Analyses of Perceptions and Adaptations to Climate Change by Rice Farmers: Case Study in the Ashanti and Northern Regions of Ghana

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DECLARATION

I hereby declare that this submission is my own work towards my MPhil degree and that, to the best of my knowledge, it contains no material published by another person or material which has been accepted in any other university for any degree except where due acknowledgement has been made in the text.

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DEDICATION

This work is dedicated to my dad, Pr. Stephen Kwadwo Adusei and my sweet mother, Doris

Adusei, for their support both spiritually and financially, as well as their encouragement throughout my education at the University. I also dedicate it to my siblings and all others who helped in my academic pursuit.

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ABSTRACT

Climate change is becoming a serious global problem that is expected to pose a serious threat on the environment and many sectors of economic growth such as agricultural production and food security and especially on rural farmers whose livelihoods depend on the use of natural resources are likely to bear the burden of the adverse impacts. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change perceived by farmers. This study analyses the perceptions and adaptations of rice farmers to climate change in the Ashanti and Northern regions of Ghana. To carry out this analysis, a multinomial logit model, in which the choices of rice farmers' adaptations to climate change are specified to be a function of socioeconomic and institutional variables, and is estimated using the maximum likelihood method. Cross sectional data was collected from a sample of 249 rice farmers from the Adansi South district, Ahafo Ano South district and the TolonKumbungu districts. The results show that rice farmers in all the surveyed districts are aware of the changing climatic conditions, and recognize climate change. The overall perception index (CBPI) of sampled rice farmers about climate change across the surveyed districts is 0.5, suggesting that rice farmers have a positive perception about climate change and as well agree to most of the perception statements about climate change. Hence, they are always willing to put measures in place to mitigate the adverse effects of climate change. The main adaptation strategies used by rice farmers are migrating to urban areas, diversification of crop, making of bonds (irrigation) and engaging in off-farm jobs. The results reveal that age significantly but negatively affects the decision of farmers to make bonds on their rice fields as well as migrate to the urban area when faced with climate variability. Policy should therefore aim at encouraging and motivating the young people to go into the rice farming business. Farm size also had negative influence on a farmer's choice of making bonds his rice field. It is therefore recommended that the bonding method of irrigation on rice fields is improved and mechanized as farmers with very large rice fields are not able to invest in the method. Off-farm income negatively influence the likelihood of a rice farmer making bonds, migrating as well as diversifying his crop types. Rice farmers should properly manage their off-farm incomeearning opportunities so that these jobs do not interfere with their farm activities. The size of a rice farmer's household, distance from house to farm, educational level, farming experience and land acquisition were all found to negatively influence a farmer's choice of an adaptation strategy. However, gender and fixed agreement between land owner and the rice farmer positively influence a farmer's choice of adaptation to climate change. It is recommended that land acquisition and property rights should be clearly defined to both land owners and rice farmers. Lack of financial resources, High cost of labor and inputs and transportation problems are the most pressing problems facing rice producers in the surveyed districts. The study therefore recommends that policies that would improve access to credit, extension service delivery, off-farm jobs, land acquisition and property rights should be pursued.

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LIST OF ABBREVIATIONS

CSIRO Commonwealth Scientific Industrial Research Organization.

CBPI

CRU

CFC

FAO	Food and Agriculture Organization
FM	Frequency Modulation station
GSS	Ghana Statistical Service
GHG	Greenhouse gas
GDP	Gross Domestic Product
GMOs	Genetically Modified Organisms
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IIPAC	Innovative Insurance Products for Adaptation to Climate Change
IIA	Irrelevant Alternatives
KJV	King James Version
MOFA	Ministry of Food and Agriculture
MEST	Ministry of Environment, Science and Technology
MDB	Murray Darling Basin of South Africa
MDGs	Millennium Development Goals
MO	Met Office
MNL	Multinomial Logit
MNP	Multinomial Probit
NOAA	National Oceanic and Atmospheric Administration
JHS	Junior High School
SHS	Senior High School

Perception Index

Climate Research Unit

Chlorofluorocarbons

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Climate is a key component that influences agricultural production (Parthasarathy and Pant, 1985). Consequently, it has large-scale impacts on food production and the overall economy (Deressa *et al.*, 2008; Kurukulasuriya and Mendelsohn, 2006). Increasing global warming caused by human and other natural activities have however caused changes in the climatic conditions, leading to various climate-related disasters thereby adversely affecting agriculture, food security, water resources and biodiversity as a whole (Dhaka *et al.*, 2010).

Climate change is occurring in every part of the planet earth. Natural processes can lead to climate change; however, anthropological activities such as coal mining, bush burning, fumes from cars and industries as well as emission of greenhouse gasses (IPCC, 2007) contribute a major part of climate change. These activities lead to rises in CO_2 concentration in the earth's atmosphere which forms a blanket in the earth's atmosphere. The blanket prevents radiations from the sun from leaving the earth. The radiation from the sun heats the earth causing higher temperature levels as well as melting of the Polar Regions. This therefore leads to rising sea levels and unpredictable climatic events such as erratic rainfall, floods and drought conditions. According to Umar *et al.* (2008) climate change is the changes that happens in the earth's climate for a given time and can also last for a number of years. The change and variability in climate is becoming a serious global problem that affects many sectors of economic growth in the world. Those sectors that are widely affected by the impacts of climate-related hazards and calamities include; agriculture, water, fisheries, forestry, wildlife, energy, industrial processes and product use, waste management, human health, and the sustainable livelihood of both rural and urban communities (Lema and Majule, 2009; Bie *et al.*, 2008).

In Ghana and most developing countries, climate change has the tendency of having adverse effects on the environment, agricultural production and food security, with peasant farmers being the most vulnerable since their source of income is highly dependent on the use of natural resources (Acquah and Onumah, 2011). Ghana is currently reaching a lower middle income status but is vulnerable to climate change since Ghana's agriculture is still dependent on climate and it has been detected that the temperature conditions in all the ecological zones in Ghana are rising, as well as less predictable rainfall patterns (MEST, 2010). Such changes may manifest in the reduction in land quality and low agricultural yields (Idrisa *et al.*, 2012).

Rice is a staple food which constitutes a major part of the diet of many countries in the world (Oteng and Anna, 1999). It is widely cultivated with high production in South-East Asia, and largely exported by the United States of America in the world and Southern Europe regions (Longtau, 2000). In Sub-Saharan Africa, West Africa is the leading producer and consumer of rice. The crop is widely produced in Cote d'Ivoire, the Gambia, Guinea, Guinea Bissau, Liberia, Burkina Faso, Senegal and Sierra Leone (NISER, 2002). The sub region produces 42% of all the rice produced in Africa while the other four regions North Africa, East Africa, Central Africa and Southern Africa produce 32%, 23.8%, 1.2% and 1% respectively showing insignificant levels of production (Oteng and Anna, 1999). Africa has great potential for expanding its agricultural production in general and rice in particular (Oteng and Anna, 1999) as the potential arable land in Africa is 637 million ha and about 68 percent of the total area is in reserves (Okigbo, 1982).

In Ghana, the cultivation of rice has been in existence for a very long time. It was one of the major commercial food crops in the 17th and 18th centuries (Mobil and Okran, 1985). The crop is very important with regards to the diets of Ghanaians, as well as its availability throughout the year is of great concern as the crop, maize, millet and sorghum and other cereals are grown for food and income for both the rural and urban households in Ghana (Mabe *et al.*, 2012). Presently, rice is one of the major cereals produced in Ghana, but its production as for other crops, is affected by extremities in weather and climate such as floods, salt stress and extreme temperatures. All these extremities are expected to get worse with climate change (Darko *et al.*, 2013). Kranjac-Berisavljevic *et al.* (2003) also stated that factors such as shortage of water and the dependence of farmers on rainfall significantly influence rice production in the country. The combination of changes in the rainfall patterns and rising temperatures is expected to negatively affect the growing conditions of the rice crop due to drought, flooding, etc. thereby changing the growing seasons which could later reduce crop productivity (Darko *et al.*, 2013). Sarr *et al*. (2007) also stated that the major climate change impacts will be on rainfall, which will be changing and less reliable. This is expected to affect the onset and length of growing seasons of the crop, particularly in semi-arid areas where yields from agricultural farmlands that are mostly rain-fed could be reduced by up to 20 to 50% by 2050. The increase in temperatures is also likely to reduce the duration of the hot offseason period for irrigated rice farming, owing to increased risk of sterility due to high temperatures at flowering stage of the crop (Darko *et al.*, 2013).

The production of rice in Ghana is therefore expected to reduce by 36 per cent as many rice farmers have abandoned their rice fields as a result of the effects climatic pressures in the country (Oppong-Ansah, 2011). The three northern regions of Ghana are already experiencing the highest mean temperatures and the predominance low rainfall, causing poverty across these regions. Projected climate pressures such as higher temperatures, changing rainfall patterns and increased number of floods are expected to intensify the poverty issues and threaten settlements near the coastline (MEST, 2010). The southern parts of Ghana are also threatened with the effects of climate change as thousands of people wailed when properties worth several millions of Ghana cedis and some human lives were lost following a seven hour torrential rainfall in October, 2011 (Oppong-Ansah, 2011). The root and tuber sector of Ghana's agriculture, which accounts for 58% of the per capita food consumption is also at risk of being affected by the damaging effects of changes in the climatic conditions (Sagoe, 2006) as production in the sector reduced during the drought period in 1990. Despite the damaging effects of climate change to

Ghana's agriculture, options aimed at responding (adapting) to climate change are few and therefore makes the poor who depend on farming, fishing and/or forestry as their main livelihood become more vulnerable to the changes in climatic condition (Sagoe, 2006).

Therefore, the need to encourage rural farmers' adaptation to the changing climatic conditions cannot be over emphasized.

Adaptation is generally seen as the most basic way by which one can respond to the adverse impact of climate change. It is how individuals, groups and natural systems make preparation for and react to the changes in climate (Mitchell and Tanner, 2006). According to Bryant *et al.* (2000) adaptation is how individuals take decisions based on their perceived changes in the climatic conditions. Successful adaptation can reduce humans' exposure to external shocks (such as flood) and stresses (such as gradual temperature increase) by building on and strengthening existing coping mechanisms and assets (Mitchell and Tanner, 2006). Studies have therefore shown that without adaptation, climate change poses a serious threat on the agriculture sector; however with adaptation, the adverse effects the change can largely be reduced (Smith, 1996). According to (IPCC, 2001), the level of damage caused to any agricultural system by climate change will depend on its ability to adapt. This adaptive capacity of the agricultural system is the ability of the system to adjust to climate change to avert any estimated damage and take advantage of opportunities so as to be able to cope with the consequences. Therefore, the adaptive capacity of any agricultural system is its ability to make changes in its behavior to enable it withstand the changes in external conditions.

Nonetheless, for a farmer to adapt to climate change, he must first detect that change followed by the identification and implementation of a better adaptation (Maddison, 2006). Literature has suggested many adaptations to climate change some of which include crop diversification, changing the timing of operations, diversification of sources of income, development and promotion of new crop varieties, and improvement of water management techniques (Smith and Lenhart, 1996). Some of these adaptations are only potential adaptation measures instead of the ones actually used by the farmers. In fact, it has not been proven that these adaptation options are feasible, realistic, or even likely to occur. Additionally, they would only be possible if and only if farmers have full information of climatic conditions. This implies that studies on the impact of climate change often take on certain adaptations with very little information on how, when, why, and under what conditions these adaptations occur.

Ghana has a great potential in producing rice in Sub Saharan Africa, but lack of adequate supply of water together with undesirable climate change indicators such as temperature, precipitation, relative humidity and bright sunshine duration have the tendency of negatively affecting rice yields in the districts of study and in Ghana as a whole (Mabe *et al.*, 2012). To be able to continue high rice production in the country and in the districts of study, it is very important for rice farmers to adapt to climate change (Mabe *et al.*, 2012). There exists very little knowledge on whether farmers perceive climate change and have adopted any adaptation to climate change. This study therefore intends to capture the extent of farmers' awareness and perceptions of climate change and variability and the types of adaptation strategies they have put in place in response to these changes.

The study's main objective was to analyze rice farmers' perceptions and adaptations to climate change and examine their relationship to socio-economic characteristics of farmers. Specifically the study tried to investigate farmers' awareness of the changes in the climatic condition, investigate farmers' perception on climate change over the past years, ascertain the factors that influence farmers' perception about climate change, identify the various adaptation strategies to climate change, determine the factors that affect the adoption of the various adaptation strategies, and to find out the constraints to the implementation of existing climate change adaptation strategies used by rice farmers.

1.2 Problem Statement

Climate has been found to be one of the major components that significantly influence agricultural production, with large-scale impact on food production and the overall economy (Parthasarathy and Pant, 1985). Both natural and human activities such as emission of greenhouse gasses (IPCC, 2007) cause various climate-related disasters that adversely affect agriculture, food security, water resources and biodiversity as a whole (Dhaka *et al.*, 2010). Farmers always respond to the adverse impact of climate change by putting in place some adaptation measures (Winarto *et al.*, 2008). But adaptation to climate change requires that farmers must first detect that change followed by the identification and implementation of a better adaptation options. A lot of these measures employed by farmers to manage the negative effects of climate change have been suggested in literature but according to Gbetibouo (2009) these adaptation strategies are not the ones used by rice farmers in response to the changing climatic conditions. Again, it has also not been proven that these adaptation strategies occur or whether it is practicable everywhere (Risbey *et al.*, 1999).

Climate change is a matter of importance to the poor and farmers since it tends to increase the vulnerability of this group by having a negative effect on their health and livelihood. Because climate change is expected to significantly aggravate water stress, reduce food security, increase impacts from extreme weather events, displace millions of people due to floods and rise in sea level and potentially increase the transmission of vector–borne diseases, the need to improve their adaptive strategies to reduce their vulnerability becomes more relevant (Nelson and Agbey, 2005). This study therefore seeks to determine the perception of rice farmers about climate change and find out the types of adaptation strategies they have put in place in response to these changes in the Ashanti and Northern regions of Ghana.

1.3 Research Questions

1. Are rice farmers aware of climate change adaptation strategies?
2. What are the perceptions of rice farmers on climate change?
3. What climate change adaptation strategies do rice farmers adopt?
4. What factors influence the adoption of climate change adaptation strategies by rice farmers?
5. What are the constraints to the adoption of existing climate change adaptation strategies by rice farmers?

1.4 Objectives of the study

The main objective of the research is to analyze rice farmers' perceptions and adaptations to climate change in the in the Ashanti and Northern regions of Ghana. The specific objectives are as follows:

1) Investigate rice farmers' awareness of climate change in the study area.
2) Investigate rice farmers' perception of climate change in the study area.
3) Identify the various climate change adaptation strategies that rice farmers adopt in the study area.
4) Determine the factors influencing the adoption of the various adaptation strategies by rice farmers in the study area.
5) To find out the constraints to the adoption of existing climate change adaptation strategies by rice farmers.

1.5 Justification of the study

Climate change is expected to have a significant impact on the livelihoods of the rural poor in developing countries (Below *et al.*, 2010). According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate change is likely to have a significant effect on agricultural production in many African countries. The projected reductions in yield in some African countries could be as much as 50% by 2020, and net crop revenues could also fall by 90% by 2100 (Boko *et al.*,2007).

Jones and Thornton (2003) reports that variability in climatic conditions has proved to be a stumbling block to food security in most developing countries and especially in Sub-Saharan Africa. This is because Sub-Saharan Africa experiences high temperatures and low (and highly variable) precipitation, the economies are highly dependent on agriculture and lastly, because there is low adoption of modern technology.

In Ghana increased climate variability reflected in changing climate regimes is obvious. Extreme climatic conditions led to periods of severe drought, decline in crop production and livestock herds, with the severe food shortages experienced in the country, especially in the early 1980's, pointing to the potential future threats. The adverse impacts of climate change on the natural resources base and the sustainable livelihoods of rural communities can translate in increased poverty and limited economic development (GFDRR, 2011).

Rice is important to Ghana's economy and agriculture. It is produced in all the ten regions of Ghana, covering all the major ecological-climatic zones. The rice sector serves as an important provider of rural employment to economy of Ghana (Kranjac-Berisavljevic, 2000). Amongst the four main cereals (rice, maize, millet and sorghum) that are produced and consumed in Ghana, rice contributes 10.8 percent of total output of 1.6 million tonnes of all the cereals produced every year. However, report indicates that rice production in Ghana is expected to reduce by 36 per cent (Oppong-Ansah, 2011). This can be attributed to the changing climatic condition and the impact on food production. Many rice farmers in the major rice producing districts in the northern and other regions in Ghana are unable to meet their rice production targets due to inadequate rains (Oppong-Ansah, 2011). The following reasons could therefore be brought forward for determining the adaptation strategies employed by rice farmers on their farms. Firstly, identifying both the generic and climatespecific elements of farmers' adaptation behavior is vital in order to facilitate a societal response to the changes in climate that scientists have predicted. Tailoring these adaptation practices to specific societies may make it possible to offset the adverse impacts of climate change (Fussel, 2007). Secondly, the current climate change scenarios demand the adaptation of smallholder farmers in dry lands to temperature increases, changing amounts of available water, greater climatic instability and increased frequency of extreme weather events. Thus the future crop farming techniques and food production systems will have to be better adapted to a range of abiotic stresses such as greater heat accumulation, dwindling water and salinity availability in order to cope with the consequences of progressively changing climate phenomena (Ojwang *et al*., 2010), hence identifying adaptation practices can serve as a more widespread adaptive strategy towards environmental change. Thirdly, the results of the study will provide reliable information towards understanding of future climate change and adaptation options to supplement existing knowledge that could be shared among farmers, media, public/private authorities and development partners interested in food security issues in semi-arid zone of Sub-Saharan African (Tachie-Obeng *et al*., 2010).

1.6 Organization of the study

The study was organized into five chapters as follows. Chapter one dealt with the background of the study, problem statement, objectives of the study as well as the research questions and the justification of the study. Chapter two focused on the review of relevant literature. Chapter three outlines the methodology employed to achieve the objectives of the study. In particular, it describes the study area, discusses the conceptual framework on the standard theory of adoption, and the sampling techniques adopted for the data collection. The descriptive and empirical results are provided in the fourth chapter. Chapter five provides a summary of the research findings, conclusion and some policy recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter discusses the sources of information that relate to climate change, farmers' perceptions of climate change and adaptations to the changing climatic conditions as well as the barriers to the implementation of adaptation strategies. It begins with the climate system, farmers' perceptions of climate change adaptation strategies, adaptation strategies adopted by farmers in response to the changing climatic conditions. Empirical literature on the factors that influence farmers' perceptions of climate change adaptation strategies as well their decision to adapt a climate change adaptation strategy are also reviewed. It concludes with the barriers to the implementation of climate change adaptation strategies.

2.1 Climate System

2.1.1 Climate and Weather

Weather and climate have been found to have an intense influence on life on Earth, where the two are essential for food production, health and well-being of human beings. The two terms are occasionally confused, but they are very different concepts (Ashfold, 2012). Weather is the local condition of the atmosphere of a place at a particular time. It includes temperature, wind speed, rainfall, humidity, etc. It is what happening right now and varies from day to day and from season to season (Ashfold, 2012). Climate on the other hand is a statistical summary of all the weather that occurs at a certain location over a relatively long period of about 30 years. It also includes information about probability of a particular weather events occurring (Ashfold, 2012). When differences occur in long-term climate over shorter periods of say a month or year, such differences are known as climate variability (Ashfold, 2012).

2.2 Climate Change

Climate change can be defined as a long-term and significant change in the average weather condition of a region and can last for a significant period of time (Nzuma *et al.*, 2010). Climate change can also be defined as a change in the climate that is characterized by variability of its properties and that remains for an extended period, typically decades or longer (IPCC, 2007). The condition is further defined as a change in the average weather condition especially average temperature and precipitation of an area (Mabe *et al*., 2012). It is the result of the combination of several factors, such as Earth's dynamic processes, external forces, and more recently, human activity. The external forces that result in changes in climate include processes such as variations in solar radiation, deviations in Earth's orbit, and variations in the level of greenhouse gas concentrations (Nzuma *et al.*, 2010).

Climate change is now one of the greatest environmental, social, and economic problems that faces the planet currently (Nzuma *et al.*, 2010). The Fourth Assessment Report of the IPCC (2007) indicated that most land areas will have warmer and fewer cold days and nights. Fancherean *et al*. (2003) also pointed out that the earth in times past has observed significant increases in temperature and decreased rainfall as a result of climate change. According to De Jonge (2010), climate change is expected to result in very high temperatures and changes in the water balance. Report indicates that there is a large diversity in climate conditions with rainfall decreasing from east to west and temperature increasing from south-east to northwest across the Murray Darling Basin (MDB) of South Australia (De Jonge, 2010).

Africa is considered the world's most vulnerable region with regard to the effects of climate change due to the instability of its economies. In spite of the vulnerability of Africa to climate change, the latest report of the Intergovernmental Panel on Climate Change (IPCC) has shown Africa would experience a more severe global warming as compared to the rest of the world in the 21st century. This is expected to cause rainfall in some parts of the region to decline (IPCC, 2007). Recent research indicates that decreased precipitation is expected to be recorded even in East Africa where increased rainfalls were often recorded due to climate change (Funk *et al*., 2008). These expected climate changes remain a great challenge to food and water security, public health, natural resources, and biodiversity (McCarthy *et al.*, 2001). According to Nzuma *et al.* (2010), climate change is expected to have a significant impact on the livelihoods and living conditions of the poor and thus threaten the attainment of the Millennium Development Goals (MDGs) and sustainable development in Sub-Saharan Africa.

In Ghana, the following climate indicators reveals that the climate has changed; rising temperatures, declining and increased variability of rainfall, rising sea levels and high incidence of weather extremes such as floods and droughts (De Jonge, 2010). According to Pinto *et al.* (2012), Ghana records increased mean annual temperature and decreased monthly rainfall per decade since 1960, though rainfall over Ghana was particularly high in the 1960s. The increase in temperature and decrease in rainfall are 1°C per decade and about 2.4% per decade respectively (Pinto *et al.*, 2012). Records further indicate that temperatures are likely to continue rising in the future with an average annual temperature increase between 0.8°C and 5.4°C for the years 2020 and 2080 respectively. Rainfall is also predicted to decrease in all the agro-ecological zones with an average annual rainfall total within the same period of 2020 and 2080 estimated to decline by between 1.1%, and 20.5% (www.ccdare.org). Based on the review of some climate models, Pinto *et al.* (2012) concludes that by 2060 the mean annual temperature will increase by 1.0°C - 3.0°C, and further increase to 1.5°C - 5.2°C by 2090 with changes being expected to be more severe in northern Ghana. Other studies such as Owusu and Waylen (2009) reported that the decline in the annual mean rainfall of the southwestern regions of the country has been the most severe. In the remaining parts of the country such as the Volta Basin, shorter dry spells have been replaced by prolonged dry seasons, indicating changes in the climatic condition (Owusu *et al.*, 2008). Such predicted changes in climate are expected to significantly affect estimates for future crop yields (Pinto *et al.*, 2012).

2.2.1 Temperature changes as an Indicator of Climate Change

Change in the global-average surface temperature is an important indicator of climate change (Levinson and Waple, 2004). Many studies show that the Earth's climate is changing and it is worth noting that increasing temperature is one of the elements of observed global climate change (www.ncdc.noaa.gov). According to Graham (1995) global average tropospheric temperatures have been rising during the past century, with a sharp rise since the mid- 1970s. Global temperature in the year 2005 was noted for its global warmth, both at the surface and throughout the troposphere. Surface temperature in that year remained above average in all 12 months and reached a record high value for the year. The observed rate of increase in temperature in the year 2005 was three times as great since 1976 (Shein *et al.*, 2006). Global warmth continued in 2006. The ten warmest years on record have all occurred since 1995, with 2006 ranking fifth or sixth warmest in the 1880–2006 record, depending on the dataset analyzed. Global temperature for 2006 ranks as the fifth highest on record according to NOAA/ NCDC and NASA's GISS, and as the sixth highest according to the University of East Anglia Climate Research Unit (CRU)/Met Office (MO) Hadley Centre estimate **(**Arguez *et al.*, 2007**).** Levinson *et al.* (2008) also reported that surface temperature for 2007 fell within the 10 highest on record, while the average land temperature was the warmest since global records began in 1880.

The average temperature in Australia has increased by 0.9°C since 1910, with most of this increase occurring since the 1950's (Hennessy *et al.*, 2007), and it is still expected to rise with 1°C to 5°C by the year 2100 (CSIRO and BoM, 2007). This rise in temperature is expected to reduce the water availability by 15% (Cai and Cowan, 2008), leading to a drier future on the average (CSIRO, 2008).

A report by Fosu-Mensah *et al.*, (2010) also indicated a rise in the historical mean annual temperature data in the Sekyedumase District in Ejura, Ghana from 1972 to 2008 (with the exception of 2003). The data showed that temperature was increasing especially from 1999 to 2008.

Maharjan *et al.* (2010) reported that temperature increases in Nepal at a high rate of 0.06 degree Celsius per year. Communities which experience this increment also face extreme weather events such as erratic rainfall, longer droughts, landslides, floods both in terms of magnitude and frequency that ultimately leads to climate change impacts in their daily life mostly in the field of agriculture, forestry and natural resource management.

2.2.2 Precipitation changes as an Indicator of Climate Change

Global warming has a direct influence on precipitation. Increased temperatures lead to greater evaporation and thus surface drying, causing increased intensity and duration of drought (Trenberth, 2011). Nonetheless, the water holding capacity of air increases by about 7% per 1°C warming, which leads to increased water vapor in the atmosphere. This supplies the storms with increased moisture to produce more intense precipitation events. Such events are occurring even in areas where total precipitation is decreasing, thereby increasing the risk of flooding (Trenberth, 2011). When changes in winds are modest, patterns of precipitation do not change much, but causes dry areas become drier while wet areas become wetter, especially in the mid to high latitudes (Trenberth, 2011).

Murnane (2004) defined hydrological extreme events as floods and droughts. Floods are associated with extremes in rainfall including tropical storms, thunderstorms, orographic rainfall, widespread extra tropical cyclones, etc., while droughts are associated with a lack of precipitation and often extremely high temperatures that contribute to drying. Floods are often fairly local and develop on short time scales, while droughts are extensive and develop over months or years.

Generally, precipitation in the subtropics and tropics outside of the monsoon trough have been found to be decreasing but increases in land precipitation at higher latitudes, especially over North America, Eurasia, and Argentina. The decreases are especially evident in the Mediterranean, southern Asia, and throughout Africa (Knowles *et al.*, 2006).

According to Trenberth (2011) in his work on changes in precipitation with climate change found that as the climate warms, water-holding capacity increases with higher temperatures resulting in increases in water vapor amounts since relative humidity is more likely to remain the same. The observed increases in water vapor affect both the greenhouse effect, thus providing a positive reaction to climate change, and the hydrological cycle, by providing more atmospheric moisture for all storms to feed upon. This has ramifications for

precipitation.

On the contrary Kendon and Clark (2008) reported that any specific heavy rainfall event should not and cannot be attributed to climate change. However, they were able to make statements about the risk of such events altering as a result of climate change.

2.3 Causes of climate change

It cannot be argued that climate change is the world's number one complex and challenging environmental problem facing the world today. Increasing human populations coupled with the demand for agricultural land for the production of food have been found to worsen the climate change problem (Ojwang'*et al.*, 2010). In their quest of acquiring land for food production, the vegetative cover is destroyed and subsequently leads to rampant environmental degradation. The demand for food, fuel wood and forest products for various uses gives further details about the problem, some of which are environmental degradation, climate change, droughts, floods and food insecurity both to domestic and wild animals, and human beings (Ojwang'*et al.*, 2010).

The Intergovernmental Panel on Climate Change (2007) reported that climate change or variability can either be caused by natural variability or as a result of anthropogenic activities.

The report concluded that more than 90% of the increased warming of the past 50-60 years is caused by the activities of the human population. Blum and Törnqvist (2000) also reported that human activities were altering climatic and environmental conditions over very short timescales. Some human contributions to changes in climate include emission of greenhouse gases in the Earth's atmosphere (IPCC, 2007). Such greenhouse gases which exacerbate climatic conditions, thereby causing changes in climate include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFC) and some other halogen compounds (IPCC, 1994).

According to IPCC (2007) human activities such as the use of coal to heat their homes, oil and natural gas to generate electricity to power their industries and run their cars, changing land use and deforestation contribute to greenhouse gases. The frequent cutting down of trees by the human population increases the level of carbon dioxide and other gasses in the earth's atmosphere. This traps heat in the atmosphere causing temperature levels to rise. The result is significant changes in the frequency and amount of precipitation (IPCC, 2007).

In Sub-Saharan Africa and especially Ghana, agriculture is the second largest contributor to greenhouse gas (GHG) emissions. The main sectors in the agriculture sector that cause the emission of these gases especially nitrous oxide (NO_2) and methane (CH_4) are livestock farming, rice farming, biomass burning and the use of chemical fertilizers (Breisinger *et al.*, 2008). The emission of greenhouse gases especially (NO_2) and (CH_4) is by agriculture and is expected to increase steadily (Smith *et al.*, 2007) because of the increasingly high demand for agricultural commodities in Ghana (Pinto *et al.*, 2012).

2.4 Effect of climate change on the agricultural sector

Climate is a very essential component affecting many regions of the world such as Africa, Southern and Central America, and South and Southeast Asia. Climates are extremely variable from year to year in these regions while recurrent drought and flood problems often affect entire countries over multiyear periods (Iglesias, 2006). The persistent drying trend in some parts of Africa over the last decades has affected food production, including freshwater fisheries, industrial and domestic water supplies, as well as hydropower generation (Iglesias and Moneo, 2005).

The agricultural sector contributes significantly to the GDPs of most developing countries and employs a greater proportion of their populations (Pinto *et al.*, 2012), but this can be jeopardized if the climate change problem is not addressed (Pinto *et al.*, 2012; Turral *et al.*, 2008), as agriculture is strongly dependent on water resources and climatic conditions, particularly in regions of the world that are particularly sensitive to climatic hazards, such as Africa, South and Central America and Asia (Iglesias, 2006). According to Pinto *et al.* (2012), climate change climate change will reduce the amount of water and limit crop productivity, but studies have shown that crop production in these regions is extremely sensitive to large yearto-year weather fluctuations. Crop diseases as well as pest infestations are also weatherdependent, and tend to cause more damages in countries with lower technological levels (Iglesias, 2006). Although the precise extent of the fluctuations in weather and their consequences have not been scientifically proven, but one thing is certain: developing countries are the most vulnerable to climate change since agricultural activities in these regions depend on the climate (Maddison *et al.*, 2007).

Changes in climatic conditions impact agricultural production and activities as the plant and yield it produces depend on the weather. These effects can be associated with increased levels of CO_2 in the atmosphere and other climate change indicators. Although there have been many technological advances in agricultural production, the local climatic conditions of any region determines the amount of food that should be produced (Masters *et al.*, 2010). They indicated that despite these advancements, rainfall and temperature levels continue to remain a significant influence on agricultural activities and output.

A report by Turral *et al.* (2011) indicated that climate change will impact the extent and productivity of both irrigated and rain fed agriculture across the globe. In their report, they indicated that decreased amount of water in rivers and aquifer recharge in the Mediterranean basin and in the semi-arid areas of the Americas, Australia and southern Africa, were affecting water availability in those areas.

Research has shown that climate change will not equally affect all countries, but will have the biggest impact in equatorial regions such as sub-Saharan Africa. Projected yield patterns indicate that yields from farming in some African countries are expected to reduce by up to 50 percent by 2020 (Ellis, 2008). In Ghana, climate change has intensified seasonal and interannual rainfall and temperature variations resulting in drought conditions and floods. In terms of temperature variations, average temperatures in the future are expected to rise across countries due to climate change (Challinor *et al.*, 2007). The Food and Agriculture Organization (FAO) warns that increases in average global temperatures of 2°C to 4°C above preindustrial levels could reduce crop yields by 15-35 percent in Africa and potentially cause the extinction of millions of species (Ellis, 2008).

2.4.1 Effects of Increasing Temperatures on agriculture

The level of food production in the world would continue to increase if temperature levels fall within a range of 1°C-3°C, however, increases in temperature above 3°C is likely to cause global food production to decrease (Easterling *et al.*, 2007).

Temperature is known to be one of the major factors that affects agricultural crop production. The amount of the crop that can be grown, the quality of the crop and where the farmer can even grow his crop are partly determined by temperature. It is therefore worth knowing that any slight changes in temperature due to changes in climatic conditions is likely to have significant impact on the crops under production. Very high temperatures cause plants to become infertile leading to lower productivity in crops. When temperature rises, water evaporates from the plants and the soil, reducing the amount of water needed by the plant for growth and other functions. Finally, increased temperatures shortens the time between crop planting and harvesting. This can lead to crop senescence (Masters *et al.*, 2007).

2.5 Farmers' perception of Climate Change

Perception in psychology and the cognitive sciences is defined as the process having awareness of something or understanding of sensory information (Ofuoku, 2011). Wikipedia dictionary defines it as the organization, identification and interpretation of sensory information in order to represent and understand the environment. According to (Ofuoku, 2011) Anything that is perceived must be based on the repetition of someone's cultural experience and how that perception is interpreted. Man reacts to secure his comfort and future based on his perception of his environment. Because of this security, he reacts accordingly to the way he perceives and interprets the environment. The same way farmers are expected to react according to the way they perceive and interpret climate change.

The perception of farmers about their environment is very important for adaptation to climate change (Ofuoku, 2011). Literature on adaptations to climate change has shown that perception is needed before one can adapt to climate change (Maddison, 2006). For farmers to decision to adopt any adaptation they must first perceive that climate change has actually occurred (Kasulo *et al.*, 2012) and then decide on which adaptation to use (Maddison, 2006). A study by Howe *et al.* (2012) indicates that people can perceive aspects of climate variability and change based on personal observations, thus perception about climate is different for different people. These different perceptions or views about climate variability and change include increase in the levels of temperature, decrease in precipitation, changes in the timings of rain, frequency of drought, drier conditions and others (Ndambiri *et al.*, 2012; Nhemachena and Hassan, 2008). De Wit (2006) has asserted that preliminary evidence from some African countries indicate that many people in the farming business already perceive increasing temperatures and less rainfall patterns. Bryan et al. (2011) further emphasized that farmers perceive long-term changes in temperature and rainfall.

Some empirical studies such as Dhaka *et al.* (2010) have shown that most farmers in the Bundi district of Rajasthan in India perceive a significant shift in the temperature in addition to the overall increase in temperatures in the area. According to Gbetibouo (2009) majority of the famers representing 91 per cent of the total number of respondents perceived increasing temperatures where as a few of about 1.5 per cent noticed the contrary of a decrease in temperature. The study confirmed the accuracy of farmers' perception as the data showed an increase in temperature of 1 degree Celsius in the area (Gbetibouo, 2009). The use of a fourpoint likert's scale to obtain information on rural farmers' perception also revealed that farmers observed that afternoons were hotter, implying increased temperatures in the climatic condition of the Delta state in Nigeria (Ofuoku, 2011). Vedwan and Rhoades (2001) also reported that apple farmers in Western Himalayas of India perceived long term changes in climate in terms of temperature. They indicated that temperature distribution was perceived by farmers to have undergone a significant shift in addition to an overall increase in temperatures. Fosu-Mensah *et al.* (2010) measured the accuracy of farmers' perception by comparing their perception of temperature with temperature data of past years in Ejura and found that farmers' perception of an increase in temperature was in line with the data which showed an increasing trend in temperature. However, they indicated that a few farmers of about 3.3% were contrary to this opinion. Acquah and Onumah (2011) also reported that most of the farmers (84.7%) perceived climate change as a serious phenomenon while the rest of the respondents did not perceive changes. They indicated that almost half of the farmers (49%) indicated that temperature has increased whilst 33% of the farmers said temperature is decreasing. Ayanwuyi *et al.* (2010) study on the perception of farmers on the impact of climate changes on food crop production in Ogbomosho agricultural zone of Oyo State, Nigeria revealed that farmers perceived higher temperatures in the climate of the area.

They indicated that these changes had serious consequence such as late fruiting on tree crops.

Farmers' perceptions of climate change with respect to changes in precipitation have also been reported in literature. An analysis of farmers' perception of the effects of climate change in Kenya by Ndambiri *et al.*, (2012) revealed that farmers observed changes in the timing of rains as well as changes in precipitation. They indicated that 70% and 61% of the respondents they interviewed observed a reduction in rainfall patterns and fluctuations in the time of onset of rains respectively. Similar findings were revealed as farmers in the Bundi district of Rajasthan also believed that the rainfall levels have decreased, with pronounced changes in the timing of rains (Dhaka *et al.*, 2010). In the Limpopo Basin of South Africa, farmers' perception of precipitation was not different. Majority of the farmers said the amount of rainfall had decreased as well as fluctuations in the timing of onset of rains (Gbetibouo,

2009). However, upon comparing farmers' perception of precipitation with rainfall data,

Gbetibouo (2009) concluded that farmers' perception was not congruent with data since there was no statistically significant trend in the data. It was also pointed out that apple farmers perceived long term changes in climate in terms of snowfall and rainfall. A reduction in snowfall coupled with changes in the timing of snowfall was observed by the farmers.

However, rainfall was perceived by farmers to have increased (Vedwan and Rhoades, 2001). Most farmers were found to have perceived a decreasing trend in precipitation as well as changes in rainfall patterns in most areas (Acquah and Onumah, 2011; Sofoluwe *et al.*, 2011; Fosu-Mensah *et al.*, 2010). However, some farmers were reported to have perceived an increasing trend in precipitation (Acquah and Onumah, 2011).

2.6 Empirical literature on factors which Influence Perceptions of farmers on Climate Change adaptation strategies

Many studies have established that the perception of farmers about climate change is greatly affected by some institutional and socio economic characteristics of the farmer (Mustapha *et al.*, 2012; Dhaka *et al.*, 2010). These factors include the age of the farmer, educational level, farming experience, farm size, and gender (Ofuoku, 2012). Dhaka *et al.* (2010) pointed out that, innovativeness, environment consciousness, and contact with extension personnel, and exposure to mass media positively and significantly influence a farmer's perceptions to climate change. Further emphasis was made by Mustapha *et al.* (2012) that variables such as farmers' age, educational level, farm size, farming experience significantly influenced the level of farmer's perception on climate change. Ayanwuyi *et al.* (2010) further emphasized that farm size, mulching, mixed cropping, row orientation with respect to slope, access to extension and credit facilities, zero tillage, educational level and years of farming experience also affect the perceptions of farmers about climate change.

The age of farmers is believed to have an influence on the farmer's perception of the changes in climatic conditions. This is so since farming experience increases with an increase in age of the farmer (Addai, 2011). Some empirical studies such as Dhaka *et al.* (2010) have shown a positive and a significant relationship between a farmer's age and his perception of the changes in the climatic condition. Deressa *et al.* (2008) also identified that the age of farmers significantly influence the perception of farmers to climate change. Ndambiri *et al.* (2012)

pointed out that the age of a farmer has a positive and significant influence on his perception of climate change. They concluded that that older farmers can perceive climate change than younger farmers because they have been in the farming business for a long time, hence have more experience in farming than younger farmers.

As far as the influence of gender on farmers' perception of climate change is concerned, literature offers mixed results. Empirical results on the gender of a farmer showed a significant and a positive relationship between farmers' gender and their perception of climate change. The positive relationship implied that male headed households better appreciated and perceived climate change (Ofuoku, 2011). Other studies such as Ndambiri *et al.* (2012) further established that male farmers can perceive climate change more than female farmers. They conclude that the finding was so since male farmers are capable of acquiring more information than female farmers. Mustapha *et al.* (2012) studying the perception of farmers on climate change in Nigeria had contrasting result that the sex of a farmer had no influence on the farmer's perception of climate change. Ugwoke *et al.* (2012) also pointed out that there is no relationship between the sex of a farmers his perception of climate change.

The educational level attained by a farmer is found to influence their perception of climate change. According to Ndambiri *et al.* (2012) farmers with higher educational levels were found to perceive climate change than those with lower levels of education. Thus the higher the educational level attained by farmers, the better they appreciated and perceived climate change. They conclude that these farmers are able to receive, interpret and understand important information on climate through education. Ofuoku (2011) also reported that the correlation between the number of years farmers schooled and their perception of climate change is significant and positive. He added that as the educational level of household heads increased, the better their appreciation of and ability to perceive climate change. Again the level of farmers' education was found to be positive and significant in terms of its relationship with farmers' perception of the changes in the climatic condition. It was therefore noted that farmers with higher levels of education are always aware of and perceive climate change (Ugwoke *et al.*, 2012).

Farming experience is gleaned from the act of agricultural production, and it involves a conscious accumulation of know-how from farming practices (Addai, 2011). The experience of farmers has been found to influence their perception of changes in climatic conditions (Ndambiri *et al.*, 2012; Mustapha *et al.*, 2012; Ugwoke *et al.*, 2012). Ofuoku (2011) pointed out that the number of years a farmer engaged in farming practices significantly and positively influenced his perception of the changes that have occurred in the climate. He concludes that increasing the farming experience a farmer will enhance his perception of climate change. Ndambiri *et al.* (2012) also affirmed that the more farmers acquire experience in the farming business, they are likely to perceive changes in the climate. They explained this by stating that these farmers may have acquired both farming and management skills which enable them to detect any change that occurs in the climate. Similarly, it was found that as one continues to farms for a long period of time, the more he gains more experience on climate change (Dhaka *et al.*, 2010; Ofuoku, 2011; Mustapha *et al.*, 2012; Ugwoke *et al.*, 2012)

Another important factor that affects the perception of farmers about climate change is the size of the farmer's household. Ndambiri *et al.* (2012) analyzing farmers' perceptions of the effects of climate change concluded that households with greater number of individuals have a lower probability of perceiving climate change than households with very few individuals. Their conclusion was based on the fact that household size could serve as a proxy for labor and hence farmers who had more mouths to feed were not likely to perceive climate change because members of such households could be employed in other off-farm jobs to support their families. Ugwoke *et al.* (2012) however indicated that household size has a positive effect on farmers' perception of climate change. The possible explanation they gave to this conclusion was that families with many members have an advantage of sharing information on climate change.

The size of a farmers' farm also influences their perception of the changes that have occurred in the climatic condition over a period of time (Ofuoku, 2011; Mustapha *et al.*, 2012). Empirical results on farm size on the perception of farmers are mixed. A positive relationship is consistent with the hypothesis that farmers with larger farms have a better appreciation of and perceive any change that has occurred in the climatic condition (Mustapha *et al.*, 2012). Ofuoku (2011) however, reports that there is no relationship between farm size and the perception of farmers about climate.

Another important factor that affects farmers' perception is access to extension services. Gbetibouo (2009) found that when farmers have access to extension services, they would be in the position to perceive any change in temperature. That is farmers who have extension contacts and received information from extension officers perceived a change in temperature. Other studies such as Ndambiri *et al.* (2012) also reported that when farmers receive information on climate through extension visits, they can better perceive climate change.

2.7 Farmers' Adaptations to Climate Change

Studies have established that agricultural production is dependent on weather and climate regardless of the introduction of new technologies and innovations into the agricultural system

(Adetunji *et al.*, 2005). It is therefore obvious that climate change has impact on agriculture. Although the causes and effects of climate change are different for different regions, one can still not prevent climate change from happening (Hennesy *et al.*, 2007). However, a report by Klein *et al.* (2007) indicates that though climate change cannot be avoided, its impact on the farming business can be lessened adapting to it. Studies have shown that any agricultural system that adapts to climate change reduces the adverse effects associated with the changes in climatic conditions (Easterling *et al.*, 1993). According to (IPCC, 2001) when rural communities adapt to climate change by putting in place better adaptation measures, they will be able to manage the adverse effects of climate change and variability. Farm level analyses by Mendelsohn and Dinar (1999) also showed that when adaptations to climate change are fully implemented, the adverse effects of the change is greatly brought to a minimum. It is therefore needed to prepare communities, regions, countries and societies for the consequences of climate change through adaptation.

The term “adapt” means to make more suitable by altering or modifying (Smit *et al.*, 2000). “Adaptation” is defined as the process of adapting to a condition. According to (Smithers and Smit, 1997) the term is defined differently depending on the particular discipline in which the term is used. In ecology, adaptation is defined as the changes humans make to enable them survive in their environment (Lawrence, 1995). In the climate change literature, however, various definitions have been proposed as follows; adaptation is the changes humans make in their environment to enable them cope with the expected impacts of climate change and variability (IPCC, 2007). The same term is defined by Burton (1992) as 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 climate environment provides. Smith *et al.* (1996) further defines the term as all the changes made in the human environment to help reduce the extent to which they are affected by changes in the climate system.

Adger *et al.* (2004) points out that adaptation to climate change can be said to be reactive and anticipatory and can be practiced in ways such as market exchanges (Smit *et al.*, 2000), extension of social networks (Adger, 2003), or through actions of individuals and organizations to so as to achieve their objectives (Adger *et al.*, 2004). Empirical studies have reported many adaptation strategies that farmers use to reduce the impact of the changing climatic conditions across the world (Sofoluwe *et al.*, 2011; Fosu-Mensah *et al.*, 2010; Ofuoku, 2011; Maharjan *et al.*, 2010; Acquah and Onumah, 2011). They include crop diversification, altering the timing of operations, income diversification and credit schemes, (Smith and Lenhart 1996)

According to Ofuoku (2011) 60.31% of farmers in the Delta State of Nigeria employed some adaptation strategies in response to the changing climatic condition. Among these strategies is the planting of trees. He indicated that farmers plant trees as an adaptation because it is less costly and there is an easy access to tree seeds and seedlings. Analysis adaptation strategies and constraints to climate change revealed that 9% of farmers planted trees to reduce the impact of perceived changes in the climatic conditions (Bryan *et al.*, 2009). When farmers were asked what measures they would like to put in place to adapt to the changing climatic condition, it was found that 39% of the farmers said they would plant trees in response to the changes (Bryan *et al.*, 2011).

Adjusting the date of planting has also been reported in the literature as farmers' strategy in response to climate change. It has been found that 60.83% of farmers changed their planting dates so they could become accustomed to climate change (Ugwoke *et al.*, 2012). Analysis of household and community adaptation strategies to climate change in Kenya revealed that about 9% of farmers responded to the perceived changing climatic condition by planting a lot of trees (Bryan *et al.*, 2011). Gbetibouo (2009) also found that farmers in the Limpopo River Basin adjusted their farming practices differently to perceived rainfall and temperature changes. Among the responses made by farmers to perceived temperature changes is the changing of planting dates. Dhaka *et al.* (2010) further emphasized that change in time of farm operations was used by farmers as an adaptation strategy in response to changing climatic. In order to respond to delayed onset of rains, majority of farmers in the Sahelian areas of Burkina Faso and Niger were found to have delayed their sowing dates to match the delay in rainfall. They do this in order to save time, effort and resource (Akponikpè *et al.*, 2010).

Another climate change adaptation strategy that is employed by many farmers is the use of short duration crop varieties. In an attempt to find out farmers' choice of climate change adaptation measures Acquah and Onumah (2011) revealed that using different crop varieties was one of the main adaptation measures used by farmers. However, Sofoluwe *et al.* (2011) pointed out that the use of planting different variety of crops as an adaptation strategy was least preferred by farmers to reduce the impact of perceived climate change. Empirical results by Ofuoku (2011) also revealed that farmers who responded to climate change did so by using different crop varieties.

It has been reported that many farmers respond to climate change by growing different crops on the same piece of land. This reduces the loss a farmer may incur in an event of complete crop failure because different crops are affected by the weather or climate differently (Nhemachena and Hassan, 2007). It also remains as a form of insurance against rainfall variability (Orindi and Eriksen 2005; Adger *et al.* 2003). In a study conducted by Gbetibouo, (2009), crop diversification was found to be one of the ways farmers use to response to increasing temperatures in the climatic condition. Fosu-Mensah *et al.* (2010) reported that farmers changed adapted to both reduced quantities of rainfalls and warmer climate diversifying their crops. They indicated that crop diversification was noted by farmers a best way of responding to climate change in the area.

An irrigation facility increases agricultural output (Orindi and Eriksen, 2005). Empirical result revealed that 7.75% of farmers increased irrigation to make up for the reduction in the amount of rainfall (Gbetibouo, 2009). Another study also revealed that farmers responded to perceived changes in the climate by irrigating their farms (Sofoluwe *et al.*, 2011). However, they concluded that only a small number of the farmers irrigated their farms and this was due to the inability of farmers to have water source close to their farms. Ugwoke *et al.* (2012) also identified the use of irrigation as one of the adjustments farmers put in place in response to excessive heat.

Engaging in off-farm jobs is another climate change adaptation strategy farmers use to cope with perceived climate change. According to Fosu-Mensah *et al.* (2010) farmers looked for off- farm jobs to generate income to sustain their households when their crops fail as a result of reduced rains and warmer climatic conditions.

The use of prayer has also been proven to be used by farmers to cope with the adverse impact of climate change. A report indicates that prayer was found to be a main climate change adaptation measures used by farmers, where majority of farmers (74.5%) used it as a way of coping with climate change (Acquah and Onumah, 2011). Akponikpè *et al.* (2010) further stated that the services of churches, mosques as well as that of rainmakers are often sought, where prayers are performed to deal with dry spells.

Although majority of farmers been reported to have adapted to climate change, others did not. Some empirical studies such as (Sofoluwe *et al.*, 2011) have shown that 28.2% of the farmers they interviewed did not adapt to their perceived climate change condition. Other studies further emphasized that despite the perceived changes in the climate as said by the farmers, many of them did not put in place any adaptation measure to adapt to climate change (Gbetibouo, 2009; Ofuoku, 2011)

2.7.1 Farmers' Adaptations to Climate Change in Ghana

To respond to climate change, farmers in Ghana have adopted certain adaptation strategies on their farms to enable them manage the risks posed by climate change (Ford *et al.*, 2011). Empirical studies have shown that these adaptation strategies include the IIPAC, an abbreviation for innovative insurance products for adaptation to climate change (Würtenberger *et al.*, 2011), intercropping with different crop types (Tonah, 1993), use of short duration crop varieties (Dietz *et al.*, 2004; Tonah, 1993), alternative sources of livelihood (Laube, 2007), migration (Nabila, 1987), changing crop planting dates (FosuMensah *et al.*, 2010), diversification of livelihoods and livestock farming (Whitehead, 2006).

Peasant farmers living in local communities in northern Ghana responded to the changing climatic conditions by adopting alternative crops (www.careclimatechange.org). To be able to reduce the risk posed by changing climatic conditions, some farmers diversify the kinds of crop grown. This was done by these farmers to reduce the risk in case of a particular kind of crop (Tonah, 1993).

Whitehead (2006) reported that some farmers in the northern region of Ghana integrated into crop growing the rearing of livestock. He indicated that these farmers engage in livestock husbandry serves as a source of manure and animal traction on their farms. Other studies indicated that these animals also serve as important nutritional needs. The livestock also serves as a source of income for purchasing food in time of food shortages (Tonah, 1993).

Alternative sources of livelihood such as hunting, fishing and gathering of shea and kapok fruits have also been reported to be livelihood strategies employed by some farmers in the northern region of Ghana to deal with the effect of climate change. According to Chalfin (2003) many women collect Shea fruits (*Vitellariaparadoxa*) as well as Kapok tree (*Ceibapentandra*), process them partly, and then sell the produce to obtain income. These activities enable them to purchase food items to survive in case of extreme weather conditions (Laube, 2007).

The use of short duration crop varieties was adopted by some Ghanaian farmers in the north (Laube *et al.*, 2011). Report indicates that these crops have certain characteristics that enable them to withstand the changing climate. Examples of such crops are early maturing millet and groundnut (Tonah, 1993 and Dietz *et al.*, 2004).

Another important adaptation used by some Ghanaian farmers is labor migration to southern parts of Ghana. According to Lentz (1998), people migrated because of coercive labor recruitment, but as time went on some people will move to the urban areas to work so as to earn some income to cater for their needs (Nabila, 1987).

Changing crop planting dates has also been found to be used by farmers in the Sekyedumase district in Ghana to cope with warmer climate (Fosu-Mensah *et al.*, 2010).

2.8 Empirical literature on factors which influence adoption of climate change adaption strategies.

A range of household, farm characteristics, institutional factors, and other factors that describe local conditions have been hypothesized to influence farmers' choice of climate change adaptation strategy. Generally the household characteristics considered to have differential impacts on adoption of adaptation strategies are age, education level and gender of the head of the household, family size, years of faming experience, and wealth (Gbetibouo, 2009). ACCCA (2010) reported that household characteristics considered to have differential impacts on adoption or adaptation decisions are age, education level and gender of the head of the household, family size, primary occupation of the head of household. Nhemachena and Hassan (2008) further pointed out that gender, access to credit and markets, access to electricity and technology, free extension services, and land tenure also affect a farmer's decision to choose a climate change adaptation strategy.

The influence of gender on a farmer's choice of an adaptation strategy is location specific (Gbetibouo, 2009). Some empirical studies such as Sofoluwe *et al.* (2011) and Fosu-Mensah *et al.* (2010) have shown an insignificant but a positive relationship between gender and a farmer's decision to adapt any climate change adaptation strategy. Gbetibouo (2009) in her study conducted in the Limpopo Basin of South Africa identified planting different crops, changing crop variety, changing crop planting dates, increased irrigation, using crop diversification, changing the amount of land under cultivation, building water-harvesting schemes and investing in livestock by buying feed supplements as the adaptations strategies farmers adopted in response to changing rainfall and temperature patterns. In her study the gender of a household head was hypothesized to influence the decision to adapt any adaptation measure (Gbetibouo, 2009). De Groote and Coulibaly (1998) pointed out that women have lesser access to critical resources such as land, cash, and labor; hence their ability to carry out labor-intensive agricultural innovations is often undermined. Hence women are less likely to adapt to climate change. However, a study by Nhemachena and Hassan (2007), in South Africa indicated that female-headed households are more likely to engage in climate change adaptation methods. They further explained by indicating that much of the agricultural work in the rural smallholder farming communities is done by women. In view of this, they tend to have more farming experience and information on various management practices and therefore are better adapters to climate change. Nonetheless, it could still be argued that male-headed households are better adapters to climate change than female-headed households. Other studies have also shown that there is no evidence that gender of farmers influences the probability of adaptation (Maddison, 2006).

Farming experience increases the probability that a farmer chooses an adaptation option since experienced farmers have better knowledge and information on changes in climatic conditions and crop and livestock management practices (Nhemachena and Hassan, 2007). Maddison (2006) reported that farmer experience is an important determinant of adaptation.

An analysis of farmers' perception and adaptation strategies to climate change by Dhaka *et al.* (2010), based on India revealed that more experienced farmers had a higher probability of adopting any of the following climate change adaptation strategies; integrated farming system , use of short duration crop varieties, use of water conservation techniques, change in time of farm operation, soil conservation techniques, pre-monsoon dry seeding, stubble mulching, crop rotations, intercropping, rainwater harvesting, zero tillage to conserve soil moisture and save time, use of drought tolerant crop and crop varieties, agro forestry and use of insurance. Gbetibouo (2009) found that experienced farmers had an increased likelihood of using climate change adaptation strategies such as portfolio diversification, changing planting dates, and changing the amount of land under production.

Another important determinant of adaptation is access to free extension services. Nhemachena and Hassan (2007) in a micro-level analysis of farmers' adaptation to climate change in Ethiopia and Southern Africa found that farmers' access to free extension services significantly increased the probability of the farmers taking up adaptation options such as diversifying crops, planting different crops or crop varieties, replacing farm activities with nonfarm activities, changing planting and harvesting dates, increasing the use of irrigation, increasing the use of water and soil conservation techniques. Their conclusion was based on the fact that extension services serve as an important source of information on climate change as well as agricultural production and management practices. Thus farmers who have extension contacts have better chances to be aware of changing climatic conditions so as to enable them adapt to the changes in climatic conditions. Dhaka *et al.* (2010) and Maddison (2006) further emphasized that being a receipt of extension advice relating to either livestock or crop production strongly increased the probability of the farmer adapting any climate change adaptation strategy.

It is expected that access to credit should increase the possibility of a farmer adapting to climate change. Thus farmers who have access to credit have higher chances of adapting to changing climatic conditions. According to Nhemachena and Hassan (2007) affordable credits increases a farmer's financial resources as well his ability to meet any transaction cost that is associated with the various adaptation options such as use of different varieties, different crop, crop diversification, different planting dates, diversifying from farm to nonfarm activity, increased use of irrigation, groundwater, watering, increased use of water and soil conservation techniques in Ethiopia and South Africa. Thus with more financial resources at the farmers' disposal, they are able to change their management practices in response to changing climatic conditions (Nhemachena and Hassan, 2007). Caviglia-Harris (2002) pointed out that access to credit has a positive effect on the adaptation behavior of farmers. In another study that was conducted in South Africa, Gbetibouo (2009) reported that access to credit increased the likelihood that farmers will take up portfolio diversification and buy feed supplements for their livestock. Ghanaian farmers who have access to credit or loan facilities were found to respond to climate change by taking up either crop diversification, change in crops, reducing farm size, changing planting date, finding off- farm jobs or planting short season variety as an adaptation strategy, since access to cash allows farmers to purchase inputs like seeds of improved varieties and fertilizer (Fosu-Mensah *et al.*, 2010).

Literature has shown that there is no agreement between a farmer's age and his decision to take up an adaptation strategy (Adesina and Forson, 1995). However, the age of a farmer is expected to negatively influence his decision to take an adaptation strategy as older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies Gbetibouo (2009). On the other hand, age is expected to have a positive influence on a farmer's decision to take up an adaptation strategy as older farmers tend to have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice (Gbetibouo, 2009).

Another important determinant of a farmers' decision to take up an adaptation to climate change is land ownership. It is vital to adaptation as landowners tend to adopt new technologies quickly than tenants (Shultz *et al.*, 1997). Land ownership is likely to influence the adoption of an innovation if the innovation requires investments fixed to land (Gbetibouo,

2009). Micro-level analysis of farmers' adaptation to climate change in southern Africa revealed that farmers who owned their land were more likely to invest in adaptation options such crop and livestock management practices and water conservation (Nhemachena and Hassan, 2007). Again land tenure was found to significantly influence farmers' adaption strategy to climate change in the Sekyedumase district in Ghana (Fosu-Mensah *et al.*, 2010).

2.9 Constraints to Adaptation to Climate Change

Literature has shown that when one responds to climate change, it can greatly reduce vulnerability. It can be achieve by increasing support for research and knowledge, expanding assessments for decision makers of the risks of climate change, introducing climate change into policies and plans, promoting awareness, and better dealing with climate issues. That notwithstanding, there still remain some obstacles to the implementation of adaptation (IPCC, 2007).

Some empirical studies have reported some barriers to adaptation (Ofuoku, 2011; Sofoluwe *et al.*, 2011; Mertz *et al.*, 2008; Acquah and Onumah, 2011). Some of these barriers included lack of information on appropriate adaptation options, lack or no access to credit or capital, shortage of labour, shortage of land, no access to water and so on (Gbetibouo, 2009; Acquah and Onumah, 2011).

A study by Ofuoku (2011) revealed that (39.69%) of farmers interviewed did not respond to climate change. Farmers who failed to adapt to climate change generally gave many reasons such as lack of information, lack of money, inadequate labor supply, inadequate land and poor potential for irrigation.

Sofoluwe *et al.* (2011) also reported five major constraints militating against adoption of adaptation methods by farmers in the Osun State of Nigeria. These included lack of information on appropriate adaptation options, lack of capital, shortage of labour, shortage of land and poor potential for irrigation. They attributed Lack of information on appropriate adaptation options to the inefficient extension service in the country. They also explained that lack of money reduced the farmers' purchasing power for resources and technologies that facilitated adapting to climate change.

Mertz *et al.* (2008) in group interviews toward appropriate adaptation to climate change and variability identified the main constraints to adaptation. They included lack of funds to initiate small businesses (credit access), lack of success in doing business (low income, low benefit), underpaid manual work, high price of basic supplies and food, and theft of livestock.

Acquah and Onumah (2011) found no access to information, credit, water, inputs and high cost high cost of adaptation as well as insecure property rights s as the main obstacles that prevent farmers to respond to the perceived changes in the climate. For each of these barriers they reported some farmers had different views whilst others agreed to.

CHAPTER THREE

3.0 METHODOLOGY

Methodology provides a sound foundation to a research regarding how the research is conducted. The validity and reliability as well as the generalization of the research findings are highly dependent on the research methodologies employed. This chapter presents six subsections. The first and second sections present a detailed theoretical discussion and the empirical model on rice farmers' adaptation to climate change. This is followed by the concept of farmers' perceptions of climate change and adaptation to climate change in sections three and four. The hypothesis that was tested in the study area is presented in section five. The fifth section presents the study location, the sampling procedure, sample size and the methods of data collection. Finally, the methods of data analyses used for each specific objective are presented in section six.

3.1 Conceptual framework

Adaptation serves as one of the policy options to climate change that influences development practices (Tanner and Mitchell, 2008). It is the adjustments made in someone's activities to minimize impacts of climate change and maximize profit (Smithers and Smit, 2009). According to Tol (1998), it is the changes made in ecological, social, and economic systems to help cope with the impacts of climatic conditions. The ability of farmers to adapt to climate change can be significantly influenced by the level of awareness about climate change in their communities. Hence, the awareness about climate change has great capacity to drive farmers to create local technologies to aid adaptation (Tol, 1998).

Several adaptations practices have been found to be used by farmers in response to changing climatic conditions. They include water harvesting, early planting, deep planting, planting of cover crops, application of mulch to conserve moisture, planting of draught tolerant, planting of early maturing crops, alley farming, and enterprise diversification (Kartz and Brown, 1992; Selvaraju *et al.*, 2006). However, adaptation strategies that were identified in the study areas include changing planting dates, planting early maturing crop varieties, migrating to urban areas, practicing crop diversification, alternating crop farming and rearing of farm animals, increasing farm size, making trenches (in case of flooding), engaging in off-farm jobs, mixed cropping, making of bonds (irrigation) and engaging in dry season vegetable production (in the northern region).

3.1.1 Conceptual framework and empirical model on adaptation to climate change

The study employs the standard theory of adoption, where the problem facing the farmer is to choose an adaptation strategy that will maximize his expected utility (Yesuf, 2008; Magombo *et al.*, 2011). When farmers are faced with making a choice given a set of adaptation strategies, they would choose the strategy that would maximize their utility. Consequently, a rational farmer or a decision maker will choose a climate change adaptation strategy given that expected utility of adaptation strategy 1 exceeds the expected utility of adaptation strategy 2, that is $E[U(A_1)] > E[U(A_2)]$, where A_1 is climate change adaptation strategy 1 and A_2 is climate change adaptation strategy 2 (Yesuf, 2008).

For any farmer who wants to make enough gains from his production, and must choose among a set of J adaptation options, the farmer i decides to use j adaptation option if the perceived benefit from option j is greater than the utility from other options (say k) and is presented as

$$U_{ij}(\beta_j' X_i + \varepsilon_j) > U_{ik}(\beta_k' X_i + \varepsilon_k), \quad k \neq j \qquad (1)$$

where U_{ij} and U_{ik} are the perceived utilities by farmer i of adaptation options j and k, respectively; X_i is a vector of explanatory variables that influence the choice of the adaptation option; β_j and β_k are parameters to be estimated; and ε_j and ε_k are the error terms.

According to Gbetibouo (2009) the likelihood of any farmer i choosing the *j* adaptation option from the set of adaptation options is defined as:

$$P(Y=1/X) = P(U_{ij} > U_{ik}/X)$$
$$= P(\beta'_j X_i + \varepsilon_j - \beta'_k X_i - \varepsilon_k > 0/X)$$

(2)

$$=P\left((\beta'_j-\beta'_k)X_i+\varepsilon_j-\varepsilon_k>0/X\right)$$

$$=P(\beta^* X_i+\varepsilon^*>0/X)=F(\beta^* X_i)$$

Where ε^* is a random disturbance term, β^* is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing adaptation, and $F(\beta^* X_i)$ is the cumulative distribution of ε^* evaluated at y.

When many adaptation options are investigated, the multinomial logit (MNL) and multinomial probit (MNP) regression models have proved to be the fitting econometric model. Both models estimate the effect of explanatory variables on a dependent variable involving multiple choices with unordered response categories (Gbetibouo, 2009).

In describing the multinomial logit model, let y denote a random variable taking on the values $\{1,2,....,J\}$ for J a positive integer, and let x denote a set of conditioning variables.

Thus, y denotes adaptation options or categories and x contains different household, institutional and environmental attributes. The model reveals how changes in the elements of x affect the response probabilities $P(y=j/x), j=1,2,....,J$. The response probabilities associated with the MNL model is specified as follows;

$$P(y=j|x)=\frac{\exp(x\beta_j)}{1+\sum_{h=1}^{J}\exp(x\beta_h)}, j=1,...,J \qquad (3)$$

Where β_j is $K\times1$, j=1,.....J.

Unbiased and consistent parameter estimates of the MNL model in Eq. (3) require the assumption of independence of irrelevant alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation method by a given household needs to be independent from the probability of choosing another adaptation method, that is, P_j/P_k is independent of the remaining probabilities (Deressa *et al.*, 2009).

According to Green (2000) the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change or probabilities, hence differentiating Eq. (3) with respect to the explanatory variables provide marginal effects of the explanatory variables given as

$$\frac{\partial P_j}{\partial x_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{J-1} P_j \beta_{jk}\right) \qquad (4)$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green, 2000).

3.2 Empirical model for farmers' Adaptation to climate change.

A number of studies have analyzed the factors which influence the decision of a farmer to choose a climate change adaptation strategy using a discrete choice model (Nhemachena and Hassan, 2007; Gbetibouo, 2009; Fosu-Mensah *et al.*, 2010; Bryan *et al.*, 2011). The dependent variable is a dummy variable equal to 1 if the farmer adopted any of the adaptation options in response to perceived changes in temperature or rainfall and 0 otherwise. Analysis of this dependent variable requires a binary response model. Two options for this analysis are the logit and probit models.

The main difference between the probit and logit models is the assumption of the distribution of the error term, ε. The error term is assumed to have the standard logistic distribution in the case of the logit, and the standard normal distribution in the case of the probit model (Bryan *et al.*, 2009). According to Greene (2003) the logit and probit models have desirable statistical properties as the probabilities are bound between 0 and 1.

A multinomial logit (MNL) specification is adopted in this study to model climate change adaptation behavior of farmers involving discrete dependent variables with multiple choices. The main advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Deressa *et al.*, 2009) and very simple to compute (Tse, 1987). The empirical model is specified as

$$Y^* = \beta_0 + \beta_1 GEND + \beta_2 AGE + \beta_3 EDU + \beta_4 FSIZ + \beta_5 HSIZ + \beta_6 FEXP + \beta_7 LANT + \beta_8 ATCRE + \beta_9 EXT + \beta_{10} ATINFO + \beta_{11} PECLIM + \beta_{12} OFE + \beta_{13} OCF + \beta_{14} ATT + \beta_{15} FINC + \beta_{16} NFINC + \beta_{17} FTFEXT + \beta_{18} EADAN + \beta_{19} EAHAF + \beta_{20} ETOLN + \varepsilon \quad (5)$$

Here Y^* denotes unobserved or latent variable, GEN denotes dummy variable 1 if farmer is a male, 0 otherwise, AGE denotes the age of the farmer in years, EDU denotes farmers level of education in years, FSIZ denotes farm size (acres), HSIZ denotes the size of farmers' household, FEXP denotes farming experience of farmer (years), LANT denotes land tenure, ATCRE denotes dummy variable 1 if farmer has access to credit facilities, 0 otherwise, EXT denotes dummy variable 1 if farmer has access to extension services, 0 otherwise, ATINFO denotes dummy variable 1 if farmer has access to climate information, 0 otherwise, PECLIM denotes dummy variable 1 if the farmer perceives changes in the climatic condition, 0 otherwise, OFE denotes dummy variable 1 if farmer has off-farm work, 0 otherwise, OCF denotes dummy variable 1 if farmer's main occupation is farming, 0 otherwise, ATT denotes dummy variable 1 if farmer has access to technology, 0 otherwise , FINC denotes income generated from the farm (farm income), NFINC denotes nonfarm income, FTFEXT denotes dummy variable 1 if farmer has farmer -to-farmer extension, 0 otherwise, EADAN denotes dummy variable 1 if farmer is located in the local agro ecology of Adansi South district, 0 otherwise, EAHAF denotes dummy variable 1 if farmer is located in the local agro ecology of Ahafo Ano South district, 0 otherwise, ETOLN denotes dummy variable 1 if farmer is located in the local agro ecology of Tolon -Kumbungu d istrict, 0 otherwise, βs are the unknown parameters to be estimated and ε is the random error term, assumed to be normally distributed.

Variables	**Variable description and measurement**	**Expected signs**
Gender	Gender of respondent, 1 if male, 0 if female	+/-
Level of education	Years of formal education	+
Age	Years	+/-
Farm size	Farm size in acres	+
Household size	Number of dependants in the household	+
Farming experience	Years of being a rice farmer	+

Land ownership	1 if farmer owns the land, 0 otherwise	+
Access to credit	1 if farmer has access to credit, 0 otherwise	+
Access to extension services	1 if farmer has access to extension services, 0 otherwise	+
Access to climate information	1 if farmer has access to climate information, 0 otherwise	+
Off-farm work	1 if farmer engages in any off-farm work, 0 otherwise	-
Access to technology	1 if farmer has access to technology, 0 otherwise	+/-
Farm income	Amount in Gh¢	+
Nonfarm income	Amount in Gh¢	+/-
Farmer-to-farmer extension	1 if farmer has access to farmer-to-farmer extension services, 0 otherwise	+
Local agroecology Adansi South district	1 if farmer is located at Adansi South district, 0 otherwise	+/-
Local agroecology Ahafo Ano South district	1 if farmer is located at Ahafo Ano South district, 0 otherwise	+/-
Local agroecology Tolon-Kumbungu district	1 if farmer is located at Tolon-Kumbungu district, 0 otherwise	+/-

Table 3.1: Explanatory variables considered in model (5).

3.3 Statement of Hypotheses

1. Rice farmer's age, gender and the level of education achieved by the farmer will significantly influence choice of climate change adaptation strategy positively.
2. Farm size, household size, and the number of years of farming will significantly influence rice farmers choice of climate change adaptation strategy positively.
3. Income from off-farm jobs will significantly influence rice farmers choice of climate change adaptation strategy negatively.
4. Rice farmers access to institutional factors such as credit, extension services, technology, information on climate and land will significantly influence rice farmers choice of climate change adaptation strategy positively.

5. Income from farming and farmer-to-farmer extension will significantly influence rice farmers choice of climate change adaptation strategy positively.

3.4 Data collection

3.4.1 Study area

The study was conducted in the Ashanti and Northern regions of Ghana. Table 3.1 compares the four districts that were selected for the study. They are the Adansi South, Ahafo Ano south, Tolon and Kumbungu districts. The Adansi South district is situated at the South western part of the Ashanti Region and covers a total land area of 889km^2 and falls within the semideciduous forest belt with thick forest cover. The climate of the district is the semiequatorial type. The District experiences double maximum rainfall regime with mean annual rainfall value ranging between 1800mm and 2100mm while average temperatures are approximately 29.7^{o}C at mid – day and 21.10^{o}C at night. Mean temperature however, is
25.39^{o}C.

The climatic conditions across Ghana have changed over the last years. Draughts and floods which occur as a result of climate change are destroying especially the crops and harvest of farmers in most African countries of which Ghana is not an exception. Report indicates that the quality of agricultural crops across the Ashanti region and other regions of Ghana was worsened due to bad weather conditions (Müller-Kuckelberg, 2012). Some crops were also reported to have reduced in production as a result of bad weather conditions in the Ashanti region. They include cassava and cereals such as rice and maize (Müller-Kuckelberg, 2012). Farmers in the area therefore face the risk of losing crops as well as worsened quality of the products over the years and in the future due to bad weather. This may result in little income for farmers and their inability to afford high investments for their businesses.

The Ahafo Ano South District is located on the North-Western part of the Ashanti region. It covers about 1241 km sq. of the region's total surface area and falls within the forest belt of Ghana. The climate of the district is the wet semi-equatorial type. The rainfall pattern in the district consists of two rainy seasons with a mean monthly temperature of about 26°C. Maximum temperature is about 29°C and is recorded in March and April just before the onset of the rainy season. The district enjoys two major rainy seasons with mean annual rainfall ranging between 150-170cm. Rainfall totals and incidence varies widely from year to year. The district is likely to be faced with similar problems of worsened quality of agricultural crops as well as a reduction in the production of agricultural crops such cassava and cereals such as rice and maize due to bad weather conditions associated with climate change as it lies within the Ashanti region of Ghana. As a result of low agricultural production and climate change, the ability of farm households to earn income is greatly reduced due to their inability to produce cash crops, hence majority of the farmers in area are confronted with severe poverty (MüllerKuckelberg, 2012).

The third and fourth districts being compared is the Tolon/Kumbungu districts. The two districts lie in the north-eastern part of the northern region. They fall within the Guinea Savanna zone and cover a total land area of about 2,741sqkm. The climate of the districts is the tropical continental type. The area experiences single rainy season from April/May to September/October with a peak season in July/August. Mean annual rainfall recorded is about 1,100mm within 95 days of rainfall.

However, changes in this climatic condition across the northern regions of the country have made households which depend on agriculture for their livelihoods food insecure due to the direct impact of climate change on agriculture (Akudugu *et al.*, 2012). This is because climate conditions such as erratic rainfall patterns which result in droughts and floods, increasing length and severity of the dry season as well as increasing temperatures across the region cause crop yields to decline. When farmers harvest less, the amount of food is highly affected. This results in little or no surplus to sell (Akudugu *et al.*, 2012).

In 2007, climate change caused one of the worse climatic consequences by delaying rains in the north, and later followed by heavy rains. This condition caused farmers to plant the same piece of land so many times during the season. This resulted in farmers running out of seeds and the destruction of farms and farm animals (Akudugu *et al.*, 2012). The production of some agricultural crops have also been have reduced as a result of climate change in northern Ghana. They include rice, yam and groundnut (Müller-Kuckelberg, 2012). The overall effect is that, those who do not produce crops either have to buy food at high costs or starve and this definitely leads to scarcity of food in the area.

Table 3.2: A General Description of the Characteristics of the various Study Areas

GENERAL CHARACTERISTICS	**ADANSI SOUTH DISTRICT**	**AHAFO ANO SOUTH DISTRICT**	**TOLON/KUMBUNGU DISTRICTS**
LOCATION	South western part the of the region.	North-Western part of the region.	North-eastern part of region.

TOTAL LAND AREA	889sqkm. About 4% of the of area.	1241sqkm. About 5.8% of the region’s total surface area.	2,741sqkm. About 3.9% of the regions total region’s total surface area.
TOPOLOGY	Undulating creating a series of valley bottoms.	Undulating landscape and forms part of the Ashanti Plateau.	Generally undulating with a number of scattered depressions.
CLIMATE	Semi-deciduous type.	Wet semi-equatorial type.	Tropical continental climate.
VEGETATION	Forest belt with thick forest cover.	moist semi-deciduous	Guinea Savanna.
RIVER/DRAINAGE	Drained by the NumiaSubin, Pra, Offin rivers.	Drained by the Mankran, Abu and Aprapom, Aboabo rivers.	Drained by the White Volta.
GEOLOGY	The district lies within the gold belt.	Birimian formationsmainly phyllites and schistintruded with granite rocks.	
SOILS	High quality clay and sand.	Forest ochrosols.	Alluvial soil and savannah ochrosols.
RAINFALL(MEAN)	1800mm-2100mm.	1500mm-1700mm.	1,000mm.
TEMPERATURE	Mean temperature is 25.39^{0}C.	Mean monthly temperature is about 26°C.	Generally hot at day and very cool at night.
POPULATION (2000)	98,437.	133,632.	122,550.
MAJOR CROPS	Major food crops produced include maize, rice, cassava, cocoyam, plantain, tomato vegetables.	Major food crops produced include rice, cassava, maize and yam, plantain, and pepper.	Major food crops produced include maize, groundnuts, yam, cassava, sorghum, rice, cowpea, millet, pigeon pea, soya-beans.
ECONOMIC ACTIVITIES	Agro base industry.	Activities of economic importance are agro based industry including farming.	Agriculture, smock weaving, sheabutter and groundnut oil extraction.

Source: (www.ghanadistricts.com)

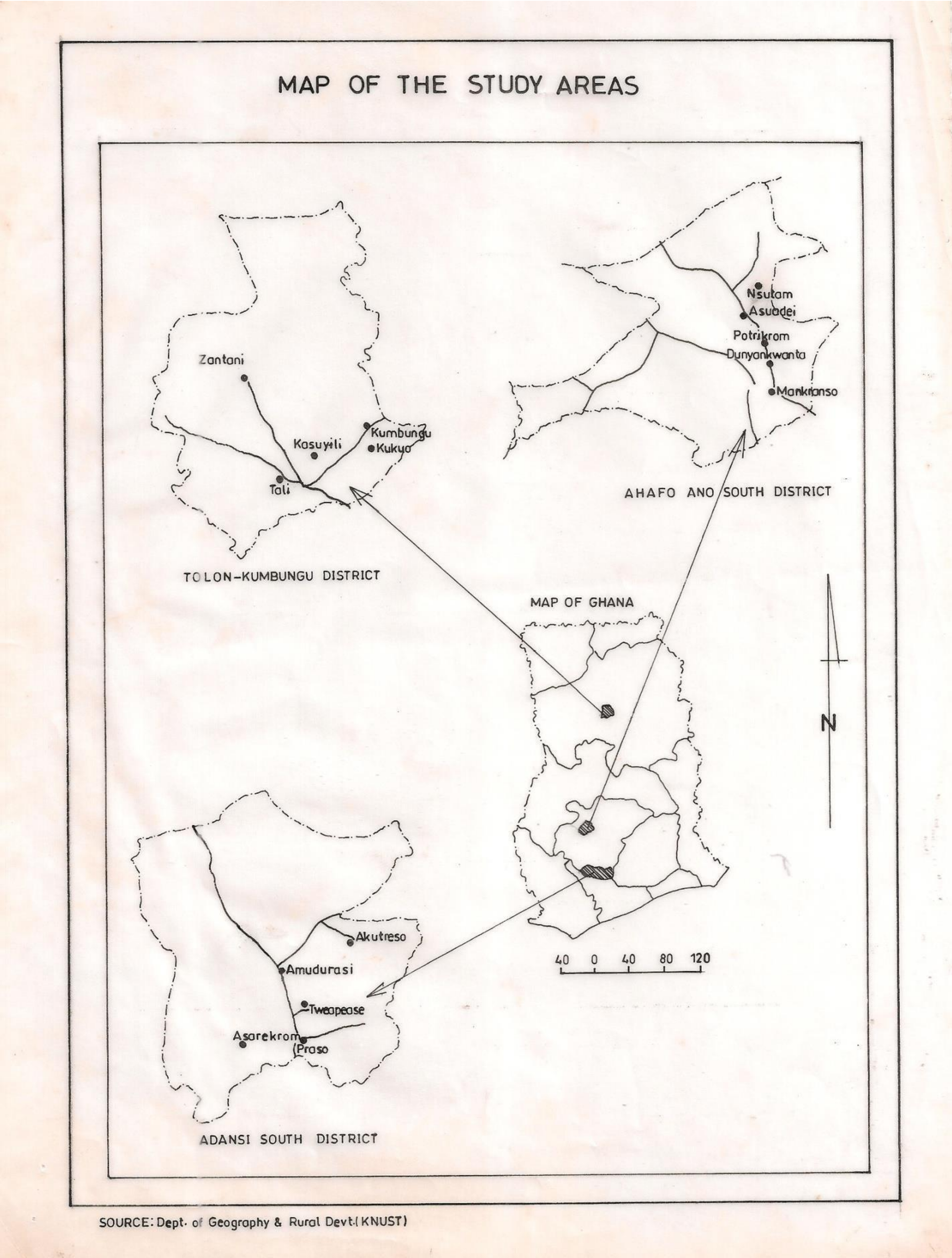

Figure 3.1: A map of the study areas in national context.

3.4.2 Sample size and Sampling Technique

In order to establish the perceptions and adaptations of rice farmers to the changes in rainfall and temperature patterns, the research employed the use of primary source of data. The data was obtained through a cross-sectional survey that was conducted in the two different regions which are the Ashanti and Northern regions. These regions were selected purposively based on the fact that rice is among the major food crops produced in the two regions.

In the second stage of the sampling design, two districts were selected from each of the two regions purposively. These districts were selected based on their agricultural potential and high level of rice production in their regions. In the third stage, five villages or communities from operational areas of the ministry of food and agriculture (MOFA) were randomly selected from each of the districts to represent the regions.

The final stage involved a simple random selection of rice farmers in the various communities since they were the target group. A total of 83 rice farmers was sampled in the Adansi South district (Ashanti region), 83 rice farmers in the Ahafo Ano South district (Ashanti region) and 83 in the Tolon/Kumbungu districts (Northern region).

3.4.3 Types of Data and Methods of Data collection

Primary data was obtained in the course of the study. The primary data was used to obtain information from rice farmers through personal interviews with the farmers by use of structured questionnaires. The questionnaires was used to collect socio-economic data from sampled farmers in each community. The questionnaires was also used to capture information on farmers' awareness and perceptions of climate change, the choice of farmers' adaptation strategies (described in 3.1), the factors that influence the choice of farmers' adaptation strategies and information on constraints faced by rice farmers when choosing an adaptation strategy.

3.5 Methods of Data Analysis

Both descriptive and inferential analyses were used to achieve the objectives of the study. Descriptive analysis such as frequencies, percentages and mean were used to analyze farmers' awareness and perceptions of climate change, existing adaptation strategies used by farmers as well as farmers' constraints to the selection of existing climate change adaptation strategies. The perception of rice farmers about long -term changes in rainfall and temperature was also determined by using the perception index. A multinomial logit model was also estimated with the maximum likelihood method. The multinomial logit model was used to obtain the factors that influence rice farmers' decision to adapt to long-term changes in rainfall and temperature.

CHAPTER FOUR
4.0 RESULTS AND DISCUSSION

This chapter discusses the results of the study in the framework of the objectives. It consists of two main sections. The first section covers the descriptive analysis of household and farm characteristics of rice farmers in the area under study. Also included in this section is the information on rice farmers' awareness, perception of climate change, their adaptations to the changing climatic conditions as well as the constraints to these adaptation strategies. The second section presents discussions on the empirical results.

4.1 Descriptive Analyses

4.1.1 Farm and Household Characteristics of Respondents

Respondents (rice farmers) selected for the study had diverse characteristics which were expected to influence their perception and choice of adaptation to climate change. These farm and household characteristics as presented in Table 4.1 shows the categorization of respondents into different age groups. In all the study districts, the middle aged group or the working class (30 - 65 years age group) formed the majority in the sample with 89.2 percent. The percentage of rice farmers within this age group are 81.9, 88 and 89.2 in the Adansi South, Ahafo Ano South and Tolon-Kumbungu districts respectively. In all only a few aged class (above 65 years) representing 6% was recorded in the Adansi South district.

Considering the gender of rice farmers, the table shows that majority of the respondents were males with 68.7% in the Adansi South, 73.5% in the Ahafo Ano South and 78.3% in TolonKumbungu district. In total about 74% of the respondents were found to be males. This reflects the national situation where a majority (70.5%) of households in Ghana are headed by males (GSS, 2008). Tolon-Kumbungu districts recorded the majority of male rice farmers where as the Adansi South district recorded the majority (31.3%) of female rice farmers.

Table 4.1 Farm and Household Characteristics

Characteristic	Adansi South District		Ahafo Ano South District		Tolon-Kumbungu District	
Age	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
		10.8				
		81.9				
		6				
Gender						
Males	57	68.7		73.5	65	78.3
Females	26	31.3		26.5	18	21.7
Ethnicity						
Ashanti	3	3.6		0	0	0
Fante	7	8.4	6	7.2	0	0
Northerner	30	36.1	54	65.1	78	94
Ewe	43	51.8	7	8.4	5	6
Bono	0	0	3	3.6	0	0
Others	0	0	13	15.7	0	0
Access to Extension						
	48	57.8	58	69.9	54	65.1
	35	42.2	25	30.1	29	34.9
Access to Credit						
Yes	8	9.6	4	4.8	8	9.6
No	75	90.4	79	95.2	75	90.4
Organization						
Yes	36	43.4	44	53	38	45.8
No	47	56.6	39	47	45	54.2
Off-farm Income						
		25.3		21.7		
		74.7		78.3		
<30	9		10	12	9	10.8
30-60	68		73	88	74	89.2

>60	5		0	0	0	0
			61			
			22			
			0			
Yes						
No						
Yes	21		18		23	27.7
No	62		65		60	72.3

Experience

Below 10 44 53 58 69.9 52 62.7 10-20 31 37.3 21
25.3 24 28.9

Above 20	8	9.6	4	4.8	7	8.4
Tenancy						
Fixed rent	17	20.5	15	18.1	16	19.3
Share	39 2	47	51 0	61.4 0	40 1	48.2 1.2
Gift	25	2.4	17	20.5	26	31.3

Other		30.1				
Land Ownership	57		65	78.3	58	69.9
Tenant	25	68.7	17	20.5	24	28.9
Owner		30.1				

Source: Field Survey, 2015

Table 4.1 Continued. Farm and Household Characteristics

Characteristic	Adansi South District		Ahafo Ano South District		Tolon-Kumbungu District	
Marital Status	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Married Single	69	83.1	75 8	90.4	77 6	92.8
	14	16.9 9.6	7.2	***Education***		
Primary	14	16.9	28	33.7	19	22.9
JHS	35	42.2	28	33.7	38	45.8
SHS	11	13.3	3	3.6	7	8.4
Tertiary	1	1.2	3	3.6	2	2.4
Other forms	1	1.2	0	0	1	1.2
None	21	25.3	21	25.3	16	19.3
Religion						
Christian	47	56.6	42	50.6	43	51.8
Muslim	31	37.3	40	48.2	39	47.0
Traditionalist	1	1.2	0	0	0	0
None	4	4.8	1	1.2	1	1.2

Source: Field Survey, 2015

Level of education refers to the highest level of formal school that a person ever attended or was attending. An individual's level of education is known to impact his awareness, perception as well as adaptations to climate change. Among the regions, there are variations in the levels of school attendance. The proportions of the respondents who have JHS education in the three districts ranges between 42.2 percent in Adansi South district, 33.7 percent in Ahafo Ano South district and 45.8 percent in the Tolon-Kumbungu district in the Northern region. It can also be observed from Table 4.1 that respondents who have never had any form of formal education were predominant in the Adansi South and Ahafo Ano South districts, with each district recording 25.3%, whereas only 19.3% was recorded in the TolonKumbungu district. The Ahafo

Ano South recorded the highest percentage (33.7%) of rice farmers who had primary level education, followed by Tolon-Kumbungu (22.9%) and then the Adansi South district (16.9%). Second cycle and tertiary levels are the least attended in all the districts. The percentage of respondents who attended SHS is less than half the percentage of farmers who attended JHS across all the three districts.

The results further showed that about 93 percent of rice farmers who were in the TolonKumbungu district are married. The district which recorded the least married couples is the Adansi South recording about 83% of rice farmers who were married. This implies that the Adansi South district recorded the greater number of rice farmers who are single (16.9%), followed by Ahafo Ano South (9.6%) and finally Tolon-Kumbungu district (7.2 percent).

Respondents sampled for the study fall within different categories of religious denominations. Table 4.1 revealed that most of the respondents across all the three districts profess the Christian faith, with the Adansi South district recording 56.6 percent of Christians, followed by Tolon-Kumbungu and then Ahafo Ano South district with both recording 51.8% and 50.6% respectively. The table further shows that the next most professed faith after the Christian faith is Islamic faith. It was found that Ahafo Ano South district recorded the highest percentage of 48.2%, followed by Tolon-Kumbungu (47%) and then Adansi South recording the least of 37.3%. Table 4.1 also shows that only Adansi South district recorded a percentage (1.2%) of the respondents who adhere to the traditionl religion as well as the highest percentage (4.8%) of rice farmers who do not belong to any faith. These results agree with GSS (2012), where majority of the population 71.2 percent were found to profess the Christian faith, while 17.6% belonged to the Islamic faith, with only a small proportion of the population either adhering to traditional religion or not affiliated to any religion.

It can also be inferred from table 4.1 that respondents sampled for the study fall within different categories of years they have stayed in agriculture. It is observed 53%, 69.9% and 62.7% of rice farmers have had farming experience below 10 years in the Adansi South, Ahafo Ano South and the Tolon-Kumbungu districts respectively. Generally, quite an appreciable number of the farmers representing (61.85%) had been farming for less than 11 years with the rest of the respondents representing 38.15% having farming experience above eleven years. It can be seen from table that farmers sampled for the study had gleaned a lot of experience from the act of agricultural production, and that their responses to changes in the climatic conditions can be based on past knowledge in the field of agricultural production.

Rice farmers who were interviewed for the study either own, is a tenant or works on the farm land as gift from a friend or a relative. It can be deduced that from the table that 68.7% of rice farmers in the Adansi South district, 78.3% in the Ahafo Ano district as well as 69.9% of rice farmers in the Tolon-Kumbungu district are tenants. In total 72.3% of rice farm lands do not belong to the farmers who work on them. 26.5% of the respondents however own the lands on which they farm. A few of the farmers representing 1.2% indicated that the farm lands were given to them as gifts. This is likely to have a direct effect on a farmers' decision to adopt a particular type of climate change adaptation strategy as many land owners determine the type of crop their lands should be used to cultivate.

By birth, Ghanaians belong to various ethnic groups across the country. Table 4.1 gives a detailed summary of the ethnic affiliation of rice farmers. The people of Northern Ghana and

Ewes were the majority of people who engage in the production of the rice crop. The two ethnic groups represented 65.1% and 22.1% of the sample respectively. In the Adansi South district, 36.1% of northerners were recorded where as 65.1% of northerners were recorded in the Ahafo Ano South district. In the Tolon-Kumbungu district, 94% of northerners were recorded. This observation tends to agree with the fact that the bulk of Ghana's rice come from the Northern Sector of the country since the 1960s (Akanko *et al.*, 2000) and thus majority of the people from this region are always into the production of the crop, even in the Ashanti districts where lands are owned by indigenes of the land. It is therefore not surprising that the percentage of tenants is high as many Northerners who come to the southern part engage in the cultivation of the rice crop. In all the surveyed districts, it can be seen that most of the sampled rice farmers have access to extension services, with 57.8% in the Adansi South district, 69.9% in the Ahafo Ano South district and 65.1% in the Tolon-Kumbungu district.

It is expected that access to credit should increase the possibility of a farmer adapting to climate change. Thus farmers who have access to credit have higher chances of adapting to changing climatic conditions (Gbetibouo, 2009). It can be seen from the table that less than 10% of the sampled respondents have access to either formal or informal forms of credit. In the Adansi South and Tolon-Kumbungu districts, only 9.6% of the respondents have access to credit facilities whilst as little as 4.8% rice farmers in the Ahafo Ano South district have access to credit. The remaining majority however, do not receive any form of credit. The farmers indicated that, this makes it very difficult for them to make any changes in their farming practices, thus making it difficult to adopt any climate change adaptation strategy that requires the use of lots of capital.

With regards to the affiliation of rice farmers to farmer based organizations, almost half of the respondents representing 47.4% are affiliated to rice farmers' organizations that are present in their respective communities. However, more than 50% of the respondents do not see the need to join these organizations. Most of these farmers argued their position by indicating that the organizations are not organized and that no major benefits are derived for joining the organizations. Specifically, 43.4% of the respondents belong to a farmer based organization in the Adansi South district, 53% in the Ahafo Ano South district and 45.8% was also affiliated a form of organization in the Tolon-Kumbungu district.

4.1.2 Major Occupation of respondents

The major occupation of respondents is an important factor that determines whether farmers will adopt climate change adaptation strategies. From the figure below, it can be seen that 218 of farmers interviewed representing 87.6% depend solely on agriculture for their livelihood. This therefore implies that any slight changes in the climatic condition is likely to affect these farmers either positively or negatively. A few others however, representing 12.4% of the sample cultivate rice as a part-time job.

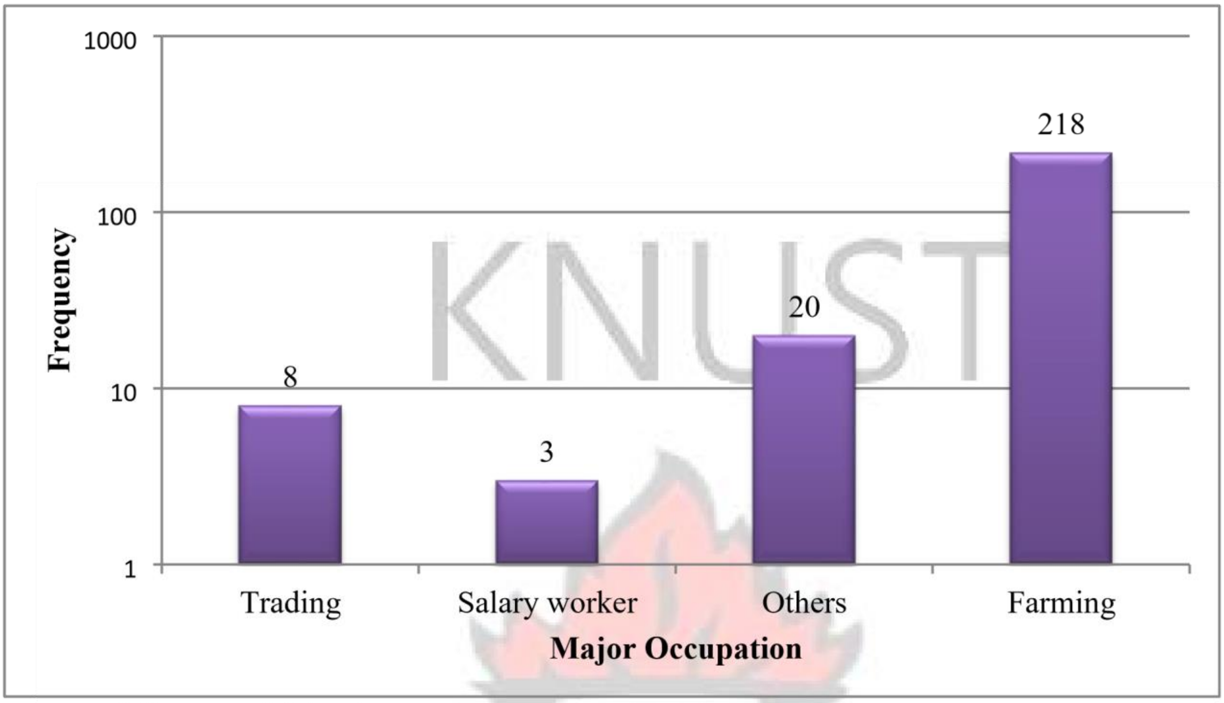

Figure 4.1 Farmers' Major Occupation

4.1.3 Rice farmers' Reasons For Growing Only Rice on their fields

Though the study revealed that farming is the major occupation on which majority of the respondents depend on, it was evident that some of the farmers cultivate only the rice crop. When the farmers were asked why they cultivated only rice, they gave the following reasons. Figure 4.2 shows the reasons why farmers cultivated only rice and the distribution of farmers among these reasons. Majority of the respondents (33.2%) cultivate only rice because their fields are waterlogged and cannot support the growth of any other crop apart from the rice crop. Another reason of importance is the fact that some farmers (2%) are financially constrained and hence cannot afford to invest in more than one crop at a time. A very small percentage (1.2%) were also of the view that there were no enough lands. Less than 1% of the farmers cultivated only rice because their land owners had insisted that they use their fields for cultivating only rice. About 1 percent also indicated that they were constrained by time since rice cultivation requires lot of time and attention. Again, it was revealed that another

1.2% decided not to cultivate other crops alongside the rice crop so as to avoid competition for nutrients among the crops. Other respondents cultivated only rice to prevent animals from destroying the crop (0.4%), for specialization in the production of the crop (about 1%) and for passion (about 1%).

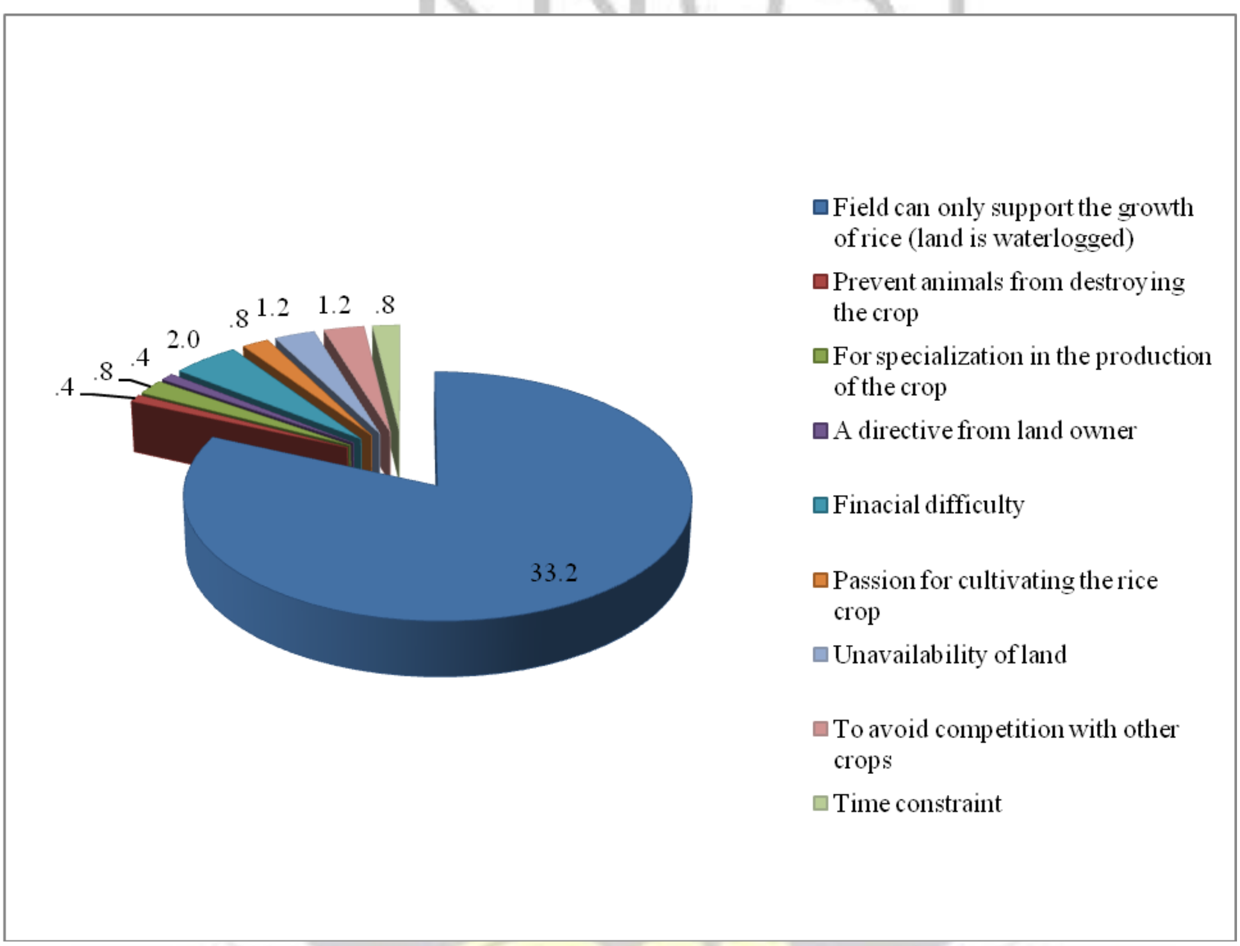

Figure 4.2 Rice farmers' reasons for cultivating only rice on their fields .

4.1.4 Rice Farmers' Reasons For Growing Other Crops and Rice on their fields

Farmers who cultivated more than one crop (rice) on their fields also gave their reasons for such initiatives. Majority of the farmers stated that they cultivate other crops alongside the rice crop so as to obtain extra income to support the income they obtained from selling their rice.

The figure 4.3 also indicates that about 4% of the sample interviewed cultivate not only rice so they can off-set some of the negative effects should the rice crop fail as a result of changes in the climatic conditions. Other farmers (less than 1%) cultivate other crops just to diversify the types of food they eat in their homes. The study also revealed that some farmers (7.8%)

cultivate other crops based on the fact that the soil can support the growth of these crops. Only a few rice farmers (less than 1%) operated under the directive of the land owners. Two percent of the respondents stated that they cultivate the rice crop to generate income for the household whilst the other crops serve as food for the household. About 1% of the respondents used the income from other crops to support rice cultivation and vice versa.

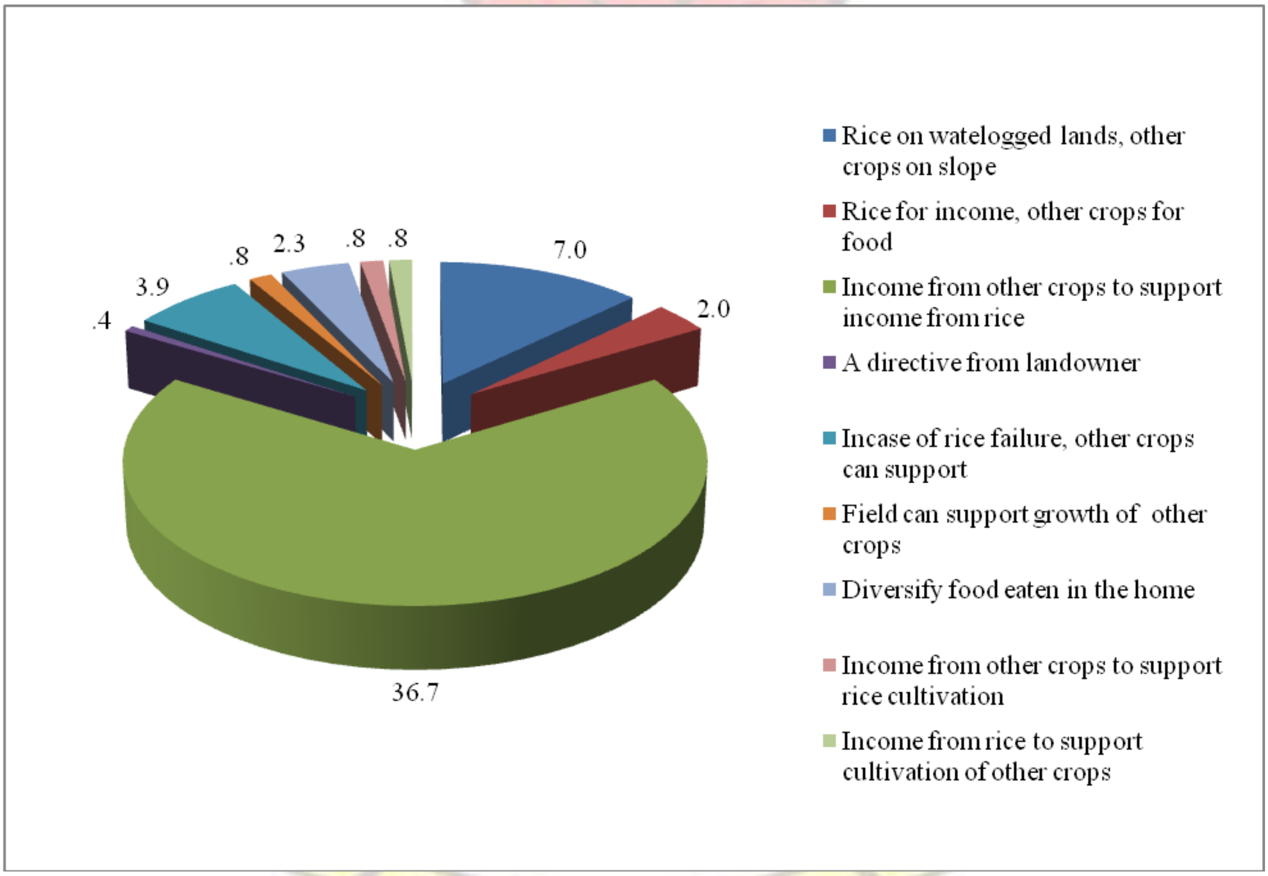

Figure 4.3 Rice farmers' reasons for cultivating more than one crop on their fields.

4.1.5 Respondents off-farm income

Rice farmers were asked to determine whether they receive income aside the ones they obtain from cultivating crops and rearing of animals. The table below shows the distribution of farmers according to their responses on whether they receive any off-farm income. From the table 4.12, only 61 respondents representing 24.5% of the sample claimed they receive some form of income apart from the income they get for cultivating rice. More than half of the farmers however, indicated that they do not receive any off-farm income. Thus their households are dependent on the agriculture, and that any slight change in the climatic condition would cause these farmers to make changes in their activities.

4.1.6 Source of labor for rice farmers

Analysis of the source of labor as used by rice farmers indicated that respondents resorted to the use of either the household as labor or hired or a combination of both household and hired labor. The figure 4.4 below shows the distribution of respondents according to the source of labor. It can be seen from the figure that majority of respondents sampled for the study across all the districts of study depend largely on hired labor for production activities. The Ahafo Ano South district recorded the highest percentage of rice farmers who resort to the use of hired labor, followed by the Tolon-Kumbungu and finally the Adansi South district. The use of both hired and family labor was almost evenly distributed across all the districts. Tolon-Kumbungu district however, recorded majority of rice farmers who depend solely on their households for source of labor. This was followed by the Adansi South district and then the Ahafo Ano South district. It can also be seen from figure 4.4 that 174 of the respondents representing 69.9% of the sample hire labor for their production activities, thus increasing the cost of production.

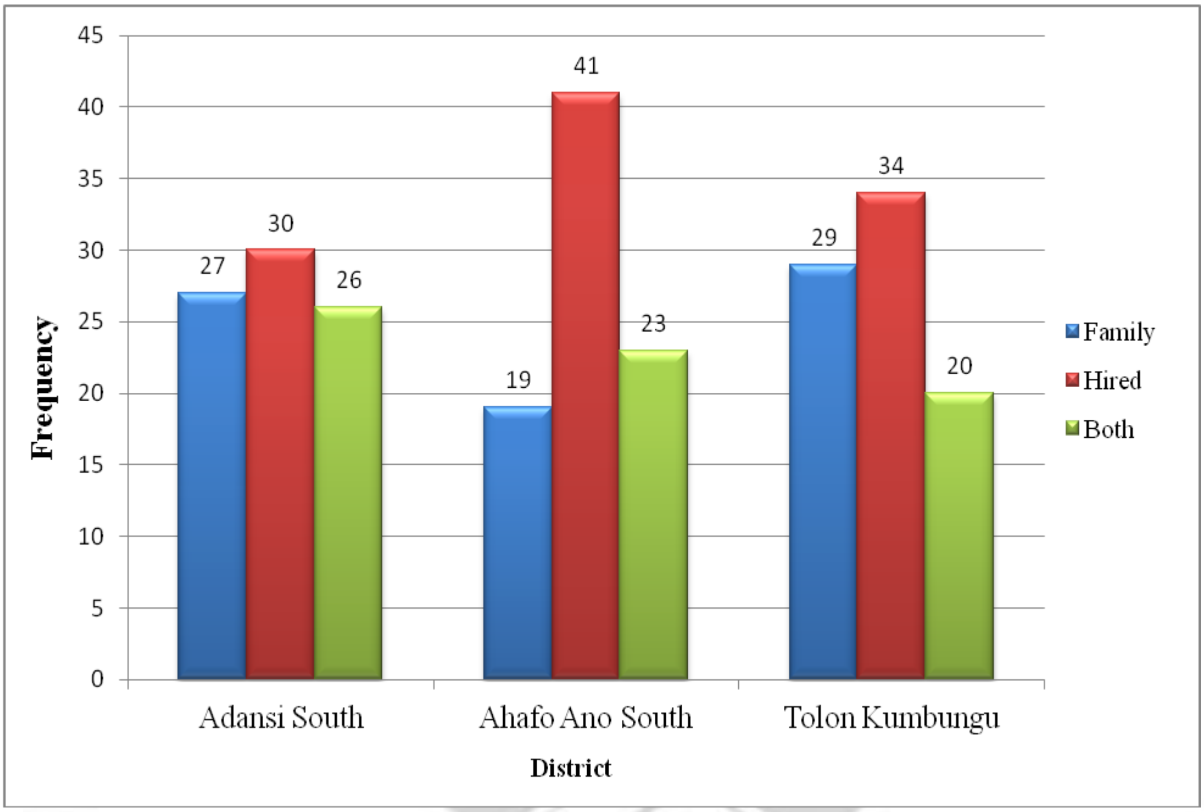

Figure 4.4: Source of Labor for Rice Farmers.

4.2 Rice Farmers' Awareness and Perception of Climate Change

4.2.1 Rice Farmers' Awareness of Climate Change

Rice farmers in the survey districts were asked about their awareness of changes in the climatic condition in their respective districts. Specifically, farmers were asked whether they receive weather and climate information, and whether they have noticed any changes in the climatic condition in their area of farming. Farmers that responded positively indicated that they receive weather information and reported the changes they have observed. The results show that an overwhelming majority of the farmers (90.4%) receive information on weather and climate. The remaining minority of 9.6% however indicated they don't receive any weather or climate information. Fig 4.5a shows the distribution of rice farmers with respect to their awareness

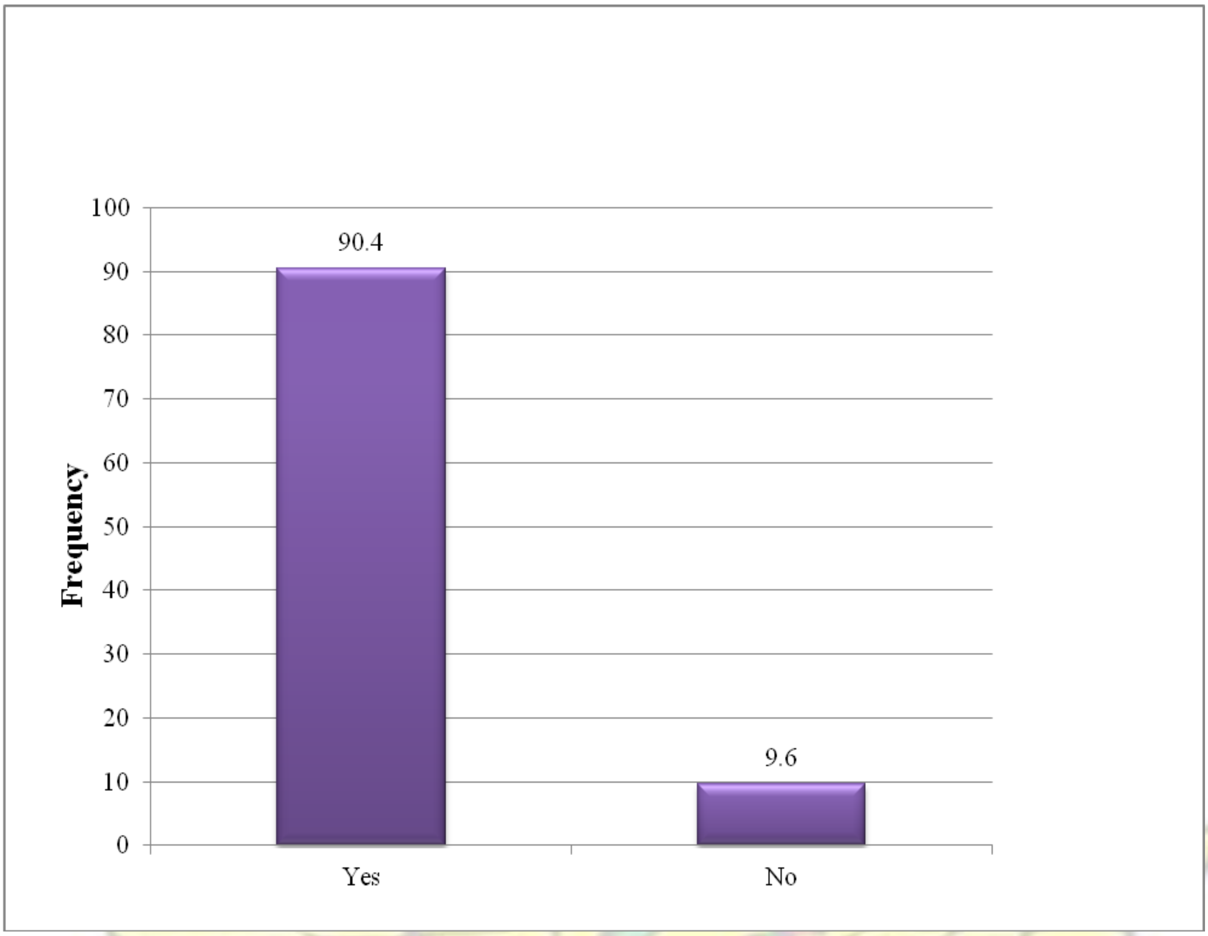

Figure 4.5a: Whether rice Farmers have Access to Climate Information

With respect to whether rice farmer have noticed any change in the climatic condition, 94% reported they had noticed changes in the climate of the areas in which they operate. 6% indicated they have seen no change in the climatic condition. Figure 4.5b shows distribution of rice farmers' view on changes in the climatic conditions.

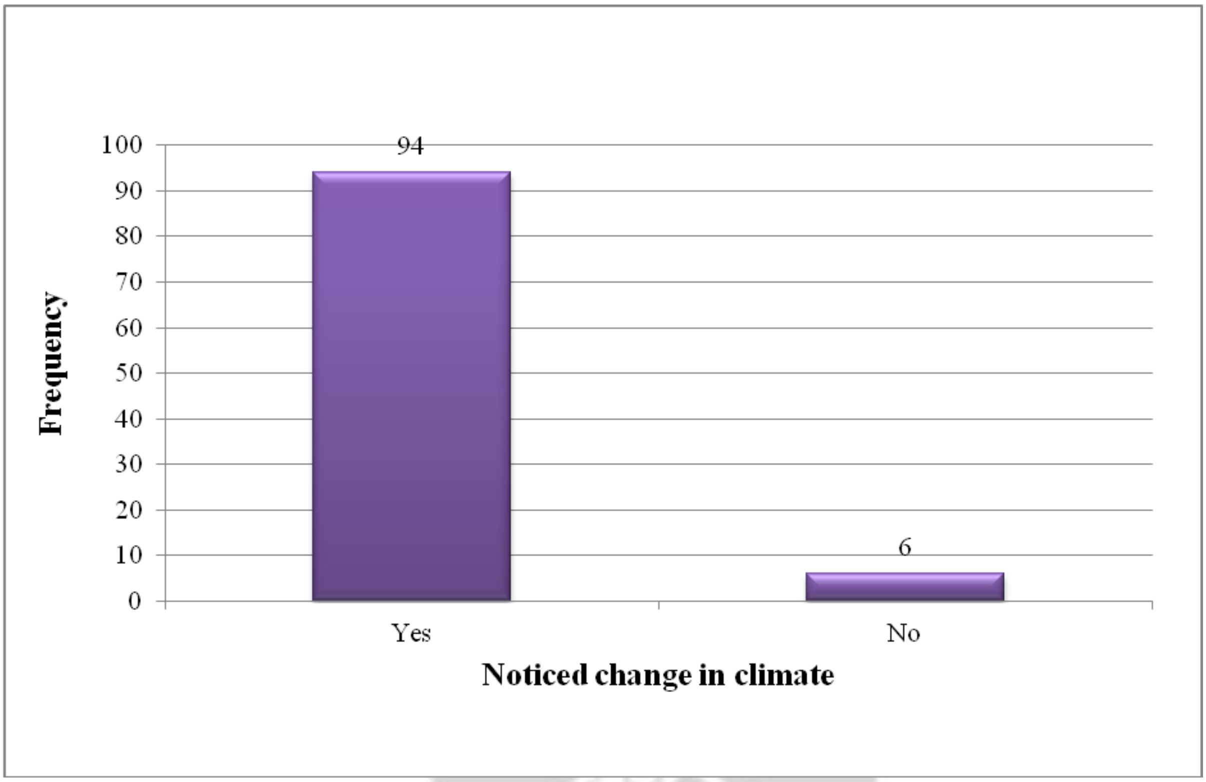

Figure 4.5b: Whether Rice Farmers have Noticed change in climate

4.2.2 Rice Farmers' Source of Information on Climate.

Getting information on climate is very crucial for being aware of the changes in the climatic condition of an area. Rice farmers who were selected for the survey listed some major sources through which they acquire information on climate. Specifically, rice farmers were asked "what is the source of information on climate or weather". The figure below shows the responses of the farmers to the questi on. From the figure, five major sources were identified; radio (FM stations), television, extension officers, personal observation by the farmer and friends. It was evident that majority (73.6%) of the farmers interviewed received major news on national issues as well as weather and climate through their radio sets. This may be due to the fact that most of these communities do not have access to electricity, hence the use of radio sets as a medium for retrieving important information that are in connection with their lives and livelihoods. The second most used medium as revealed by the study is television.

Though farmers had other sources of information on climate, it was expected that extension officers in their operational areas would descend information concerning the climate to their farmers, on the contrary, only 4% of the farmers received weather and climate information

from extension officers. Rice farmers who monitor the weather and climate by receiving information from friends and through personal observation were 2.8% and 7.2% respectively.

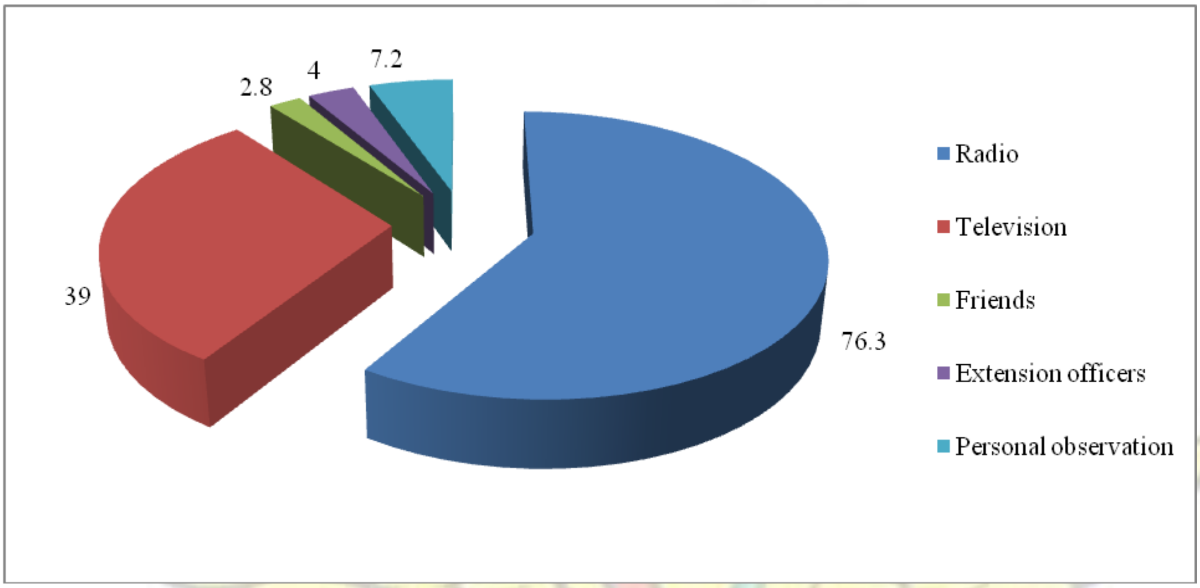

Figure 4.6: Sources of Weather or Climate Information.

4.2.3 Temperature Changes

There is the perception among rice farmers that the temperature in the districts of study is increasing. Majority of rice farmers (64.3%) who were interviewed indicated that the temperatures in their various districts have increased over the past years. Again, 35.5% of the respondents indicated a decline in the temperature conditions in their area. With respe ct to no changes in the temperature conditions, only 2% of the respondents interviewed reported that they have not seen any changes in the temperature conditions in their area of operation. The results however revealed that a few rice farmers (1.2%) indica ted that they have no idea with respect to the change that has occurred in the temperatures of their area of operation. This result conform with Dhaka *et al.* (2010) and (Ofuoku, 2011) who reported that most farmers perceived that the temperature distribution in their respective areas of operation has undergone a significant shift in addition to an overall increase in temperatures. According to the findings of Vedwan and Rhoades (2001), apple farmers in Western Himalayas of India, perceived an overall increase in temperature conditions. Fosu-Mensah *et al.* (2010) also reported increase in temperature when they measured the accuracy of farmers' perception in Ejura. Ayanwuyi *et al.* (2010), when they studied the perception of farmers also came out with similar findings that farmers perceived higher temperatures in the climate of the area. Acquah and Onumah (2011) and Gbetibouo (2009) also reported that 49% and 91% of farmers respectively indicated higher temperature conditions in the climate. Figure 5 below shows the distribution of rice farmers perception of changes in the temperature conditions.

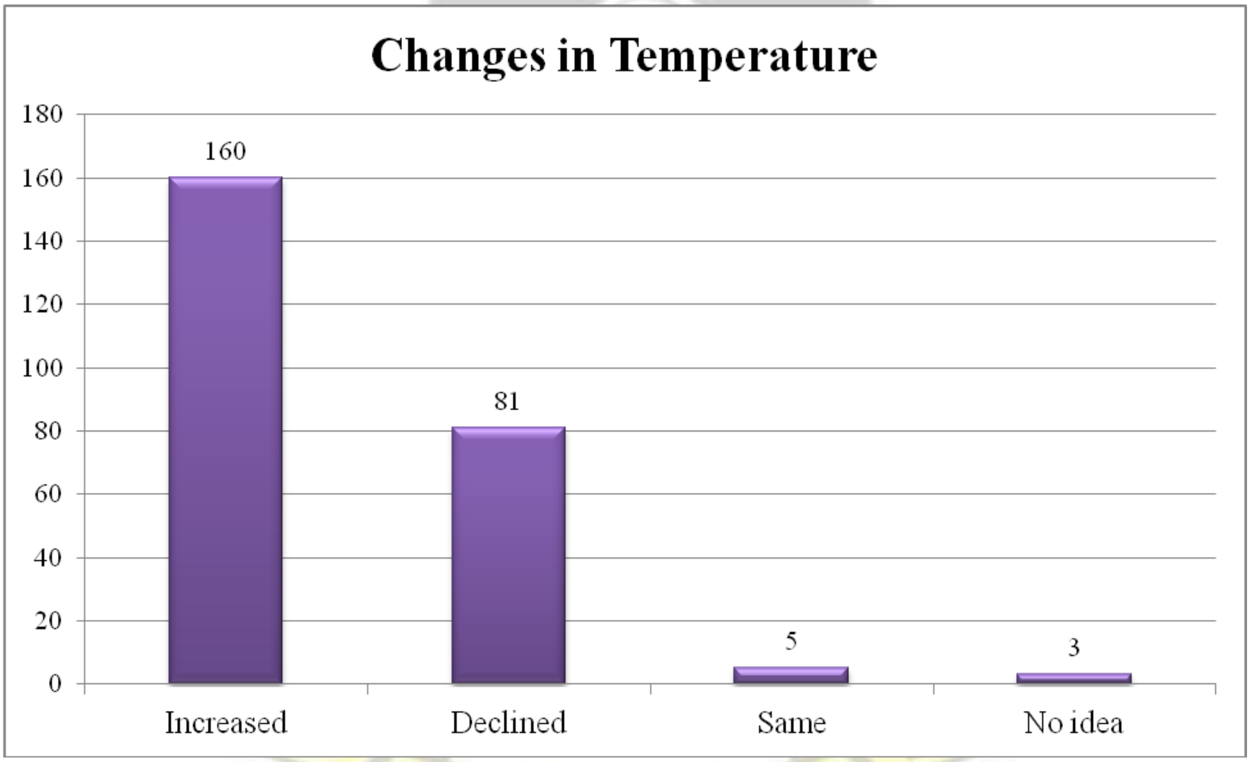

Figure 4.7: Rice Farmers' Perception of Changes in Temperature

4.2.4 Rice Farmers' perception of Temperature 10-20 years Ago

Apart from the results presented above, rice farmers' own perceptions concerning the changes that have occurred in the climate were also sought. Specifically, rice farmers were asked to compare the nature of the climate in terms of temperature and rainfall some years ago and now. Rice farmers' own perception of the nature of climate in terms of temperature were as follows; temperature alternates between low and high, increased/high temperature conditions and lower/decreased temperature conditions giving farming longer durations. A few oth ers however gave no response. Figure 4.8 below shows rice farmers perception of climate change in terms of temperature some years ago.

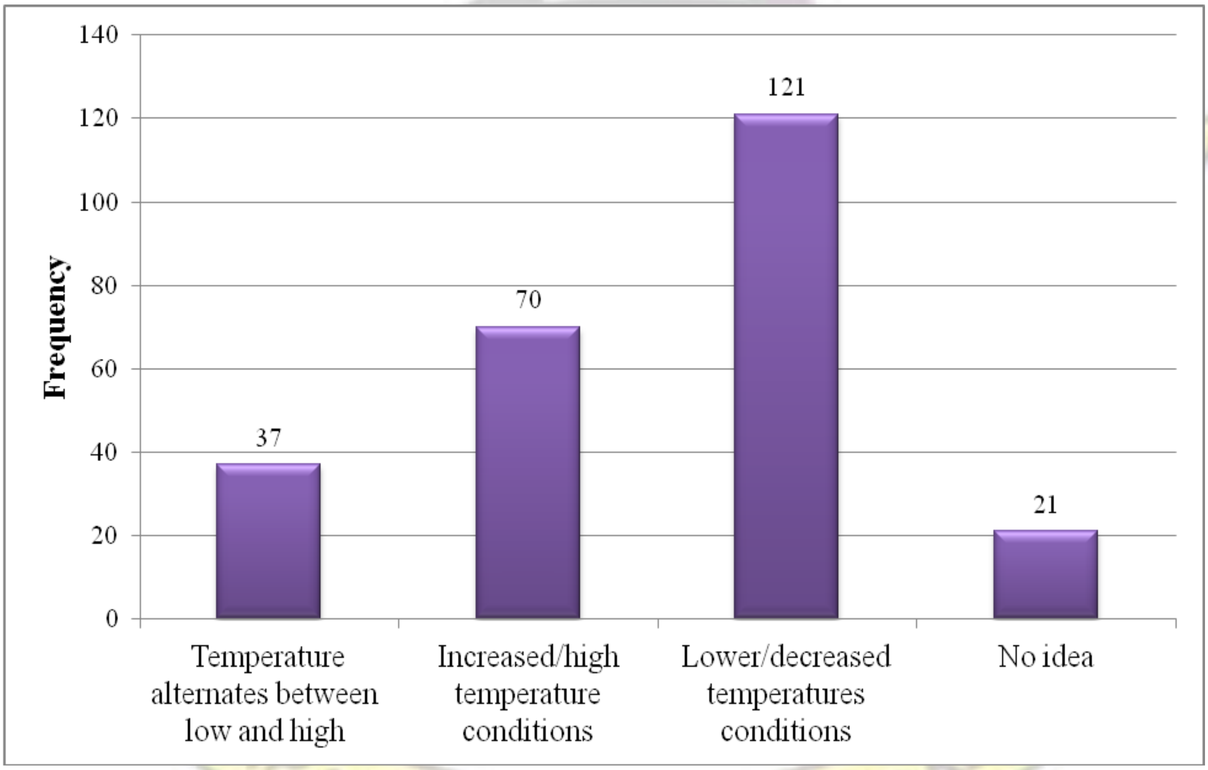

Figure 4.8: Rice Farmers' Perception of Temperature Years Ago.

Figure 4.8 shows that 121 rice farmers representing 47.1% of the respondents interviewed believe that the climate in the past was conducive for farming activities. They indicated that temperature conditions in the past were low giving them longer durations to do their farming activities. 14.4% of them also affirmed that temperature conditions alternated between low and high conditions in the past. It also be seen that 27.2% rice farmers believed that temperatures in the past were high. Despite the perceptions of the farmers about temperature,

a total of 21 rice farmers reported that they have no idea concerning the nature of temperature conditions in the past.

4.2.5 Rice Farmers’ perception of Temperature Now

With regards to farmers perception of temperature now,farmers specified the changes they had noticed**.** Sixty-three percent of rice farmers reported an increasing temperature conditions. Rice farmers acknowledged that this change in temperature gives them a very little time to perform their farming activities. Though majority of farmers reported an increasing trend in temperature, 27.3 percent reports that temperatures are now low or decreasing. Changes reported less frequently by rice farmers is normal temperature conditions (2%). More than 5% of rice farmers interviewed indicated that they had no idea concerning the changes in temperature now. The distribution of rice farmers' perception about temperature now is shown in figure 4.9.

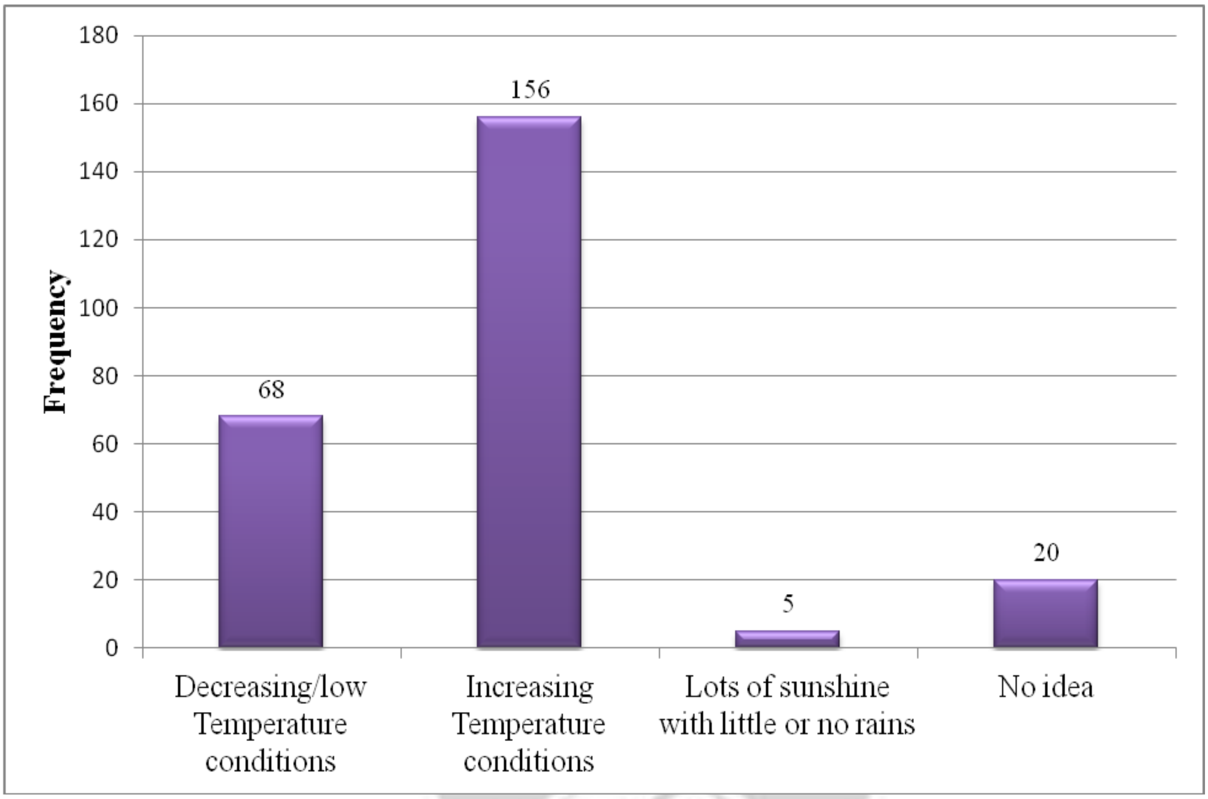

Figure 4.9: Rice Farmers' Perception of Temperature Now.

4.2.6 Rainfall Changes

The distribution of the perception of the farmers concerning changes in rainfall pattern showed that 38.2% perceived an increase in rainfall; 53.4% perceived a decrease in precipitation. Though most of the farmers who were interviewed perceived changes in rainfall pattern, 8.4% of respondents representing 21 rice farmers reported no change in rainfall pattern. Though majority of rice farmers interviewed perceived a decline in rainfall patterns, quite a considerable number also indicated an increase in rainfall. This finding can be as a result of good rainfall distribution during the 2014 cropping season. However, these results agree with the findings of Dhaka *et al.* (2010), Vedwan and Rhoades (2001) and Sofoluwe *et al.*, (2011) who indentified that farmers observed a decrease in precipitation and changes in the timing of rains. Gbetibouo (2009) also revealed that majority of the farmers reported that the amount of rainfall had decreased or the rainy season had become shorter as well as changes in the timing of rains. Figure 4.10 below shows the distribution of rice farmers concerning their perception of rainfall.

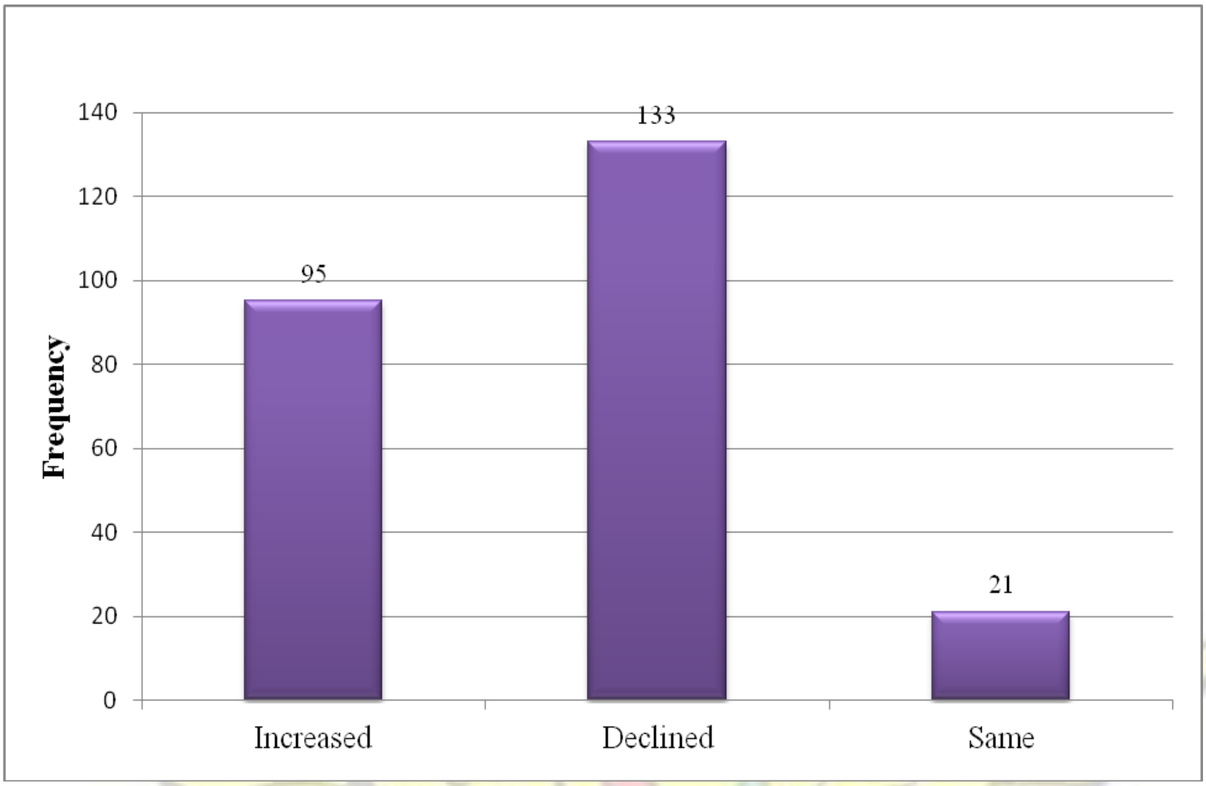

Figure 4.10: Rice Farmers' Perception of Changes in Rainfall.

4.2.7 Rice Farmers' perception of Rainfall 10-20 years Ago

The views of rice farmers concerning the nature of the climate in terms of rainfall conditions some years ago were also sought. Their perceptions with regard to rainfall patterns were specified in figure 4.11. Out of the total rice farmers who were interviewed, almost close to half (45%) indicated that rainfall conditions in the past was very good and was able to sustain crop growth during the cropping season. 9.6% of the sample also confirmed that rainfall patterns could be predicted when they began the business of rice cultivation. The view of some rice farmers (5.6%) also revealed that rains during the past came at the right time in the cropping season, from year to year until the changes in the weather occurred. Rice farmers who indicated that rains come in June/July and with good distribution, rainfall patterns change from year to year and rainfall alternates with sunshine were 8.4%, 5.2% and 2.8% respectively. Though majority of the respondents indicated that rainfall patterns and conditions were good for rice cultivation in the past, about 3% reported that rains delayed in the past, while about 13% also reported that they observed small quantities of rains in the past. About 8% however, indicated that they have no idea as to how the nature of rainfall patterns were during the past. The figure 4.11 below shows the distribution of rice farmers according their perception of rainfall conditions some years ago. Although some rice farmers reported negatively with regards to their views on the nature of rainfall patterns in the past, quite a good number of them also indicated that rainfall in the past had a good distribution and was also good for the cultivation of crops including rice.

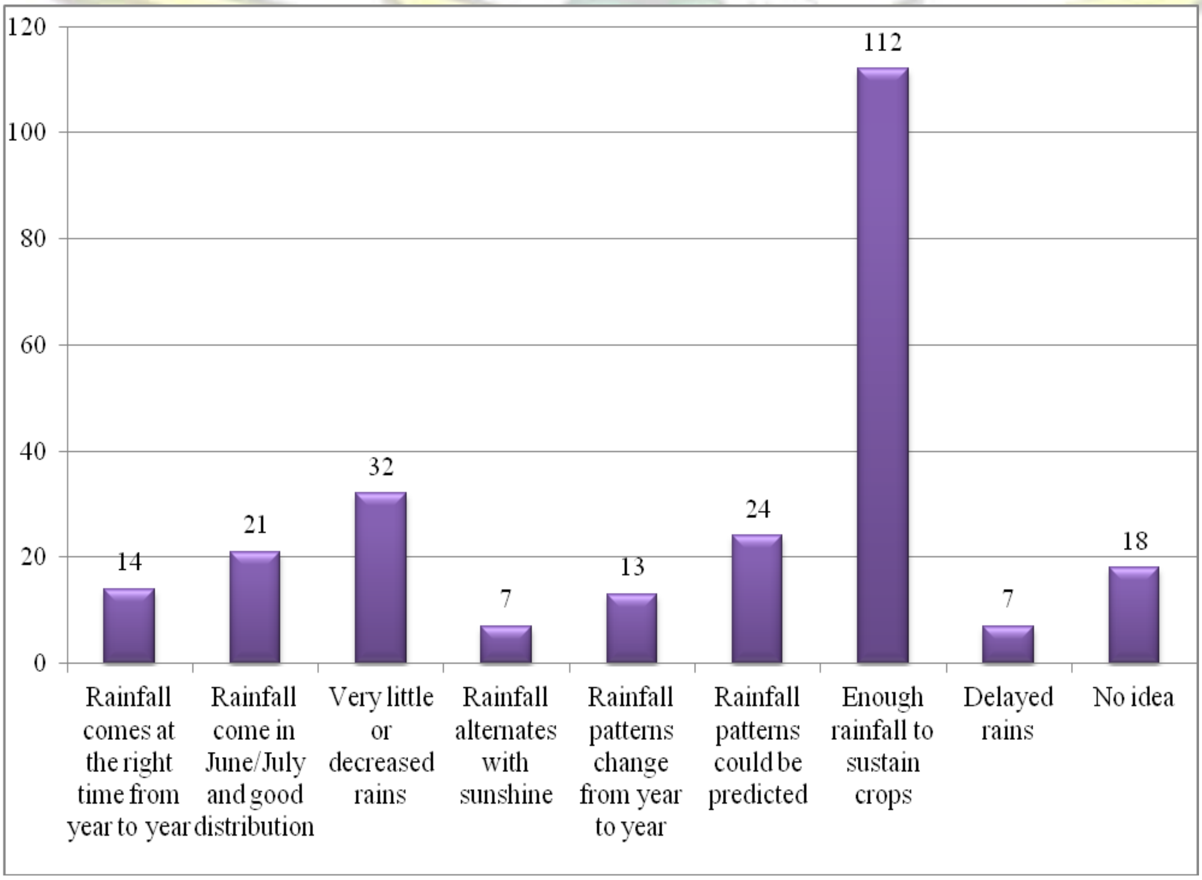

Figure 4.11: Rice Farmers' Perception of Rainfall Years Ago

4.2.8 Rice Farmers' perception of Rainfall Now

The views of rice farmers concerning the nature of rainfall patterns now are revealed in the figure 4.12. About 21% of the farmers confirmed that the amount of rainfall no wadays has decreased or reduced. It was also reported that rainfall patterns could no longer be predicted (14%) as farmers could predict rainfall patterns and even when it will fall. About 11% also reported that the onset of the rainy season is always delayed, as it sometimes begin in August. Some rice farmers also reported that even when the rains fall as it used to, it is either unstable (3.2%) or the amount of rain is increased or becomes too much to cause flooding which leads to the destruction of their crops (19.3%). Although many rice farmers reported negatively, some other farmers had a divergent view of rainfall patterns. About 15% of the respondents revealed that rainfalls are still enough to sustain the growing of crops, while 9.6% also indicated that rainfall patterns are still normal and good but irregular or unstable. Only 7.6% reported that they had no idea of the changes that have occurred over the years.

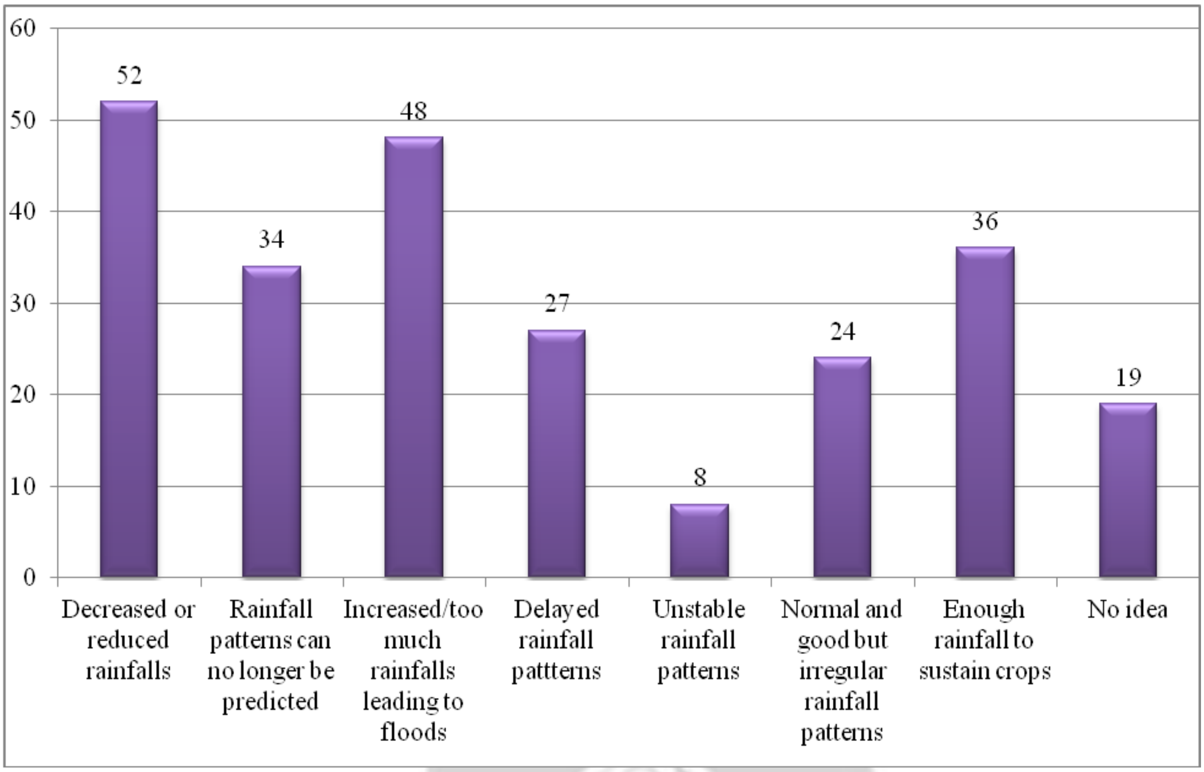

Figure 4.12: Rice Farmers' Perception of Rainfall Now

4.3 Adjustments to Climate Change

Despite the perceptions of rice farmers about climate change, some of the farmers made no adjustments. When farmers were asked whether they have made any adjustments in their farming practices in response to climate change, 95.6% of the respondents made adjustments in their day to day activities on the farm due to the changing climatic conditions. However, 4.4% of the had not adopted any measure to cope with the adverse impacts of climate change. The figure below shows the distribution of the responses of the respondents to the question.

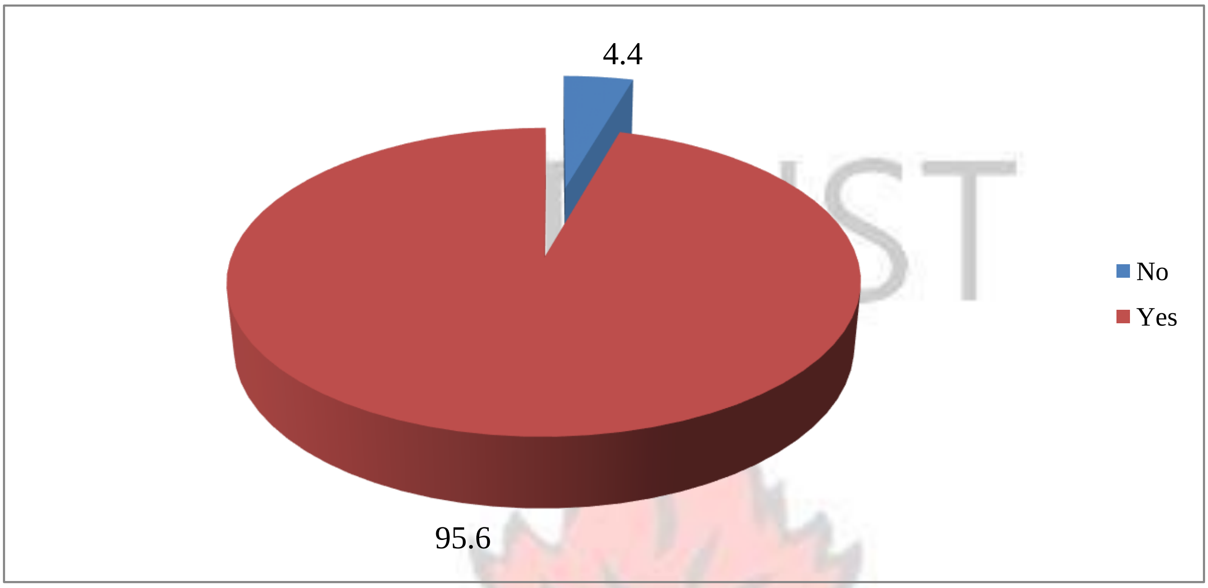

Figure 4.13: Distribution of Farmers' Responses to Climate Change

4.3.1 Choice of Climate Change Adaptation Strategy

Figure 4.14 below shows the distribution of rice farmers according to their choice of climate change adaptation strategy. The major climate change adaptation strategies that were identified to be used by rice farmers included crop diversification, migratin g to urban areas, making of bonds as well as engaging in off-farm jobs. The results show that 4.4%, representing 11 of the farmers interviewed do not adopt any climate change adaptation strategy on their rice farms despite their perception of the changing climatic conditions. In contrast, the remaining 95.6% were found to make use of one of the four major adaptation strategies on their fields. Majority representing about 49% of the rice farmers diversify their crops so as to mitigate the effects of increasing climate variability. The remaining 6.4%, 16.1% and 23.1% of the respondents migrate to urban areas, engage in offfarm jobs and construct bonds on their farms respectively.

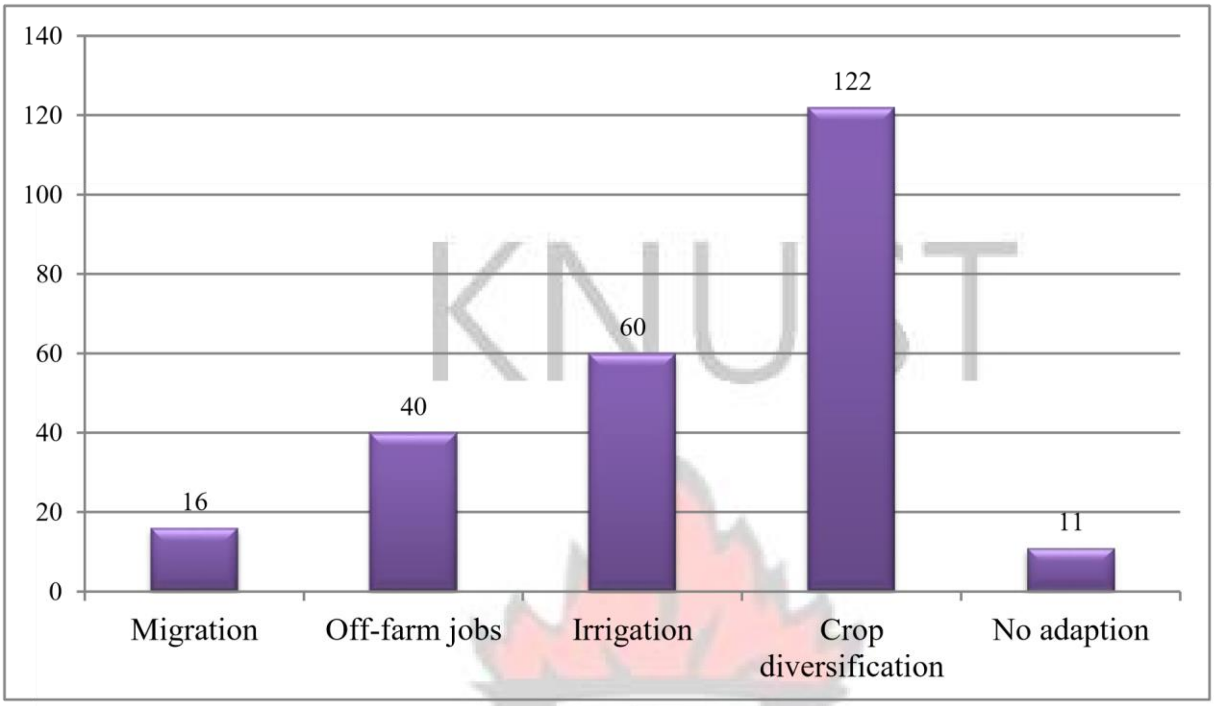

Figure 4.14: Distribution of Farmers according to their choice of Adaptation Strategy

4.4 Descriptive Statistics

The sample for the study was found to have an average household size of eight and average number of children of five (5) per household. The average of children below 15 years is three (3) and above 15 years is two (2). This implies that there are five children out of the eight in every household. Out of the five, three (3) are below the fifteen while two are above fifteen years. This means that rice farmers have the human resource that will help them in their farming activities. However, figure 3 shows that as many as 174 of the sample interviewed, representing almost 70 percent of the respondents hire laborers for works on their farms, indicating that most of these children are either schooling or do not stay with their parents in the villages.

It can also be seen from the table that the average farm size per respondent is 3.2 acres. Implication is that majority of rice farmers in the survey districts are smallholder farmers as most farmers in Ghana (about 90%) farm on lands that are less than 2 hectares in size (MoFA, 2011). Such farmers depend on the traditional system of farming where hoes and cutlasses are the main tools used in agricultural activities. Farmers in this category produce on small scales just for a little income and consumption, as majority of respondents interviewed stated that the reason why they go into rice cultivation is to get a little income to support the family and also diversify the types of meals eaten in their households.

The average farming experience of rice farmers in the surveyed districts is 11 years. The minimum years in rice cultivation is 1 year while the farmer with the maximum number of years in rice cultivation had 45 years. This means that majority of the rice farmers must have a fair idea of any change that might have occurred in the climate of their various areas of operation, as shown in figure 4b, where 94% of respondents interviewed reported a change in the climatic condition. The experience rice farmers have gleaned would also enable them to have knowledge of climate change adaptation strategies and how to apply them.

On the average, a rice farmer produced an average of 16 bags of paddy rice during the 2013 cropping season and received an average income of GH¢1695.374 during the season. It is with this income received that the average rice farmer is expected to depend on for the season till the next time for harvesting. It can also be revealed from the table that the average number of years a rice farmer noticed a change in the climatic condition is about 7 years. This implies that respondents who were interviewed have noticed a change in the climate of their respective areas of operation and hence, will make changes in their farming practices to overcome the adverse effects that may arise from these changes. Despite rice farmers' knowledge of the changes in climatic conditions, figure 4.13 reveals that some rice farmers did not respond to climate change.

Table 4.2: Summary statistics of the variables entering the regression models

variable	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	249	18	75	41.80	11.697
Household size of respondent	249	1	25	8.00	4.144
Number of children for respondents	249	0	20	4.89	2.856
Distance of farm from house	249	0	9.0	1.75	1.1948
Farm size	249	0.25	30.00	3.216	3.323
Farming Experience of rice farmers	249	1	45	11.45	8.746
Rice output (paddy) in 2013	244	2.0	120.0	15.686	18.9347
Rice price per maxi bag (grawa) in 2013	244	20.0	180.0	108.082	31.241
Children below 15 yrs per respondent	249	0	12	2.71	1.827
Children above 15 yrs per respondent	249	0	11	2.04	2.280
Income from remittances (Gh¢)	40	5	500	130.95	116.418
When change noticed (in years)	211	1	56	6.50	7.885

Source: Field Survey, 2015

4.5 Rice Farmers' Perception of climatic change and Adaptation Strategies

4.5.1 Farmers' perception of climate

The analyses of the perceptions of rice farmers in the surveyed districts was done by using the perception index in order to determine the agreement or non-agreement of farmers who were interviewed on some climate conditions. The table below provides their perceptions. It may be evident from the table that almost all the rice farmers who were interviewed agreed (mean score of 0.52) to the occurrence of hotter weather conditions in their respective operational areas. This finding may be true as Oppong-Ansah (2011) reported that the three northern regions of Ghana experienced the highest mean temperatures and the predominance decreased rainfall, causing poverty across these regions. Such changes as reported is expected to reduce production of rice in Ghana by 36 per cent as many rice farmers have abandoned their rice fields as a result of the effects climatic pressures in the country. MEST (2010) also reported of projected climate pressures such as higher temperatures in some parts of Ghana. Bryan *et al*. (2009) in their study observed increased temperature. With respect to the statement as to whether rains have become less or low and unexpected, the mean score obtained was almost 0.7, indicating that rice farmers in the surveyed districts agree to the change in climatic condition which has led to rains becoming less and unexpected in the surveyed districts. This finding go well together with Bryan *et al*. (2009) who reported that rainfall patterns had decreased. The mean score obtained for the responses of farmers with regards to the unevenly distribution of rainfall also indicates that the farmers strongly agree to the fact that rainfall is unevenly distributed. The views of farmers concerning the weather becoming more unexpected were also sought. The mean score obtained for this perception statement establishes that, the respondents who were interviewed were all in agreement to the conclusion that generally, the weather has become more unexpected in all the surveyed districts. The climate perception index of 0.56 means that farmers have a strong positive perception about the climate and strongly agree to the perceived statements.

4.5.2 Farmers' perception of response to climate change

Responding to climate change issues in the agricultural sector has been suggested to be a very important step that should be undertaken in order to reduce the impact of climate change in the sector. The perception of rice farmers as to whether responding to climate change is important to farm business, as well as whether responding to climate change is very necessary was sought. The mean scores attained were both 0.82, suggesting that the farmers strongly agreed to the fact that, response to climate change was a very important issue and as such very necessary.

However, a study conducted by De Jonge (2010) on farmers' perception on adaptation to climate change in the river land of South Australia suggested that farmers do not only deal with climate change as the only problem facing their farm business, but also with other problems. With regards to "adaptation to climate change being beneficial to farmers", respondents expressed their strong agreement (mean score= 0.8). Thus rice farmers would put in place all necessary measures to maximize profit on their farms. De Jonge (2010) however, established that most farmers did not consider adaptation to climate change as being beneficial to them. The response perception index of 0.81 also suggests that respondents have strong positive perception about the responses made to changing climatic conditions and therefore strongly agree to most of the perceived statements

4.5.3 Farmers' perception of impact of climate change

Many literary works have shown that climate change is expected to adversely affect agricultural production. It is therefore a threat to many farm business in Africa (Bryan *et al., 2011*). The perception of respondents who were interviewed in the survey showed that they are all in agreement to the fact that changes in the climate threatens their farm business (mean score= 0.71). As to the impact of climate change on farm profitability, so many studies have established that climate change is generally detrimental (Mendelsohn, 1998; Smit and Skinner, 2002 and Gbetibouo, 2009). Rice farmers in the surveyed districts perceived that changes in climate had a great impact (negative) on the returns they received from their farm business. They however agreed to the statement "climate change impact on farm profitability" (mean score = 0.68). This implies that adaptation to climate change is profitable to these farmers. This finding is contrary to the work of De Jonge (2010) which showed that most farmers did not see adaptation to climate change as being beneficial them. Rice farmers knowledge and perception were sought on the issue of climate change inducing them to make changes in their farming practices. The mean score (0.74) obtained suggests that rice farmers agree to the statement "climate change induce farmers to make changes in farm practices". The impact perception index (0.71) rice farmers have strong positive perception about the impact of climate change and hence strongly agree to most of the perceived statements.

4.5.4 Adaptation perception index

It is expected that farmers who notice changes in the climatic conditions identify useful adaptation strategies and implement them. Analysis of the statement "I have made significant changes to my farm practices due to climate change" gave a mean score of 0.71, indicating that rice farmers in the surveyed districts have made some changes in their farming practices in response to the changes they have observed in the climatic conditions of their respective areas of operation. To test the validity of the earlier statement, the direct opposite of the statement was also analyzed and the result proved positive. The mean score of -0.66 suggests that rice farmers disagree with the statement "I have not made any changes to my farm practices". This confirms that farmers have really adapted to the changing climatic conditions. Again, rice farmers disagreed (mean score=-0.05) on the issue of whether adaptation to other problems was more important than to climate change. Most of the farmers pointed out that all household issues are of equal importance, hence all matters are treated with urgency. Though the farmers disagreed with some of the perception statements regarding adaptation to climate, the adaptation perception index (0.005) suggests that, rice farmers in the surveyed districts have strong positive perception about the adaptation of rice farmers changes in climatic conditions and therefore strongly agree to most of the perceived statements about adaptation.

4.5.5 Effect of adaptation perception index

The perception of farmers on the immediate effect of adapting to the changing climatic conditions in the surveyed areas were also sought. It was investigated whether adapting to climate change caused rice farmers to make demand for new varieties and other inputs. This was found to be true as all the rice farmers who were interviewed for the survey agreed to the fact that one major effect of responding to the changing climatic condition was the increased demand for new rice varieties. These new varieties as indicated by the farmers matured earlier than the old varieties. The early maturity of the new crop types enabled the rice crop to escape the harsh conditions such as low amount of rainfall, etc. caused by climate change. The study captured some of these new rice varieties such as; "lapez" and "jasmin". It was established that some farmers would travel to the major cities in search for jobs in case the weather or climate fails their crops. However, analysis of their perception on frequent migration to urban areas gave a mean score of -0.5, indicating that rice farmers showed a total disagreement to the statement. Changing from crop production to livestock production was also investigated. From the table, it can be seen that, rice farmers do not switch entirely from their rice cultivation to rare animals as a way of adapting to changes in climatic conditions. Again, the farmers showed a total disagreement to that statement. On the other hand, the farmers agreed that any time they responded to the changes in climate by making any change in their farming practices, their farm profit either increased or was maintained. Hence, the threat on their farm business is reduced greatly. This confirms the findings of Easterling *et al.* (1993) and Smit and Skinner (2002), who reported that impact of climate change on farmers is largely reduced if they responded to the changing climatic conditions. The mean scores of 0.66 and 0.65 reveal farmers agreement to the two statements. Rice farmers also agreed to the fact that the prices of commodities will increase with adaptation. This may be true as rice farmers invest a lot of money in new methods of cultivation. These new methods include the preparation of bonds on rice fields, buying of improved seeds as well as diversifying the types of crop cultivated, in order to sustain their households in case of failure of the rice crop due to climate change. The effect of adaptation perception index obtained also indicates that the rice farmers agree most of the statements asked about the effects of adaptation to climate change.

Table 4.3: Rice Farmers' perception of climate change and Adaptation Strategies

Perception Statements	Strongly Agree (1)	Agree (0.5)	Undecided (0)	Disagree (-0.5)	Strongly Disagree (-1)	**Mean Score**
Weather gets hotter	151(60.6)	37(14.9)	12(4.8)	14(5.6)	34(13.3)	0.52
Rains have become less and unexpected	143(57.4)	78(31.3)	5(2.0)	11(4.4)	7(2.8)	0.69
Weather becomes more unexpected	152(61.0)	80(32.1)	6(2.4)	1(0.4)	9(3.6)	0.74
Uneven rainfall distribution	187(75.1)	54(21.7)	5(2.0)	0	2(0.8)	0.85
Climate perception index						**0.59**
Farmers' perception of response to climate change						
Responding to climate change is important to farm business	165(66.3)	75(30.1)	7(2.8)	0	0	0.82
Farmers' response to climate change is very necessary	165(66.3)	73(29.3)	8(3.2)	0	0	0.82
Responding to climate change is profitable to farm business	155(62.2)	82(32.9)	9(3.6)	0	0	0.80
Response perception index						**0.81**

Source: Field Survey, 2015

Table 4.3 Continued. Rice Farmers' perception of climate change and Adaptation Strategies

Farmers' perception of impact of climate change	Agree (1)	(0.5)	(0)	(-0.5)	Disagree (-1)	**Score**
Climate change is a threat to farm business	184(73.9)	31(12.4)	1(0.4)	11(4.4)	19(7.6)	0.71
Climate change impact on farm profitability	138(55.4)	74(29.7)	21(8.4)	2(0.8)	9(3.6)	0.68
Climate change induce farmers to make changes in farm practices	163(65.5)	61(24.5)	11(4.4)	8(3.2)	5(2.0)	0.74
Impact perception index						**0.71**
Farmers' attitude of adaptation to climate change						
I have made significant changes to my farm practices due to climate change	173(69.5)	45(18.1)	9(3.6)	7(2.8)	15(6.0)	0.71
I have not made any changes to my farm practices	21(8.4)	7(2.8)	5(2.0)	53(21.3)	160(64.3)	-0.66
I believe it is not necessary to respond to climate change	66(26.0)	53(21.3)	7(2.8)	70(28.1)	52(20.9)	0.02
Adaptation to other problems is more important than to climate change	17(6.8)	48(19.3)	104(41.8)	37(14.9)	35(14.1)	-0.05
Adaptation perception index						**0.005**

Source: Field Survey, 2015

	Strongly	Agree	Undecided	Disagree	Strongly	**Mean**

Table 4.3 Continued. Rice Farmers’ perception of climate change and Adaptation Strategies

Farmers’ perception of effectiveness of adaptation options	Strongly Agree (1)	Agree (0.5)	Undecided (0)	Disagree (-0.5)	Strongly Disagree (-1)	**Mean Scores**
Increased demand for new varieties and other inputs	131(52.6)	42(16.9)	54(21.7)	2(0.8)	7(2.8)	0.61
Frequent migration to urban areas	32(12.9)	18(7.2)	11(4.4)	35(14.1)	143(57.4)	-0.5
Change crop variety	129(51.8)	48(19.3)	20(8.0)	18(7.2)	19(7.6)	0.53
Change from crop to livestock production	5(2.0)	11(4.4)	43(17.3)	46(18)	131(52.6)	-0.61
Farm profit will increase or maintained	121(48.6)	89(35.7)	27(10.8)	4(1.6)	2(0.8)	0.66
Threat on farm business will be reduced	135(54.2)	76(30.5)	8(20)	9(3.6)	7(2.8)	0.65
Commodity prices will increase with adaptation in our life time	103(41.4)	54(21.7)	71(28.5)	3(1.2)	6(2.4)	0.52
Effect of adaptation perception index						**0.27**
Perception Index						**0.5**

Figures in parenthesis are percentages

Source: Field Survey, 2015

4.6 Choice of Climate Change Adaptation Strategies

The types of climate change adaptation strategies employed by rice farmers were sought. Of the farmers interviewed, 95.6% used a particular type of adaptation strategy whilst 4.4% do not employ any climate change adaptation strategy. Migrating to urban areas, crop diversification, making of bonds and engaging in off-farm jobs were some of the main adaptation strategies employed by the rice farmers.

4.7 Constraints to Rice Farmers' Adaptation to Climate Change.

Rice farmers in the three districts are facing constraints that can make the adaptation to climate change ineffective. The sampled rice farmers listed some constraints that are associated with adapting to climate change. Responses are shown in figure 11. Lack of financial resources was reported to be the most significant constraint by the majority of rice farmers (69.1%). High cost of labor and inputs were also reported by 64.7% and 55% respectively. Other reported constraints were transportation problems (49.4%), shortage of agricultural land (35.4%) and insecure property rights (18.5%). Only a few sampled farmers did report no access to water (10.4%), off -farm employment (4%), lack of climate information (3.6%) and inadequate knowledge on adaptation (2%) as barriers to effective adaptation. The results suggests that expanding rice farmers' access to credit or cash earning opportunities will enable the farmers to meet their initial cost of investments in the rice farming business.

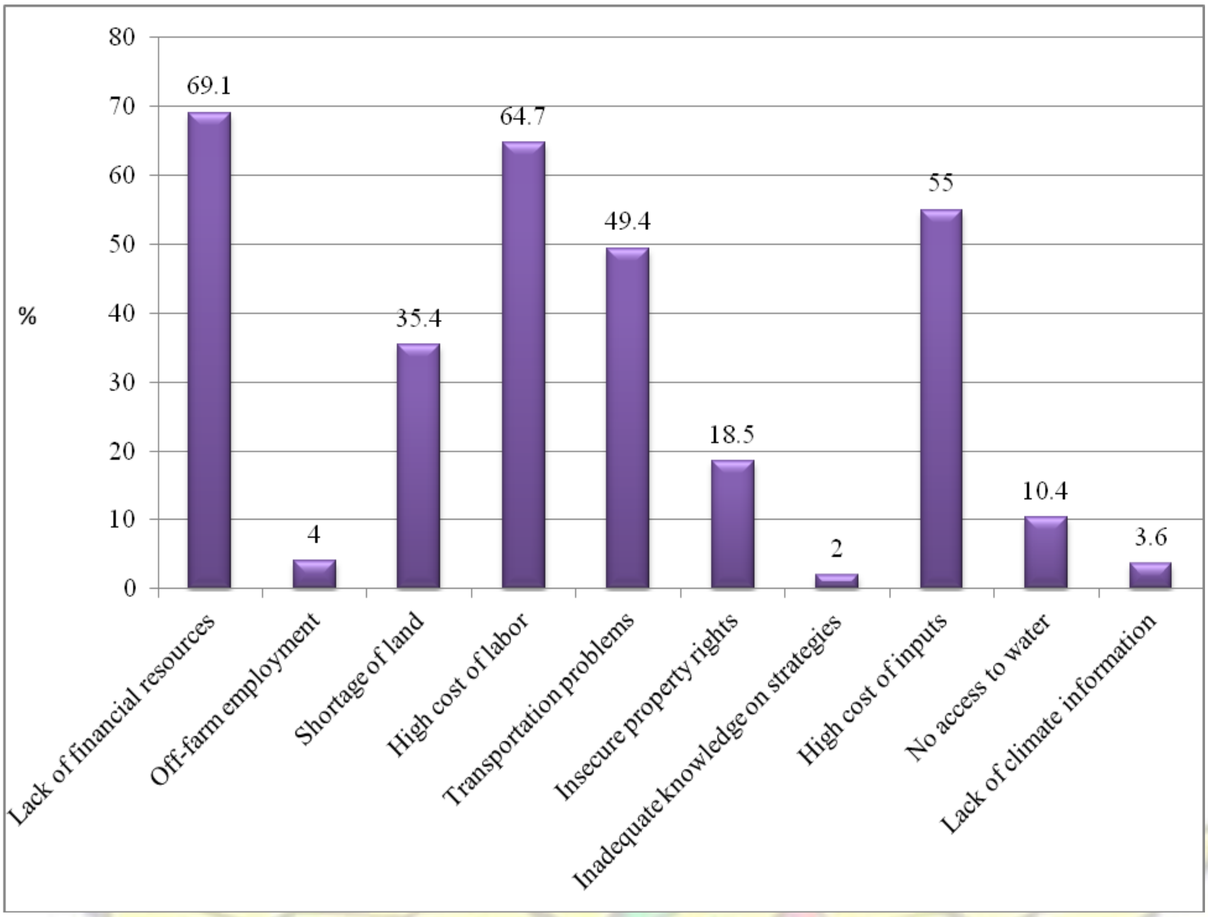

Figure 4.15: Constraints to Adaptation to Climate Change

4.8 Descriptive Statistics of Rice Farmers According to Choice of Adaptation

Descriptive results of socio-demographics of rice farmers based on their choice of an adaptation strategy was also analyzed in table 4.4. The results show that the mean age of rice farmers who resort to migration when faced with climate related hazards was 38 years. This finding may be true as those who migrate to urban areas in search of better jobs are mostly the youth, who are often strong and energetic, and can engage in more laborious activities. The results also show that the average number of persons in the households of rice farmers who migrate is 6. It was also found that any rice farmer who migrated in the fac e of changing climatic conditions has an average farm size of three (3) acres and walks a distance of one (1) kilometer to his farm. The percentage migrant farmers with JHS and SHS education are 20% and 10% respectively.

The percentage who had no formal education are also 10%. Again, table 4.4 reveals that only 20% rice farmers who migrate have a fixed agreement with their land owners. The number of years of farming experience of rice farmers who migrate revealed that 20% have been farming for years between 11 and 20. However, ten percent have farming experience above 20 years. From the table, fifty percent of farmers who migrate receive extension contact whilst another thirty percent belong to rice farmers' organization.

With regard to rice farmers who engage in off- farm jobs so as to mitigate the adverse effects of climate change, the results show that the average age of rice farmers who adapt to climate change by engaging in off-farm activities is 43 years. An average of 9 persons were found in the house of rice farmers who engage in off-farm activities. The results reveal that rice farmers who adapt to the changing climatic conditions by engaging in off-farm activities have an average farm size of about five (5) acres and walk a distance of two (2) kilometer to his farm. Sixty percent were found to have had JHS education while 10% had SHS education. The results show that 20% of rice farmers who engage in off-farm jobs have not had any formal education. Again, table 4.4 reveals that only 10% of rice farmers who engage in offfarm jobs have a fixed agreement with their land owners. The table shows that 40% of rice farmers who have off-farm jobs have attained experience between 11 and 20 years whereas 10% have attained farming experience above twenty years. Sixty percent use hired labor and also belong to rice farmers' organization. It was shown that eighty percent receive extension services.

Rice farmers who constructed bonds on their fields were found to have an average age of 39 years. The average household size of this group of farmers was shown to be 8 persons. Each farmer has an average farm size of 3 acres and walks 2 kilometers to farm. Fifty percent attained

JHS education whereas 20% had no education at all. The table also reveals that 30% of the farmers have fixed land agreements with their land owners and also have farming experience eleven and twenty years. The result showed that 50% of rice farmers who engage in off-farm jobs use hired labor on their farms, 70% belong to farmer based organizations whilst 80% receive extension contacts.

The age of rice farmers who diversified the types of crops grown were also found to have an average age of 44 years. Their average household size is about 9 persons. This may explain why only an average of one person of this group resort to the use hired labor on their rice fields. The average farm size of farmers who diversified is about 3 acres e ach farmers walks at least two kilometers before reaching his farm. It was found that thirty percent had JHS education, 10% had SHS education while another 30% have had no form of education at all. The results also show that 30% of this group have been faming for between eleven and twenty years while 10% have farming experience above twenty years. Only 40% were found to use hired labor on their farms whereas 60% receive extension visits. As shown by table 4.4, about 40% belong to rice farmers' organization.

Table 4.4: Descriptive statistics of rice farmers according to their choice of adaptation strategy.

Variable	Migration		Off-farm jobs		Irrigation		Diversification	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation

Age	38.4	11.6	42.5	8.1	38.6	8.8	43.7	13.4
Gender	1.0	0.0	0.7	0.5	0.8	0.4	0.7	0.5
Household size	6.1	2.2	8.7	4.9	7.7	3.4	8.5	4.4
Farm size	2.9	1.6	4.7	6.3	2.6	1.9	2.9	2.2
Distance	1.2	0.5	2.0	1.5	1.6	1.0	1.8	1.1
No formal education	0.1	0.2	0.2	0.4	0.2	0.7	0.3	0.4
JHS education	0.2	0.4	0.6	0.5	0.5	0.5	0.3	0.5
SHS education	0.1	0.3	0.1	0.3	0.0	0.0	0.1	0.3
Fixed agreement	0.2	0.4	0.1	0.2	0.3	0.4	0.2	0.4
Gift agreement	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0
Exp 11-20	0.2	0.4	0.4	0.5	0.3	0.5	0.3	0.4
Exp above 20 yrs	0.1	0.3	0.1	0.2	0.0	0.2	0.1	0.3
Hired labor	0.2	0.4	0.6	0.5	0.5	0.5	0.4	0.5
Off-farm income	0.1	0.3	0.9	0.3	0.1	0.3	0.1	0.3
Extension contact	0.5	0.5	0.8	0.4	0.8	0.4	0.6	0.5
FBO	0.3	0.5	0.6	0.5	0.7	0.5	0.4	0.5

Source: Field Survey, 2015.

4.9 Empirical Results

The various climate change adaptation strategies being used by farmers in response to perceived changing climatic conditions included crop diversification, migrating to urban areas, making of bonds, and engaging in off-farm jobs. The estimated coefficients and marginal effects of the multinomial logit model are presented in tables 4.5 and table 4.6 respectively. The model summary as presented in Table 4.5 show that the likelihood ratio statistics as indicated by $\chi 2 = 279.36$ are highly significant at 1 percent, suggesting a strong explanatory power of the model. The estimated coefficients must be compared with the base category of adapting to climate change by engaging in off-farm jobs.

With regard to the choices of climate change adaptation strategies among rice farmers across the three districts, the estimated coefficients of the multinomial logit model provide some important insights. The parameter estimates in Table 4.5 have the relevant signs, indicating the impact of explanatory variables on the probability of a rice farmer choosing a climate change adaptation strategy. Explanatory variables with a large impact should be the main focus in an effort to improve the production of rice in Ghana, since these can be influenced relatively easily.

The multinomial logistic regression results presented in Table 4.5 show that the age of a rice farmer statistically affect the probability of a farmer migrating and also using bonds on their rice fields. The results suggest that as a farmer's age augments, the probability of the farmer migrating to the urban area when faced with climate variability is reduced. Similarly, the age of rice farmers negatively and significantly affects the decision of farmers to make bonds on their rice fields. This implies that younger farmers are more likely to travel to the cities in search of jobs, as well as make bonds on their rice fields should the climate change. This may be true as working in the urban areas requires more energetic people than the aged. The making of bonds on the other hand is very costly and requires more energetic ones to prepare. This is consistent with the findings of Adesina and Forson (1995), who established that the age of a farmer negatively influences his choice of an adaptation strategy. The results as presented in table 4.6 also show that a unit change in a rice farmers' age reduces the probability of the farmer making bonds in his or her rice field by 0.3%. The results also establish that a unit change in the age of rice farmers however increases the probability of the farmer diversifying his or crops by 0.3%.

The size of a rice farmer's household is included to estimate the impact of the household on the probability of a farmer choosing an adaptation strategy. It can be seen from the table that the size of rice farmer's household is significantly but negatively related to a farmers' decision of not choosing any adaptation strategy. This implies that, as the number of individuals in the household increase, the probability of the farmer not adapting any adaptation strategy is reduced. The results confirms the findings of Gbetibouo (2009) who found that as the number of individuals in the rice farmers' household increases, the probability of choosing the 'other' adaptation strategy also increases.

The coefficient of farm size was expected to be positive, however, table 4.5 shows that the size of a farmer's farm is significant but negatively related to the probability of rice farmers choosing to make bonds in their rice fields. This may be true as the making of bonds as explained by the by farmers is cost and labor-intensive, hence farmers cannot afford to invest in irrigation technologies because the farmers are small-scale farmers. The results also show that a unit change in the size of the farm reduces the probability of a rice farmer making bonds by 1.3%. This finding disagrees with Gbetibouo (2009), who established that farm size has a positive influence on a farmers' decision to adapt to climate change by irrigating.

There is also a negative correlation between the distance from a rice farmers' house to his or her farm to the farm and the probability of travelling to any urban area in search of new jobs, should there be any change in the climatic condition of the farmer's operational area.

The educational level of a rice farmer has a negative sign for rice farmers decision to adapt to climate change. The negative sign indicates that the higher the educational level attained by a rice farmer, the lower the probability of the farmer putting in place any measure to lessen the impact of climate change on the farmer's household. It was however expected that as one progressed on the academic ladder, his ability to receive, interpret and comprehend information relevant to making innovative decisions in their farms is enhanced. From the results obtained, no formal education has a significant but a negative impact on the farmer's decision to adapt any climate change adaptation strategy. This implies that a farmer with no formal education has a lower ability to receive, interpret and comprehend information relevant to making innovative decisions, hence a reduced probability to adapt to climate change. From table 4.6, no formal education reduces the probability of farmers taking up irrigation by 4.2%. Again, it can be revealed that a farmer being either a JHS or SHS lever had a negative impact on a farmer's decision to adapt in the face of climate change. JHS levers are less likely to adapt irrigation and collection diversification. Such farmers also have a reduced probability of not adapting at all. Senior high graduates on the other hand also have a reduced tendency to migrate and to make bonds on their farms. The probability of such farmers to employ no strategy was also reduced. This finding may be true as climate information at the JHS and SHS educational levels may be trivial, hence not enough to keep the farmers informed about adverse effects of climate change.

Farming experience significantly, but negatively influenced a farmer's decision of not implementing a climate change adaptation strategy. From table 4.5, as the number of years spent by a farmer in rice farming business increase above 20 years, the probability of the farmer not using any strategy at all is greatly reduced. This implies that the more rice farmers acquire more experience in the farming business; they are more likely to employ a strategy to mitigate the effects of climate change. The result is in line with the findings of Gbetibouo (2009), who found that experienced farmers had an increased likelihood of using climate change adaptation strategies. These results also confirms the findings of Nhemachena and Hassan (2007). Dhaka *et al*. (2010) and Maddison (2006) also confirmed that farmers with more experience were more likely to adopt any climate change adaptation strategy.

Farmers who acquired their rice fields through gifts were found to have an increased likelihood of making bonds on their rice farms in response to the changing climatic conditions. The results also indicated that gift agreement significantly but negatively influenced the decision of a rice farmer to migrate and also diversify the types of crops grown on their fields. The finding might be true as one cannot afford to migrate to urban cities in search of jobs whilst he has been given a land without paying any returns for the land. This may be due to the fact that the returns that would be accumulated for not paying any returns for the land might be equivalent or higher than the profit that would be obtained for working in the cities. Again farmers who acquire their lands through gifts have a reduced likelihood of diversifying their crops. This might also be true as these lands cannot be used to cultivate perennial crops since the lands may belong to an entire family.

The result also shows that the likelihood of a farmer to make bonds and also diversify their crops is increased if there existed a fixed agreement between the rice farmer and the land owner. Table 4.6 shows that fixed land agreement reduces the probability of migrating and engaging in off-farm jobs by 0.054% and 5.9% respectively. However, fixed land agreement between rice farmers and land owners increased the probability of farmers choosing to diversify their crops by 6.9%. This finding agrees with Gbetibouo (2009), who confirmed that farmers with secured property rights have 9% increased probability of adapting to climate change.

The empirical result suggests that farmers who earn off-farm income have a reduced probability making bonds, migrate as well as diversify their crop types. This means that as the incomes farmers receive from off-farm jobs increased, the likelihood of these farmers adapting in the face of changing climatic conditions reduces. The result is confirmed as offfarm jobs may present a constraint to adaptation since it competes with activities on the farm (McNamara *et al.*, 1991). However, Gbetibouo (2009) suggested that a farmer who engages in off-farm jobs has an increased probability of buying feed supplements for the livestock as an adaptation strategy.

Results of the multinomial logit regression analysis have shown that being male rice farmers appear to have an increased likelihood of migrating in face of changing climatic conditions (P=0.000). It is clear that this strategy require males who have enough capacity and strength. The results further reveal that male rice farmers have a reduced probability of not employing any strategy at all in the face of changing climatic conditions. With regards to the average marginal effects it is explicitly shown that as a male invests in the rice farming business, the probability of him making bonds increases by 5.6%, but reduces by 13% with regard to diversifying the types of crops grown. This finding is in line with Temesgen *et al.* (2010). These authors have argued that male farmers are more capable of coping with different climate extremes than female farmers. Legesse *et al.* (2013) also indicated that the sex of a farmer is significantly and positively associated with choosing a climate change adaptation strategy. Their findings mirrored that male farmers were able to cope with the situation of increasing pressure on pasture for farm animals as well as severe shortage of animal feed by selecting some strategies . However, this result say the opposite to the finding of Apata *et al.* (2009) which indicates that there is no statistical significance between the sex of a farmer and their choice of an adaptation strategy.

Table 4.5: Results of the Multinomial Logit Adaptation Model of Rice Farmers

Variable	Migration	Irrigation	Collection Diversification
Age	-0.113***(0.044)	-0.095***(0.033)	-0.014(0.027)
Gender	16.136***(0.993)	0.972(0.918)	-0.984(0.827)
Household size	-0.224(0.175)	0.084(0.104)	0.015(0.093)
Farm size	-0.023(0.156)	-0.441***(0.155)	-0.140(0.101)
Distance	-1.228***(0.501)	-0.225(0.278)	-0.077(0.212)
No formal edu.	-6.490*** (2.137)	-4.427*** (1.723)	-3.4693**(1.511)
SSS education	-5.787***(1.984)	-29.353***(2.181)	-1.709(1.387)
JSS education	-5.647(1.377)	-3.790***(1.215)	-3.235***(1.149)
Fixed agremt.	0.4508(1.294)	1.8453*(0.988)	2.1537**(0.959)
Gift agreement	-14.697*** (2.487)	11.652***(1.299)	-16.883*** (1.915)
Experience above 20yrs	-1.472(2.578)	-2.970(2.954)	-1.660(2.291)
Experience between 11-20	-0.044(0.891)	-0.095(0.655)	0.248(0.599)
Hired labor	-1.230(1.046)	0.292(0.722)	-0.491(0.645)
Off-farm income	-4.943***(0.935)	-4.960***(0.891)	-4.284***(0.718)
Extension contact	-1.268(1.098)	0.109(0.932)	-1.016(0.810)
FBO	-0.152(1.048)	0.933(0 .734)	-0.028(0.585)
Intercept	-0.523(3.444)	9.753(3.080)	8.792***(2.892)
Observations	249	Pseudo R-square	0.430
Wald Chi-square	279.36***	Log-Likelihood	-184.995

*, **, and *** indicate statistical significance of 0.1, 0.05 and 0.001 levels respectively.

Figures in parenthesis represent standard errors.

NB: The base outcome is off-farm jobs

Source: Field Survey, 2015.

Table 4.6: Results of marginal effects of the MNL adaptation model of rice farmers

Variable	Migration	Off-farm jobs	Irrigation	Collection diversification
Age	0.000 (0.000)	0.001(0.001)	-0.003*** (0.001)	0.003*(0.002)

Gender	0.043(0.032)	0.031(0.029)	0.056***(0.017)	-0.130*** (0.046)
Household size	0.000(0.000)	0.000(0.004)	0.003(0.002)	-0.002(0.005)
Farm size	0.000(0.000)	0.007(0.005)	-0.013**(0.006)	0.006(0.008)
Distance	-0.001 (0.000)	0.004(0.009)	-0.006 (0.009)	0.003(0.014)
No formal education	0.393(0.239)	-0.042**(0.019)	-0.349 (0.229)	
SSS education	-0.000(0.000)	0.166(0.188)	-0.322*** (0.046)	0.156(0.194)
JSS education	-0.001(0.000)	0.237***(0.093)	-0.031*(0.018)	-0.205** (0.093)
Fixed agreement	-0.001* (0.000)	-0.059**(0.029)	-0.009 (0.018)	0.069**(0.035)
Gift agreement	0.000(0.000)	-0.038*(0.021)	0.968***(0.009)	-0.930*** (0.023)
Exp above 20yrs	0.000 (0.001)	0.147 (0.289)	-0.037*(0.020)	-0.120 (0.279)
Exp 11-20	0.000(0.000)	-0.010 (0.026)	-0.013 (0.016)	0.023(0.032)
Off-farm income	0.000(0.000)	0.538***(0.103)	-0.040*** (0.015)	-0.496*** (0.101)
Extension contact	0.000(0.000)	0.038(0.027)	0.041**(0.021)	-0.079** (0.036)
FBO	0.000 (0.000)	-0.001 (0.025)	0.042* (0.025)	-0.041(0.036)
Probability	0.001	0.046	0.044	0.910

*, **, and *** indicate statistical significance of 0.1, 0.05 and 0.001 levels respectively. Figures in parenthesis represent standard errors

Source: Field Survey, 2015

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents a summary of the main findings, conclusion drawn and recommendations originating from the study. It also presents the limitations of the study as well as the suggestions made for future research.

5.1 Summary

The study examined the perceptions of rice farmers about the changing climatic conditions as well as their adaptations to these conditions, taking into account household and institutional characteristics. The study was motivated by the need to provide accurate analysis of rice farmers' perception to climate change and the coping mechanisms they put in place to mitigate the adverse effects of these conditions that will inform policy formulation.

In order to choose a suitable model for this study, a detailed review of the body of literature on the standard theory of adoption was provided. Comparative assessment led to the selection of the multinomial logit model because it allows the analysis of decisions across more than two categories, determines choice probabilities for different categories and very simple to compute. The model was used to obtain the factors that influence rice farmers' decision to adapt to longterm changes in rainfall and temperature.

Among others, the following specific findings were made from the study.

5.1.1 Rice Farmers' Awareness of Climate Change

Majority of rice farmers (94%) across all the surveyed districts have noticed changes in the climatic conditions of the areas in which they operate. The most important reason for this observation is that majority of these farmers receive information on weather and climate. The main sources from which rice farmers receive information on climate were found to be radio (FM stations), television, extension officers, and personal observation by the farmer and friends. Results across the surveyed districts show that most of the farmers (>73%) interviewed received major information on weather and climate through radio sets.

5.1.2 Rice Farmers' Perception on Climate Change and Adaptation Strategies

The results reveal that 64.3% of the respondents perceive an increase in the temperature conditions. It was further shown that rice farmers (47.1%) noticed low temperature conditions in the past, giving them longer durations to do their farming activities as compared to increasing temperature conditions now, where farmers have less time to perform their farming activities.

The results also showed that most farmers (53.4%) perceived a decrease in precipitation. However, rice farmers' perception of rainfall conditions in the past showed that rainfall condition was very good and was able to sustain crop growth during the cropping season. It was also shown that rainfall patterns could be predicted when rice farmers begin their rice cultivation, but can no longer be predicted when rice farmers (14%) noticed the changes in the climatic condition. Apart from rice farmers not being able to predict rainfall patterns, the results also showed the following rice farmers' perceptions about changes in rainfall patterns; delayed rains, too much rains leading to floods and unstable rainfalls.

The analyses of rice farmers' perception of climate change by use of perception index also revealed that rice farmers were in agreement to the following perception statements; weather gets hotter, rains have become less or low and unexpected, uneven distribution of rainfall and unexpected weather conditions. Generally, the analyses gave a climate perception index of 0.59. The perception results also showed that rice farmers were in strongly agree that responding to climate change is a very important issue and very necessary (mean score=0.82). The analyses of the statement "adaptation to climate change is profitable to my farm business" also gave a mean score of 0.8 whilst the general perception of rice farmers of response to climate change gave a perception index of 0.81. The mean scores obtained after analyzing "changes in the climate threatens my farm business", "climate change impact on farm profitability" and "climate change induce farmers to make changes in farm practices" were 0.71, 0.68 and 0.74 respectively. Generally, the results showed a perception index 0.71 for rice farmers' perception of impact of climate change. The analyses of respondents perception to the statements concerning adaptation to climate change gave a mean score of 0.71 for "I have made significant changes to my farm practices due to climate change", -0.66 for "I have not made any changes to my farm practices" and -0.05 for "adaptation to other problems was more important than to climate change". The overall adaptation perception index was shown to be 0.005. Again, the results of the study established that the mean scores for the effectiveness of adaptation options statements; "frequent migration to urban areas", "change crop variety", "change from crop to livestock production", "farm profit will increase or maintained", "threat on farm business will be reduced", "commodity prices will increase with adaptation in our life time" and "increased demand for new varieties and other inputs" were found to be 0.61, -0.5, 0.53, -0.61, 0.66, 0.65 and 0.52 respectively. The perception index for these statements on the effectiveness of adaptation options was shown to be 0.27.

The overall perception index was shown to be 0.5.

5.1.3 Choice of Rice Farmers' Adaptation Strategies

The results across the surveyed districts indicate that the main climate change adaptation measures that rice farmers use to cope with the changing climatic conditions are migrating to urban areas, crop diversification, making of bonds (irrigation) and off-farm jobs.

5.1.4 Determinants of Rice Farmers Choice of Climate Change Adaptation Strategies

The principal determinants of rice farmers' choice of climate change adaptation strategies in all the surveyed districts were identified to include age of the rice farmer, size of a rice farmers' household, size of the farm, educational level of a rice farmer, farming experience, tenancy agreement, income earned from off-farm jobs and the gender of the rice farmer.

Among the significant determinants of rice farmers' choice of migration and the making of bonds (irrigation) as an adaptation strategy is the age of the rice farmer. The age of the farmer significantly but negatively affects rice farmers' decision to migrate as well as making of bonds in the face of changing climatic conditions. This means that as one ages, the likelihood of such a farmer migrating to any urban city in search of jobs is reduced. Thus, rice farmers who are capable of resorting to migration in the face of climate change are the young. The results has also shown that a unit increase in a farmers' age reduces the probability of the farmer making bonds in his or her rice field by 0.3%, but increases the probability of the farmer diversifying his or her crops by 0.3%.

The empirical results also showed that a rice farmer's decision of not taking up any adaptation strategy was significantly but negatively related to the number of persons in the farmer's house. Results of the marginal effect of size of the farmer's household size was however insignificant. Again, the results of the study revealed a significant and a negative relationship between the probability of rice farmers choosing to make bonds in their rice fields and the size of a farmers' farm. The results also showed that a unit change in the size of the farm reduces the probability of a rice farmer making bonds by 1.3%. The results also showed a negative correlation between the distance from a rice farmers' house to his or her farm to the farm and the probability of travelling to any urban area in search of new jobs, should there be any change in the climate of the farmer's operational area.

The educational level of a rice farmer was also found to have a negative influence on a rice farmers' decision to adapt to climate change. The results indicated that the higher the educational level attained by a rice farmer, the lower the probability of the farmer putting in place any measure to lessen the effects of climate change on the farmer's household. The results showed that for rice farmer to have no form of formal education had a significant but a negative impact on the farmer's decision to adapt any climate change adaptation strategy. Having graduated from JHS was also found to have a reduced tendency of not adapting at all, whereas senior high graduates were found to have a reduced probability of migrating as well as making of bonds on their farms.

The results also showed that rice farming experience above 20 years had a negative influence on the farmer's decision of not adapting any climate change adaptation strategy to mitigate the effects of climate change.

Gift acquisition of one's farm land also showed a significant but a negative influence on a rice farmer's decision to migrate and also diversify the types of crops grown on their fields. However, fixed agreement between rice farmer and land owner showed a significant and a positive influence on rice farmer's decision to diversify their crops. Results of the marginal effects revealed that fixed land agreement reduces the probability of rice farmers migrating and engaging in off-farm jobs by 0.054% and 5.9% respectively, but increases the probability of these farmers choosing to diversify their crops by 6.9%.

The empirical result showed that off-farm income had a significant and negative influence on a rice farmer's decision to adapt. Farmers who earn some amounts of off-farm income were shown to have a reduced probability making bonds, migrate as well as diversify their crop types. The MNL regression analysis has also mirrored that being male rice farmers appear to have an increased likelihood of migrating in face of changing climatic conditions (P=0.000). The result indicated that the probability of male farmers making bonds increases by 5.6%, but reduces by 13% with regard to diversifying the types of crops grown.

Lack of financial resources, high cost of labor and inputs and transportation problems are the most pressing problems facing rice producers in the surveyed districts.

5.2 Conclusion

Climate change is anticipated to have significant impacts on Ghana. Although there will be variations in both annual temperatures and precipitation, there is the tendency of warming in all the regions in the near future due to the changing trends of temperature conditions in the country. Because Ghana's economy is predominantly based on agriculture, it will suffer severe economic consequences from climate change. The need to understand rice farmers' perceptions and adaptations to climate change which make them resilient is therefore relevant. This study examined the perceptions and adaptations of rice farmers to climate change in the Ashanti and Northern regions of Ghana. Due to the expected impact of water stress, reduced food security and extremities in weather caused by changes in climatic conditions, it is very useful to identify and improve farmers' adaptive strategies to climate change so as to reduce their vulnerability.

In conclusions, majority of rice farmers from both the Ashanti and Northern regions receive weather and climate information and are also aware of the changes occurring in the climatic condition. It was also shown that most of the rice farmers are conscious of climate change adaptation strategies and thus implement these strategies when changes in climatic conditions occur. With regard to farmers' perception of climate and adaptation, majority of farmers perceived increase in temperature and decline in rainfall patterns. Perception index results revealed that rice farmers are conscious of the changes in temperature and rainfall patterns in the study areas. It also indicated that farmers agree with most climate change perception statements. The types of climate change adaptation strategies used by rice farmers include crop diversification, migrating to urban areas in case of failure of the rice crop, making of bonds in their rice fields (irrigation) and engaging in off-farm jobs. However, lack of financial resources, high cost of labor and inputs, transportation problems, shortage of agricultural land, insecure property rights were reported to be the constraints to adaptation. Using a multinomial logit model, econometric investigation revealed that the probability of rice farmers deciding to cope with climate change decreases with household size, farm size, educational level of the farmer, gift acquisition of one's rice field and off-farm income. However, being a male rice farmer and fixed agreement between land owner and the rice farmer increase the probability of farmer's choosing an adaptation to climate change.

5.3 Recommendations

From the findings of the study, the following recommendations are made to improve the awareness and perception of rice farmers of climate change as well as the adaptive capacity of farmers so as to encourage the cultivation of the rice crop to increase the output of rice in the country.

1. Rice farmers who engage in off-farm jobs to earn income tend to have a reduced likelihood of adapting to climate change. Provision of affordable credit may help to promote adaptation as this can help the rice farmers to settle any cost incurred during the process of adaptation and also buy other farming inputs needed in the rice farming business.
2. The findings on the relationship between the acquisition of a farm land and the likelihood of a rice farmer adopting an adaptation strategy suggests that proper acquisition of land increases of the likelihood of the farmer to put in place measures to mitigate the effects of climate change. In particular fixed agreement in land acquisition will encourage the rice farmer to diversify the types of crops grown. Therefore, land acquisition and property rights should be clearly defined.
3. Rice farmers who acquire more experience and skill in the farming business are more likely to cope with climate change. The Ministry of Food and Agriculture should therefore intensify its visits by training and educating these rice farmers on the changing climatic conditions.
4. Rice farmers should properly manage their off-farm income-earning opportunities so that these jobs do not interfere with their farm activities.
5. The findings on the relationship between a farmer's age and the likelihood of the farmer adopting an adaptation strategy suggests younger farmers are more likely to migrate to urban areas when faced with climate change. They are most likely to construct bonds on their rice fields when faced with changes in the climatic conditions. It is therefore expected that these group of farmers be encouraged and motivated to go into the rice farming business.

6. Policy should also aim at improving and mechanizing the bonding method of irrigation on rice fields as farmers with very large rice fields are not able to invest in the method.

5.4 Limitations of the Study

The study is limited in its findings in the following ways:

1. The study takes into account the perceptions and adaptations of farmers of a single crop type (rice), however in practice decisions are made on the basis of rotating the kinds of crops grown.
2. This study also suffers from the weakness associated with survey interviews when data accuracy depended heavily on the respondent's ability to recall past information about the climate and to answer survey questions accurately.

5.5 Suggestions for Future Research

On the basis of the present study, the following suggestions can be made for possible future research. The impact of rice farmers' adaptation to climate change on their household food security is an interesting topic to explore. Further study can also take into account the possibility of conducting multi crop farmers' adaptations to climate change in Ghana.

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APPENDICES APPENDIX A: QUESTIONNAIRE FOR RICE FARMERS

Name of the interviewer………………………… Date of interview…………………..

Name of the respondent…………………………. Region………................................

Questionnaire Number…………………………...... District...

Respondent's Contact Number…………………...... Community…………………………....

PERSONAL AND HOUSEHOLD CHARACTERISTICS

1. Gender of respondent

1=Male [ ]

0=Female [ ]

2. Age of respondent……………………years

3. Marital status

1= Single [ ]

2= Married [ ]

4. Are you a native of the community?

1=Yes [ ] 2=No [ ]

5. Religion

1=None [ ]

2=Christian [ ]

3=Muslim [ ]

4=Traditionalist [ ]

5=Others (Specify)……………………………………..

6. Ethnicity

1=Ashanti [ ] 2=Fante

3=Northerner [ ]

4=Ewe [ ]

5=Bono [ ]

6=Others (Specify)……………………………………..

7. (i) What is your total household size?................................

(ii) Number of children………………………… (iii)

Children with age <15 years……………………… (iv)

Children with age >15 years……………………….

8. What is your highest level of education?

1=None [ ]

2=Primary [ ]

3=JHS/Middle [ ]

4=SHS/Technical [ ]

5=Tertiary [ ]

6= Others (Specify)……………………………………..

FARM CHARACTERISTICS

9. What is the distance of your farm from your house?..

10. What is the type of soil on your farm?..

11. Is the soil on your farm able to support the growth of plants?

1=Yes [ ]   2=No [ ]

[ ]

12. What is the vegetation on your farm?

1=Shallow rooted vegetation or crops [ ]

2=Deep rooted vegetation or crops [ ] 3=Others (specify)………………………………………………………………

13. Is your farm plot located on a slope?

1=Yes [ ] 2=No [ ]

14. What is your farm size?..............................acres.

15. (i) Are you a tenant or landowner?...

(ii) If tenant, what type of contract have you entered with landowner?

1=Fixed rent [ ]

2=Share cropping [ ]

3=Gift [ ]

4=Others (Specify)……………………………………..

RICE CULTIVATION AND ON-FARM INCOME

16. How long have been a rice farmer?......................................years

17. (i) What is the major source of labour for your rice production activities?

1=Family [ ]

2=Hired [ ]

3=Others (Specify)…………………………………….

18. (i) Do you grow only rice on your farm plot (mono cropping)?

1=Yes [ ]

0=No [ ]

19. If yes, why…………………………………………………….

20. If no, what crops do you grow apart from rice and why?

....

21. What is the quantity of rice output for the 2013 crop season?..............……mini/maxi bags.

22. What was the price per mini/maxi bag? Gh¢………………………………

23. Do you receive any income for cultivating other crops apart from rice?

1=Yes [ ] 0=No [ ]

24. If yes, approximately what was your total household farm income from various sources last year?

Crops	**Quantity sold**	**Unit Price (**Gh¢**)**	**Total value (**Gh¢**)**
Yam			
Beans			
Vegetables			
Cocoa			
Plantain			
Cassava			
Others (Specify)			
Livestock			
Cattle			
Sheep			
Goat			
Guinea fowl			
Chicken			
Others (Specify)			

OFF-FARM INCOME GENERATION

25. What is your major occupation?

1=Farming [ ]
2=Trading [ ]
3=Salary worker [ ]
4=Artisan [ ]
5=Others

(Specify)………………………………………………………………………………..

26. Do you receive any off-farm income?

1=Yes [ ]

0=No [ ]

27. If yes, indicate the non-farm activity you engaged in, in 2013

1	Self-employment	Type of business?		
		Hours spent on the work every day?		
		Costs (Gh¢) of business in 2013?		
		Income (Gh¢) from the business in 2013?		
2	Non-agricultural wage employment	Actual job		
		Number of days used for this work		
		Monthly wage (in cedi)		
3	Off-farm agricultural employment(e.g. hired labour)	Actual job		
		Number of days used for this work		
		Daily wage (Gh¢)		

28. Household income from remittances:

i) In cash

(GH¢)……………………………………………………………………………………

ii) In kind

………………………………………………………………………………………………

iii) Value of remittance in kind

(GH¢)……………………………………………………………

INSTITUTIONAL CHARACTERISTICS Extension and veterinary contacts

29. Do you have access to any extension or veterinary services?

	1= yes		2 = No
	Very often	Not often	Not at all
Extension			

Veterinary			

Credit acquisition

30. Did you have access to credit in 2013crop season? Yes [ ] No [ ]

31. If yes, in what form was the credit accessed? Cash [ ] Inputs [ ] others (specify)

....

32. If yes, provide the information below

Source of credit	Amount of credit (GH¢)	Mode of payment a) in-cash b)in-kind
Informal sources		
Family / relatives		
Friends		
Money lenders		
Formal sources		
Banks		
NGO's		
MCA		
Others (specify)		

33. (i) Do you belong to any farmer based organization?

1=Yes [ ]

0=No [ ]

(ii) If yes, what are their names and their assistance to farmers?

Number	Name of organization	Assistance to farmers

......

FARMERS' AWARENESS AND OF CLIMATE CHANGE

34. Do you get information about weather and climate?
    1= Yes [ ]   0 = No [ ]

35. If yes, what is the source of information on climate or weather?...
....
......

36. Do you use climate data or information to assist you in your farming activities?

    1=Yes [ ]   0=No [ ]

37. Have you noticed any change the climatic condition?

    1=Yes [ ]   0=No [ ]

38. What was the nature of the climate (in terms of rainfall and temperature conditions) 20 years ago?...

39. What is the nature of the climate (in terms of rainfall and temperature conditions) now?

…………………………………………………………………………………………………

40. Comparing the past and present, have you noticed any changes in the climatic condition?

    1=Yes [ ]

    0=No [ ]

41. Since when did you notice these changes?...

42. Can you give a list of the changes which have occurred?..

43. Has the number of hot days stayed the same, increased, or declined over the last 20 years?

....

44. Has the number of rainfall days stayed the same, increased, or declined over the last 20 years?...

45. What is your opinion about the causes of climate change? ....

FARMERS' PERCEPTION ON CLIMATE CHANGE

46. Please tick the perception statement(s) that apply to you.

Perception	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Weather conditions					
The weather gets hotter;					
rains have become less unexpected over the years					
The weather becomes more unpredictable from year to year					
Uneven rainfall distribution will increase in our lifetime					
Farmers response					
Responding to climate change is most important issue for farm business					
Farmers' response to changes in climate is very necessary?					
Responding to climate change is profitable to farm business					
Impact of climate change					
changes in climate is a threat to farm business					
Climate change impact on farm profitability					
Climate changes induce farmers to make changes in their farm practices					

FARMERS' AWARENESS OF CLIMATE CHANGE AND ADAPTATION OPTIONS

47. Have you made any adjustments in farming in response to climate change?

    1=Yes [ ]   0=No [ ]

48. What adjustments in your farming have you made to these long-term shifts (if any) in temperature? Please list...

49. What adjustments in your farming have you made to these long-term shifts (if any) in rainfall? Please list below.

....

50. (i) Do you use any of the following as an adjustment to the changes in the climatic condition?

CODE	ADAPTATION OPTION	YES	NO	IF Yes, what is the extent of adoption in years?
0	Change of planting dates			
1	Planting short duration crops			
2	Migrating to urban areas			
3	Crop diversification			
4	Change from crop to livestock production			
5	Construction of bonds			
6	Off-farm jobs			
7	Mixed cropping			
8	Engaging in dry season vegetable production			

51. Please tick the perception statement(s) about adaptation options that apply to you

Perception	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Type of adaptation option					
I have made significant changes to my farm practices because of climate change.					
I have not made any changes to my farm practices.					
I believe it is not necessary to respond to climate change.					
I think adaptation to other problems is more important than adaptation to climate change.					
Effectiveness of adaptation option					

Increased demand for new varieties and other inputs.					
Frequent migration to urban areas.					
Change crop variety.					
Change from crop to livestock production.					
Impact of adaptation option					
Farm profitability will increase or maintained.					
Threat on farm business will be reduced.					
Commodity prices will likely rise with adaptation in our lifetime.					

Constraint to farmers' adoption of climate change adaptation options

52. What constraints do you face in the adoption of climate change adaptation options? Determine the extent of severity of constraint

Constraint/Problem	Very High	High	Low	Very low	None
Change of planting dates					
Off-farm employment					
Lack of knowledge on adaptation strategy					
Labour constraints					
Lack of information on climate change					
Transport problems (Access to markets)					
Insecure property rights					

Planting short duration crops					
Off-farm employment					
Lack of knowledge on adaptation strategy					
Shortage of land					
Labour constraints					
Lack of inputs (eg. seeds)					
No barriers					
Lack of information on climate change					
Transport problems (Access to markets)					
Migrating to urban areas					
Lack of financial resources					
Lack of knowledge on adaptation strategy					
Lack of information on climate change					
Crop diversification					
Lack of financial resources					
Off-farm employment					
Lack of knowledge on adaptation strategy					
Shortage of land					
Labour constraints					
No barriers					
Lack of information on climate change					
Transport problems (Access to markets)					

Change from crop to livestock production					
Off-farm employment					
Lack of knowledge on adaptation strategy					

Lack of financial resources					
Shortage of land					
Labour constraints					
Lack of information on climate change					
No barriers					
Transport problems (Access to markets)					
Off-farm jobs					
Lack of financial resources					

Labour constraints					
No barriers					
Mixed cropping					
Off-farm employment					
Lack of knowledge on adaptation strategy					

Lack of financial resources					
Labour constraints					
Lack of information on climate change					
Making of Bond (Irrigation)					
Off-farm employment					
Lack of knowledge on adaptation strategy					
Labour constraints					
Lack of information on climate change					
No access to water					

APPENDIX B: RESULTS OF THE MULTINOMIAL LOGIT ADAPTATION MODEL

mlogit adaptchoice age gen household size distance no_formal sss_edu jss_edu fixed_agrment gift_agrment exp_abov20 exp_11_20 hired_lab > off_incom ext_contact fbo , baseoutcome(2) vce(robust)

Iteration 0: log pseudolikelihood = -324.67415
Iteration 1: log pseudolikelihood = -225.11582
Iteration 2: log pseudolikelihood = -194.27093
Iteration 3: log pseudolikelihood = -186.42673
Iteration 4: log pseudolikelihood = -185.20806
Iteration 5: log pseudolikelihood = -185.04458
Iteration 6: log pseudolikelihood = -185.0061
Iteration 7: log pseudolikelihood = -184.99665
Iteration 8: log pseudolikelihood = -184.995
Iteration 9: log pseudolikelihood = -184.9948
Iteration 10: log pseudolikelihood = -184.99476
Iteration 11: log pseudolikelihood = -184.99475

Multinomial logistic regression	Number of obs	=	249
	Wald chi^2 (62)	=	279.36
	Prob > chi^2	=	0.0000
Log pseudolikelihood = -184.99475	Pseudo R^2	=	0.4302

adaptchoice	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
age	-.1124662	.0436924	-2.57	0.010	-.1981017	-.0268306
gen	16.13569	.9933879	16.24	0.000	14.18868	18.08269
household	-.2236893	.1745806	-1.28	0.200	-.5658611	.1184824
size	-.023172	.1559667	-0.15	0.882	-.3288612	.2825171
distance	-1.22828	.5013979	-2.45	0.014	-2.211002	-.2455585
no_formal	-6.49009	2.136699	-3.04	0.002	-10.67794	-2.302238
sss_edu	-5.787073	1.984326	-2.92	0.004	-9.67628	-1.897866
jss_edu	-5.647421	1.376858	-4.10	0.000	-8.346013	-2.948828
fixed_agreement	.4508481	1.293957	0.35	0.728	-2.085261	2.986957
gift_agrment	-14.69708	2.486972	-5.91	0.000	-19.57145	-9.822701
exp_abov20	-1.472105	2.578389	-0.57	0.568	-6.525655	3.581444
exp_11_20	-.0443279	.8905895	-0.05	0.960	-1.789851	1.701195

hired_labor	-1.230037	1.045769	-1.18	0.240	-3.279707	.8196333
off_income	-4.942965	.9349345	-5.29	0.000	-6.775403	-3.110527
ext_contact	-1.267509	1.097604	-1.15	0.248	-3.418774	.8837564
					-2.207273	1.902753
					-7.272767	6.22651
2	(base outcome)					

Multinomial logistic regression continued

adaptchoice		Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
3	age	-.0954463	.0328957	-2.90	0.004	-.1599206	-.0309719
	gen	.97179	.9175206	1.06	0.290	-.8265174	2.770097
			.104042	0.81	0.418	-.119573	.2882643
			.1547297	-2.85	0.004	-.7439756	-.1374463
			.2784995	-0.81	0.420	-.770624	.3210741
			1.723225	-2.57	0.010		
			2.180958	-13.46	0.000		
			1.214879	-3.12	0.002		
			.9875341	1.87	0.062		
	gift_agrment	11.65219	1.299071	8.97	0.000	9.106053	14.19832

fbo -.1522603 1.048495 -0.15 0.885 _cons -
.5231282 3.443756 -0.15 0.879

household .0843457
size -.4407109
distance -.2247749
no_formal edu -4.42729 -7.804749 -1.049831 sss_edu -29.35285 -33.62744 -25.07825 jss_edu -3.790106 -6.171225 -1.408987

fixed_agreement	1.845257				-.0902745	3.780788
exp_abov20	-2.970022	2.953874	-1.01	0.315	-8.759508	2.819465
exp_11_20	-.0951734	.6546414	-0.15	0.884	-1.378247	1.1879
hired_labor	.2923826	.7215142	0.41	0.685	-1.121759	1.706524
off_income	-4.960077	.8907558	-5.57	0.000	-6.705926	-3.214228
ext_contact	.1090374	.9318068	0.12	0.907	-1.71727	1.935345
fbo	.9334399	.7341831	1.27	0.204	-.5055326	2.372412
_cons	9.752809	3.079527	3.17	0.002	3.717047	15.78857

4 age -.0141685 .0268027 -0.53 0.597 -.0667009 .0383639 gen -.9838958 .8266864 -1.19 0.234 -2.604171 .6363798 household .0150228 .0927161 0.16 0.871 -.1666974 .1967429 size -.1395036 .1006704 -1.39 0.166 -.3368139 .0578067 distance -.0766252 .2117248 -0.36 0.717 -.4915982 .3383478
no_formal edu -3.469287 1.511419 -2.30 0.022 -6.431614 -.5069593 sss_edu -1.709319 1.38688 -1.23 0.218 -4.427554 1.008915 jss_edu -3.234809 1.149083 -2.82 0.005 -5.48697 -.9826474
fixed_agreement 2.153666 .9585315 2.25 0.025 .2749785 4.032353 gift_agrment -16.88306 1.915009 -8.82 0.000 -20.63641 -13.12971 exp_abov20 -1.66025 2.291348 -0.72 0.469 -6.151209 2.83071 exp_11_20 .2478621 .5993284 0.41 0.679 -.9268 1.422524 hired_labor -.4905517 .6453067 -0.76 0.447 -1.75533 .7742262 off_income -4.283717 .7182083 -5.96 0.000 -5.691379 -2.876054 ext_contact -1.015917 .8097087 -1.25 0.210 -2.602917 .5710824 fbo -.0280044 .5846273 -0.05 0.962 -1.173853 1.117844

_cons	8.791768	2.891968	3.04	0.002	3.123615	14.45992

APPENDIX C: MARGINAL EFFECTS AFTER MULTINOMIAL LOGIT

Marginal effects after mlogit

size	.0000616	.00009	0.68	0.496	-.000116 .000239	3.21586
distance	-.0005743	.00036	-1.60	0.111	-.00128 .000131	1.76636
no_for~l*	-.0009943					.232932
sss_edu*	-.0004931	.00034	-1.43	0.152	-.001168 .000182	.084337
jss_edu*	-.0012653	.00096	-1.32	0.188	-.003148 .000618	.405622
fixed_~t*	-.0005438	.00032	-1.72	0.085	-.001162 .000074	.192771
gift_a~t*	-.0004978	.0004	-1.26	0.208	-.001272 .000277	.012048
exp_a~20*	.0000305	.0006	0.05	0.960	-.001155 .001216	.076305
exp_1~20*	-.0001271	.00038	-0.33	0.740	-.000876 .000622	.305221
hired_~b*	-.0003829	.0003	-1.27	0.204	-.000974 .000208	.417671
off_in~m*	-.0004559	.00033	-1.38	0.166	-.001101 .000189	.24498
ext_co~t*	-.0001764	.00044	-0.41	0.685	-.001029 .000676	.64257
fbo*	-.0000844	.00044	-0.19	0.847	-.00094 .000771	.473896

y = Pr(adaptchoice==1) (predict, outcome(1))
= .00050024

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]	X
age	-.0000477	.00004	-1.16	0.248	-.000129 .000033	41.7952
gen*	.0429147	.032	1.34	0.180	-.019807 .105637	.73494
househ~d	-.0001205	.00008	-1.55	0.122	-.000273 .000032	8.00402

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]	X
age	.0007846	.00114	0.69	0.489	-.00144 .003009	41.7952
gen*	.0309887	.0293	1.06	0.290	-.026431 .088409	.73494
househ~d	-.0007898	.00423	-0.19	0.852	-.009084 .007505	8.00402
size	.0066998	.00542	1.24	0.217	-.003932 .017331	3.21586
distance	.0036733	.00861	0.43	0.670	-.013196 .020543	1.76636
no_for~l*	.392573	.23872	1.64	0.100	-.075319 .860465	.232932
sss_edu*	.1657864	.18779	0.88	0.377	-.202282 .533855	.084337
jss_edu*	.2371044	.09268	2.56	0.011	.055447 .418762	.405622
fixed_~t*	-.0591466	.02927	-2.02	0.043	-.116518 -.001775	.192771
gift_a~t*	-.0381812	.02098	-1.82	0.069	-.079311 .002948	.012048
exp_a~20*	.1465381	.28899	0.51	0.612	-.419865 .712941	.076305
exp_1~20*	-.0097816	.02595	-0.38	0.706	-.06064 .041077	.305221
hired_~b*	.0204968	.03102	0.66	0.509	-.040303 .081296	.417671
off_in~m*	.5375952	.10316	5.21	0.000	.335411 .739779	.24498
ext_co~t*	.0382786	.0272	1.41	0.159	-.015042 .091599	.64257
fbo*	-.000809	.02536	-0.03	0.975	-.050508 .04889	.473896

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Marginal effects after mlogit
y = Pr(adaptchoice==2) (predict, outcome(2))
= .04581535

(*) dy/dx is for discrete change of dummy variable from 0 to 1 Marginal effects after mlogit

househ~d	.0029372	.00243	1.21	0.226	-.001822 .007696	8.00402
size	-.0128891	.00561	-2.30	0.022	-.02389 -.001888	3.21586
distance	-.006329	.00947	-0.67	0.504	-.024887 .012229	1.76636
no_for~l*	-.0422568	.0186	-2.27	0.023	-.078713 -.0058	.232932
sss_edu*	-.3215881	.04596	-7.00	0.000	-.411673 -.231503	.084337
jss_edu*	-.0309604	.01803	-1.72	0.086	-.066308 .004387	.405622
fixed_~t*	-.0094177	.01759	-0.54	0.592	-.043889 .025054	.192771
gift_a~t*	.9682822	.00903	107.28	0.000	.950592 .985973	.012048
exp_a~20*	-.0369181	.01972	-1.87	0.061	-.075562 .001726	.076305
exp_1~20*	-.013122	.01589	-0.83	0.409	-.044263 .01802	.305221
hired_~b*	.0341591	.02406	1.42	0.156	-.013005 .081323	.417671
off_in~m*	-.040272	.01499	-2.69	0.007	-.069655 -.010889	.24498
ext_co~t*	.0405838	.021	1.93	0.053	-.000583 .08175	.64257
fbo*	.0422876	.02545	1.66	0.097	-.007592 .092167	.473896

y = Pr(adaptchoice==3) (predict, outcome(3))
= .04376949

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]	X
age	-.003428	.00114	-3.00	0.003	-.005669 -.001187	41.7952
gen*	.0564238	.01687	3.35	0.001	.023363 .089484	.73494

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]	X
age	.002691	.00158	1.70	0.089	-.000408 .00579	41.7952
gen*	-.1302723	.04641	-2.81	0.005	-.221226 -.039318	.73494
househ~d	-.0020169	.00462	-0.44	0.663	-.011081 .007047	8.00402
size	.0061247	.00756	0.81	0.418	-.008691 .020941	3.21586
distance	.0032319	.01383	0.23	0.815	-.023879 .030343	1.76636
no_for~l*	-.3493206	.22886	-1.53	0.127	-.797881 .099239	.232932
sss_edu*	.1563295	.19448	0.80	0.422	-.22485 .537509	.084337
jss_edu*	-.2048474	.09313	-2.20	0.028	-.387387 -.022308	.405622
fixed_~t*	.0691143	.03514	1.97	0.049	.000235 .137993	.192771
gift_a~t*	-.9295943	.0233	-39.90	0.000	-.975254 -.883934	.012048
exp_a~20*	-.1096187	.27885	-0.39	0.694	-.656163 .436925	.076305
exp_1~20*	.0230175	.03206	0.72	0.473	-.039818 .085853	.305221
hired_~b*	-.0542406	.03862	-1.40	0.160	-.129934 .021452	.417671
off_in~m*	-.4963481	.10054	-4.94	0.000	-.693405 -.299291	.24498
ext_co~t*	-.0786912	.03625	-2.17	0.030	-.149744 -.007638	.64257
fbo*	-.0413832	.03619	-1.14	0.253	-.112318 .029551	.473896

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Marginal effects after mlogit y = Pr(adaptchoice==4) (predict, outcome(4))
= .90990406

(*) dy/dx is for discrete change of dummy variable from 0 to 1