
Positive effect	1 to 12		30	34.1		
Total			88	100.0		

Table 4.13 reveals that 65.9 percent of the farmers had negative effect category, 0 percent had no effect category and 34.1 percent had positive effect of climate change on agriculture. Thus, an overwhelming majority (65.9 percent) of the farmers had negative effect of climate change on agriculture category.

4.3 Factors related to the effect of climate change on agriculture

In order to assess the factors contributing to the effect of climate change on agriculture, multiple regression analysis was conducted.

4.3.1 Factors related to the change in the yield of cereal crops

Table 4.14 shows that there is a significant contribution of respondents' age, level of education, training exposure, agricultural knowledge, knowledge on climate change. Of these, level of education, training exposure and knowledge on climate change was the most important contributing factors (significant at the 1% level of significance). Age, agricultural knowledge (significant at the 5% level of significance) was also important contributing while coefficients of other selected variables don't have any significant contribution on change in yield of cereal crops as well as effect of climate change on agriculture in the saline prone areas of Bangladesh.

The value of R^2 is a measure of how of the variability in the dependent variable is accounted for by the independent variables. So, the value R^2 0.422 means that independent variables accounts for 42% of the variation in change in yield of cereal crops as well as effect of climate change on agriculture. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.410) tells us how much variance in Y (change in yield of cereal crops) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 11.97 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

Table 4.14 Multiple regression coefficients of contributing factors related to change in the yield of cereal crops

Dependent variable	Independent variables	B	*p*	R^2	Adj. R^2	F	*p*
Change in yield of cereal crops	Age	-.005	.030*	0.422	0.410	11.974	0.003**
	Level of education	-.168	.002**				
	Family size	.169	.513				
	Effective farm size	.381	.240				
	Annual family income	-.003	.356				
	Farming experience	.038	.542				
	Training exposure	-.228	.000**				
	Extension media contact	.332	.068				
	Organizational participation	-.060	.712				
	Agricultural knowledge	-.180	.037*				
	Knowledge on climate change	-.136	.004**				

** Significant at $p < 0.01$; * Significant at $p < 0.05$

The b-values indicate the individual contribution of each predictor to the model. Almost all predictors have negative b-values indicates if scores/ values of predictors (e.g. level of education) increases so do the extent of change in yield of cereal crops as vice-versa. Therefore, the b-value of training exposure is negative value (-0.228). So, it can be stated that as training exposure increase by one unit, change in yield of cereal crops decrease by 0.228 units. This interpretation is true only if the effects of all other predictors are held constant. However, each predictor may explain some of the variance in respondents' change in yield of cereal crops conditions simply by chance. In summary, the models suggest that the NGOs and DAE should consider farmers' age, level of education, training exposure, agricultural knowledge and knowledge on climate change while offering and implementing any sustainable agricultural development program.

4.3.2 Factors related to the change in the yield of vegetables

Table 4.15 shows that there is a significant contribution of respondents' level of education, farming experience, training exposure and knowledge on climate change. Of these, level of education and training exposure was the most important contributing factors (significant at the 1% level of significance). Farming experience 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 change in yield of vegetables as well as effect of climate change on agriculture in the saline prone areas of Bangladesh.

The value of R^2 is a measure of how of the variability in the dependent variable is accounted for by the independent variables. So, the value R^2 0.390 means that independent variables accounts for 39% of the variation in change in yield of vegetables. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.372) tells us how much variance in Y (change in yield of vegetables) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 11.97 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

Table 4.15 Multiple regression coefficients of contributing factors related to change in the yield of vegetables

Dependent variable	Independent variables	B	*p*	R^2	Adj. R^2	F	*p*
Change in yield of vegetables	Age	.004	.872	0.390	0.372	18.684	0.009**
	Level of education	-.058	.001**				
	Family size	.016	.890				
	Effective farm size	-.061	.674				
	Annual family income	-.001	.506				
	Farming experience	-1.48	.018*				
	Training exposure	-.060	.000**				
	Extension media contact	.088	.278				
	Organizational participation	.052	.481				
	Agricultural knowledge	.057	.502				
	Knowledge on climate change	-.279	.025*				

** Significant at $p < 0.01$; * Significant at $p < 0.05$

The b-values indicate the individual contribution of each predictor to the model. Almost all predictors have negative b-values indicates if scores/ values of predictors (e.g. level of education) increases so do the extent of change in yield of vegetables as vice-versa. Therefore, the b-value of knowledge on climate change is negative value (-0.279). So, it can be stated that as knowledge on climate change increase by one unit, change in yield of vegetables decrease by 0.279 units. This interpretation is true only if the effects of all other predictors are held constant. However, each predictor may explain some of the variance in respondents' change in yield of vegetables conditions simply by chance. In summary, the models suggest that the NGOs and DAE should consider farmers' level of education, farming experience, training exposure and knowledge on climate change for offering program to increase the cereal crop production.

4.3.3 Factors related to the change in the yield of pulse crops

Table 4.16 Multiple regression coefficients of contributing factors related to change in the yield of pulse crops

Dependent variable	Independent variables	B	*p*	R^2	Adj. R^2	F	*p*
Change in yield of pulse crops	Age	.014	.542	0.586	0.568	21.574	0.000**
	Level of education	-.022	.000**				
	Family size	.071	.536				
	Effective farm size	.108	.448				
	Annual family income	-.251	.043*				
	Farming experience	.000	.990				
	Training exposure	-.104	.002**				
	Extension media contact	.115	.151				
	Organizational participation	.018	.806				
	Agricultural knowledge	-.273	.037*				
	Knowledge on climate change	-.312	.007**				

** Significant at $p < 0.01$; * Significant at $p < 0.05$

Table 4.16 shows that there is a significant contribution of respondents' level of education, annual family income, training exposure, agricultural knowledge and knowledge on climate change. Of these, level of education, training exposure and knowledge on climate change was the most important contributing factors (significant at the 1% level of significance). Annual family income and agricultural knowledge (significant at the 5% level of significance) was also important contributing while coefficients of other selected variables don’t have any significant contribution on change in yield of pulse crops as well as effect of climate change on agriculture in the saline prone areas of Bangladesh.

The value of R^2 is a measure of how of the variability in the dependent variable is accounted for by the independent variables. So, the value R^2 0.586 means that independent variables accounts for 58% of the variation in effect of climate change on agriculture. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.568) tells us how much variance in Y (change in yield of pulse crops) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 21.574 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

The b-values indicate the individual contribution of each predictor to the model. Almost all predictors have negative b-values indicates if scores/ values of predictors (e.g. level of education) increases so do the extent of change in yield of pulse crops as vice-versa. Therefore, the b-value of agricultural knowledge is negative value (-0.273). So, it can be stated that as agricultural knowledge increase by one unit, change in yield of pulse crops decrease by 0.273 units. This interpretation is true only if the effects of all other predictors are held constant. However, each predictor may explain some of the variance in respondents’ climate change in yield of pulse crops simply by chance. In summary, the models suggest that the NGOs and DAE should consider farmers’ level of education, annual family income, training exposure, agricultural knowledge and knowledge on climate change for offering program to increase the pulse crop production.

4.3.4 Factors related to the change in the adopted new varieties

Table 4.17 shows that there is a significant contribution of respondents' level of education, farming experience, training exposure and knowledge on climate change. Of these, level of education, farming experience and knowledge on climate change was the most important contributing factors (significant at the 1% level of significance). Training exposure (significant at the 5% level of significance) was also important contributing while coefficients of other selected variables don't have any contribution on change in adopted new varieties as well as effect of climate change on agriculture in the saline prone areas of Bangladesh.

Table 4.17 Multiple regression coefficients of contributing factors related to change in the adopted new varieties

Dependent variable	Independent variables	B	*p*	R^2	Adj. R^2	F	*p*
Change in adopted new varieties	Age	.008	.794	0.493	0.478	7.713	0.000**
	Level of education	-.381	.000**				
	Family size	.039	.800				
	Effective farm size	.155	.426				
	Annual family income	-.001	.409				
	Farming experience	-.611	.006**				
	Training exposure	-.082	.033*				
	Extension media contact	.176	.106				
	Organizational participation	-.003	.972				
	Agricultural knowledge	.004	.975				
	Knowledge on climate change	-.413	.001**				

** Significant at $p < 0.01$; * Significant at $p < 0.05$

The value of R^2 is a measure of how of the variability in the dependent variable is accounted for by the independent variables. So, the value R^2 0.493 means that independent variables accounts for 49% of the variation in effect of climate change on agriculture. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.478) tells us how much variance in Y (change in adopted new varieties) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 7.713 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

The b-values indicate the individual contribution of each predictor to the model. Almost all predictors have negative b-values indicates if scores/ values of predictors (e.g. level of education) increases so do the extent of change in adopted new varieties as vice-versa. However, each predictor may explain some of the variance in respondents' effect of climate change on agriculture conditions simply by chance. In summary, the models suggest that the NGOs and DAE should consider farmers' level of education, farming experience, training exposure and knowledge on climate change for offering program to adopt new varieties.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The study was conducted in the Protapnagar union of Assasuni upazila to find out the effect of climate change on agriculture in the saline prone areas. Total 88 farmers were selected from the study area as the study group and 30 respondents as Control Group (CG) farmers who cultivated field crops where they did not face the climatic hazards. A well-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, annual family income, farming experience, training exposure, extension media contact, organizational participation, agricultural knowledge, knowledge on climate change. The dependent variable of this study was the effect of climate change on agriculture in the saline prone areas. Data collection was started from 20 March and completed in 15 April, 2017. Various statistical measures such as frequency counts, percentage distribution, average, and standard deviation were used in describing data. In order to estimate the contribution of the selected characteristics of farmers to the effect of climate change on agriculture, multiple regression analysis (B) was used. The major findings of the study are summarized below:

5.1 Major Findings

5.1.1 Selected characteristics of the farmers

Age: The middle-aged farmers comprised the highest proportion (45.5 percent) and the lowest proportion by young aged category (15.9 percent).

Level of education: Primary education constituted the highest proportion (46.6 percent) and the lowest 1.1 percent in above secondary category.

Family size: The large size family constituted the highest proportion (71.6 percent) and the lowest 8.0 percent farmers had small family size.

Effective farm size: The medium farm holder constituted the highest proportion (51.1 percent), whereas the landless farm holder was not found.

Annual family income: The farmers having medium annual income constituted the highest proportion (38.6 percent), while the lowest proportion was high income (13.80 percent)

Farming experience: The majority (64.8 percent) of the farmer fell in medium farming experience category and the lowest 15.9 percent in high farming experience category.

Training exposure: The highest proportion (78.4 percent) of the farmers had medium training exposure and no farmers (0.0 percent) had any training.

Extension media contact: The highest proportion (79.5 percent) of the farmers had medium extension media contact and lowest extension media contact was 9.1 percent of them having high extension media contact

Organizational participation: The highest proportion (50.0 percent) of the farmers had medium organizational participation and the lowest 5.7 percent farmers had high organizational participation.

Agricultural knowledge: The highest 73.9 percent of farmers had medium and the lowest 5.7 percent had high agricultural knowledge.

Knowledge on climate change: The 75.0 percent of the farmers had medium and the lowest 9.1 percent had high knowledge on climate change.

5.1.2 Effect of climate change on agriculture in the saline prone areas

Study group changed mean score of agricultural production was found -4.62 while the control group gained only -3.89. The score of effect of climate change on agriculture found -0.73. So, there was a negative effect of effect of climate change on agriculture.

From the study group, the 61.4 percent of the farmers had medium effect, 17.0 percent had low effect and 21.6 percent had high effect of climate change on agriculture.

5.1.3 Factors related to the change in the yield of cereal crops

There is a significant contribution of respondents' age, level of education, training exposure, agricultural knowledge, knowledge on climate change. The value of R^2 is 0.422 that means independent variables accounts for 42% of the variation in change in yield of cereal crops as well as effect of climate change on agriculture. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.410) tells us how much variance in Y (change in yield of cereal crops) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 11.97 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

5.1.4 Factors related to the change in the yield of vegetables

There is a significant contribution of respondents' level of education, farming experience, training exposure and knowledge on climate change. The value of R^2 is 0.390 that means independent variables accounts for 39% of the variation in change in yield of vegetables. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.372) tells us how much variance in Y (change in yield of vegetables) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 11.97 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

5.1.5 Factors related to the change in the yield of pulse crops

There is a significant contribution of respondents' level of education, annual family income, training exposure, agricultural knowledge and knowledge on climate change. The value of R^2 is R^2 0.586 that means independent variables accounts for 58% of the variation in effect of climate change on agriculture. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.568) tells us how much variance in Y (change in yield of pulse crops) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 21.574 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

5.1.6 Factors related to the change in the adopted new varieties

There is a significant contribution of respondents' level of education, farming experience, training exposure and knowledge on climate change. The value of R^2 is 0.493 that means independent variables accounts for 49% of the variation in effect of climate change on agriculture. The adjusted R^2 indicates the loss of predictive power or shrinkage. Therefore, the adjusted value (0.478) tells us how much variance in Y (change in adopted new varieties) would be accounted if the model has been deprived from the populations from which the sample was taken. The F ratio is 7.713 which is highly significance ($p<.001$). This ratio indicates that the regression model significantly improved the ability to predict outcome variable.

5.2 Conclusions

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

i. It is concluded that the composite effect of climate change on agriculture needs to minimize.

ii. It is concluded that old and medium aged farmers faced more effect of climate change on their agriculture.

iii. Conclusion could be drowned that these farmers could be more ameliorated in all aspects of socio-economic of life if government takes more educational project to make it more educated.

iv. It is concluded that high annual family income encouraged the farmers to mitigate effect of climate change on agriculture.

v. Conclusion is drowned that farming experience influenced the farmers to their effect of climate change on agriculture.

vi. It is concluded that training exposure incited the farmers to tackle effect of climate change on agriculture.

vii. It is concluded that agricultural knowledge of the farmers had influenced to reduce the effect of climate change on agriculture

viii. Conclusion could be drowned that knowledge on climate change of the farmers had influenced to reduce the effect of climate change on agriculture.

5.3 Recommendations

5.3.1 Recommendations for policy implications

On the basis of observation and conclusions drawn from the findings of the study following recommendations are made:

i. It is, therefore, recommended that an effective step should be taken by the Department of Agricultural Extension (DAE) and Non-Government Organizations (NGOs) for strengthening the farmers' qualities in favor of mitigating effect of climate change on agriculture in the saline prone areas.

ii. It is recommended that extension workers should work with middle to old aged farmers for minimizing the effect of climate change on agriculture.

iii. It is recommended that arrangements should be made for enhancing the education level of the farmers by the concerned authorities through the establishment of night school, adult education and other extension methods as possible.

iv. Therefore, it is recommended that the extension workers should work with the farmers and motivate them to enhance the annual income which would help to reduce effect of climate change on agriculture.

v. It is recommended that extension workers as well as the concern authorities should work with experienced farmers with a view to minimizing effect of climate change on agriculture.

vi. Therefore, it is recommended that the extension workers should encourage the farmers to participate the farmers in training program so that farmers themselves could come in contact training facilities with a view to reducing the effect of climate change on agriculture.

vii. It is recommended that arrangements should be made for enhancing the agricultural knowledge of the farmers by the concerned authorities through the priority basis agricultural program.

viii. It is recommended that action should be taken for increasing the knowledge on climate change of the farmers by the concerned authorities through the non-formal educational program.

5.3.2 Recommendations for further study

On the basis of scope and limitations of the present study and observation made by the researcher, the following recommendations are made for future study.

i. The present study was conducted in Protapnagar union of Assasuni upazila. It is recommended that similar studies should be conducted in other areas of Bangladesh.

ii. This study investigated the contribution of eleven characteristics of the farmers to the effect of climate change on agriculture as dependent variables. It is recommended that further study should be conducted with other characteristics of farmers to effect of climate change on agriculture

iii. The present study was concern only with the extent of the effect of climate change on agriculture. It is therefore suggested that future studies should be included more reliable measurement of concerned variable is necessary for further study.

iv. The study was based on the effect of climate change on agriculture. Further studies may be conducted in respect of other effects on agriculture.

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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

Effect of climate change on Agriculture in the Saline Prone Areas of Bangladesh

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

Union: ………………………………………….

Village: ………………………………………….

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

1. Age

How old are you? _________ years.

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.

3. Family size

How many members do you have in your family? ………………….. Nos.

4. **Effective farm size**

What is your total farm size according to use?

Sl. No.	Use of land	Land possession	
		Local unit	Hectare
1.	Homestead area (A_1)		
2.	Own land under own cultivation (A_2)		
3.	Land taken from others on borga system(A_3)		
4.	Land given to others on borga system (A_4)		
5.	Land taken from others on lease (A_5)		
Total			

Total farm size = $A_1 + A_2 + 1/2\ (A_3 + A_4) + A_5$

5. Annual family income

Please mention the amount of annual income from the following sources during last year:

a) Income from agricultural crops

SL. No.	Crop Name	Production (Kg or Maund)	Income/Unit (Tk)	Total Income (Tk)
1.	Rice			
2.	Wheat			
3.	Maize			
4.	Jute			
5.	Potato			
6.	Pulse crop			
7.	Oil crop			
8.	Spice crop			
9.	Vegetables			
10.	Fruits			
Total				

b) Income from animals and fish resources

Sl. No.	Income resources	Production (Kg or Maund/Number)	Income/Unit (Tk)	Total Income(Tk)
1.	Livestock			
2.	Poultry			
3.	Fish resources			
Total				

c) Income from other resources

Sl. No.	Income resources	Total Income (Tk.)
1.	Service	
2.	Business	
3.	Day labor	
4.	Other family members	
5.	Other income source	
Total		

6. Farming experience

How long have you been practicing farming activities? .... years

7. Training exposure

Please mention about your training exposure on agriculture:

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

8. Extension media contact

Please state the extent of your contact with the following ones:

Sl. No.	Name of the information sources	Extent of contact				
		Regularly (4)	Frequently (3)	Sometimes (2)	Rarely (1)	Not at all(0)
1.	Seed, Insecticide, Fertilizer dealer	>9times/year	7-9 times/year	4-6 times/year	1-3 times/year	0 time /year
2.	Ideal vegetable cultivators	>9times/year	7-9 times/year	4-6 times/year	1-3 times/year	0 time /year
3.	Agricultural Extension Officer (AEO)	> 6 times/year	5-6 times/year	3-4 times/year	1-2 times/year	0 time /year
4.	Sub Assistant Agriculture Officer (SAAO)	> 6 times/year	5-6 times/year	3-4 times/year	1-2 times/year	0 time /year
5.	Group discussion	Once in a month	Once/ 2 months	Once/ 3 months	Once/ 4 months	0 time/6 months
6.	Watchingagril. related programs on TV	Daily	Weekly	Fortnightly	Once/ month	0 time/6 months
7.	Listening agril. related programs on radio	Daily	Weekly	Fortnightly	Once/ month	0 time/6 months
8.	Reading agril. related leaflet, booklet	> 6 times/year	5-6 times/year	3-4 times/year	1-2 times/year	0 time /year
Total						

9. Organizational participation

Please mention the nature of your participation:

Sl. No.	Name of the organizations	Nature of participation			
		Not involved (0)	Ordinary Member (1)	Executive Member (2)	President/ Secretary (3)
1.	GO organized co-operative				
2.	Youth club				
3.	NGO organized co-operative				
4.	Farmers' co-operative organized by themselves				
5.	IPM club				
6.	FFS				

10. Agricultural knowledge

Please answer the following questions:

Sl. No.	Questions	Total Marks	Marks Obtained
1.	Mention the name of two high yielding varieties (HYV) of Boro rice	2	
2.	Mention the name of two chemical fertilizers	2	
3.	Mention the name of two harmful insects of crops	2	
4.	Mention the name of two beneficial insects of crops	2	
5.	Mention the name of two timber crops	2	
6.	Mention the name of two insecticides	2	
7.	Mention the name of two varieties of fruit	2	
8.	Mention the name of two agricultural program broadcasted on TV	2	
9.	Mention the name of two practices suitable for rodent killing/management	2	
10.	Mention the name of two diseases of poultry	2	
11.	Mention the name of two diseases of cattle	2	
12.	Mention the name of two practices suitable for fishes	2	

11. Knowledge on climate change

Please answer the following questions:

Sl. No.	Questions	Total Marks	Marks Obtained
1.	Have you ever heard about Climate Change?	3	
2.	What are the elements responsible for climate change?	3	
3.	In which months of the year do the temperature find to be highest and lowest?	3	
4.	What are the effects of temperature on agriculture?	3	
5.	Which month do we call the rainy season?	3	
6.	When does the rain fall occur highest?	3	
7.	Why does flood occur?	3	
8.	What are the effects of flood?	3	
9.	What is salinity?	3	
10.	What are the effects of salinity on agriculture?	3	

12. Effect of climate change on agriculture

12.1 Change in the yield of cereal crops

Sl. No.	Item	February, 2015		January, 2017	
		Cultivated Area (Decimal)	Yield (Kg)	Cultivated Area (Decimal)	Yield (Kg)
1.	Boro rice				
2.	Wheat				
3.	Maize				

(Score 1 for 100kg change in yield of cereal crops)

12.2 Change in the yield of vegetables

Sl. No.	Item	February, 2015		January, 2017	
		Cultivated Area (Decimal)	Yield (Kg)	Cultivated Area (Decimal)	Yield (Kg)
1.	Cauliflower				
2.	Cucumber				
3.	Brinjal				
4.	Bottle gourd				
5.	Tomato				
6.	Amaranth				
7.	Sweet gourd				

(Score 1 for 40kg change in yield of vegetables)

12.3 Change in the yield of pulse crops

Sl. No.	Item	February, 2015		January, 2017	
		Cultivated Area (Decimal)	Yield (Kg)	Cultivated Area (Decimal)	Yield (Kg)
1.	Lentil				
2.	Black gram				
3.	Mungbean				

(Score 1 for 40kg change in yield of pulse crops)

12.4 Change in the adopted new varieties

Sl. No.	Item	February, 2015	January, 2017
		Number of adopted new varieties of agricultural crops	Number of adopted new varieties of agricultural crops
1.	Cereal crops		
2.	Vegetables		
3.	Pulses		

(Score 1 for each change in adopted new varieties)

Thanks for your kind co-operation.

Dated: ------------------ (Signature of 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

Effect of climate change on Agriculture in the Saline Prone Areas of Bangladesh

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

Union: ………………………………………….

Village: ……………….……………………..….

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

1. Age

How old are you? __________ years.

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.

3. Effective farm size

What is your total farm size according to use?

Sl. No.	Use of land	Land possession	
		Local unit	Hectare
1.	Homestead area (A_1)		
2.	Own land under own cultivation *(A_2)*		
3.	Land takenfrom others on borga system*(A_3)*		
4.	Land given to others on borga system (A_4)		
5.	Land taken from others on lease (A_5)		
Total			

Total farm size = $A_1 + A_2 + 1/2\ (A_3 + A_4) + A_5$

4. Effect of climate change on agriculture

4.1 Change in the yield of cereal crops

Sl. No.	Item	February, 2015		January, 2017	
		Cultivated Area (Decimal)	Yield (Kg)	Cultivated Area (Decimal)	Yield (Kg)
1.	Boro rice				
2.	Wheat				
3.	Maize				

(Score 1 for 100kg change in yield of cereal crops)

4.2 Change in the yield of vegetables

Sl. No.	Item	February, 2015		January, 2017	
		Cultivated Area (Decimal)	Yield (Kg)	Cultivated Area (Decimal)	Yield (Kg)
1.	Cauliflower				
2.	Cucumber				
3.	Brinjal				
4.	Bottle gourd				
5.	Tomato				
6.	Amaranth				
7.	Sweet gourd				

(Score 1 for 40kg change in yield of vegetables)

4.3 Change in the yield of pulse crops

Sl. No.	Item	February, 2015		January, 2017	
		Cultivated Area (Decimal)	Yield (Kg)	Cultivated Area (Decimal)	Yield (Kg)
1.	Lentil				
2.	Black gram				
3.	Mungbean				

(Score 1 for 40kg change in yield of pulse crops)

4.4 Change in the adopted new varieties

Sl. No.	Item	February, 2015	January, 2017
		Number of adopted new varieties of agricultural crops	Number of adopted new varieties of agricultural crops
1.	Cereal crops		
2.	Vegetables		
3.	Pulses		

(Score 1 for each change in adopted new varieties)

Thanks for your kind co-operation.

Dated: ------------------- (Signature of interviewer)