

**TECHNOLOGY ADOPTION BY THE FARMERS OF RANGPUR DISTRICT
FOR CLIMATE CHANGE ADAPTATION**



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**MASTER OF SCIENCE
IN
AGRICULTURAL EXTENSION**

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ABSTRACT

Technology Adoption by the Farmers of Rangpur District for Climate Change Adaptation

The study was carried out to assess the extent of technology adoption by the farmers for climate change adaptation. The specific objectives of the study were: i) to determine and describe the extent of adoption of technologies by the farmers for climate change adaptation, ii) to explore the relationship between extent of adoption of technologies for climate change adaptation by the farmers and their selected characteristics, and iii) to determine the problems confrontation of the farmers in adopting technologies for climate change adaptation. The study was conducted in Gangachara Upazila under Rangpur district. Ninety three (93) respondents were selected as sample from a recent list of 310 farmers using random sampling method. Data were collected by a pre-tested interview schedule during 15 February to 25 March 2013. Besides the usual descriptive statistical parameter, Pearson product moment correlation coefficient (r) was also used for the statistical analysis. Among ten selected technologies for technology adoption of the farmers for climate change adaptation included in the study area "crop rotation" was the highest with Technology Adoption Index (TAI) of 168 and it was followed by "irrigation in drought" (TAI= 158), while "sweet gourd cultivation in sandbar" was ranked lowest (TAI= 7) followed by "relay cropping" (TAI= 46). Slightly more than two-fifths (41.9 percent) of the respondents had medium adoption of technologies for climate change adaptation, while 36.6 percent of them had low adoption and 21.5 percent had high adoption. Computed ' r ' value indicated that 'extension media contact', 'organizational participation', 'cosmopoliteness' and 'climate change knowledge' showed significant positive relationship with their adoption of technologies for climate change adaptation. 'educational qualification', 'annual income', 'farm size' and 'climate change awareness' had positive but non-significant relationship with technology adoption. Age and family size had negative and significant relation with technology adoption. "lack of knowledge on climate change" was the main problem in technology adoption" followed by "lack of training facilities for technology adoption".

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Abbreviations and Acronyms

<i>aus</i>	:	<i>Paddy grown in summer season</i>
<i>aman</i>	:	<i>Paddy grown in monsoon season</i>
<i>boro</i>	:	<i>Paddy grown in winter rice</i>
BAU	:	Bangladesh Agricultural University
BINA	:	Bangladesh Agricultural Institute of Nuclear Agriculture
BCAS	:	Bangladesh Centre for Advanced Studies
BCM	:	billion cubic meters
CCC	:	Climate Change Cell
CCCM	:	Canadian Climate Change Model
DAE	:	Department of Agricultural Extension
DRR	:	Disaster Risk Reduction
FAO	:	Food and Agriculture Organization
GDP	:	Gross domestic product
GHG	:	Green House Gases
GFDL	:	Geophysical Fluid Dynamics Laboratory
HYV	:	High Yielding Variety
ICDDR,B	:	International Centre for Diarrheal Diseases, Bangladesh
IPCC	:	Inter Governmental Panel on Climate Change
IPM	:	Integrated Pest Management
ITK	:	Indigenous Technical Knowledge
ISDR	:	International Strategy for Disaster Reduction
MoEF	:	Ministry of Environment and Forest
MONRE	:	Ministry of Natural Resources and Environment, Vietnam
MPO	:	Metropolitan planning organization
PETTRA	:	Poverty Elimination Through Rice Research Assistance
RDRS	:	Rangpur Dinajpur Rehabilitation Service
SAAO	:	Sub Assistant Agricultural officer
STW	:	Shallow Tube Well
UAO	:	Upazila Agricultural Officer
UNFCCC	:	United Nations Framework Convention on Climate Change
UNISDR	:	United Nations International Strategy for Disaster Reduction
WARPO	:	Water Resources Planning Organization
WMO	:	World Meteorological Organization

CHAPTER 1

INTRODUCTION

1.1 General Background

Bangladesh is primarily a low, flat and fertile land. The land area of Bangladesh is 147,570 square kilometers with a population of 14,97,72,364 (BBS, 2011). It is a developing country in South Asia, is primarily deltaic flood plains, and elevations in most of the country do not exceed 10m. The country has a humid tropical climate. Average rainfalls in drier and wetter regions are 1500mm and 5000mm per year respectively. In winter, the average minimum and maximum daily temperatures are about 9.7°C and 26.6°C respectively. In the summer, the average maximum temperature is about 32.2°C (BARC, 1991). Bangladesh is frequently cited as one of the most vulnerable countries to climate change (Rahman and Alam, 2003, and Huq and Ayers, 2007) because of its disadvantageous geographic location; flat and low-lying topography; high population density; high levels of poverty; reliance of many livelihoods on climate sensitive sectors, particularly agriculture and fisheries and inefficient institutional aspects (CCC, 2006). Many of the anticipated adverse effects of climate change, such as sea level rise, higher temperatures, enhanced monsoon precipitation and an increase in cyclone intensity will aggravate the existing stresses that already impede development in Bangladesh, particularly by reducing water and food security and damaging essential infrastructure (MoEF, 2005). Agriculture is the single largest producing sector of the economy and it contributes about 22 percent to the total Gross Domestic Product (GDP) of the country. GDP growth rate of Bangladesh mainly depends on the performance of the agricultural sector. Although due to natural calamities loss of food and cash crop is almost regular phenomenon. Bangladesh incurs annual loss of 1.81 percent of GDP due to extreme weather events. Total losses were 2.19 billion dollar a year from 1990 to 2008. Bangladesh scores eight on risk index (Anonymous, 2010).

According to Inter Governmental Panel on Climate Change (IPCC) in their published fourth assessment, the following changes have been observed in climate trends, variability and extreme events:

- In Bangladesh, average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the period 1985 to 1998.
- The annual mean rainfall exhibits increasing trends in Bangladesh. Last ten years rain anomalies are above long term averages since 1960s.
- Serious and recurring floods have occurred during 2002, 2003, 2004 and 2007.
- Frequency of monsoon depressions and cyclones formation in Bay of Bengal has increased.
- Water shortage has been attributed to rapid urbanization and industrialization, population growth and inefficient water use, which are aggravated by changing climate and its adverse impacts on demand, supply and water quality.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season.
- A rise of 1^o to 2^o C temperatures in combination with lower solar radiation causes sterility in rice spikelets.
- High temperature was found to reduce yields of HYVs of *aus*, *aman* and *boro* rice. The effect was particularly evident at a rise of temperature by 4^oC.
- Temperature, humidity and radiation have great effects on the incidence of insect pests, diseases and microorganisms.
- A change of 1^oC changes the virulence of some races of rust infecting wheat.
- Crop production is hampered by too much water during the wet season and too little during the dry season.
- Decline of groundwater table at a rapid rate ultimately causing STW (Shallow Tube Well) non-operating in many parts of the country during dry period.
- Lack of surface water during the dry season limits the function of Low Lift Pumps.
- Intergovernmental Panel on Climate Change (IPCC) prediction, global temperature will rise between 1.8 degrees and 4 degrees (Celsius) by the last decade of the 21st century.
- IPCC estimates that, by 2050, changing rainfall patterns with increasing temperatures, flooding, droughts and salinity (coastal belt) could cause a

decline in rice production in Bangladesh by 8 percent and wheat by 32 percent, against 1990 as the base year.

- World Bank 2009 project by 2050 the reduction of rice production caused by climate variability will be as high as 12.8 percent of the production that would have been achieved without climate variability. All rice, Aus, Aman and Boro are affected by climate change parameters.

Variability in climate system affects six sectors which are found to be the major users of water in Bangladesh. These include agriculture (for irrigation), domestic or municipal, fisheries, navigation, industry, and environment (in-stream flow including salinity control). Other than in the low-flow season, available water resources are found to be sufficient to meet the present demand. Over the next 25 years, however, with the increase in the absolute size of the population the per capita water availability in Bangladesh will progressively be reduced (Ahmad *et al.*, 2001).

Climate Change impacts broadly divided into two groups:

a) Biophysical impacts:

- Sea level rise, changes to ocean salinity;
- Changes in land, soil and water resources(quantity, quality)
- Physiological effects on crops, pasture, forests livestock (quantity, quality)
- Increased weed and pest challenges;
- Shifts in spatial and temporal distribution of impacts;
- Sea temperature rise causing fish to inhabit different ranges.

b) Socio-economic impacts:

- Reduced marginal GDP from agriculture;
- Decline in yields and production;
- Fluctuations in world market prices;
- Changes in geographical distribution of trade regimes;
- Increased number of people at risk of hunger and food security;
- Migration and civil unrest (Uddin, 2004)

Bangladesh's proximity to sea level is another natural condition that increases its vulnerability to the effects of global warming. The frequency and severity of these natural disasters are rapidly escalating because of climate change. Because, Bangladesh is both low-lying and densely populated, the impacts of climate change on the country will be particularly intense. Minor environmental changes will have major consequences. Bangladesh is in risk for climate-related problems. It is seriously at risk for all of the five main climate threats: drought, floods, storms, sea-level rise, and agricultural crop loss. A one-meter rise in sea level as the result of the melting of the Himalayan glaciers and Greenland ice sheet could flood one-third of the country and displace as many as 40 million people. In other areas of Bangladesh, climate change may contribute to salinity intrusion and increase the likelihood of winter drought. In both of these scenarios, a shortfall in crop production would ensue, threatening the food security of a society that is highly dependent on agriculture. The repercussions of global warming on Bangladesh are diverse and wide-reaching. The environmental changes that are occurring directly affect all aspects of society. Human health, food security, industry and energy security, infrastructure, and economic development are all threatened by climate change. As the effects of climate change continue to intensify the potential for social, economic, and humanitarian disaster is rapidly increasing. One of the most serious impacts of climate change is on human migration. Bangladesh becomes inundated; many will have no choice but to flee their homes. Bangladeshi land squatters have for decades settled on vulnerable islands of silt known as chars already vulnerable during monsoons, this rootless population is sure to increase. With higher sea levels and stronger storms, the chars are quickly eroding under their inhabitants' feet. Farmers who can no longer cultivate their land, inhabitants of coastal areas that have been submerged in sea water, and other impoverished Bangladeshis who are forced to leave their homes to escape from climate change will become environmental refugees (Matthews, 2009).

1.2 Conceptual Approach towards Adaptation

Adaptation to climate change is defined by IPCC (2001) as 'the adjustment in natural of human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'. The extreme weather and climatic events are likely to increase the number and scale of disaster, while at the same time, the existing methods and tools of disaster risk reduction provide powerful capacities for adaptation to climate change (UNISDR, 2008).

The term adaptation means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change (Smit *et al.*, 2000). They further added that adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system. They still further went on saying that adaptation to climate on their health, agriculture fisheries, forests and food security, and take advantage of the opportunities that their climatic environment provides.

There are various ways to classify or distinguish between different adaptations strategies. Depending on the timing goal and motive of its implementation, adaptation can be either "reactive" or "anticipatory". Reactive adaptation takes place after impacts of climate change have become manifest, while anticipatory adaptation takes place before impacts are apparent. The boundary between reactive and anticipatory adaptation is not clear however. Adaptation activities are often implemented in response to an adverse event, aimed at preventing its recurrence or minimizing future impacts. Moreover, it is difficult to define 'before' and 'after' in a continuously changing system. Second, Adaptation may be considered to be 'autonomous' or 'planned'. Autonomous adaptation takes place without intervention of an informed decision maker, while planned adaptation requires informed and strategic actions. Most natural and socio-economic systems will undergo autonomous adjustments in response to changing climatic conditions. These adjustments are likely

to occur both to gradual changes and more drastic events. Planned adaptation requires a strategic policy decision based on an awareness that climatic conditions have changed or are about to change, and that action is needed to return to or maintain a desired state. Thus, planned adaptation can be both reactive anticipatory, while autonomous adjustments are always reactive and autonomous, whereas adaptation to socio-economic systems can be either reactive and anticipatory, and autonomous or planned (Ahmed *et al.*, 1999).

1.3 Statement of the Problem

The northern part of Bangladesh is situated in the Tista-Jumuna basin and contains many tributaries to these rivers. Topography and micro-climate make northern Bangladesh ecologically vulnerable to destabilizing variations of natural livelihood that is affected by floods, river erosion, drought spells and often cold waves, all of which occur more frequently and intensely than in other region of Bangladesh. Climate change incidents will affects the entire region and people will be affected at large scale. It is already mentioned that the region is characterized by high temperature and low rainfall compare to average condition of Bangladesh. It is prone to flood, flash flood, river bank erosion, drought, cold wave pattern which is likely to become more frequent and intense along with horizontal expansion due to climate change. It is also important to note that changes in timing of this natural phenomenon which is influenced by the micro and macro level climatic condition is really alarming resulting from erratic behavior and distribution of rainfall and temperature rise. The major impacts would be on agriculture, fisheries, availability of water resources for agriculture and domestic use, wet lands, food security, education, gender, human health and working capacity, assets and assets developments, social security and on many more.

Many technologies have been used to adapt the contemporary climate variability and extremes. The existing adaptation technologies include air conditioning, flood defense systems and irrigation but also monitoring, forecasting and early warning systems for natural hazards. There adaptation technologies for climate change may need to

improve and new technologies may need to be developed because climate change is likely to exact new and higher standards of reliability and performance. Therefore, it is necessary to assess the technology that is suited for the climate change adaptation and what type of technology the farmer adopts. The researcher put forward the following question for conducting research in planned and appropriate manner,

- a) What is the level of adoption of technologies by the farmers for climate change adaptation?
- b) What are the relationship between the individual characteristics of the farmers and their extent of adoption of technologies for climate change adaptation?
- c) What are the problems faced by the farmers in adopting technologies for climate change adaptation?

1.4 Specific Objectives

The following specific objectives were set forth in order to give proper direction to the study:

- a) To determine and describe the extent of adoption of technologies by the farmers for climate change adaptation
- b) To explore relationship between selected characteristics of the farmers and their extent of adoption of technologies for climate change adaptation.

The characteristics are:

1. Age
2. Educational qualification
3. Family Size
4. Annual Income
5. Farm Size
6. Extension media contact
7. Organizational participation
8. Cosmopolitaness
9. Climate change knowledge
10. Climate change awareness

- c) To determine the problem faced by the farmers in adopting technologies for climate change adaptation.

1.5 Justification of the Study

Climatic change possess serious threat to our country specially on our economy through damaging agricultural resources, but the use of adaptation technologies are very few. Majority of farmers are illiterate and have small farm size. Farmers do not change agricultural practices to improve water efficiency and crop diversification. This not only in areas that are affected by climatic change but in the whole country. The development and introduction of new varieties and corresponding dissemination measures are important and need to be facilitated by national research. As climate change is a serious threat to farm products and its changing effort is unstoppable so adaptation with this is the only way as a result adoption of technologies and new technology development is necessary.

The findings of the research may be helpful to the field workers of agricultural extension service providers to improve strategies of action for adoption of technologies and new technologies for climate change adaptation that will conserve agricultural resources. The researcher also believes that the findings and recommendations of this study will be helpful for formulating extension programs in reducing risk of production, health and environment.

1.6 Assumptions of the Study

An assumption has been defined as the supposition that an apparent fact or principle is true in the light of the available evidence (Good and Hatt, 1952). An assumption is taken as a fact or believed to be true without proof. The researcher made following assumptions while undertaking the study.

1. The social and cultural environment the study area was well aware of to the researcher who acted as an interviewer. Therefore, the data collected by the researcher were free from bias and the respondents furnished their opinions without any hesitations.

2. Views and opinions furnished by the respondents included in the sample were the representative views and opinions of the whole population of the study area,
3. The respondents selected for the study competent to satisfy were the quarries of the research and their responses were reliable.
4. The respondents were capable of furnishing proper responses to the questions included in the interview schedule.

1.7 Limitations of the Study

In order to conduct the research in a meaningful and manageable way, it became necessary to impose some limitations in certain aspects of the study. Considering the time, money, labor and other necessary resources available to the researcher, the following limitations have been observed throughout the study:

1. The study was confined to three villages namely Alambiditor, Kisamatkutub and Sitkutub under Gangachara upazila of Rangpur district.
2. There were many people in the study area, but only the people who were involved in farming activities were considered for this study.
3. Population for the present study was kept confined within the heads of farm families in the study area, because they were the decision makers in their respective families.
4. Characteristics of the farmers were many and varied but only ten characteristics were selected for investigation in this study.
5. There were many adaptation technologies practiced by the farmer in farming but only ten technologies were selected for measuring the extent of their adaptation.

1.8 Definition of Important Terms

Certain terms frequently used through the study are defined and interpreted as follows:

Adaptation: Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton, 1992).

Adoption: Adoption is a decision to make full use of an innovation as the best course of action available. When an individual takes up a new idea as the best course of action and practices it, the phenomenon is known as adoption.

Awareness: Awareness may be defined as one's consciousness about an object or thing of different situation in his or her surroundings.

Climate: Climate is the average state of the lower atmosphere, and the associated characteristics of the underlying land or water, in a particular region, usually spanning at least several years

Climate Change: Climate Change any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007).

Farmer: Farmer means the principal decision maker involved in the management of a farm, not always be the head of the farm-household.

Intercropping: Intercropping is the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include the vegetative stage e.g. sugarcane and potato.

Knowledge: Knowledge literally means knowing or what one knows about a subject, fact, person etc. Knowledge, however, refers to the amount of facts or information about an idea, object, or person which a person knows. Regarding technological aspect knowledge occurs when an individual is exposed to a technology's existences and gains some understanding of how it functions.

Mixed cropping: Mixed Cropping is the process of growing two or more crops together in the same piece of land. This system of cropping is generally practiced in areas where climatic hazards are frequent and common.

Relay cropping: Relay cropping is growing two or more crops in sequence, planting the succeeding one after the flowering but before the harvest of the farmer.

Technology: Technology refers to the combination of knowledge, inputs and management practices which are used together with productive resources to gain a desired output.

CHAPTER 2

LITERATURE REVIEW

The present study is concerned with technology adoption by the farmers for climate change adaptation in a selected area. This chapter deals with the review of past studies and findings related to the present study. In fact, very few research works have been done so far on technology adoption by the farmers for climate change adaptation in Bangladesh. This research, therefore, made exhaustive effort to review the previous research works directly or indirectly related to the present study by different researchers in home and abroad. Literatures reviewed are presented below in two major sections. In the first section, literatures on general context i.e., related to the climate change adaptation and adoption of technology. The second section contained literatures concerning relationship of the selected characteristics of farmers and their adoption.

2.1 General Information

2.1.1 Concepts of Climate change

According to Ramamasy *et al.* (2007), “climate is statistical information, a synthesis of weather variation focusing on a specific area for a specified interval; climate is usually based on the weather in one locality averaged for at least 30 years”. So, climate is often defined as the weather averaged over time (typically, 30 years, WMO) (MONRE, 2008). On the other hand, Weather is the day-to-day state of the atmosphere and its short-term (from hours to a few weeks) variations such as temperature, humidity, precipitation, cloudiness, visibility or wind.

Climate change is the natural phenomenon but is also accelerated by human activities (O'Brien *et al.*, 2006). Climate changes are likely to manifest in four main ways; slow changes in mean climate conditions, increased inter-annual and seasonal variability, increased frequency of extreme events, and rapid climate changes causing catastrophic shifts in ecosystems (Tompkins and Adger, 2004). In IPCC (2007), climate change was understood as any changes of climate over time due to natural changes or results

of human activities. With this definition, climate change can be the resulting changes of internal processes or external forces (Nicholls, 2007).

According to United Nations Framework Convention on Climate Change (UNFCCC), climate change refers to direct or indirect activities of humans, leading to change in global atmosphere components and create changes of natural climate variability observed over comparable time. Regarding climate change views, Smit *et al.*, (1999) and Cruz *et al.*, (2007) and as well as in my view in this study, climate change is defined as changes through increasing in frequency and intensity of extremes weather events including storm, flood, drought and irregular rain over time and irregular climate signal.

Climatic variability means the fluctuation that occurs from year to year and the statistic of extreme conditions such as severe storms or unusually hot seasons (ISDR, 2008). According to Oxfam organization, climatic variability is natural variations in the climate that are not caused by greenhouse gas emissions (e.g., it rains more in some years and less in others). Climate extreme (weather extreme event) is small changes in average conditions that can have big influence on extremes such as droughts or floods. These changes are already noticeable, and the trend is expected to continue (Selvaraju *et al.*, 2006).

2.2 Concept of Adoption

Eveland (1979) reported that adoption is the original dependent variable in innovation research the criterion which is sought. It is the desirable property of innovative systems which change agents seek to enhance. "Innovation" is broadly defined as any change in structure, design, products, or processes in which there is a definable new element introduced in to the system; the process is essentially the same for technologies of all degrees of "hardness" although the specifics may vary. By far the largest body of knowledge relating to innovation is the so called "correlates of innovativeness" research the information about which characteristics of people or organizations are associated with higher levels of adoption. The voiced or unvoiced assumption underlying the examination of correlates of innovativeness is causal: If we

manipulate the characteristics of organizations or individuals so that they more closely resemble those of the highly innovative, we will make the organizations or individuals themselves more innovative (i.e., more prone to "adopt" our innovations).

Rogers (1995) called the "pro-innovation bias", a tendency to assume that adoption of the innovation should be carried out by all possible adopters. In accounting for this slant, it is useful to remember that innovation research began as market research that is, studies aimed at identifying ways to get people to buy more goods and services, particularly in agriculture.

2.3 Concept of Technology

Technology can be most broadly defined as the entities, both material and immaterial, created by the application of mental and physical effort in order to achieve some value. In this usage, technology refers to tools and machines that may be used to solve real world problems. It is a far reaching term that may include simple tools, such as a crowbar or wooden spoon, or more complex machines, such as space station or particle accelerator.

Macek (2007) defined technology is the application of math, science and arts for the benefit of life as it is known. A modern example is the rise of communication technology, which has lessened barriers to human interaction and as a result, has helped spawn new subcultures; the rise of cyber culture has at its basis the development of the Internet and the computer.

Sci-tech Encyclopedia (2010) referred technology as systematic knowledge and action, usually of industrial process but applicable to any recurrent activity. Technology is closely related to science and to engineering. Science deals with human's understanding of the real world about them the inherent properties of space, matter, energy, and their interactions. Engineering is the application of objective knowledge to the creation of plans, designs, and means for achieving desired objectives. Technology deals with the tools and techniques for carrying out the plans.

Britannica Concise Encyclopaedia (2010) referred that application of knowledge to the practical aims of human life or to changing and manipulating the human empowerment.

Technology includes the use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productive. Whereas science is concerned with how and why things happen, technology focuses on making things happen. Technology began to influence human endeavour as soon as people began using tools. It accelerated with the Industrial revolution and the substitution of machines for animal and human labour. Accelerated technological development has also had costs, in terms of air and water pollution and other undesirable environmental effects.

2.4 Adaptation Terminology

The adaptation concept is rather new for the research community it also used for a longer history in ecology, natural hazards and risk management fields (Smit *et al.*, 1999).

“Adapt” means to make something or system more suitable by altering it (Smit *et al.*, 1999). Adaptation refers to the process of adapting and the condition of being adapted. According to Burton (1992), adaptation in social sciences was concerned with “the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides” as cited in Smit *et al.*, (1999). Similarly, Carter *et al.*, (1994) described that adaptation refers to any adjustment, whether passive, reactive or anticipatory that can respond to anticipated or actual consequence associated with climate change.

According to Antle (2009), 'Agricultural adaptation can occur in many ways, from the individual field where a crop is grown; crop varieties are selected; and management decisions such as tillage, fertilization, and pesticide application are made to the farm level, where managers choose among crop, livestock, and other activities and capital investment decisions are made. Beyond the farm gate, many other decisions are made that affect the economic environment in which farms operate, including infrastructure investments, research and development, and policy. Many of these adaptations at the farm level and in the broader food system and economy are made without government involvement and are referred to as autonomous adaptation in the IPCC assessment

reports (IPCC 2007 and Parry *et al.*, 2007). Other adaptations that involve government intervention are referred to as planned adaptations'.

In short, basing on many concepts of different authors, adaptation to climate change in this research is understood as adjustments by community and individual to respond to the changing of climate over time in order to moderate negative impacts or enhance adaptive capacity of community and individual. Understanding adaptation concepts is important to make the foundation for evaluating and identifying impacts of climate change as well as choosing the appropriate adaptation measures in order to decrease negative climate changes impacts, reduce significantly vulnerability and risk for human, environment and nature in climate change context.

2.5 Use of Technologies

The core challenge of climate change adaptation and mitigation in agriculture is to produce (i) more food, (ii) more efficiently, (iii) under more volatile production conditions and (iv) with net reductions in Green house gases (GHG) emissions from food production and marketing. As long as climate change and policy responses it induces do not interrupt long-term income growth or alter the long-term decline in relative food prices so much that the path towards improved diets is reversed, aggregate food demand will continue to grow along with population and income growth. As climate change affects input availability, especially water in many places, input use efficiency must increase with these productivity demands. Carbon emission polices may simultaneously encourage or force producers to recognize GHG emissions as an important and costly 'input' in production processes and open new opportunities and incentives for on farm GHG mitigation. Producers will grapple with these growing demands and shifting incentives amidst more volatile production conditions. (Lybbert and Sumner, 2010)

They also found that increasing productivity of several new varieties and traits offer farmers greater flexibility in adapting to climate change, including traits that confer tolerance to drought and heat, tolerance to salinity (e.g., due to rising sea level in coastal areas), and early in order to shorten the growing season and reduce farmers'

exposure to risk of extreme weather events. These promising new traits and varieties, which are mostly still in development, can emerge from traditional breeding techniques that leverage existing varieties that are well suited to vagaries of the local production environment as well as from more advanced biotechnology techniques such as marker assisted selected and genetic modification.

2.6 Effects of Technology on Climate Change

The production of food crops is the most climate dependent economic activity. Changes in climate can be expected to have significant impacts upon crop yields through changes in both temperature and moisture. As climate patterns shift, changes in the distribution of plant diseases and pests may also have adverse effects on agriculture. At the same time, agriculture has proven to be one of the most adaptable human activities to varied climate conditions. Many investments are relatively short-term and crops and cultivars can be quickly changed to suit new conditions. There is flexibility also in farming practices, the application of irrigation water and other inputs. For these reasons, agriculture at the global level can probably adapt to a moderate amount of global warming (perhaps up to 2.5 degrees Celsius above current levels, assuming no dramatic change in climate variability). There are likely to be considerable regional variations. However, crops in low latitudes are more often close to their limits of heat tolerance, while growing conditions are likely to improve in higher latitudes, where agriculture might gain in competitive advantage. As in other sectors, adaptive capacity is likely to be a major factor in determining the relative distribution of adverse impacts. (Burton *et al.*, 2006).

Agriculture is responsible for over a quarter of total global greenhouse gas emissions. Given that agriculture's share in global Gross Domestic Product (GDP) is about 4 percent; these figures suggest that agriculture is highly GHG intensive. The potential role innovative agricultural practices and technologies can play in climate change mitigation and adaptation aims to address the question: what policy and institutional changes are needed to encourage the innovation and diffusion of these practices and technologies to developing countries? (IPCC, 2007).

Climate change is expected to have significant impacts on water supplies creating or exacerbating chronic shortages on water quality. There is already widespread acceleration of glacial retreat and in many areas stream flow is shifting from spring to winter peaks. If continued, these shifts could affect the availability of water for agriculture and other uses. Sea-level rise will result in saltwater intrusion into coastal fresh water aquifers, potentially reducing water resource availability. Changes in quantity and intensity of precipitation are likely to result in more floods and droughts and increased demand for irrigation water. Water management often requires costly investment in infrastructure. Given the long economic and physical life of reservoirs, water withdrawal, treatment, delivery, and disposal systems, adaptive responses are generally slower in water management than in agriculture. Climate has obvious and direct effects on agricultural production. Greenhouse Gas (GHG) implications of agriculture are also obvious and large.

Lybbert and Sumner (2010) reported that Agricultural technologies will play a central role in enabling producers to meet these core challenges. Because, agriculture is inseparably linked to climate and feedback runs in both directions, most agricultural technologies have direct or indirect climate linkages. Most new technologies change the use of farm inputs, often in ways that alter the impact of weather on production and of production on carbon emissions. While most agricultural technologies therefore have climate implications, there are a handful of current and emerging technologies with particular relevance to developing country agriculture and climate change.

2.7 Need for Adaptation

Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed and expected changes in climate and associated extreme events. Adaptation occurs in physical, ecological and human systems, which involves changes in social and environmental processes, perceptions of climate risks, practices and functions to reduce potential damages or to realize new opportunities. Biological adaptation is slow and reactive, whereas individuals and societies adapt to both observed and expected changes through autonomous, anticipatory, and planned actions. However, adaptive capacity is uneven across and

within societies, and there have been limits and barriers to adaptation (Adger *et al.*, 2007).

Burton (2006) observed that the most effective, adaptation must proceed at several levels simultaneously. Adaptation is in fundamental ways inherently “local” the direct impacts of climate change are felt locally, and response measures must be tailored to local circumstances. However, for this effects to be robust or many cases, even possible that they must be guided and supported by national policies and strategies. For some countries, these, in turn, need to be facilitated through international measures.

BCAS (2010) has reported to enhance the adaptive capacity of the vulnerable communities and ecosystems to tackle climate impacts, risks and vulnerability in the local contexts and protect the lives and livelihoods of the common people. There were several commonalities in the adaptation strategies. The common strategies included the following:

- Participatory planning and social mobilization;
- To improve understanding about risks and vulnerability;
- Awareness raising and communication of climate risks;
- Improve coping abilities and strengthen DRR (Disaster Risk Reduction);
- Conservation of natural resources and enhancement of ecosystem services
- Facilitate local innovation and technology generation;
- Promotion of food and livelihood security;
- Local capacity and institution building; and
- Learning, sharing and policy advocacy

2.8 Literature Related to Relationships of Selected Characteristics of the Farmers and their Adoption

2.8.1 Age and technology adoption by the farmers for climate change adaptation

Salehin *et al.* (2009) found that age of the farmers had a significant negative relationship with their adoption of rice production technologies. The relationship between concerned variables was low. This finding indicates that the less is the age of the farmers the more was their adoption of rice production technologies. Thus, it could

be said that young farmers had favourable tendency to adopt rice production technologies.

Sardar (2002) observed that age of the farmers had a negatively significant relationship with their adoption IPM practices.

Islam (1996) stated that age of the farmers had significant negative relationship with their extent of the use of ITK.

Ahmed (1977) in his study found that age of the farmers had no significant influence on the use of information sources in the adoption of improved farm practices.

Razzaque (1977) in his study indicated no relationship between age of the farmers and their adoption of HYV rice.

2.8.2 Educational qualification and technology adoption by the farmers for climate change adaptation

Hossain (2003) found that education of the respondents had significant and positive relationship with their knowledge on modern boro rice.

Islam (2002) observed that education of the farmers had a positive significant relationship with their adoption of IPM practices.

Ahmed (1977) in his study showed that education of farmers had a significant relationship with information sources in the adoption of plant protection measures.

2.8.3 Family size and technology adoption by the farmers for climate change adaptation

Hossain (2006) conducted a study on a Adoption of technology of selected HYV rice cultivation and found that the farmers had significant relationship with their extent of farmers' adoption of selected HYV rice.

Islam (2005) observed that family size of respondents had insignificant relationship with their extent of adoption of posu pusti in cattle rearing at farmers' level.

Haque (2003) found that the family size of respondents had negatively insignificant relationship with their extent of farmers' adoption of modern maize cultivation technologies.

2.8.4 Annual income and technology adoption by the farmers for climate change adaptation

Sardar (2002) conducted a study on adoption of IPM practices by the farmers under PETRRA project of RDRS. He observed that annual income of the farmers had no relationship with their adoption of IPM practices.

Hussen (2001) conducted an investigation on adoption modern sugarcane practices by the farmers of Dewanganj upazila in Jamalpur district. He found that there was a significant relationship between annual income of the farmers and their adoption of modern sugarcane cultivation practices.

2.8.5 Farm size and technology adoption by the farmers for climate change adaptation

Aurangozeb (2002) observed no relationship between homestead area and adoption of integrated homestead farming technologies.

Hussen (2001) found significant positive relationship between farm size of the farmers and their adoption of modern sugarcane cultivation practices.

Ahmed's (1977) study showed that farm size had significant influence on the use of information sources in the adoption of plant protection measures

2.8.6 Extension media contact and technology adoption by the farmers for climate change adaptation

Haque (2006) observed that the extension contact of the rice growers had significant and positive relation with the adoption of modern varieties.

Hussen (2001) found that there was a positive significant relationship between extension contact of the farmers and their adoption of modern sugarcane cultivation practices.

Rahman (2001) found that there was a significant positive relationship between the extension contact of the farmers and their adoption of that hybrid rice.

2.8.7 Organizational participation and technology adoption by the farmers for climate change adaptation

Sardar (2002) found that the organizational participation of farmers had no significant relationship with their adoption of IPM practices.

Mostofa (1998) observed that organizational participation of mango growers had a significant positive relationship with their adoption of mango cultivation practices.

Chowdhury (1997) observed that there was a significant positive relationship between farmers' organizational participation and their adoption of selected BINA technologies.

2.8.8 Cosmopoliteness and technology adoption by the farmers for climate change adaptation

Ahmed (1977) found no relationship between cosmopoliteness of the farmers and each of the adoption of recommended variety of jute, recommended dose of fertilizers and plant protection measures in jute cultivation.

Karim (1973) found a significant positive relationship between cosmopoliteness of the transplanted aman rice growers and their adoption of fertilizers.

2.8.9 Climate change knowledge and technology adoption by the farmers for climate change adaptation

Reza (2007) found that maize cultivation knowledge of farmers had a significant relationship with their adoption of modern maize cultivation technology by the farmers.

Miajy (2005) observed that a significant positive relationship between agricultural knowledge and adoption of hybrid varieties of maize.

2.8.10 Climate change awareness and technology adoption by the farmers for climate change adaptation

After through searching no information was found on this aspect. Hence it was not possible to put relationship in this context.

2.9 Conceptual Framework

The key objective of the present study was to have an understanding about technology adoption of farmers on climate change adaptation. In Bangladesh, many agricultural activities to solve the need of growing population years after years. Climate change has crucial effect on agriculture. Many research findings recognized climate change effect on agriculture, human health hazards and deterioration of socio-economic condition of rural people. To reduce the loss in order to climate change there are important essential to adapt with the climate by applying some adaptation technique. The extension agents are trying to motivate the farmers to change their agricultural practices. Hence, in advance taking any extension activity we have to know farmers present status of understanding, feelings, actions, and problems in this regard.

It is essential to know and understand on the climate change adaptation and its advantages in farming practices and farmers reaction about the issue. In this study, attempt to address the subject that what does the client get benefit from climate change adaptation.

Farmers' adoption of technologies almost depends on their individual characteristics. Farmers can take knowledge of technology if their education level is high. They can get knowledge of technologies if they have high extension media contact and organizational participation. Their adoption of technologies will be encourages if GOs and NGOs provide required initiatives and supports like training, credit etc. Considering the above factors, that adoption of technologies for climate change adaptation would be increased in a positive way that will be better sustainable agricultural development in changed climatic condition.

The conceptual framework was kept in mind the structure arrangement on the dependent and independent variables. It is also included the other factors that may play probable role in this case. The technology adoption was considered as dependent variables and individual ten selected characteristics were selected as independent variables in the present study. In the light of the foregoing discussions, a conceptual framework has been developed for this study, which is diagrammatically shown in the Figure 2.1

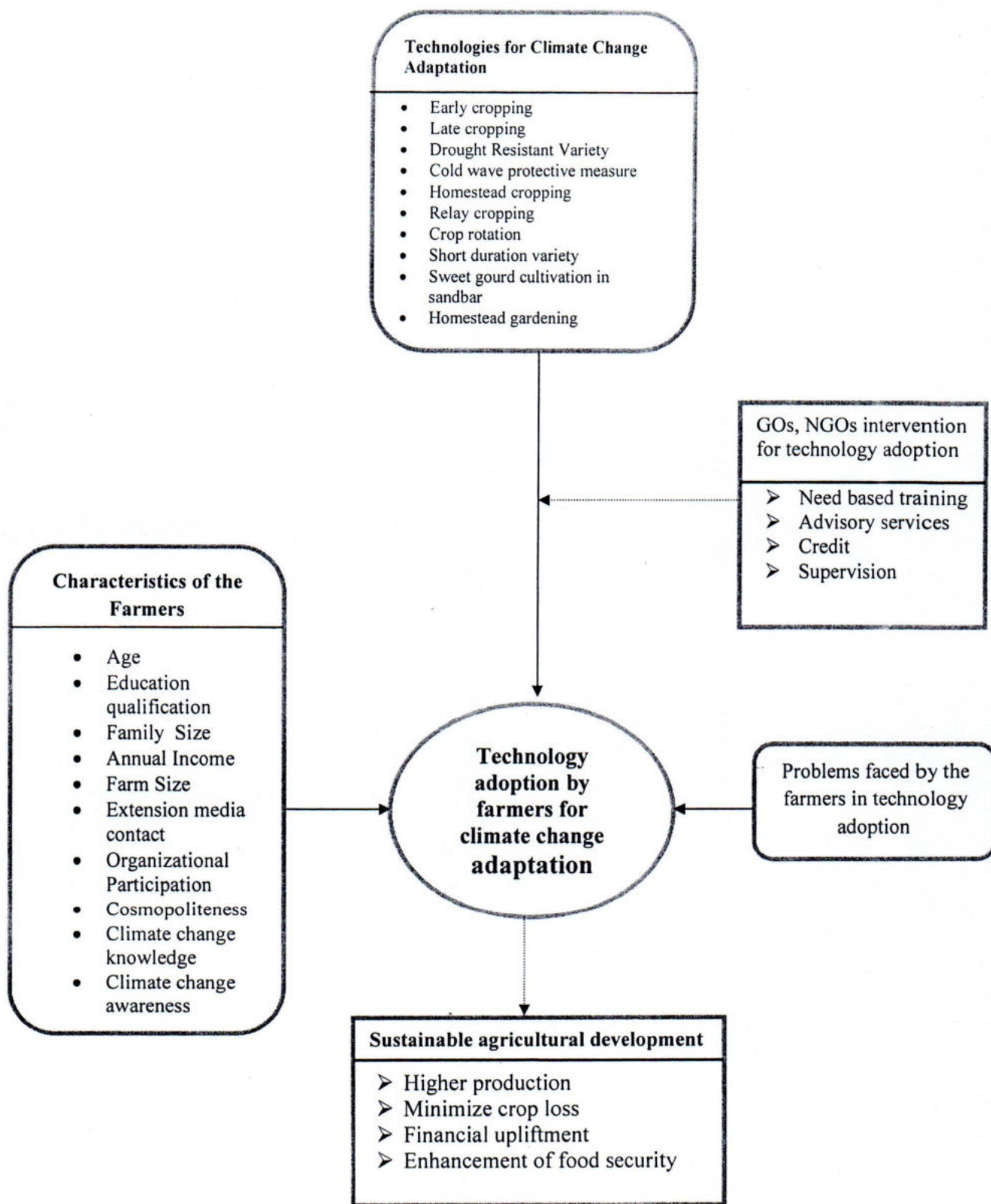


Fig 2.1 Conceptual Framework of the Study

CHAPTER 3

METHODOLOGY

Methodology is the factors in conducting a research. Appropriate methodology used in research helps to collect valid and reliable data and analyze the information purposively to reach at correct decision. The methods and procedures followed in conducting this study are described in this Chapter.

3.1 Locale of the Study

The study was conducted in the Alambiditor union of Gangachara upazila under Rangpur district. There are 8 upazilas in Rangpur district. Among these, Gangachara upazila was selected purposively for the study. It is one of the agricultural important upazila where rice, wheat, maize, tobacco, vegetables are intensively cultivated along with tree plantation, fish culture, dairy and poultry raising. This upazila is bounded by Kaliganj upazila of Lalmonirhaat district and Kishoreganj upazila of Nilphamari district on the north, Sadar and Kaunia upazila of Rangpur district on the south, Aditmari and Sadar upazila of Lalmonirhaat district on the east, and Taraganj of Rangpur and Kishoreganj upazila of Nilphamari on the west. A map of Rangpur district including its upazilas as well as a map of Gangachara upazila show the sampling area (Figure 3.1 and 3.2) respectively.

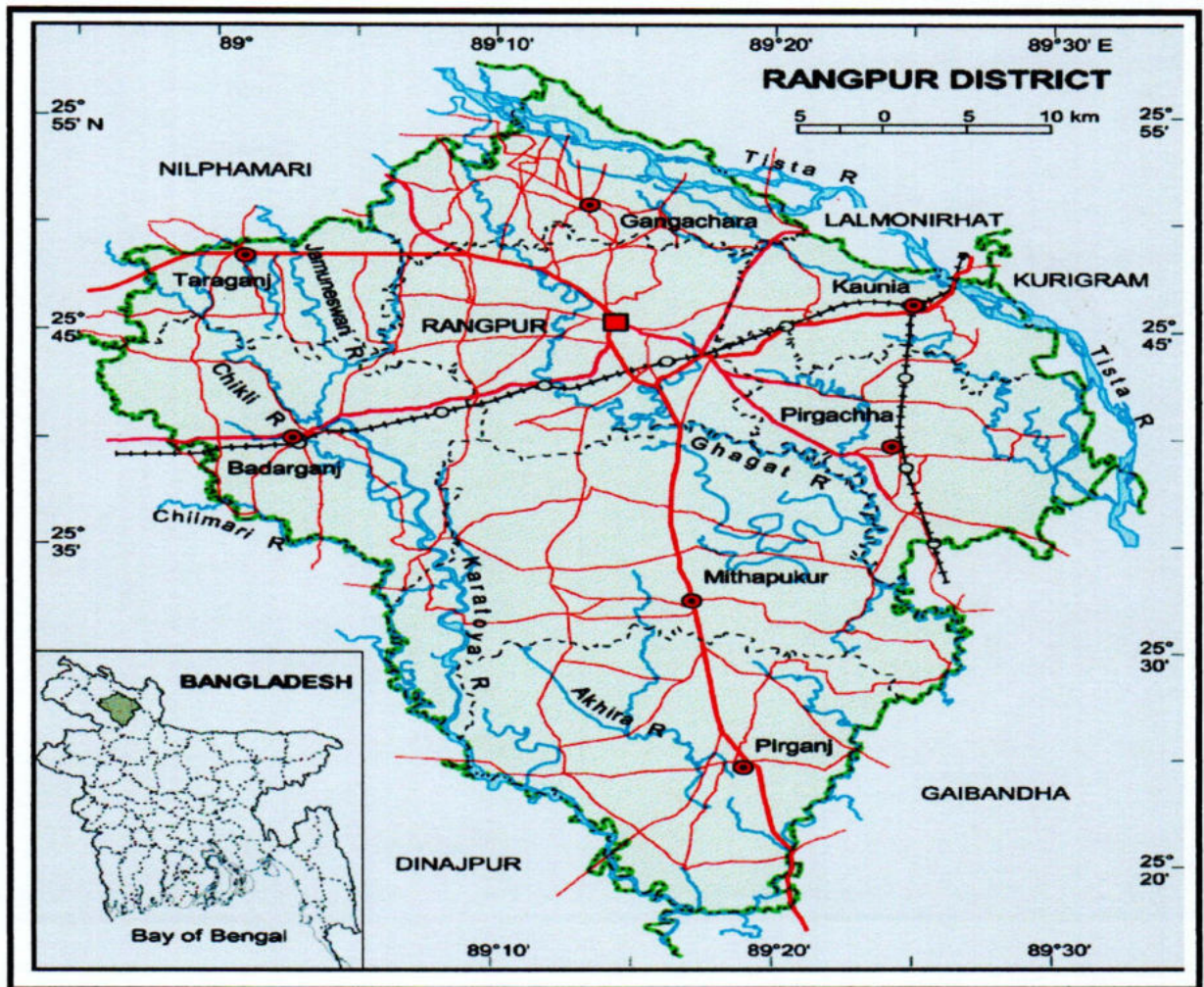


Fig.3.1 Map of Rangpur District

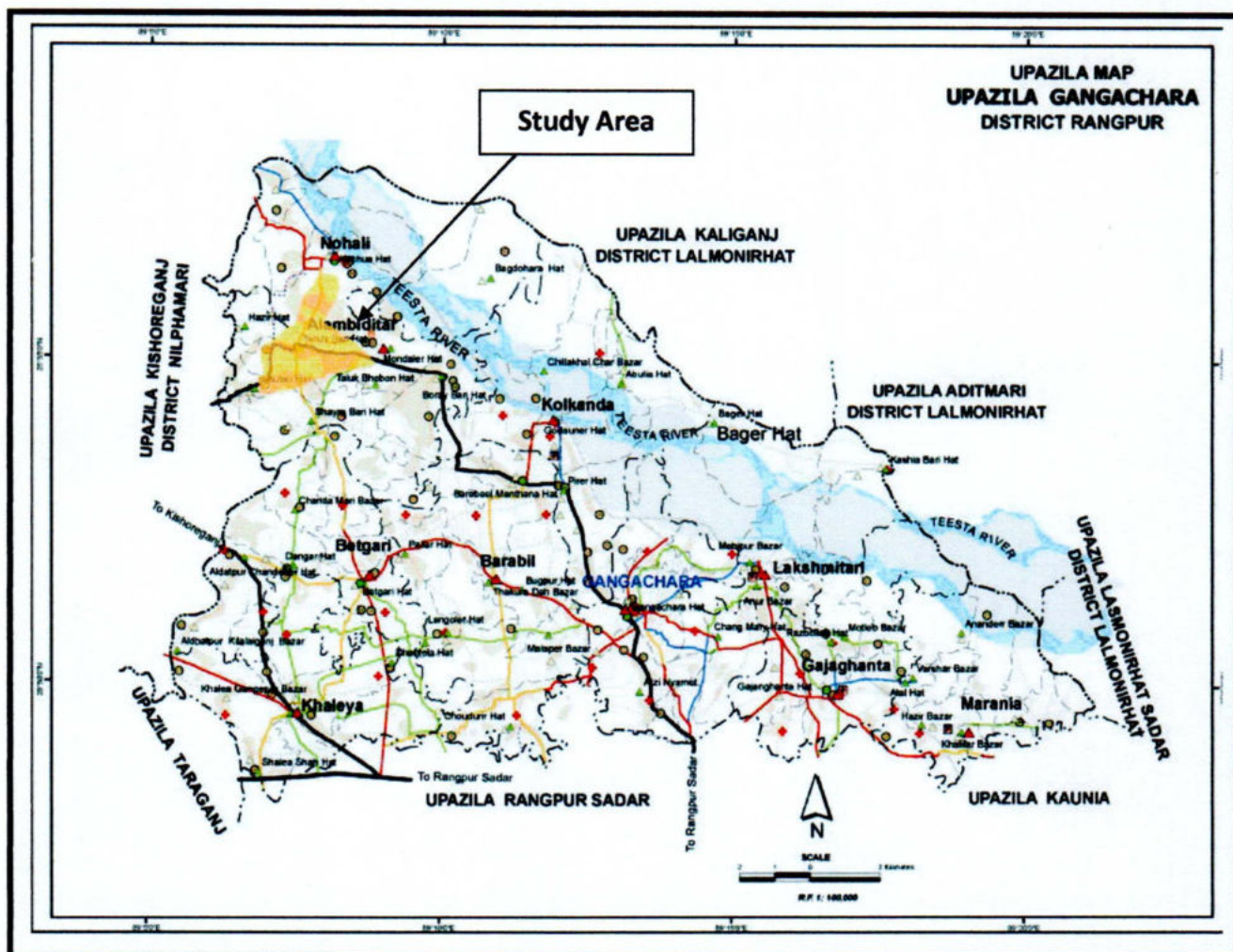


Fig: 3.2 Map of Gangachara Upazila

3.2 Sampling Procedure

Multi-stage random sampling procedure was followed in this study. The reason behind selection of the villages was the fact that these villages situated beside the tista riverside area of the upazila which is naturally a low land. Every year various climatic hazards like flood, hailstorm, river bank erosion etc. occur in these villages and cause human sufferings and damages to agricultural resources. An up-to-date list of farmers was prepared with the help of concerned Upazila Parishad and Upazila Agriculture Office (UAO) of the Department of Agricultural Extension (DAE). Secondly, Gangachara upazila of Rangpur district was also purposively selected due to investigator's familiarity of the area, language and culture of the people.

One union of Gangachara upazila namely Alambiditor was selected by random sampling procedure from 10 unions. This union consists of 14 villages. Three villages (about 20 percent) were selected from this union by using random sampling.

Total number of farmers in these 3 villages was 310 out of which 93 (30 percent) was selected as the sample by using random sampling procedure. A reserve list of 10 farmers (about 10 percent) was prepared for use in case of any missing. The detailed plan of selection and distribution of population and sample are shown in Figure 3.3

Table 3.1 Distribution of population and sample of farmers of the selected unions in the upazila of Gangachara

Name of Union	Village	Population	Sample	Reserve list
Alambiditor	Alambiditor	110	33	3
	Sit kutub	124	38	4
	Kutub	76	22	3
Total		310	93	10

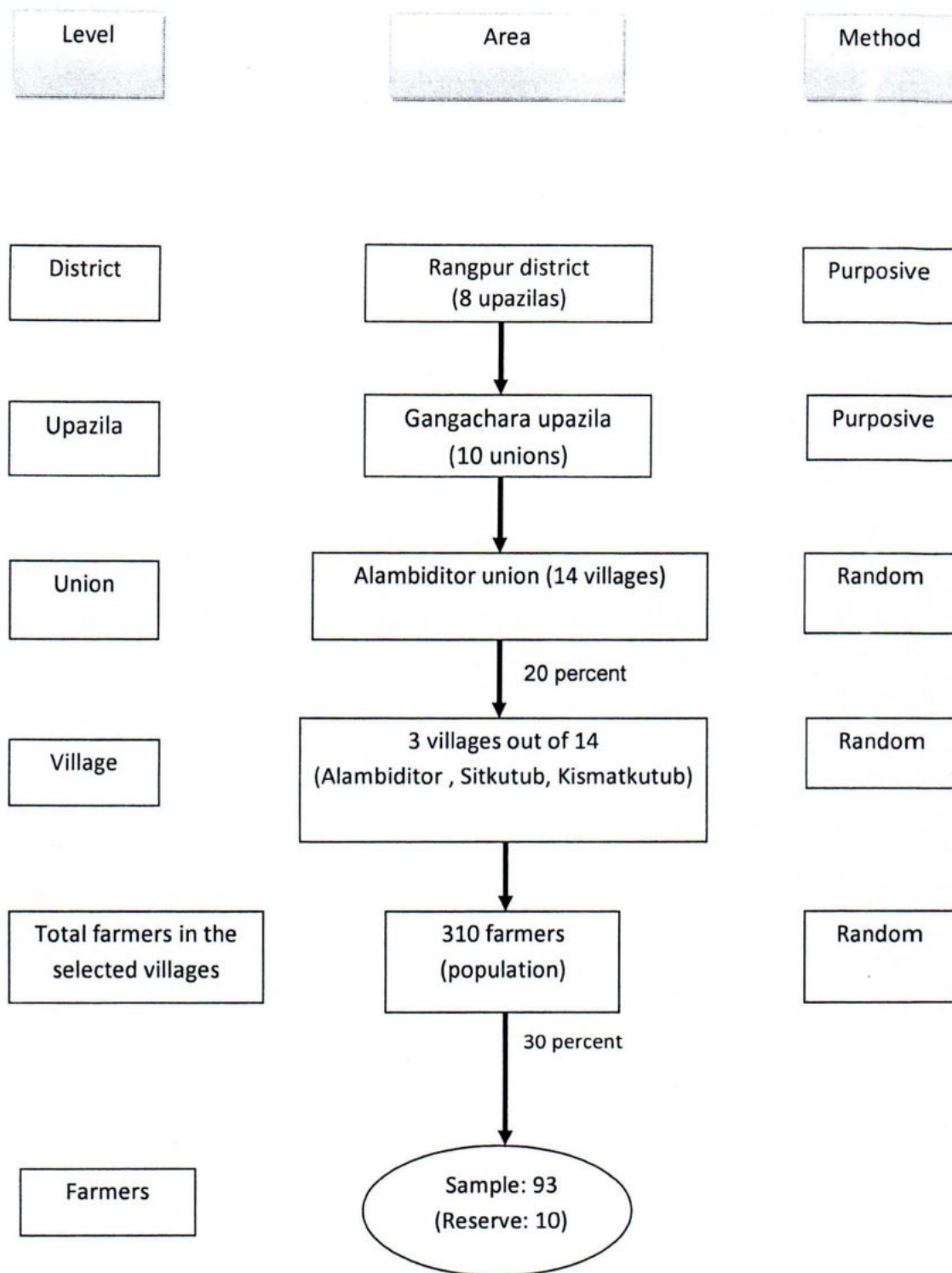


Figure 3.3 Layout of the sampling procedure of the study area

3.3 Selection of Variables

A variable is any measurable characteristic which can assume varying or different values in successive individual cases (Ezekiel and Fox, 1969). A well organized piece of research usually contains at least two important elements, viz. an independent variable and a dependent variable. An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationships to an observed phenomenon. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variables (Townsend, 1953).

In any scientific research, the selection and measurement of variables constitutes a significant task. In this connection, the researcher reviewed the literature to widen his understanding about the nature and scope of the variables relevant to this piece of research.

3.3.1 Measurement of independent variables

Many factors are likely to influence the adoption of technology. But it was difficult to deal with all the factors in a single study. This led the researcher to be selective regarding the choice of independent variables restricting the number. The following steps were undertaken in selecting independent variables:

- a) continuous review of related literature as far as possible;
- b) visited the study area, observing and sharing knowledge and experiences with farmers;
- c) consultation with the research supervisor;
- d) discussing with experienced researchers;

After careful consideration, 10 independent variables namely Age, educational qualification, family size, annual income, farm size, extension media contact, organizational participation, cosmopolitaness,, climate change knowledge and climate change awareness were selected as independent variables.

The measurements of each of 10 variables have been presented in the following sub-sections.

3.3.1.1 Age

The age of the respondents was measured in terms of actual years from his birth to the time of interview. The respondents were asked to mention their age in terms of completed years. One score was given for one completed year of age (Jalal, 2009). Question on this variable appeared in item 1 in the interview schedule (*Appendix-A*)

3.3.1.2 Educational qualification

Educational qualification of a respondent was measured in terms one's year of schooling. A score of 1 (one) was assigned for each year of complete schooling. For example if a respondent passed the final examination of class VI, then his level of education score was taken as 6. A score of 0.5 was given to a respondent who could only sign his name.

3.3.1.3 Family size

The family size of a respondent was measured on the basis of the actual number of members in his family living in a dwelling unit and used to eat from the same cooking arrangement. The family members included the respondent himself, husband, children together with dependent members who lived jointly. A unit score was assigned for each member of the family. If a respondent has 5 members in his family then his family size score was 5.

3.3.1.4 Annual income

The annual income of a respondent was measured on the basis of his all family members earning during the last one year from different sources such as agricultural (crops, poultry, livestock etc.), business, service, day labor etc. Thus the total income was calculated by added together all earning from all sources and was expressed in 1,000 taka. A score of one (1) was assigned for each '1000' Taka for the annual income scores of the respondents.

3.3.1.5 Farm size

Farm size of a respondent refers to the total area of land on which his family carried out farming operations, the area being estimated in terms of full benefit to the family. It was computed in hectare using following formula.

$$FS = A_1 + A_2 + A_3 + \frac{1}{2} (A_4 + A_5)$$

Where,

FS = Farm size

A_1 = Homestead area (including garden and fellow land)

A_2 = Own land under own cultivation

A_3 = Land taken from others as lease

A_4 = Land taken from others on barga (one-half share)

A_5 = Land given to others on barga (one-half share)

3.3.1.6 Extension media contact

Agricultural extension enhances the efficiency of making adoption decisions. Among the sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. In this study, the extension media contact score was computed for each respondent on the basis of his extent of contact with 14 selected extension media as ascertained from his responses to question 6 in the interview schedule (Appendix-A).

Items of extension contact	Nature of extension contact	Score assigned
1. Sub Assistant Agricultural Officer (SAAO)	Not even once per month	0
	1 time per month time	1
	2 times per month	2
	3 or more times per month	3
2. Health worker	Not even once per month	0
	1 time per month time	1
	2 times per month	2
	3 or more times per month	3
3. Agricultural input dealer	Not even once per month	0
	2-3 time per month time	1
	4-7 times per month	2
	8 or more times per month	3
4. Upazila Agriculture Officer/ Agriculture Extension Officer	Not even once per month	0
	1 time per month time	1
	2-3 times per month	2
	4 or more times per month	3
5. Model farmer	Not even once per year	0
	1 time per month year	1
	2 times per year	2
	3 or more times per year	3

6. Neighbor	Not even once per month	0
	1-2 time per month time	1
	3 times per month	2
	4 or more times per month	3
7. Participation in group discussion	Not even once per year	0
	1 time per year time	1
	2-3 times per year	2
	4 or more times per year	3
8. Participation in demonstration meeting	Not even once per year	0
	1 time per year time	1
	2-3 times per year	2
	4 or more times per year	3
9. Participation in field day/rally	Not even once per year	0
	1 time per year time	1
	2-3 times per year	2
	4 or more times per year	3
10. Participation in training progra	Not even once per year	0
	1 time per year time	1
	2-4 times per year	2
	5 or more times per year	3
11. Listening agricultural program in radio	Not even once per week	0
	1 time per year week	1
	2-3 times per week	2
	4 or more times per week	3
12. Watching agricultural program in television	Not even once per week	0
	1 time per year week	1
	2-3 times per week	2
	4 or more times per week	3
13. Reading agricultural Magazine (Krishi khata , Leaflet ,Booklet etc.)	Not even once per month	0
	1-2 time per year month	1
	3-4 times per month	2
	5 or more times per month	3
14. Observing agricultural fair folk song etc.	Not even once per year	0
	1 time per year time	1
	2 times per year	2
	3 or more times per year	3

Extension media contact score was determined by summing the scores of all the 14 Extension media. Extension media contact score could range from 0 to 42, where zero (0) indicated no media contact and 42 indicated the highest media contact.

3.3.1.7 Organizational participation

Organizational participation score of a respondent was computed on the basis of his participation in different organizations operating in the study area. The researcher identified nine such organizations as shown in item 7 in the interview schedule (Appendix-A).

Score was assigned for participation of a respondent in an organization in the following manner:

Nature of participation**Scores assigned**

No participation	0
Ordinary member	1
Executive committee member	2
Executive committee officer	3

Organizational participation score of a respondent was determined by adding his scores for participation in all the organizations. Total organizational participation score could range from 0-27. Where 0 indicated no participation and 27 indicated high organizational participation.

3.3.1.8 Cosmopoliteness

Cosmopoliteness score of a respondent was computed on the basis of respondent's visit to 5 different places outside his own village. The respondent indicated whether they visited those places frequently, occasionally, rarely or never. Weights assigned to these visits were 3, 2, 1 and 0, respectively. A respondent's cosmopoliteness score was obtained by adding the weights for his visit to all the five places listed in the instrument. Cosmopoliteness score could range from 0 to 15; where 0 indicated no cosmopoliteness and 15 indicated very high cosmopoliteness. The scale used for computing cosmopoliteness score was done in the following way.

Places of visit	Extent of visit	Weights
1. Other village	Not even once/month	0
	1-4 times/month	1
	5-12 times/month	2
	13 or more/month	3
2. Own upazila headquarter	Not even once/month	0
	1-6 times/month	1
	7-12 times/month	2
	13 or more/month	3
3. Other upazila town	Not even once/year	0
	1-3 times/year	1
	4-7 times/year	2
	8 or more/year	3
4. Own district town	Not even once/year	0
	1-2 times/year	1
	3-5 times/year	2
	6 or more/year	3
5. Divisional or capital city	Not even once/year	0
	1 time/year	1
	2 times/year	2
	3 or more/year	3

3.3.1.9 Climate change knowledge

Climate change knowledge was measured by using eight questions as shown in the item no 9 of the interview schedule. Different score was assigned for each of the questions. The total assigned score of all the questions was 20. If a respondent was able to provide a correct answer to a question, he could receive full score for that particular question. Accordingly, a respondent could get zero (0) for wrong answer, and half or partial score was given for partial answer to a question. The total score obtained by a respondent was considered as the score on the climate change knowledge of the respondent.

3.3.1.10 Climate change awareness

Awareness referred to the mentality of farmer regarding environmental degradation due to agricultural development. There were total ten statements and a respondent was asked to respond to the statement as 'true' or 'false'. The score for 'true' statement was '1' and 'false' one is '0' and thus, the total score of a respondent varied from 0 to 10.

3.3.2 Measurement of technology adoption by the farmers for climate change adaptation

Technology adoption by the farmers for climate change adaptation was the major focus of the study. 'Thus technology adoption was the dependent variable of this research work'. The respondent was asked to express his opinion on what extent his adoption has been done in each of 10 mentioned technologies along a 4-point rating scale; 'regularly', 'occasionally', 'rarely' and 'not at all'. The responses of the scale was given scores as 3 for regularly (continuous use of technology since introduction in the area), 2 for 'occasionally' (regular but one year interval in the use of technology), 1 for rarely (two or more year interval during use of technology) and 0 for 'not at all'. The summation of the scores against all the ten mentioned technologies produces the technology adoption of the farmers. Thus the technology adoption could range from 0 to 30, while 0 indicating not at all adoption and 30 indicating high adoption of technology for climate change adaptation.

3.3.2.1 Development of indices

For comparative analysis of technology adoption by the farmers in individual activities a “Technology Adoption Index” was calculated by using the following formula:

$$\text{Technology Adoption Index (TAI)} = 3 \times f_{\text{rea}} + 2 \times f_{\text{oa}} + 1 \times f_{\text{raa}} + 0 \times f_{\text{na}}$$

Where,

P_{rea} = Frequency of farmers with regularly technology adoption

P_{oa} = Frequency of farmers with occasionally technology adoption

P_{raa} = Frequency of farmers with rarely technology adoption

P_{na} = Frequency of farmers with not at all technology adoption

In respect of any activities in technology adoption the “Technology Adoption Index” could range from 0 to 279, where 0 indicating no technology adoption and 279 indicating high technology adoption.

3.4 Measurement of Problem Faced by the Farmers for Climate Change Adaptation

A number of possible and major problems on technology adoption were selected to measure their extent of problem. The respondents were asked to indicate their extent of problem as they faced in technology adoption a four point rating scale scored as 3 for ‘high problem faced’ 2 for ‘medium problem faced’ 1 for ‘low problem faced’ 0 for ‘not at all problem faced’. A ‘Problem Index’ was prepared for analyzing the degree of severity faced by the farmers in technology adoption for climate change adaptation using following the formula:

$$\text{PI} = f_h \times 3 + f_m \times 2 + f_l \times 1 + f_n \times 0$$

Where,

PI= Problem Index

f_h = frequency of farmers mentioning the problem as ‘high’

f_m = frequency of farmers mentioning the problem as ‘moderate’

f_l = frequency of farmers mentioning the problem as ‘low’

f_n = frequency of farmers mentioning the problem as ‘not at all’

Score problem faced by the farmers were, therefore, determined by adding the total scores against all 8 selected problems. Overall problem score could range from 0 to

24, where 0 indicating not at all problems and 24 indicating high problem faced by the farmers in technology adoption for climate change adaptation activities.

3.5 Statement of Hypothesis

A hypothesis is a proposition which can be put to a test to determine its validity (Goode and Hatt, 1952). For statistical test it becomes necessary to formulate null hypothesis. The following hypothesis was formulated to examine the relationship between the selected characteristics of the farmers and their technology adoption in climate change adaptation as:

“There is no relationship between each of the selected characteristics of the farmers and their technology adoption for climate change adaptation.”

3.6 Instrument for Data Collection

A structured interview schedule containing closed form of question originally written in Bengali phonics (English version of the interview schedule is enclosed in Appendix-A) was prepared to collect necessary and relevant information in accordance with the objectives of the study. Simple and direct questions were included to ascertain the opinion of the farmers regarding a number of aspects. Though different scales were employed, mainly the rated scale was developed to determine the adoption of technology by the farmers. The interview schedule was pre-tested with 20 farmers of 3 sample villages before the final interview of data collection. Necessary corrections, additions and modifications were made in the interview schedule based on the pre-test results. The modified and corrected interview schedule was finalized for the data collection. The researcher made all possible efforts to establish rapport with respondents so that they could feel to respond to the questions and their answers were recorded sincerely.

3.7 Data Collection

Data were collected for this study by the researcher himself from the respondents during 15 February to 28 March 2013. The researcher first established necessary rapport with the respondents and clearly explained the objectives of the study. As a result, the respondents furnished proper responses to the questions and statements without any hesitation. The researcher took help of Sub Assistant Agricultural officer (SAAO) to reach the farmers. Excellent cooperation was received from the

respondents and other people of the study area and no serious difficulty was encountered during data collection.

3.8 Data Processing and Statistical Analysis

Data were systematically recorded, edited, compiled, arranged, tabulated and computerized for statistical analysis. The soft-ware SPSS were used for data management and analysis. Descriptive statistical measures such as frequency, range, mean, co-efficient of variation, rank and percentage were used to categorize the farmers.

Pearson's product moment correlation co-efficient (r) was used to examine the relationships of characteristics of the farmers (independent variables) with technology adoption by the farmers on climate change adaptation (dependent variables). At least 5 percent ($P= 0.05$) level of probability was used as a basis for rejection of the null hypothesis throughout the study.

CHAPTER 4

FINDINGS AND DISCUSSION

The findings of the study and their logical interpretation have been presented in this chapter. Presentations have been made in three sections. According to the objectives of the study the first section deals with the extent of technology adoption by the farmers for climate change adaptation, the second section focuses on the relationship between the selected characteristics of the farmers and their extent of technology adoption for climate change adaptation, and third section deals with the problem confrontation of the farmers in technology adoption for climate change adaptation.

4.1 Technology Adoption by the Farmers for Climate Change Adaptation

Extent of technology adoption was explored with some identified technologies. Technology Adoption Index (TAI) of all the selected technologies have been presented in Table 4.1. 'Crop rotation' at the highest TAI of 168 and become top in the table followed by 'irrigation in drought' and 'homestead gardening' with TAI of 158 and 145 respectively. For more than twenty years different governmental and concern agencies are trying to motivate the farmers to adopt crop rotation technology. This might be a major cause for 'crop rotation' technology becoming first in the table. 'Sweet gourd cultivation in sandbar' becomes lowest (10th) in the table with TAI of 7 followed by 'relay cropping' with TAI of 46. Sandbar cropping is a very new technology introduced in Bangladesh. It is a technical and laborious job oriented technology. Therefore, this technology got bottom most status in the table.

Table 4.1 Technology adoption status of the farmers for climate change adaptation

Name of technology	Extent of adoption				TAI	Rank
	Regularly	Occasionally	Rarely	Not at all		
Use of crop rotation	16.1	54.8	22.6	6.5	180.5	1
Early cropping	14.0	41.9	25.8	18.3	151.6	4
Late cropping	7.5	17.2	33.3	41.9	90.2	6
Relay cropping	3.2	14.0	11.8	71.0	49.4	9
Short duration variety	8.6	31.2	24.7	35.5	112.9	5
Irrigation in drought	11.8	54.8	24.7	8.6	169.7	2
Mixed cropping	2.2	21.5	34.4	41.9	84	7
Homestead gardening	11.8	43.0	34.4	10.8	155.8	3
Sweet gourd cultivation in sandbar	0.0	3.2	1.1	95.7	7.5	10
Protection of seedbed during cold wave	1.1	17.2	25.8	55.9	63.5	8

4.1.1 Overall technology adoption

Technology adoption is the decision making process to continue full use of that technology. The present research work regarded with the individual adoption which refers to the adoption of a technology where the individual himself takes the decision and implements it by using the technology. Technology adoption by the farmers for climate change adaptation was measured by computing adoption score, which could range from 0 to 30. However, the observed score ranged from 3 to 21 with an average of 10.63 and a standard deviation of 4.0. Based on adoption score the farmers were classified into three categories such as 'low adoption' (up to 9), 'medium adoption' (10-13), and 'high adoption' (above 13). The number and percentage of distribution of the farmers according to their overall technology adoption has been presented in Table 4.2.

Table 4.2 Overall technology adoption of the farmers for climate change adaptation

Range		Category	Frequency	Percent	Mean	SD
Possible	Observed					
0-30	3-21	Low adoption (up to 9)	34	36.6	10.63	4.00
		Medium adoption (10-13)	39	41.9		
		High adoption (above 13)	20	21.5		
		Total	93	100.0		

Slightly more than two-fifths (41.9 percent) had medium adoption while 36.6 percent of them had low adoption and 21.5 percent had high adoption of technology for climate change adaptation. About four-fifths (78.5 percent) of the farmers had low to medium adoption which might be a hinder for proper agricultural development in the area. Concerned GOs and NGOs should take necessary programs to minimize the short comings of technology adoption for climate change adaptation.

4.2 Selected Characteristics of the Farmers

This section deals with the representation of findings of ten selected attributes of the farmers. For detail description, the farmers were classified into suitable categories in accordance to each characteristic. The procedures followed in measuring each of ten selected characteristics are described in the following section.

4.2.1 Age

The age of the respondent farmers ranged from 20 to 65 years. The mean age was 41.98 and standard deviation was 9.73. The respondents were classified into three categories, such as young (up to 35 years), middle (36-50 years) and old (above 50) as shown in the Table 4.3.

Table 4.3 Distribution of the respondent according to their age

Range	Category	Frequency	Percent	Mean	SD
20-65	Young (up to 35)	27	29.1	41.98	9.73
	Middle (36-50)	47	50.5		
	Old (Above 50)	19	20.4		
	Total	93	100.0		

The findings indicate that the highest proportion (50.5 percent) of the farmer in the study area fell into the middle aged category compared to 29.1 percent belonging to young aged category and only 20.4 percent to old aged category. Nearly, four-fifths (79.6 percent) of the respondents belongs to middle and young aged group. It is assumed that middle and young aged farmers are more active, energetic, and enthusiastic in performing any kind of technology adoption.

4.2.2 Educational qualification

The farmers' educational qualification with scores varied from 0 to 17 with the mean being 6.04 and standard deviation was 4.41. Based on their educational qualification scores, the respondents were classified into five categories as no education (0), can sign only (0.5), primary education (1-5), secondary education (6-10) and above secondary education (above 10).

Table 4.4 Distribution of the respondents according to their educational qualification

Range	Category	Frequency	Percent	Mean	SD
0-17	No education (0)	8	8.6	6.04	4.41
	Can sign only(0.5)	16	17.2		
	Primary education (1-5)	24	25.8		
	Secondary education (6-10)	35	37.6		
	Above secondary education (>10)	10	10.8		
	Total	93	100.0		

Data presented in the Table 4.4 shows that the highest proportions (37.6 percent) of the farmers had secondary education. Only 25.8 percent of them had primary

education, while 10.8 percent had above secondary education. On the other hand, the proportions of no education 8.6 percent and can sign only 17.2 percent framers.

4.2.3 Family size

The family size score of the farmers ranged from 3 to 8 with an average of 4.82 and standard deviation of 1.17 (Table 4.5).

Table 4.5 Distribution of the respondent according to their family size

Range	Category	Frequency	Percent	Mean	SD
3-8	Small family (up to 4)	36	38.7	4.82	1.17
	Medium family (5-6)	50	53.8		
	Large family (7 and above)	7	7.5		
	Total	93	100.0		

Among the respondents 7.5 percent had large family, 53.8 percent medium and 38.7 percent had small family. The findings indicated that 92.5 percent of the respondents had small to medium family. The average family sizes (4.82) in the study area are similar to national average 4.8 (BBS, 2008). This may be due to the proper adoption of family planning measures by the respondents in the study area.

4.2.4 Annual Income

Annual income score of the farmers varied from 22 to 256 with average of 94.75 thousand and a standard deviation of 55.26 (Table 4.6).

Table 4.6 Distribution of the respondents according to their annual income

Range	Category	Frequency	Percent	Mean	SD
22-256	Low income (up to 70)	37	39.8	94.75	55.26
	Medium income (70.1-120)	29	31.2		
	High income (above 120)	27	29.0		
	Total	93	100.0		

About 39.8 percent of the respondents had low family income, while 31.2 percent and 29 percent of them had medium and high annual income, respectively. The average income of the respondents was 94.75 thousand was greater than the national average of 47,373 (BBS, 2009).

4.2.5 Farm size

The farm size score in the study area was found to vary from 0.01 to 4.70 while their average farm size was 0.74 with a standard deviation of 0.60 (Table 4.7).

Table 4.7 Distribution of the respondent according to their farm size

Range	Category	Frequency	Percent	Mean	SD
0.01-4.70	Small farm (0.01-0.45)	28	30.1	0.74	0.60
	Medium farm (0.46-1.00)	44	47.3		
	Large farm (>1.00)	21	22.6		
	Total	93	100.0		

The average farm size was 0.74 which was higher than the national average of 0.37 ha (BBS, 2009). Table 4.7 reveals that highest proportion of them (47.3 percent) had medium farm followed by small farm holders (30.1percent) and large farm holders (22.6 percent).

The findings indicate that 69.9 percent of the farmers belonged to medium and large farm holders which are not the usual trend in Bangladesh condition. This was an advantage for the farmer in receiving agricultural information and it may be greater opportunity to adopt new technology and to raise production per unit area.

4.2.6 Extension media contact

The extension media contact of the respondents ranged from 3 to 34 against the probable range of 0-42 with the average was 16.57 and standard deviation of 7.38 (Table 4.8). On the basis of extension contact score, the respondents were categorized in to three categories like 'low' (up to 12), 'medium' (13-22), 'high' (above 22) as shown in the table.

Table 4.8 Distribution of the respondents according to their extension media contact

Range		Category	Frequency	Percent	? Mean	SD
Possible	Observed					
0-42	3-34	Low (up to 12)	30	32.3	16.57	7.38
		Medium (13-22)	44	47.3		
		High (above 22)	19	20.4		
		Total	93	100.0		

Data presented in Table 4.8 indicate that 47.3 percent of them had medium extension contact, 32.3 percent farmer had low extension contact while 20.4 percent had high

extension medial contact. The findings of the study revealed that an overwhelming majority of the respondents (79.6 percent) had medium to low extension media contact which have to be increased for getting better technology adoption status.

4.2.7 Organizational participation

The farmer's organizational participation score ranged from 0 to 17 against the possible range of 0 to 27. The average score being 1.69 with a standard deviation of 3.08. On the basis of actual score of the respondents, they were classified into four categories like 'no participation' (0), 'low participation' (1-3), 'medium participation' (4-7) and 'high participation' (>7).

Table 4.9 Distribution of the respondents according to their organizational participation

Range		Category	Frequency	Percent	Mean	SD
Possible	Observed					
0-27	0-17	No participation (0)	48	51.6	1.65	3.08
		Low participation (1-3)	31	33.3		
		Medium participation (4-7)	9	9.7		
		High participation (>7)	5	5.4		
		Total	93	100.0		

Data in Table 4.9 revealed that 51.6 percent of the respondent had no participation in organization. 33.3 percent of them had low organizational participation while 9.7 percent had medium and only 5.4 percent had high participation in various organizations.

An individual comes into contact with other people, new ideas new ways of doing things through participation in organization. It is, therefore, likely that organizational participation may help individual to assess the potentiality of individuals, things and programs. Such consideration indicates that organizational participation may also help the farmers in technology adoption. This finding indicates that organizational participation only little proportion of the respondents had medium and high (15.1 percent) organizational participation. This might be fact that there is an acute dearth of organizations in the rural areas.

Data contained in the table indicates that the highest proportion (64.5 percent) of the farmer had fair knowledge while 25.8 percent had poor knowledge and 9.7 percent had good knowledge. Farmers gain knowledge in agriculture activities mostly from the parents and somewhat from the neighbor. Major portion of the respondents were middle aged farmers. They have gained knowledge about climate in course of time and through their experience generally.

4.2.10 Climate change awareness

The observed range of score of awareness on climate change was 4 to 10 while the possible range was 0 to 10 (Table 4.12).

Table 4.12 Categories of farmer according to their awareness on climate change

Range		Category	Frequency	Percent	Mean	SD
Possible	Observed					
0-10	4-10	Low awareness (≤ 6)	12	12.9	8.55	1.59
		Medium awareness (7-8)	22	23.7		
		High awareness (> 8)	59	63.4		
		Total	93	100.0		

The average score was 8.55 and standard deviation 1.59. Based on the climate change awareness score the farmers were classified into three categories as 'low awareness', 'medium awareness' and 'high awareness'. Majority of the respondents (63.4 percent) had highly awareness on the climate change, 12.9 percent had low awareness and rest 23.7 percent had medium awareness on climate change.

4.3 Relationship between the Independent and Dependent variable

This section deals with the findings exploring the relationships between the selected independent and dependent variables of the study. The selected characteristics of the farmer viz. age, educational qualification, family size, annual income, farm size, extension media contact, organizational participation, cosmopolitaness, innovativeness, climate change knowledge and climate change awareness. The dependent variable was 'Technology adoption by the farmers for climate change adaptation'.

Pearson's Product Moment co-efficient of Correlation (r) was used to determine the relationship between the selected independent and dependent variables and to accept or reject the null hypothesis. Five percent (0.05) level of probability was used as the basis for acceptance or rejection of a null hypothesis. A summary of the correlation analysis is presented in Table 4.13 and the correlation matrix in the Appendix- B.

Table 4.13 Relationship between the selected characteristics of the farmers and technology adoption on climate change adaptation

Sl. No.	Selected characteristics	Correlation coefficient (r) with 91df
1	Age	-0.060
2	Educational Qualification	0.195
3	Family Size	-0.068
4	Annual Income	0.049
5	Farm Size	0.097
6	Extension Media contact	0.450**
7	Organizational participation	0.248*
8	Cosmopoliteness	0.407**
9	Climate Change Knowledge	0.385**
10	Climate Change Awareness	0.069

** Correlation is significant at the 0.01 level ($r=0.204$), * Correlation is significant at the 0.05 level ($r=0.266$).

4.3.1 Age and technology adoption by the farmers for climate change adaptation

The correlation coefficients between the two concerned variable was ' r ' = -0.060 (Table 4.13) which was negatively insignificant even at 0.05 level of probability. Hence the null hypothesis was accepted i.e. there was no relationship between age and adoption of technologies

Based on the above findings the researcher concluded that age of the farmer had a significant negative relationship with the technology adoption. The main reason of this result might be that the older respondents did not want to adopt technologies more easily.

4.3.2 Educational qualification and technology adoption by the farmers for climate change adaptation

The correlation coefficient for education value of ' r ' was found ($r = 0.195$) which was insignificant and thus the concerned hypothesis was not rejected. This means that the

farmers had no relationship in concerning their technology adoption in climate change adaptation.

4.3.3 Family size and technology adoption by the farmers for climate change adaptation

The correlation coefficient for family size value of 'r' was found ($r = -0.068$) found to be smaller than the tabulated value. Therefore, the relation between family size and technology adoption by the farmers for climate change adaptation was not significant in the Table 4.13 and null hypothesis could not be rejected. Therefore it could be concluded that family size of the respondent might not play any significant role on their extent of technology adoption for climate change adaptation.

4.3.4 Annual income and technology adoption by the farmers for climate change adaptation

The correlation coefficient between annual income and technology adoption by the farmers for climate change adaptation was 0.049. This value was insignificant at 0.05 level as shown on the Table 4.13. Thus the null hypothesis was not rejected. This means that the farmers annual income had no effect on technology adoption by the farmers for climate change adaptation.

4.3.5 Farm size and technology adoption by the farmers for climate change adaptation

The correlation coefficient between farm size of the farmer and technology adoption was '0.097 and this value were not significant at even 0.05 levels as showed in the Table 4.13. Hence the null hypothesis was not rejected where farm size and technology adoption. Thus it might be said that farm size of the farmers was not so important factor technology adoption.

4.3.6 Extension media contact and technology adoption by the farmers for climate change adaptation

The correlation coefficient between extension media contact of the respondents farmers and their technology adoption for climate change adaptation was 0.450 and this value was significant at 0.01 level (Table 4.13). So, the null hypothesis was rejected. This finding revealed that extension media contact had immense influence on

the technology adoption activities. It is obvious that contact with extension agents and other extension teaching methods changes knowledge, behavior and being enlightened and consequently having broader outlooks and progressive attitudes. But there is utmost need for strengthening extension services to reach the affected farmer. Hussen (2001), Haque (2006) and Rahman (2001) and others also observed similar relationships in their research studies.

4.3.7 Organizational participation and technology adoption by the farmers for climate change adaptation

The correlation coefficient between organizational participation and technology adoption by the farmers for climate change adaptation was 0.248. This value was significant at 0.05 level of probability (Table 4.13). Therefore, the null hypothesis was rejected. Hence it can be concluded that organizational participation of the farmers had positive significant relationship with their technology adoption for climate change adaptation. Chowdhury (1997) Mostofa (1998) observed similar relationship on their research.

4.3.8 Cosmopoliteness and technology adoption by the farmers for climate change adaptation

The correlation coefficient (r) between cosmopoliteness of the farmers and technology adoption for climate change adaptation was 0.407 as shown in Table 4.13. This value was significant at 0.01 level. Hence, the null hypothesis was rejected and researcher found significant positive relationship between cosmopoliteness and technology adoption for climate change adaptation. Findings as documented above imply that the farmers who are cosmopolite have more technology adoption for climate change adaptation. Movement outside one's periphery creates opportunity for learning, seeing new innovations, contact with others which ultimately changes attitude. However, cosmopoliteness show great influence on technology adoption for climate change adaptation. Karim (1973) also observed similar findings.

4.3.9 Climate change knowledge and technology adoption by the farmers for climate change adaptation

The correlation coefficient between climate change knowledge and technology adoption for climate change adaptation was 0.385 as shown in Table 4.13. This value was significant at 0.01 level of probability. Therefore, the concerned null hypothesis was rejected i.e. there was a positive significant relationship between climate change knowledge and technology adoption for climate change adaptation. This is very rational to think that farmers having knowledge and experience of different climatic

change their causes helped them to develop highly positive attitude towards adoption of technologies for climate change adaptation. Similar findings were observed by Reza (2007) and Miajy (2001)

4.3.10 Climate change awareness and technology adoption by the farmers for climate change adaptation

The calculated correlation of coefficient ($r = 0.069$) between awareness of climate change awareness and technology adoption for climate change adaptation was insignificant at even 0.05 level of probability (Table 4.13). Therefore, the concerned null hypothesis could not be rejected and hence, it can be concluded that the farmers technology adoption for climate change adaptation had no significant relationship with their climate change awareness. But in general, it is assumed that people become more aware as climate change awareness and technology adoption for climate change adaptation increases. This scenario was not found in the study area.

4.4 Problems faced by the farmers in technology adoption for climate change adaptation

The extent of problems faced by the farmers in technology adoption for climate change adaptation in terms of Problem Index (PI) along with their rank order based on the PI values have been presented in Table 4.14. Data furnished in the table indicate that the problem which ranked 1st was 'Lack of knowledge on climate change with PI of 246 followed by 'Lack of training facility for technology adoption' and 3rd ranked 'Lack of knowledge of climate change adaptation' with PI 224 and 220 respectively.

Table 4.14 Rank order to the problems faced by the farmers

Name of technology	Extent of adoption				PI	Rank
	Not at all	Low	Moderate	High		
Lack of knowledge on climate change	0	6	21	66	246	1
Lack of knowledge on climate change adaptation	4	4	39	46	220	3
Unavailability of technological resources in desired amount	2	12	46	33	203	5
Lack of training facility for technology adoption	3	11	24	55	224	2
Lack of initiatives and motivation from extension worker	21	22	39	11	133	8
Lack of interest on new technology adoption	20	27	29	17	136	7
Lack of capital for technology adoption	2	13	33	45	214	4
Lack of knowledge on application of different technologies	4	19	45	25	184	6

In the relationship analysis between dependent and independent variables 'climate change knowledge' had significant positive relationship with technology adoption for climate change adaptation. But in the problem confrontation 'lack of knowledge on climate change' become first in the table which was reverse phenomenon found in the study area. Lower educational qualification (i.e. 51.6 percent respondent had less than secondary education) may be a cause behind this interesting findings. 'Lack of initiatives and motivation from extension worker' secure last i.e. 8th position in the table with PI of 133.

'Lack of interest on new technology adoption' and 'Lack of capital for technology adoption' had PI of 136 and 184 respectively and got 7th and 6th position in the ranking.

Extension media contact was selected as independent variable and showed a positive and significant relationship with the dependent variable. Due to this phenomenon might be "Lack of initiative and motivation from extension worker" become last problem confrontation in the table.

4.4.1 Overall problem confrontation of the farmers in technology adoption for climate change adaptation by the farmers for climate change adaptation

Scores of overall problem confrontation of the farmers ranged from 8 to 23 against the possible range of 0 to 24. The mean score was 16.81 with a standard deviation of 3.17 (Table 4.15). Based on the scores the problems were classified into three categories namely 'low problem' (up to 15), 'medium problem' (16-19) and 'high problem' (20 and above).

Figure 4.15 Distribution of farmers (%) according to their problem confrontation

Range		Category	Frequency	Percent	Mean	SD
Possible	Observed					
0-24	8-23	Low problem (up to 15)	26	28.0	16.81	3.01
		Medium problem (16-19)	51	54.8		
		High problem (20 and above)	16	17.2		
		Total	93	100.0		

Slightly more than half (54.8 percent) of the farmers had medium problem, 28 percent had low and 17.2 had high problem confrontation. More than four-fifth (82.8 percent) respondents had low to medium problem confrontation. Where concern GOs and NGOs extensive and coordinated approach have scope to minimize problem status of the farmers.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the whole research activities along with conclusion and recommendations based on major findings.

5.1 Summary of the Findings

The study was carried out to assess the extent of technology adoption by the farmers for climate change adaptation. The specific objectives of the study were to: i) determine and describe the extent of adoption of technologies by the farmers for climate change adaptation, ii) explore the relationship between extent of adoption of technologies by the farmers and their selected characteristics, and iii) determine the problems confrontation of farmers in adopting technologies for climate change adaptation. The study was carried out in Gangachara upazila under Rangpur district. Ninety three (93) respondents were selected as sample from an updated list of 310 farmers using multi-stage random sampling method. Data were collected by a pre-tested interview schedule during 15 February to 25 March, 2013. A summary of the major findings is given in the subsequent sections.

5.1.1 Technology adoption by the farmers for climate change adaptation

'Crop rotation' at the highest TAI of 168 and become top in the table followed by 'irrigation in drought' and 'homestead gardening' with TAI of 158 and 145 respectively. 'Sweet gourd cultivation in sandbar' becomes lowest (10th) in the table with TAI of 7 followed by 'relay cropping' with TAI of 46.

5.1.1.1 Overall technology adoption

Scores of overall technology adoption ranged from 3 to 21 with an average of 10.63 and a standard deviation of 4.0. Slightly more than two-fifths (41.9 percent) had medium adoption while 36.6 percent of them had low adoption and 21.5 percent had high adoption of technology for climate change adaptation. About four-fifths (78.5 percent) of the farmers had low to medium adoption which might be a hinder for proper agricultural development in the area.

5.1.2 Selected characteristics of the respondents

Age: The age of the farmer ranged from 20 to 65 years. The mean value was 41.98 years and standard deviation was 9.73 years. The highest proportion of the farmers in the study area fell into the middle aged (50.5 percent) category compared to 29.1 percent belonging to young aged category and only 20.4 percent to old aged category.

Educational qualification: The farmer's educational qualification scores varied from 0 to 17 with the mean being 6.04 and standard deviation was 4.41. The highest proportions (37.6 percent) of the farmer had secondary education. Only 25.8 percent of them had primary education while 10.8 percent had above secondary education. On the other hand, the proportions of no education 8.6 percent and can sign only 17.2 percent framers.

Family size: The number of family members ranged from 3 to 8 with an average of 4.82 and standard deviation of 1.17. The highest proportion of the (53.8 percent) of the respondents fell in the medium family size category (5 -6 members) while 38.7 percent had small and only 7.5 percent had large family size.

Annual Income: Annual income score of the farmers varied from 22 to 256 with average of 94.75 thousand and a standard deviation of 55.26. About 39.8 percent of the respondents had low family income, while 31.2 percent and 29 percent of them had medium and high annual income, respectively.

Farm size: The farm size score in the study area was found to vary from 0.01 to 4.70 while their average farm size was 0.74 with a standard deviation of 0.60. Highest proportion of them (47.3 percent) had medium farm followed by small farm holders (30.1percent) and large farm holders (22.6 percent)

Extension media contact: The extension media contact of the respondents ranged from 3 to 34 with average of 16.57 and standard deviation of 7.38. The major proportion had medium extension media contact (47.3 percent) whereas 32.3 percents belongs to low extension media contact and 20.4 percent had high extension media contact category.

Organizational Participation: The farmer's organizational participation score ranged from 0 to 17. The average score being 1.69 with a standard deviation of 3.08. 51.6 percent of the respondent had no participation in organization. 33.3 percent of them had low organizational participation while 9.7 percent had medium and only 5.4 percent had high participation in various organizations.

Cosmopoliteness: The cosmopoliteness score of famer ranged from 2 to 14. Average cosmopoliteness was found 7.22 with standard deviation of 2.62. Highest (43) percent had medium, 40.9 percent had low cosmopoliteness and 16.1 percent had high cosmopoliteness.

Climate change knowledge: Climate change knowledge scores of the farmers ranged from 3-17 with an average of 9.09 and standard deviation of 2.64. Highest proportion (64.5 percent) of the farmer had fair knowledge while 25.8 percent had poor knowledge and 9.7 percent had good knowledge.

Climate Change Awareness: The observed range of score of awareness on climate change was 4 to 10 with average score was 8.55 and standard deviation 1.59. Majority of the respondents (63.4 percent) had highly awareness on the climate change, 12.9 percent had low awareness and rest 23.7 percent had medium awareness on climate change.

5.1.3 Relationship between selected characteristics of the farmers' and of technology adoption for climate change adaptation

Among ten characteristics of the respondent farmers were selected as independent variables and the dependent variables were technology adoption by the farmers for climate change adaptation. Farmers extension media contact, organizational participation, cosmopoliteness and climate change knowledge had positive and significant relationship with their technology adoption for climate change adaptation. While educational qualification, annual income, farm size and climate change awareness showed positive and insignificant relationship with the technology adoption. Age and family size of the farmers found negative and insignificant relationship with the technology adoption for climate change adaptation.

5.1.4 Problems faced by the farmers in technology adoption for climate change adaptation

The extent of problems faced by the farmers in technology adoption for climate change adaptation in terms of Problem Index (PI) indicated that the problem which ranked 1st was 'Lack of knowledge on climate change with PI of 246 followed by 'Lack of training facility for technology adoption' and 3rd ranked 'Lack of knowledge of climate change adaptation' with PI 224 and 220 respectively. 'Lack of interest on new technology adoption' and 'Lack of capital for technology adoption' had PI of 136 and 184 respectively and got 7th and 6th position in the ranking.

5.1.4.1 Overall problem confrontation of the farmers in technology adoption for climate change adaptation

Scores of overall problem confrontation of the farmers ranged from 8 to 23 against the possible range of 0 to 24. The mean score was 16.81 with a standard deviation of 3.17. Slightly more than half (54.8 percent) of the farmers had medium problem, 28 percent had low and 17.2 had high problem confrontation. More than four-fifth (82.8 percent) respondents had low to medium problem confrontation.

5.2 Conclusion

Findings of the present study and the logical interpretation of other relevant facts led the researcher to draw the following conclusions:

1. The extent of technology adoption depends on the nature of the technology, availability of inputs, technical knowledge and also due to other characteristics of the farmers. Thus, it is indicative that there is scope to take necessary steps to ensure higher technology adoption for climate change.
2. Farmers' education had a significant and positive relationship with their extent of technology adoption for climate change adaptation. Therefore, it might be concluded that there remains huge scope to improve farmers' technology adoption for climate change adaptation by providing proper education facilities to them.
3. Income is correlated with purchasing or hiring technology by an individual. Thus, it is assumed that farmers having low annual income might affect their technology adoption for climate change adaptation.

4. Farmer's technology adoption for climate change adaptation cannot be increased without increasing their contact with different extension media.
5. Better knowledge and climate change awareness of the farmers helped in technology adoption for climate change adaptation. Acquiring knowledge and awareness of various environmental degradation, farmers may get ample scope to be well acquainted to the options in adoption of technologies. Different GOs and NGOs have scope to work on this sector.
6. A numbers of problems were found hindering farmers in technology adoption for climate change adaptation. Majority of these were created due to lack of their proper knowledge and experience. Thus, it may be concluded that their barriers might limit them from technology adoption for climate change adaptation until and unless those were not taken care of duly.

5.3 Recommendations

Based on the findings and conclusions of the study the following recommendations are set-forth:

5.3.1 Recommendation for policy implication

1. In view of the importance of farmers' involvement in climate change adaptation, it is recommended that all efforts should make to increase the motivation of farmers towards the technology adoption for climate change adaptation in a proportionate way. Experts GO and NGO representatives in collaboration with the farmers might to have launching intensive motivation campaign and by providing technological support in form of training, supply of required inputs in this regard.
2. Considering the findings, a suitable combination of technologies is necessary for climate change adaptation that can ensure food production with high quality. Extension workers should have to keep this in mind and put-forth greater effort to convince farmers about the benefits of different technologies used for climate change adaptation.
3. It is recommended that arrangement should be made for providing non-formal education to the farmers, those educational is low or who do not have formal education. The low level of education of the farmers might make them unable

to manage the complex issues of technology adoption. DAE and related NGOs need to take necessary steps to attain better technology adoption for climate change adaptation by the farmers.

4. Various extension services should be strengthened by the GOs and NGOs particularly for small and medium farmers. Micro-credit and other technical facilities on different income generating activities should be created for the farmers having low income, so that they can adopt technologies for climate change adaptation.
5. GOs and other concerned NGOs can play a vital role in climate change adaptation, because media contact increases farmers' knowledge in different aspects of agricultural technology adoption for climate change adaptation.
6. The necessary initiatives to be taken by GOs and NGOs to overcome this situation through creating awareness and other need based extension approaches like adult training as farmers field school, demonstration, farmers field day, rally, fair etc.
7. The encountered problems of the farmers to be solved through information and or support services so that the farmers can easily adopt technologies for climate change adaptation and ensure agricultural production.

5.3.2 Recommendation for further research

A piece of study cannot provide all information for proper understanding of technology adoption for climate change adaptation. It was felt that much investigation is needed for clear understanding of the farmers' technology adoption for climate change adaptation. Hence the following suggestion might be helpful for further research:

1. The study was conducted on technology adoption for climate change adaptation in Alambiditor union of Gangachara upazila under Rangpur district. Findings of this study should be verified by similar research in other parts of the country.
2. Relationships between the characteristics of the farmers with their overall technology adoption for climate change adaptation were investigated in this study. Many relationships were not found expected. Therefore, it is necessary

to further examine relationships of the characteristics of the farmers with technology adoption for climate change adaptation.

3. Adoption is continuous process. Due to change of the social system, technologies, human behavior, cropping patterns etc. it can be changed. So, it is suggested that there should have continuous research on adoption in various aspects of technologies for climate change adaptation.
4. Research should also be undertaken to identify other factors which hinder the adoption of technologies by the farmers for climate change.

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Appendix-A

ENGLISH VERSION OF THE INTERVIEW SCHEDULE

Department of Agricultural Extension
Hajee Mohammad Danesh Science and Technology University Dinajpur, Bangladesh
**Technology Adoption by the Farmers of Rangpur District for Climate Change
Adaptation**

Interview Schedule

Sample no.

Name:

Fathers' name:

Village:

Union:

Upazila:

Please furnish information as per following questions:

1. Age:.....year.

2. Educational qualification:

a) Cannot read and write

b) Cannot read and write but can sign only

c) Passed up to class.....

3. Family size:

a) Male..... b) Female..... Total..... nos.

4. Annual income: Income in taka for last one year from different sources

Sl. No.	Source	Taka
a) Agriculture:	1. Rice	
	2. Jute	
	3. Potato	
	4. Tobacco	
	5. Sugarcane	
	6. Vegetables	
	7. Poultry	
	8. Cattle rearing	
	9. Fish culture	
b) Non-agriculture	10. Service	
	11. business	
	12. labor wage	
	13. Others	

Total income

Taka

.....

5. Farm size:

Please mention the area of land according to tenure status

Sl. No.	Type of land use	Area of land	
		Local unit	Hectare
1	Homestead land		
2	Own cultivated land		
3	Land taken as lease		
4	Land taken for sharecropping (borga)		
5	Land given for sharecropping (borga)		

6. Extension media contact:

Mention frequency of contact with the following media

Sl. No.	Name of communication media	Frequency of contact			
		Regularly	Occasionally	Rarely	Not at all
Individual contact					
1.	SAAO	3 or more times/month	2 or more times/month	1 time/month	0 times/month
2.	Health worker	3 or more times/month	2 or more times/month	1 time/month	0 times/month
3.	Agricultural input dealer	8 or more times/month	4-7 times/month	2-3 times/month	0 times/month
4.	Upazila Agriculture Officer/Agriculture Extension Officer	4 or more times/month	2-3 times/month	1 time/month	0 times/month
5.	Model Farmer	3 or more times/year	2 times/year	1 time/year	0 times/year
6.	Neighbors	4 or more times/month	3 times/month	1-2 times/month	0 times/month
Group contact					
1.	Participation in group discussion	4 or more times/year	2 -3 times/year	1 time/year	0 times/year
2.	Participation in demonstration meeting	4 or more times/year	2 -3 times/year	1 time/year	0 times/year
3.	Participation in field day/rally	4 or more times/year	2 -3 times/year	1 time/year	0 times/year
4.	Participation in Training program	5 or more times/year	2 -4 times/year	1 time/year	0 times/year
Mass communication					
1.	Listening agricultural program in radio	4 or more times/week	2-3 times/week	1 time/week	0 times/week
2.	Watching agricultural program in television	4 or more times/week	2-3 times/week	1 time/week	0 times/week
3.	Reading agricultural magazine (Krishi kotha, Leaflet, Booklet)	5 or more times/month	3-4 times/month	1-2 time/month	0 times/month
4.	Observing Agricultural fair and folk song	3 or more times/year	2 times/year	1 time/year	0 times/year

7. Organizational participation:

Are you involved in any organization/institution? Yes..... No.....

If yes, please mention the nature and duration of your participation in the following organizations

Sl. No.	Name of Organizations	Nature of participation			
		Do not participate	Ordinary member	Executive committee member	Committee member officer
1.	Union Porishad				
2.	Farmers Cooperative Society				
3.	Mosque/Mondir/Church Committee				
4.	Market committee				
5.	Relief committee				
6.	Village defense committee				
7.	Village arbitrary committee				
8.	Youth community committee				
9.	Madrassa Committee				

8. Cosmopoliteness:

How often you visit places outside of your village

Sl. No.	Places of visit	Extent of visit			
		Frequently	Occasionally	Rarely	Never
1.	Other village	13 or more times/month	5-12 times/month	1-4 times/month	0 times/month
2.	Own Upazila headquarter	13 or more times/month	7-12 times/month	1-6 times/month	0 times/month
3.	Other Upazila	8 or more times/year	4-7 times/year	1-3 times/year	0 times/year
4.	Own district town	6 or more times/year	3-6 times/year	1-2 times/year	0 times/year
5.	Divisional or Capital city	3 or more times/year	2 times/year	1 times/year	0 times/year

9. Climate change knowledge:

Please answer the following questions

Sl. No.	Questions	Full marks	Marks obtained
1.	Mention two ways of climate change that effect on crop production	2	
2.	Mention two name of the climatic hazards that affect crop production	2	
3.	Mention two adaptive measure of climate change	2	
4.	How technologies provide scope for climate change adaptation	4	
5.	How technologies reduce hazards effect of climate change on crop production?	4	
6.	How can you protect crops from flood?	2	
7.	How can you reduce the crop loss from drought?	2	
8.	Mention two benefits of adoptive technologies on environment	2	
	Total	20	

10. Climate change awareness:

Please give your opinion regarding the following issues of climate change awareness

Sl. No.	Statements	Response	
		True	False
1.	Emission of CO ₂ from industries and vehicles cause green house effect		
2.	Refrigerator gas affect ozone layer		
3.	Deforestation increase CO ₂ intensity on atmosphere		
4.	Global warming has impact on sea level raising		
5.	Excessive use of chemical fertilizers has great impact on climate change		
6.	Increasing precipitation has effect on crop production		
7.	Excessive use of insecticide and pesticide reduce soil fertility		
8.	Fossil fuel burning affect climate		
9.	Water pollution has effect on climate		
10.	Over population has effect on climatic degradation		

11. Technology adoption by the farmers for climate change adaptation

Please mention the information about the extent of use of the following adoption technologies

Sl. No.	Name of the technology	Extent of adoption			
		Regularly	Occasionally	Rarely	Not at all
1.	Crop rotation				
2.	Early cropping production				
3.	Late cropping				
4.	Relay cropping				
5.	Short duration variety				
6.	Irrigation in drought				
7.	Mixed cropping				
8.	Homestead gardening				
9.	Sweet gourd cultivation in sandbar				
10.	Protection of seedbed during cold wave				

12. Problem faced by the farmers in technology adoption for climate change adaptation

Please indicate the extent of problems in technology adoption for climate change adaptation

Sl. No.	Problems	High	Medium	Low	Not at all
1.	Lack of knowledge on climate change				
2.	Lack of knowledge on climate change adaptation				
3.	Unavailability of technological resources in desired amount				
4.	Lack of training facility for technology adoption				
5.	Lack of initiatives and motivation from extension worker				
6.	Lack of interest on new technology adoption				
7.	Lack of capital for technology adoption				
8.	Lack of knowledge on application of different technologies				

Thank you for your good cooperation.

.....

Signature of the interviewer

Appendix-B

Correlation Matrix of the Dependent and Independent Variables

	Age	Educational qualification	Family size	Annual income	Farm size	Extension media contact	Organizational participation	Cosmopoliteness	Climate change knowledge	Climate change awareness	Technology adoption for climate change adaptation
Age	1										
Educational qualification	-.417**	1									
Family size	.394**	-.234*	1								
Annual income	.227*	.181	.246*	1							
Farm size	.209*	.262*	.122	.492**	1						
Extension media contact	.082	.365**	-.073	.379**	.269**	1					
Organizational participation	.241*	.012	.021	.275**	.153	.612**	1				
Cosmopoliteness	-.029	.421**	-.129	.459**	.303**	.462**	.283**	1			
Climate change knowledge	-.059	.356**	-.329**	.267**	.168	.545**	.270**	.438**	1		
Climate change awareness	-.113	.288**	-.039	.184	.223*	.347**	-.009	.321**	.312**	1	
Technology adoption for climate change adaptation	-.060	.195	-.068	.049	.097	.450**	.248*	.407**	.385**	.069	1

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

