MASTER'S THESIS

UNIVERSITY OF THE GAMBIA

TOPIC

FARMERS' AWARENESS AND RESPONSE TO CLIMATE CHANGE IN KAFFRINE REGION, SENEGAL

By

Baba Libasse Sow

Mat. No: 21719410

Farafenni Campus, North Bank Region, 2018

This thesis is being submitted in partial fulfilment of requirements for award of Master of Science Degree in Climate Change and Education at the School of Education of the University The Gambia.

Major Supervisor: Dr. Alagie Bah

Co-supervisor: Dr. Papa Sow

Director of Program: Dr. Sidat Yaffa

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MASTER'S RESEARCH PROGRAM ON CLIMATE CHANGE AND EDUCATION

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Date of the thesis Defense: 1st March, 2018. **Place:** UTG School of Law, Kanifing

Declaration

I, Baba Libasse Sow declare that “FARMERS’ AWARENESS AND RESPONSE TO CLIMATE CHANGE IN KAFFRINE REGION, SENEGAL” is my personal work and I have not used any sources and others than those have been indicated in the references. This thesis has not previously been submitted for any degree or examination. No part of this thesis may be reproduced without prior permission from the author and or the University of The Gambia.

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Abstract

This study analyses farmers' awareness on climate change and adaptation strategies in Kaffrine Region of Senegal. A better understanding of this awareness would help identify knowledge gaps of farmers on climatic change, and would help equip them with the requisite knowledge and skills on climatic change to boost crop yields. The study is based on a cross-sectional survey of 204 farmer household heads selected from nine communities through a multi-stage sampling technique. Data for this study were also collected from 9 focus group discussions and 9 key informant interviews. To analyze the data obtained from the households, a logistic model, climate change awareness index, and descriptive statistics were used for this study. The results of the study reveal that 64.7% of the respondents were aware of climatic change with an average awareness index of 0.5903 (59.03%). Also, a large number of surveyed farmers representing (90.2%), responded to the changing climate by adopting one or more adaptation strategies such as using different planting dates, using drought resistant crops, practicing crop diversification and crop rotation, cultivating early maturing varieties, applying chemical fertilizers, prayer/ritual offerings, implementing soil and water conservation methods, and changing the area/size of farm land. However, the major challenges inhibiting farmers' adaptation to climate change are labor constraint, inadequate credit, inadequate access to information and poor skills, inadequate access to efficient inputs, and inadequate access to land. The findings of the logistic regression model revealed that farming experience, farm land size, awareness of climate change, age, household size and educational level significantly influence farmers' response to climatic change in the study area. The study suggests that the government of Senegal should develop more effective climatic change adaptation strategies as well as improve dissemination of information to farmers through extension officers in order to increase adoption of effective climatic change adaptation strategies. Also, it would be crucial that farmers collaborate to form farmer organization to enable them have easy access to farm inputs and training on climate change in order to reduce their vulnerability and increase their resilience to the changing climate.

Keywords: Senegal, Climate Change, Adaptation, Climate Change Awareness Index

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Dedication

This thesis is dedicated to my Dear Mother Marie Ba, my Father Abdoulaye Sow for their continuous prayers, love and assistance. I would like also to dedicate it to my Wife Aminata Sow and my entire family for their invaluable assistance and advice.

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List of Abbreviations and Acronyms

AMCEN-African Ministerial Conference on Environment

ANACIM- Agence Nationale de l'Aviation Civile et de la Météorologie

ANSD- Agence Nationale de Statistique et de la Demographie

APF- Africa Partnership Forum

ARD- Agence Régionale de Developpement

ATPS- African Technology Policy Studies

CEC- Commission of the European Communities

CH_4- methane

C/N- Carbon and Nitrogen

CO_2- carbon dioxide

DAPSA- Direction de l’Analyse et de la Prévisions Statistiques Agricoles

DoI- Diffusion of Innovation

FAO- Food and Agriculture Organization (United Nations)

FBOs- Farmer Based Organizations

FGD- Focus Group Discussion

GDP- Growth Domestic Product

$GgCO_2eq$- Giga grams CO_2 equivalence

GHG- Green House Gases

ied AFRIQUE- Innovations Environnement Developpement

IPCC - Intergovernmental Panel on Climate Change

MDGs- Millennium Development Goals

NGO- Non-Governmental Organization

N_2O - nitric oxide

PANA- Plan d'Action National pour l'Adaptation aux changements climatiques

ppm- parts per million

PRACAS- Programme de Relance et d'Accélération de la Cadence de l'Agriculture au Sénégal

PSE- Plan Senegal Emergent

OECD- The Organisation for Economic Co-operation and Development

SPSS - Statistical Package for Social Scientists

SSA- Sub-Saharan African

STATA- Statistics and data

UNCTAD- United Nations Conference on Trade and Development

UNDP- United Nations Development Program

UNEP- United Nations Environmental Programme

UNESCO- United Nations Educational, Scientific and Cultural Organization

UNFCCC- United Nations Framework Convention for Climate Change

WB- World Bank

WMO- World Meteorological Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Climate change is one of the most critical challenges facing the global community today. According to the Intergovernmental Panel on Climate Change (IPCC) the average global temperature has increased with many unprecedented changes observed over decades to millennia (IPCC, 2013). Human activities such as deforestation, burning of fossil fuels, among others are the principal causes of the current changes in climate (IPCC, 2007c). Globally, climate change adversely affects livelihood activities such as farming through the occurrence of diverse extreme events such as cyclones, floods, droughts, and unpredictable rainfall patterns (Urama & Ozor, 2010). According to IPCC (2007a), although the impact of climate change is global, Africa is one of the regions that are most affected by the changing climate due to the vulnerable nature of the continent in terms of climate variability and climate change.

Climate predictions for the African Sahel indicate increases in average rainfall, rising temperatures, higher frequency of extreme events, and greater evapotranspiration (IPCC, 2014). The changes in rainfall and temperature patterns affect considerably agriculture, particularly in tropical regions where the reduction in low agricultural yields and land quality have been reported (IPCC, 2007a). The evidence that climate change will adversely affect agriculture in sub-Saharan Africa (SSA) has become a crucial challenge for sustainable development of the continent. This challenge is composed of the likely impacts on ecosystem services, agricultural production, and livelihoods (Juana *et al*., 2013). Generally, losses in the agriculture sector due to climate change causes wide economic consequences such as loss in gross domestic output, a decline in the income or consumption of the most vulnerable population; hence, a general deterioration in households' welfare (Juana *et al*., 2013). According to FAO (2008) rain-fed agriculture is considerably threatened resulting in general food insecurity. From food security and nutrition to sustainable management of natural resources, climate change is a significant threat to the welfare of millions of the continents rural poor. If adequate measures are not taken to adapt to the adverse consequences of climate change in SSA, the region will remain vulnerable to the widespread effects of climate change (FAO, 2009).

Prediction results showed that a loss of 2 - 7% of Gross Domestic Product (GDP) by 2100 in parts of SSA will occur (FAO, 2009). It has been reported that about 840 million people were malnourished between 1998-2000 of which 799 million were in the developing world (Clover, 2003). According to Hùng (2009) in 2005, 777 million people experienced food insecurity in 70 lower income countries in the world of which many African countries were victims. Food insecurity and increasing hunger are the consequences of the changing climate as it reduces the production potentials of crops (Parry, 2007). Climate change has resulted in low crop productivity, and climate change related losses in crop yields are projected to reach 50% in some countries of SSA by 2050 (IPCC, 2007). This considerable situation would severely compromise food security in many African countries (Zinyengere *et al*., 2014). According to IPCC the impacts, effects, and risks of climate change can be reduced and managed through mitigation and adaptation (IPCC, 2014). Thus, to deal with the adverse consequences of anthropogenic climate change, there is a need to adopt different adaptation and mitigation strategies in order to solve the threat food insecurity in the world.

Although, the impact of the changing climate is a global concern, its effects are regional, national and local (IPCC, 2007a). In addition, the potential effects of the changing climate are unevenly distributed, both between and within countries (O'Brien & Leichenko, 2008). Agriculture is the most important source of livelihood for millions of people in Africa (Denkyirah *et al.*, 2017). According to Kotir (2011), sub-Saharan Africa (SSA) is noted to be the region that is most vulnerable to many adverse effects of climate change because of her high dependence on rain-fed agriculture for economic growth, food security, coupled with low adaptive capacity. Therefore, variations in temperature and rainfall patterns adversely impact their social survival and economic lives (APF, 2007). Because the main long-term impacts include significant changes in temperature and rainfall patterns which affect agriculture, there is a projected significant reduction in food security; worsening water security; and rising water stress (APF, 2007). Agriculture is one of the most vulnerable areas or sectors to climate change in Africa (FAO, 2009). According to Sharma (2011), about 93% of cultivated land in SSA is rain-fed agriculture. In sub-Saharan Africa over 80% of the rural people derive their livelihoods from rain-fed agriculture (Gbetibouo & Mills, 2012). Boko *et al*. (2007) and IPCC (2007) projected yield reduction due to the changing climate and climate variability in some countries of SSA to be as much as 50% by 2020. According to IPCC (2007), Africa has already experienced worsening food production and this has been a challenge in meeting the United Nations Millennium Development Goals (MDGs) of reducing hunger by half by 2015. Thus, Gbetibouo (2009) reported that the need for mitigation and adaptation to cope with the negative effects of the changing climate through climate change awareness is an essential first step to sustainable adaptation.

Africa is at the tip of the spear of climate change impacts mainly due to the interactions of multiple stressors, including extreme poverty, over-dependence on rain-fed agriculture, insufficient public spending on rural infrastructure, poor data availability and quality, and knowledge gaps (IPCC, 2007 and UNEP, 2005). These stressors contribute to a weak overall adaptive capacity, and thus may compound poverty for vulnerable groups (Okumu, 2013). Singh *et al*. (2009) reported that majority of the people in sub-Saharan Africa depends on rain-fed agriculture for their livelihood security and about a third of the people in this zone live in drought prone dry lands. In addition, food security and agriculture- based livelihoods of such people are in general threatened. However, in the face of these adverse impacts of the changing climate, there is very little awareness on climate change among farmers in developing countries (Oruonye & Adebayo, 2015). Studies focusing on farmer attitudes towards climate change in Africa are limited (Tzemi & Breen, 2016). Thus, creating climate change education and awareness remains paramount to adaptation measures for Africa in general and Senegal in particular.

Adaptation to change climate and variability is widely acknowledged as a vital component of any policy response (Okumu, 2013). According to IPCC (2007) and Milder *et al*. (2011) low input farming systems, such as subsistence agriculture in marginal areas is not only unsustainably depleting the natural resource base; it is also demonstrably ineffective at alleviating rural poverty. Thus, FAO (2008) reported that without adaptation, climate change will push poor rural farmers on a razor’s edge of survival, but with adaptation, vulnerability can largely be reduced.

Maddison (2006) pointed out that adaptation to climate change is a two-step process, which initially requires the perception that climate is changing and then responding to changes through adaptation. Bryan *et al*. (2009) reported that farmers first need to perceive the impact of changes in the climate to take appropriate adaptation strategies in order to mitigate their vulnerability and to enhance the overall resilience of the agro-ecological system. Adaptation strategies to climate change are unlikely to be effective without an understanding of the farmers' perceptions of climate change (Alam *et al*., 2017). Thus, climate change awareness through observation and copious media attention could help farmers to plan easily for future mitigation strategies and enable policy makers to implement and facilitate adaptation strategies (Alam *et al*., 2017). In addition, United Nations Educational, Scientific and Cultural Organization (UNESCO) reported that climate change awareness is about helping learners understand and address the effects of the changing climate, while at the same time encouraging the change in behaviour and attitudes needed in order to achieve sustainable development (UNESCO, 2009). Sustainable adaptation to climate change can be ensured by climate change awareness in a long way through the prevention and elimination of mal adaptation practices. Mal adaptation practices to the changing climate could exacerbate its effects on the individuals' livelihoods. According to Roco *et al.* (2015) it is important to give all farmers information that will help them to adapt to climate change using appropriate farming technologies and practices. Projects and programs designed to enhance understanding of the consequences of climate change will help farmers to develop the management ability to cope with climate change effects. Therefore one can strengthen the adaptive capacity of the farmer to adapt to climate change through climate change awareness program and activities with proven and tested practices and techniques for sustainable agriculture in the future.

Many agricultural adaptation options have been suggested in the literature (Gbetibouo, 2009). Researchers (Smit & Olga, 2001; SEI, 2009) suggested that agricultural adaptations embrace a wide range of options that include: micro-level options, (e.g. crop diversification and altering the timing of operations); adaptive capacity and institutional strengthening, (e.g. developing meteorological forecasting capability, improvement in agricultural markets and information provision); market responses, (e.g. income diversification and credit schemes); and technological developments, (e.g. development and promotion of new crop varieties and integrated water management). Report by de Wit (2006) suggested that planting varieties of the same crop, changing the planting dates, increased use of irrigation, to water and soil conservation techniques are the main adaptation strategies to climate change in Senegal. The main adaptation strategies of farmers identified in Sekyedumase District in Ghana include change in crop types, planting short season varieties, changing planting dates, and crop diversification (Fosu-Mensah *et al*., 2012). According to Gbetibouo (2009) the main adaptation strategies of farmers in the Limpopo River Basin in South Africa are switching crops, changing crop varieties, changing planting dates, increasing irrigation, building water-harvesting schemes, changing the amount of land under cultivation, and buying livestock feed supplements. Practices involving crop diversification, adoption of different planting dates, use of drought resistant crops, application of chemical fertilizers, prayer or ritual offerings, implementation of soil and water conservation methods, crop rotation practices, cultivation of early maturing varieties, and change of farm land area or size are the main response strategies to climate change of farmers in the North Bank Region of The Gambia (Kutir, 2015). According to Boko *et al*. (2007) although, farmers have developed several adaptation options to deal with present climate variability, such adaptation might not be adequate for future changes of climate. In addition, most of the adaptation options represent possible adaptation measures rather than the actual farm level adaptation strategies. Indeed, there is limited evidence that these adaptation options are feasible, realistic, or even likely to occur (Okumu, 2013). Fosu-Mensah *et al*. (2012) reported that to enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have knowledge of farmers' perception on climate change, potential sustainable adaptation measures, and factors affecting adaptation to climate change.

Although there are numerous studies on adaptation options to climate change that are done in West Africa region, there has been little focus on farmers' awareness and response to climate change. In West Africa region short-term programs on climate change awareness among farmers with no evidence of replication are the few initiatives that are made. There is also limited knowledge on how farmers perceive climate change and how they are responding to the effects of a changing climate in general in Senegal and Kaffrine region in particular which is the study area. This study therefore intends to capture the extent of farmers' awareness and their source of climatic change information as well as identify factors influencing farmers' response to the changing climate. To address the issue of the changing climate, its impact on agriculture and appropriate adaptation strategies, one must therefore take into account farmers' understanding of climatic change (Juana *et al*., 2013).

1.2 Statement of the Problem

Located on the Western Coast of Africa between 12.8° and 16.41°N and between 11.21° and 17.32°W, Senegal is a land of climatic and geographic contrasts. Senegal is a lower middle income country with the agricultural sector accounting for 17.5% of the GDP in 2013 (FAO, 2015). The agricultural sector remained the primary means of livelihood for 69% of the workforce in 2013. Regarding agriculture, the sector has been facing major challenges that have weakened its proper development and vulnerability to climatic shocks, with high risks of drought (République du Sénégal/PSE, 2014). The Senegalese agricultural sector primarily comprised smallholder farmers practicing rain-fed agriculture. The main arable crops in Senegal, such as groundnut, millet, cotton, maize, rice, sorghum, cassava, and cowpea are highly vulnerable to drought and/or flooding, and their yearly production varies greatly with the weather (FAO, 2014). For example, the total production of groundnut, millet, sorghum, rice, and cotton was estimated between 1 and 50,000 million tons in 2007 during the drought year. On the contrary, in 2010 the production was estimated above 750,000 million tons (FAO, 2014). These data suggest that the variability in yields is correlated with the changing climate in the country. Thus, these results suggested that, in the absence of adaptation measures, climate change could affect food production in the country. Senegal suffers the consequences of climate change, characterized by an increase in temperatures, and reduction and increased variability in rainfall. For instance, average temperatures have increased by 0.9ºC (1.62º F) since 1975, and average rainfall in the 2000- 2009 period fell by 15% compared to 1920-1969 (Funk *et al*., 2012). These changes, combined with population growth, could decrease per capita cereal production by 30% by 2025 (Funk *et al*., 2012), if the government and its development partners do not take measures to ensure effective adaptation to the changing climate in agricultural development programs. The rural Senegalese population, mainly depending on rain-fed agriculture, needs to have adaptation skills and great coping strategies in order to survive negative trends, shocks and extreme events of the changing climate (Mertz *et al*., 2009).

Globally, climate change may cause the loss of livelihoods, and the onset of food insecurity, and unemployment, thereby increasing Senegal's vulnerability to climate change. According to the World Bank (WB, 2010), the southern groundnut basin of Senegal, its agricultural holdings and village communities, were adversely impacted by the groundnut crisis in 2002 and 2007. Over the past few years, this area was subjected to recurrent droughts. Weather conditions have worsened depletion of land resources and ecosystem degradation. Like its neighbouring countries, Senegal was hit by serious drought in the 1970s, which has affected the country's environment and ecology. Mostly farmers were affected, especially those living in Senegal's 'groundnut basin' including Kaffrine Region (Ndiaye *et al*., 2013). According to Ndiaye *et al.* (2013), IPCC through the Beijing Climate Center's global circulation model projects an increase in temperature and a decrease in rainfall over the Kaffrine Region (Southern groundnut basin of Senegal) in the 2020s where agriculture is the primary economic activity. In addition, this economic activity is threatened by increasing climate uncertainties such as frequent erratic rains, high temperature and droughts, resulting in low crop yield, and general food insecurity.

Kaffrine Region is a strategic location in the southern groundnut basin of Senegal with a high interannual variability of temperature, rainfall, coupled with high vulnerability of farmers to climate change where rain-fed agriculture is the major economic activity in rural communities of the region (Lo & Dieng, 2015). Consequently, climate change is undermining efforts to achieving the goals of the Accelerated Programme for Agriculture in Senegal (PRACAS) on food security and poverty reduction in this area and the country at large by 2035. PRACAS is the agricultural component of the Plan Sénégal Emergent (PSE). It was set up in 2014 and will end in 2035 with the following objectives: rice self-sufficiency, self-sufficiency in onions, optimizing the performance of the groundnut sector, and the development of the fruit and vegetable sectors of the off-season (République du Sénégal/PSE, 2014). Farmers tend to respond to climate change impacts by adopting measures in order to reduce their vulnerability and increase food productivity. Most adaptation strategies to the changing climate made by farmers without the needed technical education on response to climatic climate are based on personal experience which generally results in negative feed-back effects, referred to as mal-adaptation. To increase climate change awareness in Senegal, diverse climate change awareness programmes and campaigns have been launched by Government and NGOs like ied Afrique to enable farmers make informed decisions to respond to the changing climate phenomenon (McKune & Serra, 2016). Such awareness efforts have been introduced in Kaffrine Region. However, there appears to be little empirical evidence on how this awareness is influencing farmers in their response to the changing climate as well as the factors influencing farmers' response to climatic change. For farmers to respond sustainably to climate change impacts there is the need for them to be more aware of the phenomenon of the changing climate and its impacts on their lives and livelihoods. It is against this knowledge gap that this study seeks to evaluate farmers' awareness and response to climatic change as well as the factors that influence their responses to the changing climate in Kaffrine Region of Senegal.

1.3 Research Questions

The following research questions were used to guide the study:

1. To what extent are farmers in Kaffrine Region aware of climate change impacts in their region?
2. What are the sources from which farmers' access climatic change information in Kaffrine Region?
3. What are the perceptions of farmers about the changing climate in Kaffrine Region?
4. What factors influence farmers' response to climatic change impacts in Kaffrine Region?
5. What are the challenges faced by farmers in their response to climatic change impacts in Kaffrine Region?

1.4 Research Objectives

The principal objective of this study is to learn more about farmers' awareness and response strategies to the changing climate in selected areas in Kaffrine Region.

Specific Objectives:

The specific objectives for the study are:

1. To determine farmers' awareness about climatic change in Kaffrine Region.

2. To identify sources from which farmers' access climatic change information and identify challenges associated with response to the impacts of the changing climate in Kaffrine Region.
3. To examine the perceptions of farmers about the changing climate in Kaffrine Region.
4. To identify the factors that influence farmers' response to climatic change in Kaffrine Region.

1.5 Significance of the Study

The present study aimed to analyse farmers' awareness and response to the changing climate in the rural communities in Kaffrine Region of Senegal. The following key points are significant:

- The study results could enable farmers to make informed decisions about their livelihood activities whiles considering their effects on the environment and climate in general.
- Also, farmers would be better equipped with adequate knowledge on sustainable adaptation measures that would result in sustainable livelihoods, increased productivity, and food sufficiency for them, the community and the country at large.
- This study could anticipate on obtaining essential information for relevant institutions in Senegal such as Ministry of Environment, Ministry of Agriculture, Ministries of High Education and National Education. It could also supply data and material to Non-Governmental Organizations (NGOs) working in the area of climate change, education and agriculture in their development of programmes, policies and projects, meant to adapt and mitigate climatic change in Senegal.
- The research would also make available for use an additional literature on farmers' awareness and response to climatic change in Kaffrine Region and open up new pathway of researches.

1.6 Scope of the Study

Geographically, the scope of the research covered nine communities in three districts (Birkelane, Malèm Hoddar, and Koungheul) of Kaffrine Region of Senegal. In the study area there are diverse livelihood activities but for the purpose of this study, only farmers, their communication networks, and their response to the changing climate were considered. The climate change in this study was limited to the evolution of climatic factors such as temperature, and rainfall in the past thirty (30) years. The research also focused on the challenges farmers faced in their response to the changing climate as well as sources through which farmer's access climatic change information. Also, the factors that influenced farmers' adaptation strategies to the changing climate were examined in the study.

1.7 Limitation of the Study

The approach of the research has some limitations. In fact some information bias could result from the translation since all the data collection instruments were written in English and translated into local language for the respondents. Considering issues pertaining to time, coverage and resource limitations, it was not possible to perform an exhaustive study on farmers' awareness and response to climatic change in the whole of Kaffrine Region of Senegal.

1.8 Conceptual Framework

The conceptual framework presented in Figure 1.1 shows the linkages between climate variables (temperature, and rainfall), crop yields, farmers' livelihoods, adaptation and mitigation strategies, and national climate change education strategies of Senegal. Exposure to climate change affects crop yields and consequently the livelihoods of farmers in Kaffrine Region in particular and Senegal in general. Kaffrine Region is a strategic location in the southern groundnut basin of Senegal with a high interannual variability of temperature, rainfall, coupled with high vulnerability of farmers to climate change where rain-fed agriculture is the major economic activity in rural communities of the region (Lo & Dieng, 2015).

The framework illustrates how the farmers' decisions on adaptation measures to the changing climate based on personal experiences and perceptions without knowledge and awareness about the phenomenon of climatic change lead to negative feedback effects on farmers' livelihoods. This enhances the vulnerability of farmers and exacerbates the anthropogenic climate change. The framework also shows farmers can mitigate climate change effects or adapt to the changing climate or they can employ both mitigation and adaptation measures at the same time. However, priority is given to climate change adaptation measures in Africa countries because they contribute less to the Green House Gases (GHG) emissions. Thus, farmers mostly focus on short term adaptation measures or coping strategies that will provide benefits in the earliest possible duration.

The framework indicates that how the national climatic change education strategies of Senegal provides the opportunity for carrying out climatic change education and awareness programmes in the country. This has been done by climate change education facilitators for farmers in order to enable them understand the phenomenon of climatic variability and change. These climate change awareness and programmes for farmers can also reduce vulnerability of farmers and build resilience to climate extremes through the adoption of sustainable adaptation methods and practices.

Although climate change education and awareness programmes have been launched in Senegal in general and Kaffrine Region in particular to enable farmers make informed decisions to respond to the phenomenon of climatic change. There is, however, a scarcity of information on farmers' awareness and adaptation strategies to the changing climate in Senegal in general and the study area in particular. In the quest to have an effective response to climatic change in Senegal through sustainable adaptation measures and mitigation methods it is crucial to examine farmers' awareness of the changing climate and their response as well as the factors that influence farmers' adaptation strategies to climatic change in the study area.

Furthermore, the study used the diffusion of innovation theory which is developed by Rogers (1995) and extension theory by Röling (1988) as theoretical framework in order to describe and explain how communication among others play a crucial role in climate change adaptation process for farmers. These two theories are further developed in Chapter Two.

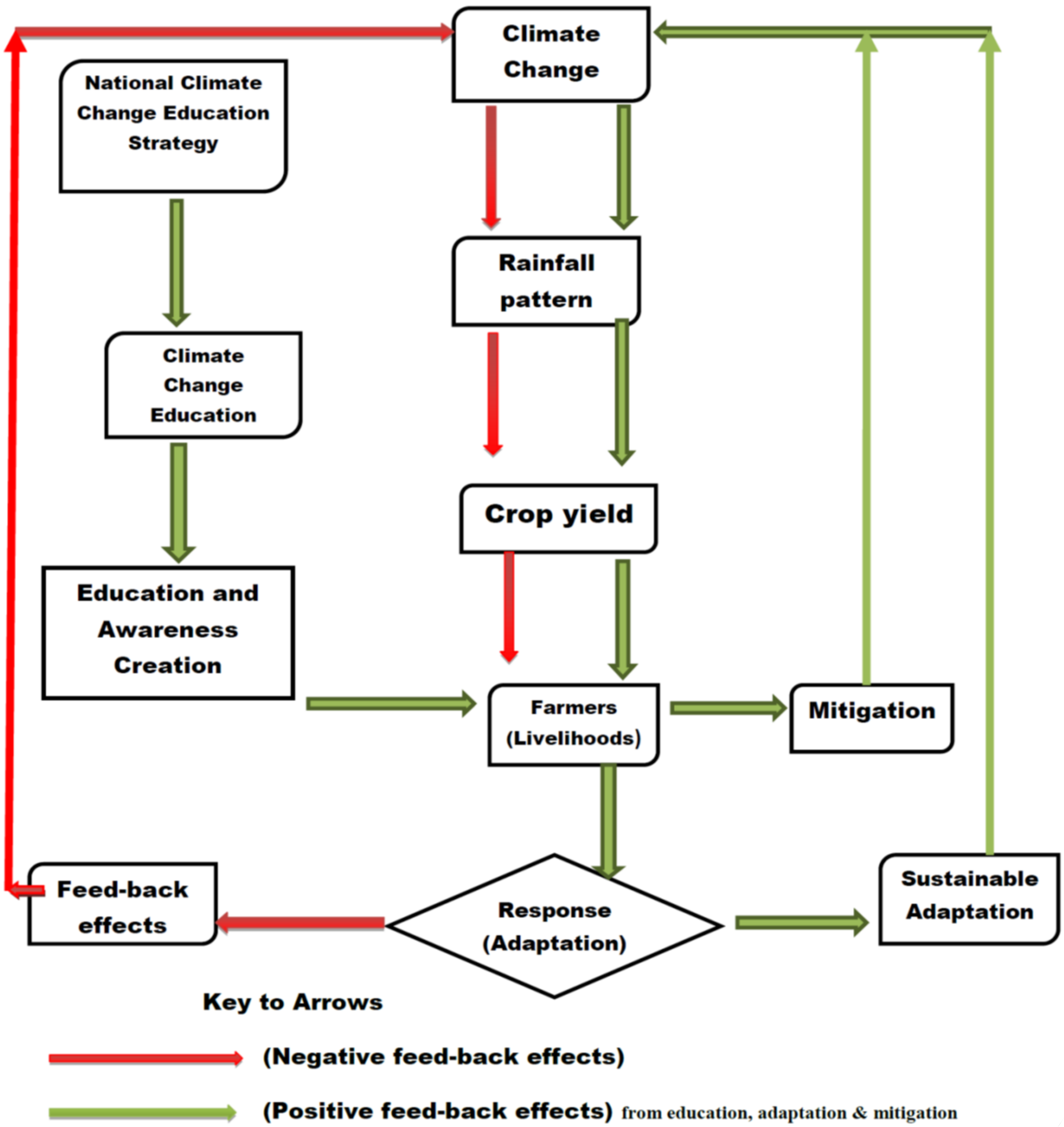

Figure 1.1: Conceptual framework (adopted from Kutir, 2015)

1.9 Terminologies and Concept Definitions

Climate: A narrow sense as the average weather (the classical period is 30 years), or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years (IPCC, 2012).

Climate change: Refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) (IPCC, 2007c). UNFCCC (2007) reported that the changing climate is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere which is in addition to natural climatic variability observed over comparable time periods.

Climate variability: Includes more than individual weather events and may result from natural internal processes within the climatic system (internal variability) or to variations in natural or anthropogenic external forces (external variability) (IPCC, 2007).

Adaptation: An Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007a).

Mitigation: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2007b).

Livelihood: Comprises the capacities, assets (stores, resources, claims, and access) and activities required for a means of living (Chambers &Conway, 1991). (UNECA, 2002) reported that the concept of livelihoods refers to the means, entitlements, assets and activities by which people make a living. Thus, for this study livelihoods could be considered as farming activities that are undertaken by people in the area. Globally there are several effects of the changing climate such as unpredictable rainfall patterns, increasing temperatures, floods, and drought that affect the lives and livelihoods of people mostly those who live in sub-Saharan Africa (SSA) including Senegal.

Response/ Resilience: Especially for this study, it refers to the adaptation measures that farmers undertake to deal with the effects of climatic change. Therefore, the study adopts the (IPCC, 2007a) definition of adaptation which refers to an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Perceptions: A process by which the person receives information or stimuli from the environment and transforms it into psychological awareness (Ban & Hawkins, 2000).

Communication: Imparting or exchanging of information by speaking, writing, or using some other medium.

Climate Change Awareness: Being conscious of our changing environment (Oduniyi, 2013).

CHAPTER TWO

LITERATURE REVIEW

2.1 Climate Change and Climate Variability

The changing climate is an altered state of the average climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007 emphasized that climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The United Nations Framework Convention on Climate Change (UNFCCC) in 2010 on the other hand defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. According to IPCC (2007a) climate variability refers to the variations in the mean state and other statistics (e.g. standard deviations or the occurrence of extreme events) of the climate on all temporal and spatial scales beyond that of individual weather events.

Variability may be due to natural external processes outside the earth system, or to natural or anthropogenic internal forcing. In addition, Bagagnan (2015) reported that an event such as a prolonged drought that is not typical in a region during a particular time period may be a result of climate variability. A comprehensive view of variability and long-term changes in the ocean, atmosphere, cryosphere, and land surface can be obtained through observation of climate system based on direct measurement and remote sensing from satellite and others platforms. According to IPCC (2007) the global mean surface temperature has increased (by about 0.07°C per decade in the past 100 years). However, the increase has been more rapid about 0.18°C per decade in last 25 years, with the last decade (2001–2010) being the warmest decade on record (WMO, 2011). Thus, IPCC (2007) has projected that global mean temperatures may increase by between 1.4 and 5.8°C by the end of the 21st century. There is already evidence that Africa is warming faster than the global average, and this is likely to continue (IPCC, 2007). Climate models suggest that West African countries will likely experience decreased annual rainfall, increased temperatures, increases in the intensity and frequency of heavy rainfall events, and a rise in sea level (IPCC, 2013). Bagagnan (2015) suggested that distinctions of the changing climate vary, not in terms of what it is, but in terms of what is responsible, and specifically whether it is attributable to natural causes and/or anthropogenic causes. Several studies suggest the positive relationship between the increase of the temperature and the increase of the concentration of the greenhouse gases in the atmosphere. As stated by IPCC (2007) it is generally accepted that the anthropogenic climate forcing is the main cause of the changing climate. This means that the changing climate is caused by the emission of greenhouse gases (GHGs) in the atmosphere. The increasing concentrations of greenhouse gases in the atmosphere are mainly due to the 80% increase in annual CO_2 emissions since 1970 (IPCC, 2007). The greenhouse gases trapping heat in the atmosphere include carbon dioxide (CO_2), nitric oxide (N_2O), methane (CH_4), and among others. The concentrations of carbon dioxide, methane, and nitrous oxide in the atmosphere have considerably increased (IPCC, 2013). The concentration of carbon dioxide (CO_2), has continued to increase from its preindustrial concentration of approximately 278 parts per million (ppm) to over 391 ppm in 2012, with the rate of rise now at 1.8 ppm per year. The emissions of CO_2 from fossil fuel and land-use change presently are about 35,000 million metric tons per year and, if this trend is not addressed, a projected rise of 41,000 million metric tons of CO_2 per year in 2020 will be reached. As claimed by Kutir (2015) agriculture which is the backbone of most African countries is one of the main contributors of the emissions of greenhouse gases in the atmosphere. Indeed, energy and chemical intensive farming lead to high levels of greenhouse gases emissions in the atmosphere, mainly as a result of the over-use of fertilizers, soil degradation, intensive animal farming, and deforestation (Smith *et al*., 2008). As stated by FAO (2007) agricultural production and the biophysical, political and social systems that determine food security in Africa are expected to be placed under considerable additional stress by climate change.

2.1.1 Senegal, Climate Change and Variability

In Senegal, temperatures have increased, while rainfall has experienced in recent decades a significant decline punctuated by a shift of isohyets from north to south. Since the 1950s, rainfall has decreased by around 30%, punctuated by a very high variability from one year to another and from one region to another. In Dakar, for example, there is a drop of 50% compared to 7% in

Kédougou between 1950 and 2000 (PANA, 2015). The overall temperature trend is marked by an average warming of 1.6 ° C with regional disparities. The highest increase is observed in northern Senegal with 3.0 ° C in Linguère and the lowest increase in the south with 0.7 ° C in Kédougou (PANA, 2015). Senegal experienced rises in average temperatures of about 0.9°C since 1960 with an average of 0.2° per decade. There are also decreases in rainfall by 10-15 mm per decade and a shortening of the rainy season, increases in daily rainfall and in the frequency of short dry spells (UNDP, 2008). Climate models predict for Senegal an increase by the 2060s of 1.1-3.1°C in mean annual temperatures from the observed (1970-99) with a mean of 27.8°C, and a decrease in annual precipitation. The models also predict greater climate variability, including in the frequency and proportion of rainfall coming in intense and extreme rainfall events (UNDP, 2008). In addition, concerning the future, most of the models projecting the rainfall trends of the coming decades show an overall drying of Senegal, yet with high inter annual variability (Boko *et al*., 2007). In Senegal the total emission of greenhouse gas from the main sectors in 2005 was estimated at 13083.74 Giga grams CO_2 equivalence ($GgCO_2eq$) of which about 40% is from the energy sector, 48.6% from agriculture sector, 7.4% from waste, and 4.13% from industrial processes (PANA, 2015).

2.2 Climate Change and Agriculture

According to IPCC (2001) agriculture is the most important source of livelihood for millions of people in Africa, since majority (70%) of Africa's population is involved in farming, and agricultural products cover about 40% of all exports. The agriculture sector generates about 70% of Gross Domestic Product (GDP) in Africa (Mendelsohn *et al*., 2000). However, Lobell *et al.*, (2008) reported that federal agencies and other institutions have expressed concerns about the potential effects of the changing climate on agricultural productivity due to the fundamental role agriculture plays in the welfare of humans. Climate change affects many institutions and productive sectors including agriculture, forestry, energy, and coastal zones, across the world (Lemma, 2016). As claimed by Tazeze *et al*. (2012) agriculture is contributing to global warming but global warming is also affecting agriculture. Edwards-Jones *et al*. (2009) argued that climatic change affects agriculture and agriculture also affects climatic change. Indeed, different farming practices affect the climate through emissions of greenhouse gases into the atmosphere

(Maraseni *et al.*, 2009). As stated by IPCC (2001) adverse climate change impacts are considered to be particularly strong in tropical Africa countries that depend on agriculture as their main source of livelihoods. Otitoju (2013) reported that the changing climate will have negative effects on the bio-physical processes that underpin agricultural systems. As claimed by Kleinschmit (2009) fossil fuel-intensive and industrial monoculture is both a cause and victim of the changing climate. The developing countries particularly those in Africa are seen as being the most vulnerable to climate variability and change coupled with poor agricultural productivity (Adger *et al.* (2003) and IPCC, 2007). According to Mertz *et al*. (2009) and Easterling *et al*. (2007) Africa's agriculture is negatively affected by the changing climate and particularly sub-Saharan Africa is likely to face the most severe challenges on food security due to climatic change and other pushing factors of global change. Fischer *et al*. (2005) argued that many farmers in Africa are likely to experience net revenue losses as a result of the changing climate, particularly as a result of increased variability and extreme events. Dry land farmers, especially the poorest ones, are expected to be severely affected by climatic change. In addition agricultural GDP in Africa is expected to fall between 2 to 8%. The variations in climatic variables, for example, amount of rainfall, wind speed, relative humidity, sunshine duration, and temperature, plays a very crucial role in determining the yields of crops (Chang, 2002). Denkyirah *et al*. (2017) reported that the climatic change increases the prevalence of insect pests and disease infection, reduces cocoa yield, cause inability to dry cocoa bean, and delays cocoa bean maturity in Ghana. Wahren (2014) argued that the changing climate threatens farmers' livelihoods and resulted in low crop yields in Cameroon. Higher temperature and decreasing precipitation levels caused by climate change depresses crop yields (Tazeze *et al*., 2012). It has been reported that high temperatures are harmful during seed formation and between grain formation and grain maturity of certain crops (Travasso *et al*., 2008). As stated by Otitoju (2013) rising atmospheric CO2, concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality and stability of food production and the natural environment in which agriculture takes place.

It has been reported that climatic variations will have consequences for the availability of water resources, pests and diseases and soils, leading to significant changes in the conditions for agriculture and livestock production (CEC, 2009). As claimed by Kurukulasuriya & Mendelsohn (2006a) a 10 % rise in temperature will lead to visible loss for rain-fed agriculture (about 8.2% of loss). Stige *et al*., (2006) reported that groundnuts in West Africa and Wheat in the Sahel are likely to be adversely affected by the changing climate.

Some of the sub-Sahara Africa countries like Senegal are likely to lose cereal production potential by the 2080s (Fischer *et al*., 2005). According to FAO (2015) the Senegal's agricultural sector employs more than 69% of the workforce in 2013 and represents about 17.5% of the of the country's Gross Domestic Product GDP in 2013. The agricultural sector remained the primary means of livelihood for the population. Currently, over 65% of Senegal's arable land is cultivated, and it is expected that by 2050, almost all arable land will be cultivated. The agriculture sector consists primarily of rain-fed agriculture, which is especially vulnerable to increases in temperature, changes in timing and amount of rainfall, and increases in the frequency of dry spells and droughts. These consequences are likely to have negative impacts on agricultural production as well as health, economic development, and the environment (FAO, 2011). This is evident in a study conducted by UNDP (2008) in which it was concluded that heavy rainfall and sea level rise can cause flooding, degradation, and salinization of agricultural lands, which can lead to crops loss and failure. Increase in droughts and floods can bring declines in crops yields and biomass production, food shortages and price increases, rural-urban migration, destabilization of peasant livelihoods, increases in bush fires and pest infestations. As stated by FAO (2011) in the Senegal River Valley, Niyes, and Lower and Upper Casamance regions, agriculture and fisheries are vulnerable to declines in rainfall, coastal erosion, salt water intrusion, and floods resulting in the communities experiencing the phenomenon of food insecurity.

Climate change-related impacts are likely to increase the negative effects of the non-climate stressors, such as overexploitation of natural resources and prolonged use of chemical pesticides that currently threaten agricultural practices, livelihoods, and financial returns. As stated by IPCC (2013) the decrease in crops yield caused by the climatic change, and the increase of the population will be a major threat to our community. Thus, the adequate response to the changing climate needs to be aligned with national and regional strategies for development, poverty alleviation, economic growth and the enhancement of human wellbeing, while increasing resilience to the physical impacts of climate change in Africa (AMCEN, 2011).

2.3 Adaptation Policies

Adaptation is a key strategy that can alleviate the severity of climate change impacts on agriculture and food production (Alam *et al*., 2017). Adaptation to climate change is an adjustment made to human, ecological, physical or socio-economic systems, in response to perceived vulnerability or expected and actual climatic stimuli, their effects or impacts (IPCC, 2001). According to Wheeler *et al*. (2013) and Smit *et al.* (2001) adaptation to climatic change refers to adjustments in the human-environment system in response to actual and/or anticipated different climatic conditions in order to avoid or to mitigate the associated risks or to realize potential opportunities. There are various types of adaptation that can be distinguished, including anticipatory or proactive adaptation, autonomous adaptation, and planned adaptation (IPCC, 2001; Smit *et al.*, 2001; Pittock & Jones, 2000). Smit *et al.* (2001) reported that individual or autonomous adaptations are considered to be those that take place in reaction to climatic stimuli (after manifestation of initial impact), that is, as a matter of course without the intervention of any public agency. Autonomous adaptations are widely interpreted to be initiatives by private actors rather than by governments, usually triggered by market or welfare changes induced by actual or anticipated climate change. According to IPCC (2001) and Pittock & Jones (2000) policy-driven or planned adaptation is often interpreted as being the result of a deliberate policy decision on the part of a public agency, based on an awareness that conditions are about to change or have changed, and that action is required to minimize losses or benefit from opportunities. Anticipatory adaptation takes place before impacts of climatic change are observed (Smit *et al.*, 2001). The negative impacts of the changing climate are likely to occur due to the past emissions of greenhouse gases even if we stop now these emissions (IPCC, 2013). Furthermore, the adaptation policy should answer the following questions: (i) adapt to what? (ii) Who and what adapt? (iii) How will adaptation occur? Therefore, it has been reported that an appropriate balance between public sector efforts and incentives, such as capacity building, creation of risk insurance and private investment, needs to be struck so that the burden can shift away from poor communities who are more vulnerable to climatic change (Rosegrant, *et al.*, 2008).

2.3.1 Senegal's NAPA and its Adaptation Priorities

Senegal like the other Parties to the United Nations Framework Convention on Climate Change (UNFCCC) has to develop its national adaption plans on climate change named National Adaptation Plan of Action (NAPA). The country has developed three (3) national communications on climate change so far. The third NAPA of Senegal which is developed in 2015 aims at helping Senegalese to deal effectively with the changing climate in short and long term projects. Climate change impacts have been observed and experienced in Senegal such as rises in average temperature since 1960, decreases in rainfall by 10-15mm per decade and a shortening of the rainy season, increases in daily rainfall and in the frequency of short dry spells, loss of shoreline from erosion of 1-2 m per year along shorelines of sand beaches, and 0.1-0.7 m per year along rocky coastline areas, aggravated by sea level rise (UNDP, 2008). In this policy document (NAPA) some policy objectives and strategies have been developed for the sectors that are vulnerable to climatic change in Senegal such as agriculture, water resources, coastal zones, wetlands, and tropical and woodland forests. Thus, there are several priority adaptation projects from Senegal's NAPA developed in 2015 such as: Restoration of mangrove swamps and reforestation; Development of infrastructure such as dams, dikes, retention basins, and anti-salinization structures to reduce flooding (particularly in the Senegal River basin); Revitalization of river networks and ecosystems; Maintenance of balance between surface and groundwater use; Increase in accessibility and availability of irrigation infrastructure; Improvement and diversity of agricultural practices, livelihoods; Increase food security; Creation of community woodlands and secure energy production; Improvement of water conservation and capture methods; Physical protection against beach erosion and saline intrusion; Establishment of early warning systems for flooding; Increase public awareness and education.

Lobell & Field (2007) reported that climatic factors and agricultural production have a particularly high correlation in Senegal and in the absence of adaptation measures; climate change could affect food production in the country. According to Mertz *et al*. (2009) in Kaffrine Region which is the study area the rainfall variability, extreme rainfall events, and long dry spells are the key climatic factors affecting agriculture and consequently food security. The Kaffrine Region is within the groundnut basin (central Senegal) where groundnut, millet, sorghum, and maize are highly cultivated. According to ANSD (2015) Kaffrine is the first producer of groundnut (21%) and third producer of cereals (12%) in Senegal. Climate change will significantly affect the socio-economic and environmental resources of Senegal. Recognizing this, the Senegalese government, and international and national institutions and organizations, have begun to identify climatic change impacts, vulnerabilities, and threats as well as to determine adaptation priorities, develop adaptation strategies, and mainstream adaptation into development planning. However, an implementation gap remains between existing adaptation plans and project realization (FAO, 2011).

2.4 Farmers' Adaptation Response to Climatic Change

Adaptation to climate change has become one of the focal points of current development discourse, particularly on agriculture (UNFCCC, 2007). According to Nhemachena & Hassan (2007) adaptation to the changing climate involves changes in agricultural management practices in response to changes in climate conditions. It often involves a combination of various individual responses at the farm-level and assumes that farmers have access to alternative practices and technologies. Thus, Johnston *et al*. (2009) argued that farmers have always lived with climate variability and have many coping strategies for droughts and floods that will form the basis for adapting to the changing climate. As stated by Kutir (2015) farmers adopt diverse response measures and strategies to reduce the impact of the changing climate on their livelihood activity and to increase crop yields. Crop diversification, changing planting dates, changing crop variety, mix cropping and soil and water management, planting trees, drought and flood resistant crops production, seeking off-farm employment, changing animal breeds, planting short season crop, and irrigation/water harvesting are mainly used by farmers to enhance social resilience to climate change in some countries like Ethiopia, India, Nigeria, Senegal, United States, and Zambia (Dey *et al*., 2017; Mase *et al*., 2017; Mulenga *et al*., 2017; Tesfahunegn *et al*., 2016; Mertz *et al*., 2009). It has been suggested that farmers use different response strategies that can fit with the types of challenges caused by climatic change they faced (Tesfay, 2014). According to Yaffa (2013) in The Gambia, the use of drought resistant cultivars, tree planting, early maturing crops, soil and water conservation methods are being used by farmers to respond to the changing climate. Kurukulasuriya & Mendelson (2006) reported that some farmers used crop and livestock choice as climate change adaptation options in Burkina Faso, Cameroon, Ghana, Niger, Senegal, Egypt, Ethiopia, Kenya, South Africa, Zambia and Zimbabwe. Alam *et al*. (2017) suggest that farmers in Bangladesh attempt to sustain and to improve their livelihood through a range of adaptation strategies to climate change such as changing planting time, cultivating pulses, cultivating spices and oil seeds, homestead gardening, tree planting and migration. According to Otitoju (2013) farmers in Nigeria do respond to climatic change through the use of multiple crop types/varieties, mulching as crop and soil management practice, multiple planting dates, land fragmentation (i.e. multiple number of farm plots), cover cropping, fertilizer application, adjusted or increased farm size, crop diversification. Denkyirah *et al*. (2017) argued that farmers in Ghana use crop diversification, increased application of pesticides and fertilizers, diversification to non-farm activities, planting of trees for shade, planting improved cocoa varieties as adaptation strategies to climate change. As stated by Ogalleh *et al*. (2012) farmers in Kenya use some adaptation strategies such as migration, crop diversification, and sale of animal to deal with climatic change.

According to Bagagnan (2015) farmers' individual action to adapt to climatic change need to be supported and coordinated at both national and local level for more synergy actions. Thus, agricultural adaptation at both the farm-level and national level is a vital policy response that will shape the future severity of climatic change impacts on food security (Okumu, 2013). In general as adaptation is a process, it is required that the ongoing learning, planning, analysis, and adjustment should respond to an evolving context and changing risks (Lemma, 2016). This again needs to be complemented by provision of appropriate, timely and locally relevant climate information such as weather forecasts, seasonal forecasts and early warnings for climate hazards that have to be made accessible to the people and institutions that need it, including the most vulnerable groups within communities (Lemma, 2016).

2.5 Barriers Affecting Farmers' Response to Climatic Change

Climate change is a global phenomenon. Its impact on agricultural activities in the developing countries has been increasing. Decreasing precipitation and higher temperature levels caused by climatic change depresses crop yields. This is particularly true in low-income countries like sub-Saharan Africa countries where adaptive capacities are perceived to be low (Tazeze *et al*., 2012).

As stated by Alam *et al.* (2017) the factors responsible for the variation in adaptive responses across communities are the socio-economics, climatic impact, agro-ecological system, and existing infrastructure and capacity. Indeed, the susceptibility of agriculture is not determined by the nature and enormousness of environmental stress like changes in climate, but by the blend of the societal capacity to deal with and/or recover from climatic change (Wisner *et al*., 2004). According to Sherwood & Huber (2010) the major barriers or challenges affecting farmers' response to the changing climate can be social, economic, technological, and biophysical barrier. Thus, the lack of information on climate change and adaptation strategies, lack of financial resources, high cost of climate change adaptation, high cost of inputs, and inadequate labour are some barriers indicated by cocoa farmers in Ghana (Denkyirah *et al*., 2017). The farmers in Yatta District of Kenya experienced challenges such as financial constraints, lack of relevant skills, lack of scientific and technical knowledge, lack of information, and lack of infrastructure and inputs among others (Mburu *et al*., 2015).

Farmers' ability to cope or adapt to the changing climate has been challenged by numerous barriers in some sub-Saharan Africa countries. These include access to information via extension services (climate information and production technologies) and access to credit (Acquah-de Graft & Onumah, 2011; Sofoluwe *et al*., 2011; Deressa *et al*., 2008; Nhemachena & Hassan, 2008). Tazeze *et al*. (2012) showed that in Ethiopia education of the household head, family size, household farm income, non/off farm income, access to credit, distance to the market center, access to farmer-to-farmer extension, agro ecological zones, access to climate information, and extension contact were the main barriers for farmers to adapt effectively to climatic change. Alam *et al.* (2017) reported that lack of access to credit and technical expertise, lack of high-value crop varieties and technologies suitable to local conditions, inappropriate communication, inappropriate transport and access to markets and services are the major challenges affecting farmers' ability to cope with climate change in Bangladesh. Lemma (2016) argued that lack of market access, resource limitations and poor infrastructure, labour availability, lack of Information related to forecasting of climate change, adaptation options and other agricultural production activities, household resource endowments among others limit the ability of most rural farmers in Ethiopia to engage in adaptation measures as a response to changes in climatic conditions. As claimed by Kutir (2015) the inadequate credit, insufficient access to efficient inputs, limited access to information and poor skills, labor constraints and inadequate access to market have adversely affected the ability of farmers to respond to the changing climate in North Bank Region of The Gambia. Therefore, failure to put in to practice adaptation options and poor agricultural performances by many African farmers has been blamed on lack of technical expertise, information, and resources (Archer *et al*., 2007).

2.6 Agricultural Mitigation to the Changing Climate

As stated by Edwards-Jones *et al*. (2009) agriculture affects climate change through the emission of greenhouse gases (GHG) from different farming practices. The three main causes of the increase in greenhouse gases observed over the past 250 years have been fossil fuels, land use, and agriculture. It is generally agreed that about 24% of CO_2 emissions are produced by agricultural sources, mainly land conversion and ploughing, deforestation, the use of fossil fuel-based fertilizers, and the burning of biomass (IPCC, 2014). Agriculture is currently responsible for about one third of the World's GHG emissions and this share is projected to grow, especially in developing countries (IPCC, 2007). According to UNFCCC (2009) most of the methane (CH_4) in the atmosphere comes from domestic ruminants, forest fires, wetland rice cultivation and waste products, while conventional tillage, manure deposited on pasture, synthetic fertilizer application and the decomposition of agriculture waste account for 70% of nitrous oxide (N_2O). Moreover, about 70% of the economic potential for the mitigation of climatic change lies in developing countries like sub-Saharan Africa countries, where the agricultural sector is often a significant source of GHG emissions but also a major source of employment. Robledo *et al*. (2012) argued that the greenhouse gases (GHG) mitigation activities in agriculture have co-benefits for, and offer synergies with, other policy objectives such as food and energy security, rural development and poverty alleviation goals. The agricultural sector has high mitigation potential, particularly through improvements in land-use management such as soil carbon sinks (FAO, 2010). Furthermore, as claimed by Matocha *et al*. (2012) reducing recurrent greenhouse gas emissions of agriculture can be done by diminishing temporary excesses of available nitrogen that induce high nitrous oxide (N_2O) emissions, reducing methane (CH4) emissions by better feeding regimes of ruminants and less inundation of rice-fields, wiser use of peatlands reducing carbon dioxide (CO2) emissions, better waste recycling, increased carbon storage in soils, and trees in the agricultural landscape (agroforestry). UNCTAD (2013) reported that mitigation in agriculture needs to be based on two pillars such as (i) technically, nitrogen inputs should be reduced, organic fertilizers should replace synthetic fertilizers and storage losses should be minimized, integrated systems with closed, efficient nutrient cycles should be the order of the day in the future; (ii) socially, food wastage should be minimized and meat consumption reduced. Bellarby *et al*. (2008) suggest that avoiding open burning biomass reduces emissions of greenhouse gases mostly in developing countries where this practice remains to be not under controlled by the authorities. The mitigation potential of carbon sequestration in optimally managed agricultural soils should be exploited. Therefore, soil carbon losses can be reduced and sequestration increased by application of organic fertilizers, minimal soil disturbance and planting legume leys in crops rotation (Smith *et al*., 2007a). The sequestration of soil carbon and reduction of methane through livestock and manure management, and reduced flooding of rice fields can play a considerable role in agricultural mitigation to climatic change (IPCC, 2007b).

2.7 Determinants of Farmer's Decisions to Adapt to Climate Change

According to Gbetibouo (2009) there is a range of household and farm characteristics, institutional factors, and local climatic and agro-ecological conditions that need to be considered as the key determinants of farmers' decision to respond to climatic change. Brulle *et al.* (2012) argued that the adaptation options taken by most farmers are not only those that enhance climate resilience and build adaptive capacity, but also those that will address conservation of environmental and natural resources. The household characteristics which have significant impact on adoption decisions include age, education level, gender of the head of the household, marital status, family size, years of farming experience, farm size, access to extension services, member of Farmer Based Organizations (FBOs), and access to credit/loan (Denkyirah *et al.*, 2017; Danso-Abbeam *et al*., 2014).

Gbetibouo (2009) opined that the effect of gender of the household head on adoption decisions is location-specific. Gender is expected to have a positive or negative effect on adaptation to climate change (Denkyirah *et al*., 2017). As stated by Gbegeh & Akubuilo (2013) and OECD (2009) in many parts of Africa, women are often deprived of property rights due to social barriers and consequently, they have fewer capabilities and resources than men. This often undermines their capacity to embrace labour-intensive agricultural innovations. Furthermore, male farmers are well endowed with resource such as land than their female counterparts and would take initiatives to adapt to climate change. In addition male farmers are more likely to have access to information about new technologies and undertake risky businesses than female farmers (Asfaw & Admassie, 2004). In many parts of Ethiopia, for example, men headed farm households are likely to have better access to extension services and adapt to agricultural technologies than female farmers and that could help to overcome problems related to climate change (Lemma, 2016). However, female-headed households are more likely to take up climatic change adaptation measures (Gbetibouo, 2009). In most rural smallholder farming communities in Africa, more women than men live in rural areas where much of the agricultural work is done. In this respect, women have more farming experience and information on various management practices and how to change them, based on available information on climatic conditions and other factors such as markets and food needs of the households (Gbetibouo, 2009; Nhemachena & Hassan, 2007). Therefore, the study seeks to observe either a positive or negative influence of gender on farmers' response to climatic change.

The age of a farmer may negatively or positively influence the decision to adopt new technologies (Gbegeh & Akubuilo, 2013). It is often said that older farmers have more experience in farming and are better able to assess the characteristics of modem technology than younger farmers, and hence a higher probability of adopting the practice. On the other hand, older farmers are more risk- adverse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies (Adesina & Forson, 1995). Younger farmers are more likely to adopt new technologies than older farmers, since; older farmers stick to primitive ways of production and do not easily adopt newly introduced technologies. In addition, younger farmers have much more energy and are more likely to invest in long term productivity (Adejumo *et al*., 2014; Marenya & Barrett, 2007; Langyintuo & Mulugetta, 2005). Thus, age is expected in this study to have either a positive or negative effect on farmers' response to the changing climate.

Denkyirah *et al*. (2017) suggested that married farmers are more likely to adapt to climate change than the non-married farmers. In addition, farmers who are married consider the survival of their family in case of any uncertainty and are more likely to adopt any innovation in order to deal with the changing climate (Danso-Abbeam *et al*., 2014). Hence, a positive influence of marital status in this study is expected on farmers' response to climatic change.

As claimed by Ukumu (2013) education and human capital endowments are often assumed to increase the likelihood of embracing new technologies. Educational level is expected to have a positive effect on adaptation to the changing climate. This is due to the fact that educated farmers are more likely to obtain information, perceive and adapt to climatic change (Lemma, 2016; Maddison, 2007). Education enhances the ability of farmers to perceive climatic change (Nkonya *et al.,* 2008). In addition, education enables households to access and conceptualize information relevant to making innovative decisions (Ochieng' *et al*., 2012; Nabbumba *et al*. 2005; McBride & Daberkow, 2003). However, higher educational attainment can present a constraint to adoption because it offers alternative livelihood strategies, which may compete with agricultural production (Ukumu, 2013). Therefore, the study expects a positive influence of educational level on response to climate change.

The influence of household size on the decision to adapt to climatic change is uncertain (Ukumu, 2013). In their studies Marenya & Barrett (2007) and Teklewold *et al*. (2006) revealed that household size as a proxy to labour availability may influence the adoption of a new technology positively as its availability reduces the labour constraints. Nkonya *et al*. (2008) opined that the bulk of labour for most farm operations in sub-Saharan Africa is provided by the family rather than hired. Lack of adequate family labour accompanied by inability to hire labour can seriously constrain adoption practices. Yet, households with many family members may be forced to divert part of the labour force to off-farm activities in an attempt to earn income to ease the consumption burden imposed by a large family size (Gbetibouo, 2009; Tizale, 2007). Thus, the study also seeks to have a positive effect of family size on farmers' response to climate change.

Farm size influences both the access to information and the adoption decisions (Okumu, 2013). According to Marenya & Barrett (2007) and McBride & Daberkow (2003) more crop acreage is likely to enhance the information exposure to site-specific crop management technologies because these technologies would likely be marketed to larger farms. In addition, farm size has a positive relationship with adaptation to climatic change (Denkyirah *et al*., 2017; Oluwatusin, 2014; Deressa *et al*., 2009). The shortage of land is a barrier to climate change adaptation, meaning that farmers who have large farm size are more likely to adapt to the changing climate (Bryan *et al*., 2009; Maddison, 2007). As claimed by Gbegeh & Akubuilo (2013) and Gbetibouo (2009) the uncertainty and the fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from adapting. Therefore, large mechanised farms will probably be the first to adapt to climate change (Lemma, 2016). It is evident that as farm size increases, farmers are likely to practice diverse cropping activities and livestock husbandry that are compatible to climate change variables. As such, the researcher expects either a positive or negative influence of farm size on farmers' response to the changing climate.

According to Denkyirah *et al*. (2017) access to extension service would have a positive effect on adaptation to climatic change. In addition, access to information on climate change phenomenon affects significantly adoption of alternative technologies that could enhance resilience against climate change impacts (Lemma, 2016). Indeed, Agricultural extension services/agents are sources of information to farmers and farmers rely on extension agents for information on farming activities among others (Fosu-Mensah *et al.* 2012). Households with access to formal agricultural extension, farmer - to - farmer extension and information about future climatic change are more likely to perceive changes in the climate, and adjust their farming practices in response to climatic change (Gbetibouo, 2009; Nkonya *et al*., 2008; Yesuf *et al.*, 2008; Mariara & Karanja, 2007; Smit *et al.*, 2001). As stated by Tesso *et al.* (2012) farmers become aware of climatic conditions by having access to extension service. Therefore, access to extension service in this study is expected to have a positive influence on farmers' response to climate change.

Farmers' interpersonal relationship in their organizational groups can serve as a source of information and persuasion (Kutir, 2015). According to Akudugu *et al*. (2009) Farmer Based Organizations (FBOs) serves as platforms where information is disseminated among farmers, meaning that FBOs educate farmers on climatic change and the importance of adapting to the changing climate. Yegbemey *et al*. (2014) assert that farmers share experiences and learn from each other through farmers' organizational groups. Thus, the study also expects a positive effect of farmers' organizational groups on response to the changing climate.

Farming experience positively influences farmers' response to climatic change (Denkyirah *et al*., 2017). This means that as the farming experience of a farmer increases by one year, he/ she is more likely to adapt to climatic change. In addition, experienced farmers are expected to have information and knowledge about climatic change and its impact on agriculture and are more likely to adapt to climatic change (Oluwatusin, 2014; Nhemachena & Hassan, 2007; Maddison, 2006). Thus, the study seeks to have a positive influence of farming experience on farmers' response to climate change.

Akudugu *et al*. (2012) argued that credit/loan helps farmers to adopt new technologies, as access to cash allows farmers to purchase farm inputs. Studies have shown that adaptation to climatic change mitigation strategies is positively influenced by access to credit/loan (Fosu-Mensah *et al*., 2012; Deressa *et al*., 2009; Gbetibouo, 2009). In this regard, the lack of borrowing capacity may hamper any efforts to embrace adaptation measures that require heavy investment upfront such as irrigation, terracing, tree planting and fertilizer use (Okumu, 2013). Thus, access to credit is expected to have a positive influence on farmers' response to the changing climate.

2.8 Climate Change Awareness

Climate change awareness is defined as being conscious of our changing environment (Oduniyi, 2013). According to Kakade *et al*. (2013) awareness is the key role to reduce the impacts of climate change. Several research studies have been conducted in various places across the globe to know and determine the level of awareness of people, especially in agriculture and farming activities. Climate change awareness needs to be practical in nature and help farmers to deal with productivity and to be able to make decisions that are aligned both with the most reliable available information and their own ethical values (Oduniyi, 2013). As claimed by Lemma (2016) farmers' perception of climatic change governance and adaptation is pivotal for future plans aiming to deal with challenges arising as result of climatic change. Several researchers Nzeadibe &Ajaero (2010); Speranza *et al. (*2009) and Getis *et al.* (2000) have suggested that the spatial behavior and behavioral responses of individuals and communities are often shaped around their perceptions of problems related to the changing climate. Thus, this urges scholars to investigate the problem of climatic change in the context of a particular socioeconomic setting (Lemma, 2016). In sub- Saharan Africa studies on farmers' awareness and/ or adaptation to climatic change have elicited significant research interest. As stated by Taderera (2010) climate change awareness is low in developing countries and this may affect farmers' ability to respond to the changing climate. Maddison (2006) and de Wit (2006) revealed that a significant number of farmers believe that temperature has already increased and that precipitation has declined with a change in the timing of the rains for eleven African countries, including Senegal. It has been reported that farmers with the greatest farming experience, access to free extension services and markets were more likely to notice changes in climatic conditions. Mertz *et al.* (2009) reported that farmers in the savanna Zone of Senegal are aware of climate variability, and identify intensive wind and occassional excess rainfall as the most destructive climatic factors which have already reduced crop yields in the area. Adebayo *et al*. (2011) reported that poor resource farmers in Southwest Nigeria have a low level of climatic change awareness. The cocoa farmers in Brong-Ahafo Region of Ghana are well aware of climate change and that would help them to adapt to it (Denkyirah *et al.*, 2017). According to Alam *et al*. (2017) hazard-prone rural households (farmers) in riverbank erosion-prone areas of Bangladesh have observed changes in the climate and in extreme events over time. Kutir (2015) suggested that farmers in the North Bank Region of The Gambia are aware of the changing climate in their area over the past decades.

Oduniyi (2013) reported that many people claim to be aware of climatic change but in actual fact they are not really aware. In this regard, although farmers in Delta State of Nigeria were aware of the phenomenon, their level of knowledge about the impact of climate change was low. Furthermore, the farmers indicated relying mostly on personal experience rather than on the mass media or extension agents as their main source of information (Aphunu *et al.,* 2012). In addition, Oloke *et al.* (2013) revealed that despite the fact that the majority indicated various levels of awareness, their understanding of the phenomenon and consequences varied significantly while their knowledge about the causes of the changing climate was generally low in in Lagos State of Nigeria. According to Thaddeus *et al.* (2011) although there is a high level of awareness of the changing climate in Niger Delta region of Nigeria, knowledge of farmers in this area on the adverse effects of the changing climate leaves much to be desired. Thus, Knowledge of climatic change impacts is related to availability and accessibility of information on the phenomenon (Francis *et al.,* 2013). In this regard, there is need for African nations to include the climate change issue as a vital component of long-term policy and planning, particularly in terms of education and awareness in order that it may be fully appreciated by the general public (Oduniyi, 2013). In addition, agricultural extension officers can play an important role in educating the farmers about climatic change, adaptation and mitigation.

In general, education can give greater knowledge and understanding to farmers about the changing climate and how they can respond to it. Education also gives access to information, new technology, and production methods and thus increases the probability of response. Educating farmers about climatic change will enlighten them and hence increases their awareness of the phenomenon (Kutir, 2015). Gbetibouo (2009) assert that if farmers are aware of the changing climate, then is a pre-condition to their response is initiated. Therefore, accurate knowledge about the importance of climatic change should be disseminated to the farmers in order for them to know what climatic change is all about and what impact is has on their farming activities, live, and livelihoods (Oduniyi, 2013).

2.9 Sources of Information on Climate Change among Farmers

According to Ani & Baba (2009) information and communication are essential ingredients needed for effective transfer of technologies that are designed to boost agricultural production. Indeed, for farmers to benefit from such technologies, they must first have access to the technologies and learn how to effectively utilize such technologies in their farming systems and practices. Information is one of the basic needs of human being after air, water, food, and shelter and the developments in society depend largely on the availability and access to accurate and reliable information (Stanley, 1990).

Communication sources or channels are defined as the means through which a message moves from person to person, thus a sender encodes a message and by using a medium or channels, sends it to the receiver who decodes the messages and after processing the information sends the appropriate feedback through the same source or other sources. Thus, the precondition for achieving information dissemination and for educating farmers on the changing climate is the right choice of communication channels or sources (Rogers, 2003). As claimed by Olorunfemi (2009) timely and useful information is necessary about consequences of climate change. Furthermore, Akinnagbe *et al*. (2015) argued that timely reception of climate change information will enable farmers take necessary measures to avert or cope with impending effects of climate change.

Moser (2012) and Rogers (2003) reported that there are indigenous or local media, interpersonal channels, electronic media, and print media as sources of information. Radio, television, telephone, and internet are considered as electronic media coverage whiles newspapers, posters, books, pamphlets among others are the print media. Farmer group organizations, extension services, training seminars, and group discussions are considered as interpersonal channels or sources.

Kutir (2015) suggests that the choice of the particular channels depends largely on the targeted audience and appropriate style one wants to convey the message to the audience. In this regard, the best channels for creating awareness is the print media whiles interpersonal channels are more effective in persuading people to accept new ideas (Moser & Dilling, 2012). In addition, awareness campaign on climate change has been on the increase in the radio, television, one on one visit by different groups of people, extension agents contact to farmers among others (Olorunfemi, 2009). Akinnagbe *et al*. (2015) opined that extension services need to include climate change information relevant to the need of the farmers in their information packages since extension agents delivered agricultural messages and technology through contact farmers. Agricultural extension agents make use of different approaches, means and media in transferring information on climatic change and improved agricultural practices to the end users. Agricultural extension, which is essentially a message delivery system, has a major role to play in agricultural development. It serves as a source of advice and assistance for farmers to help them respond proactively to climatic change and improving their production and marketing (Adams *et al*., 1998). Yohanna *et al*. (2014) reported that friends, relations and fellow farmers were the most frequent sources of information on climate change among arable crop farmers in Adamawa State of Nigeria. It is recommended that, extension providers should intensify the provision of extension services by insuring increased interaction between arable crop farmers and extension agents to complement indigenous knowledge from fellow farmers and friends and relations (Yohanna *et al.*, 2014). The task of extension education is accomplished by different extension approaches and methods, which may come under individual, group and mass contacts. The mass contact may which include both the electronic and print media, is potentially expected to play an important role in technology transfer. The electronic media has a central role in facilitating the exposure of arable crop farmers to a variety of information (Yohanna *et al.*, 2014). Ladebo *et al*. (1997) argued that 72.5% of the respondents owned radio sets although the functionality of such radio sets could not be ascertained. Hussain (1993) reported that, 66% of the farmers of Pakistan meet their information needs through mass media. Anthult (1994) reported that there is rise in farmers' preferring friends and fellow farmers as the first hand information source on climatic change and agricultural production. This may be due to the apparent ineffectiveness of the public extension service in developing countries. Omotayo *et al.* (1997) revealed that, 40 - 50% of those who had access to radio in Nigeria, obtained information on improved farming practices through it. Denkyirah *et al*. (2017) noted that the main sources of climate change information indicated by the cocoa farmers in Brong-Ahafo Region of Ghana were own experience/ observations (81.5%), fellow farmers (71.9%), farmer cooperatives (69.9%), family/ friends (57.5%). This result indicates that cocoa farmers' access to information on climate change and innovations through extension contact is a major challenge in the study area and that farmers rely on their own experiences in adopting innovations. Extension service was the least source of information on climate change to farmers in the east Hararghe Zone of Ethiopia (Tessema *et al*., 2013). Radio and mobile phone were considered important and farmers preferred communication channels in rural semi-arid areas in Tanzania (Churi *et al.*, 2012). Similarly, Nzeadibe *et al*. (2011) argued that radio and television were used to educate farmers and the general public on climate change in Niger Delta. Therefore, it is very important to provide farmers with timely and highly practical information on the changing climate so that they will be considerably able to reduce their vulnerability and increase their resilience to climate change.

2.10 Methods of Assessing Farmers' Awareness

ATPS (as cited in Kutir, 2015) indicates that "in measuring climate change awareness, the aim is not to solicit a scientific definition of climate change from respondents; but rather to evaluate people's knowledge on various aspects of climate change." (p.19)

Different methods have been used in evaluating farmers' awareness /perceptions to the changing climate. For instance, Rejesus *et al.* (2013) used the Likert's scale to assess United States Agricultural Producer Perceptions of Climate Change. In this Likert's scale method the responses obtained from the respondents (farmers) are summarized into percentage on those aware and those that are not aware of the changing climate. The level of awareness on climate change was assessed based on responses to the number of items paired by the Likert Scale statements that are administered to the farmers. Adeola (2014) adopted this technique to evaluate farmers' awareness in Oyo State in Nigeria. Daninga & Qiao (2014) also adopted this method to assess farmers' awareness of climatic change in Tanzania. Lebel *et al*. (2015a) also used this technique to evaluate Perceptions of climate-related risks and awareness of climate change of fish cage farmers in northern Thailand. Ochenje *et al*. (2016) also employed this method to assess Farmers' Perception to the Effects of Climate Change on Water Resources at Farm Level in Kakamega County, Kenya.

There is another method used in assessing farmers' awareness/ perceptions to climatic change. In fact this method is the computation of an awareness index. In this method farmers were asked a series of questions on the conceptual awareness, experiential awareness, and engagement awareness (Gbetibouo & Mills, 2012). The questions encompass all these three indicators and a climate change awareness index was created based on responses to the questions. Gbetibouo & Mills (2012) indicated that the scores from the questions were summed up in order to compute the awareness index. The minimum and maximum total scores a respondent could get was used to compute an awareness index between 0 and 1. Climate change awareness scores were further normalised to range between 0 – 100% by dividing the scores with the highest possible score and multiplying the quotient by 100 (Gbetibouo & Mills, 2012).

2.11 Theoretical Framework

Theoretically, the study is hinged on both the extension theory (Röling, 1988) and diffusion of innovation theory (Rogers, 1995). These two theories are complementary and help to explain how awareness affects farmers' adaptation strategies to the changing climate. The two combined theories offer very useful constructs for studying the adoption of technologies, ideas, and new practices by describing and explaining how communication among others play essential role in the adoption process. Thus, these theories were chosen in this study as theoretical framework.

2.11.1 Diffusion of Innovation Theory

Diffusion of Innovation (DoI) theory is a very important theory that describes the process of change, for example, diffusion of innovations in a community. As stated by Padel (2001) the theory aims to predict the behavior of social groups and individuals in the process of adoption of innovation, considering their time factor, personal characteristics, characteristics of the innovation, and the social relations. Padel (2001) reported that the DoI theory is essentially a social process in which subjectively perceived information about a new idea is communicated through appropriate channels. The theory rests on the assumption that a new idea, object or practice has perceivable channels, mode and time of being adopted by organisations or individuals (Minishi-Majanja & Kiplang'at, 2005). Rogers (1995) reported that diffusion theories have their origins in the explanation of the adoption of technological change by farmers. An innovation is an idea, practice or object that is perceived as new by members of a social system (Rogers, 2003; Rogers & Scott, 1997). Pejanović &Njegovan (2009) argued that innovation is a new method of production of known goods, discovery and production of new types of products, introduction of new production combinations. In this study new adaptation measures to climatic change undertaken by farmers are considered as innovations. Diffusion is considered as a special type of process of communication by which an innovation in the form of new ideas, practices or products, is spread, through certain channels, over time, among the members of a social system (Rogers & Scott, 1997). As claimed by Rogers (1995) diffusion is not a single, all-encompassing theory. In addition, Yates (2001) reported that it is several theoretical perspectives that relate to the overall concept of diffusion. From the definition of diffusion, there are four main concepts namely innovation, communication channel, time and social system, which form the four major elements of the diffusion process (Yates, 2001; Rogers & Scott, 1997). Innovation theorists postulated that certain characteristics determine the rate at which an innovation is adopted by a social system, and these characteristics include relative advantage, compatibility, complexity, trial-ability, and observability of the innovation (Rogers & Scott, 1997). These characteristics of innovation may singly or in combination influence its adoption/non-adoption. In the DoI theory, communication Channels refers to the means by which messages about an innovation are transmitted among members of a social system (Rogers 1995). Information regarding the innovation has to be disseminated so as to introduce the innovation, form or change attitudes, influence decisions regarding the innovation and support the evaluation of the innovation

(Rogers & Scott, 1997). In addition, diffusion of innovation theory is a social process that involves interpersonal communication. Communication is a process in which participants create and share information with one another in order to reach mutual understanding. Diffusion is a special form of communication related to new ideas (Rogers, 2003). The fundamental hypothesis of the diffusion theory is access to information. In addition, information is considered as the prime factor influencing the innovation adoption decision making (Rogers, 1995). An innovation can be communicated through mass media (newspapers, television, and radio) or through interpersonal communication (seminar, extension services). The two channels play different but complementary roles. While many individuals may initially hear about an innovation through mass communication channels, it is the interpersonal communication that is likely to influence adoption decisions (Mark & Poltrock, 2001). Furthermore, interpersonal channels are more capable of influencing people to change their conventional ways and accept new ideas, while mass media are the best channels that are used in creating awareness about innovation (Rogers, 1995). The diffusion of innovation model has a key influence in the manner information is disseminated to end-users (farmers) and in creating awareness about innovation adoption factors. In addition, the channels through which people access information are capital for changing people attitudes to innovations and for creating knowledge (Rogers, 1995). Elia *et al*. (2014) argued that the communication channels augment the transmission and the interchange of information between users by facilitating farmers' access to and use of such information.

According to Rogers & Scott (1997) innovations are seen to be communicated across space and through time which has been identified as being significant in the diffusion of innovations in three main ways. Firstly, the adoption of an innovation is viewed as a mental process that evolves over time starting an initial awareness and initial knowledge about an innovation which evolves into an attitude towards that innovation. This influences the decision of whether to adopt of reject the innovation (Botha & Atkins, 2005). Secondly, the rate of adoption amongst individuals differs throughout the social system. This starts of slowly with only a minority of people adopting the innovation increasing over time eventually reaching the rate where enough individuals have adopted the innovation and the rate of adoption becomes self-sustaining (Rogers & Scott, 1997). Thirdly, time is involved in the rate of adoption or rather the relative speed that members of a social system adopt innovations. This is often measured as the number of members of the system that adopt the innovation in a given time period (Botha & Atkins, 2005).

However, some weaknesses of Rogers Diffusion of innovation theory are identified. The theory does not consider the possibility that people will reject an innovation even if they fully understand it (Waterman, 2004). Kole (2000) also stated that the DoI theory does not take into account the fact that diffusion and adoption may fail because it was a bad idea to begin with in the considered community. Also, insufficient consideration is given to innovation characteristics and how these change over time (Wolfe, 1994). According to Kole (2000) the DoI theory is technology driven because of its ‘pro-innovation bias’ which implies that adoption should happen more quickly and all members of a social system should adopt innovations.

2.11.2 The Extension Theory

Extension theory evolved from rural sociology and over time extension has become more and more aligned with communication and social psychology (Röling, 1988). Traditionally, it was premised that all farmers would eventually see the benefit of new innovations and thus adopt them (Röling, 1988). Thus, it has been reported that measures and views of the success of an innovation were based on the level at which an innovation was adopted (Botha & Atkins, 2005). Moreover, as stated by Röling (1988) the increased adoption rates would occur as information about the innovation was communicated through farmers’social networks. According to Botha & Atkins (2005) and Röling (1988) this formal and organised process of actively communicating such information was considered as extension theory. The focus of this theory is basically the process of changing voluntary behaviour via communication (Botha & Atkins, 2005). Röling (1988) reported that the goal of extension is to determine how to convey information regarding a new innovation to a certain population (such as farmers) so that they will adopt it. Extension theory helps us better understand the contextual factors of the adoption process and provide insights into the communication aspects thereby using communication to influence adoption decision-making. Essentially the extension approach is not about studying or analysing the adoption of innovations. It is about bringing about behaviour change (Botha & Atkins, 2005).

The extension theory is the appropriate one for the study since the rationale of the study is to explain how farmers ‘awareness influence their adaptation measures to the changing climate. Furthermore, the theory emphasizes on the fact that access to information and awareness influence farmers’ adoption of an innovation.

In this study, information is considered as education or awareness creation in climatic change whiles innovation represents diverse response measures to the changing climate such as planting early maturing cultivars, using drought resistant cultivars, irrigation, staggering planting seasons among others that farmers in the study area can implement to reduce their vulnerability and increase their resilience to the changing climate.

However, Röling (1988) argued that to design an appropriate communication channel remains the challenge of extension theory. To have positive change on farms and in agriculture the term extension has also been employed to collectively include any training, technology transfer, advisory, consulting, marketing, research, industry development, learning, change, communication, education, attitude change, human resource development, facilitation, self-development activities, or collection and dissemination of information (Botha & Atkins, 2005 ;Fulton *et al.*, 2003). In this study, extension is considered as activities such as collection and dissemination of information, communication, attitudinal change through education and training in order to bring positive change on farming.

Information is a basic requirement to adopting an innovation if the two theories used in the study are combined. The study explains how farmers' awareness influences their adaptation measures to climatic change. Thus, innovation in this study refers to farmers' response measures to the changing climate and information which is considered here as climate change information, their access to different communication sources that enhance their awareness. The study also buttressed farmers preferred choice of climatic change communication channel since Rogers's theory has revealed the importance of these communication channels in the adoption process of innovations. The barriers limiting farmers' adoption of a response measure to the changing climate will also be examined in the study, thus hypothesizing that some farmers may be aware to climate change or have the knowledge about it and yet unable to respond.

CHAPTER THREE

METHODOLOGY

This chapter introduces the methodology used in this research for both data collection and analysis. Thus, it presents the location and description of the study area, study design, sampling procedures, methods, and tools of data collection. It also contains information on the empirical model used in the study, the ethical issues considered during the research, and the reliability of data collection instruments that are achieved through pilot testing.

3.1 Location of Study Area

The study was carried out in Kaffrine Region of Senegal which is located in the central part of the country. The region lies between 14 ° 07 N latitude and 15 ° 32 W longitude, and covers an area of 11181 Km^2, or 5.6% of the national territory (ANSD, 2015). Kaffrine Region also belongs to the southern groundnut basin of Senegal (agro-ecological zone) which largely contributes to the production of food in the country. The following districts in Kaffrine Region were randomly selected Birkelane, Malèm Hoddar, and Koungheul in Kaffrine Region. Simple random sampling was employed to select three communities from each selected district. Keur Elhadji Mor Coumba, Gama and Hamdallaye Wolof were the communities selected from Birkelane district, while Diokoul Wadene, Taiba Nguebanene and Tawfekh Saloum communities were selected from Koungheul district. In Malèm Hoddar district, Medina Dianke, Mbarocounda and Passy Mbelbouck were the communities selected for the study. The map of the study area is shown in the Figure 3.1.

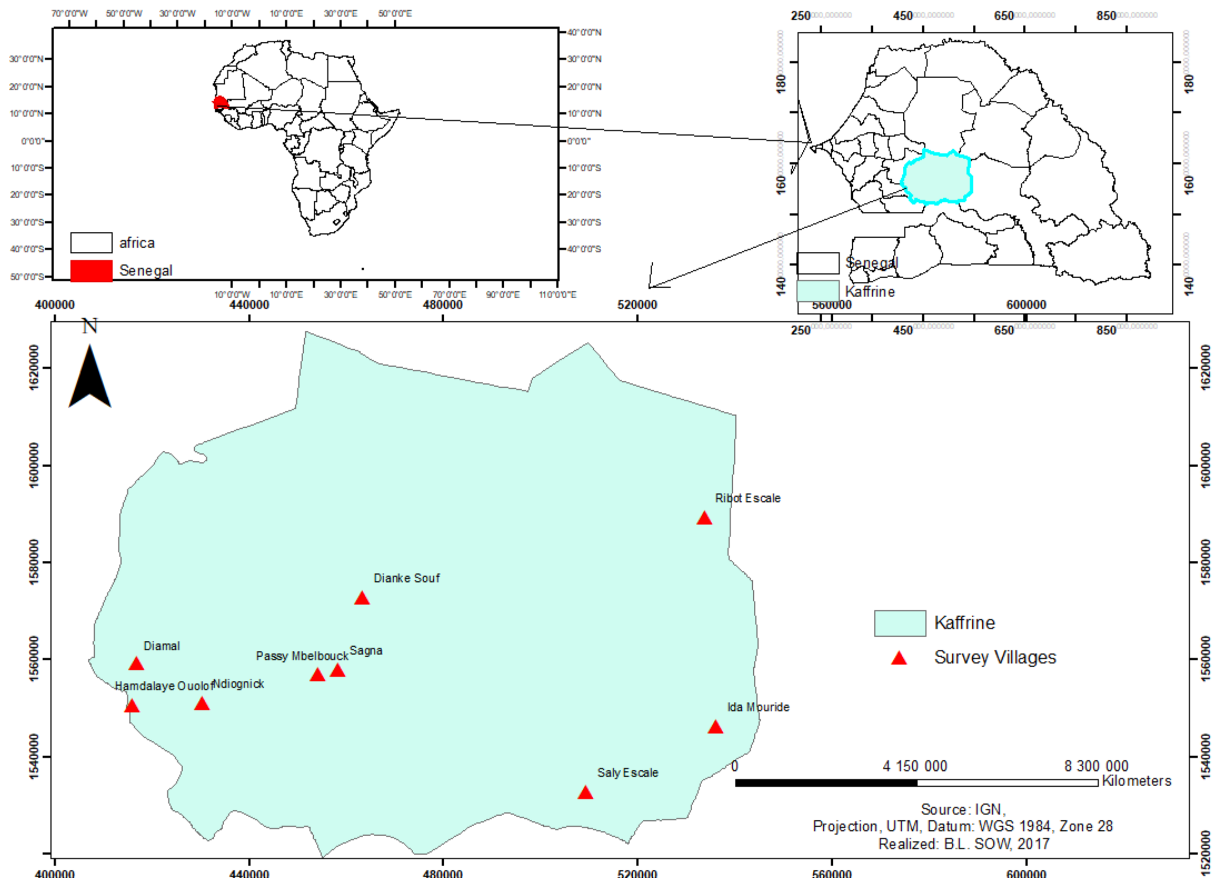

Figure 3.1: Map of the study area

NB: Diamal, Ndiognick, Sagna, Dianke Souf, Ribot Escale, Ida Mouride, and Saly Escale show the sub districts where the following communities were selected respectively: Gama, Keur Elhadji Mor Coumba, Mbarocounda, Medina Dianke, Tawfekh Saloum, Diockoul Wadene, and Taiba Nguebanene.

3.2 Description of Study Area

3.2.1 Soils of the Study Area

Kaffrine Region is located in the transition zone between the Sahelian domain and the Sudanian domains, and characterized by less vegetative cover, poor soil fertility and structure compared to the South of the country. This exposes the region to extreme climatic change since there is less vegetation to act as soil cover during times of windstorms during the dry season or heavy rains in the rainy season. In addition, all the communities of the region are facing a major land degradation challenge due to the combined effect of wind and water erosion, unsuitable farming practices, insufficient fertilizer inputs and overgrazing that poses threat to livelihoods of the rural poor. In Kaffrine Region there are three dominant types of soil. In fact, the tropical ferruginous soils (sandy to sandy-clay) are exploited for the cultivation of peanut and millet. The hydromorphic soils (clayey in nature), are a little scattered in the area, mostly found in the wetlands. The halomorphic soils, characteristic of salty or tannic environments, are mostly found in the Birkelane district. The material is often muddy, if not silt.

In Kaffrine Region, expanding groundnut production, introduced in the XIXth century, has led to the elimination of trees in the fields (Diouf, 2006). This has been done to optimize light conditions for ground nut, which is a very light-demanding crop. Instead of considering trees and shrubs as a contributing to maintaining ecological balance in the fields and field boundaries, farmers resorted to cutting trees to pave way for groundnut monocropping. The removal of the entire plant from the field leads to the reduction of organic carbon stocks, which in turn reduces the cation exchange capacity, the structural stability and the water retention of the soil (Mbow *et al.*, 2008). Furthermore, land cover change in Kaffrine Region has been characterized by agricultural expansion and degradation of the natural vegetation (Diouf, 2006). This means that the expansion of agriculture, dominated by ground nuts, results in the reduction of savanna vegetation in this part of Senegal. This will inevitably involve impacts on the ecological stability of these fragile environments, as reported by Tappan *et al.* (2004). Following the agricultural extension, clear signs of impoverishment of the top soil (0–20 cm) in terms of nitrogen, carbon and the C/N ratio have been noted (Kairé, 2003). Soil erosion is also a significant process in Kaffrine Region characterized by low tree cover and sandy soils with low clay and organic matter content. The strong winds during the dry season (called *Harmattan*) remove large quantities of sediments and nutrients from the area (Diouf, 2006), although substantial inputs of nutrients emanating from *Harmattan* dust can also be expected to be deposited during the dry season (He *et al*., 2007; Tiessen *et al*., 1991). This dry season erosion process is worsened by water erosion, particularly at the onset of the rainy season when strong rains on bare slopes favor erosion.

3.2.2 Climate of the Study Area

The climate in Senegal is tropical characterized by the alternation of a dry season from November to May and a rainy season from June to October. The average annual rainfall follows a growing gradient from north to south. In fact, the rainfall is more abundant in the south, where it ranges from 600 to 1,500mm per annum, while in the north and centre, which is part of the Sahel, the annual rainfall is lower than 600 mm (ANSD, 2015). Kaffrine Region is known for the considerable changes of its biophysical environment during the last century (Communauté Rurale de Kahi, 2003).

Kaffrine Region falls within Sudano-Sahelian zone with an interannual variability of rainfall. The average annual rainfall is, for several years, less than 800 mm (ANSD, 2015). Temperatures in Kaffrine Region are generally high, with significant variations. They oscillate between 26 and 39 ° C with an average of 29 ° C. Over the entire period (from 1931 to 2003), the overall situation of Kaffrine Region is a reduction of water resources because of severe droughts experienced in the past. Rainfall scarcity and unpredictable onset and intra-seasonal distribution of rains are major problems for rain-fed agriculture which is the main activity of the area and takes place during just 3–4 months per year. Water scarcity is a direct result of the overall decline in rainfall but also to other related hydrological stresses, such as a lowering of the groundwater table and an increase in evapotranspiration as a result of higher temperatures (Mbow *et al*., 2008). Figure 3.2 shows the trend of rainfall in Kaffrine Region from 1931 to 2003.

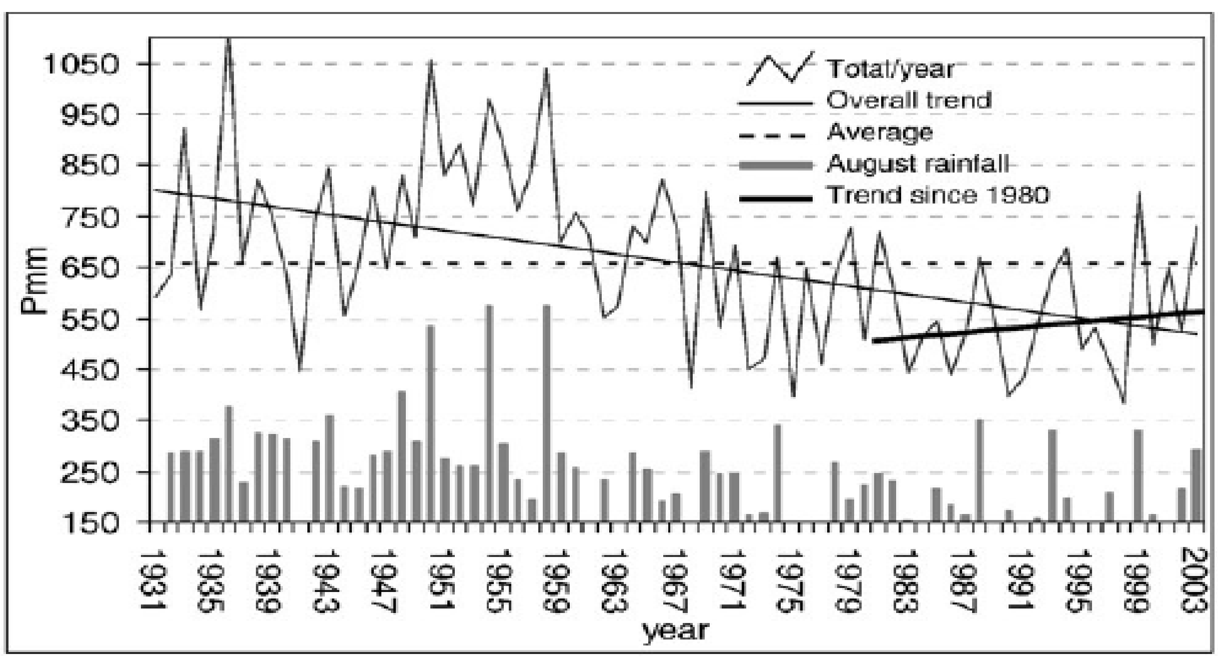

Figure 3.2: Rainfall trend in Kaffrine Region from 1931 to 2003 (Mbow *et al*., 2008)

3.3 Population of the Study Area

According to ANSD (2015) Kaffrine Region had a total population of 566,992 people out of the total Senegalese population of 13,508,715 people in 2013. Agriculture occupies an important place in the economic and social life of the Kaffrine Region. It occupies a good part of the population of the region. In 2013, 43,916 households in the region practice agriculture. This large number of practitioners combined with the satisfactory level of production highlights the agricultural vocation of the region. Furthermore, Kaffrine is the first producer of groundnut (21%) and third producer of cereals (12%) in Senegal (ANSD, 2015). In this region agriculture is the principal activity of the communities where groundnut, millet, sorghum, and maize are highly cultivated (Mertz *et al*., 2009). Despite this high agricultural potential, the region has witnessed rapid environmental degradation caused by the conversion of forest and savanna areas to agricultural land during the last 20–30 years and the combined decline in precipitation, soil degradation, a diversity of policies with little concern for the environment, fluctuating markets and population pressure, seem to threaten the food security in the area (Mbow *et al*., 2008) particularly communities in Birkelane, Koungheul, and Malem Hodar districts. Koungheul district had a total population of 163, 438 people whiles Birkelane and Maleme Hoddar districts accounted 101, 216 and 94, 662 habitants respectively in 2013. In the region, majority of the populations are Wolof, Sérére, Fullas, and Bambaras; and the large part of the population is Muslim whiles Christianity and animism represent a low percentage of the habitants.

3.4 Research Design

The research adopted and applied a descriptive design. Burns & Grove (2003) defined descriptive research as a design to depict a picture of a situation as it naturally happens. This design can be employed to make judgment and justify current pictures and also to develop theories. For this research a descriptive design was used in order to achieve the study objectives by describing farmers' awareness to climatic change, their adaptation strategies to climate change, the challenges farmers encounter in their response to the changing climate and their source of climate change information in the study site.

3.5 Sample and Sampling Procedure

A multistage cluster sampling technique was employed to select respondents for the study. The first stage was the selection of one region in the country. Senegal has fourteen (14) regions, but Kaffrine Region was purposively selected because it is one of the regions which are more affected by unpredictable rainfall, high temperatures and drought in the country, because of significant decline in rainfall during the rainy season since 1960 (Ndiaye *et al.*, 2013; Podestá *et al.*, 2013). Also, livelihoods of people in Kaffrine Region are heavily dependent on rain-fed agriculture, Kaffrine's vulnerability to climate-related shock and extreme events is more evident (Ndiaye *et al.,* 2013; Podestá *et al*., 2013). For the second stage, simple random sampling technique was then used to select three districts from the four districts in the region. Using the lottery method, the districts were labeled on pieces of paper, placed in a box and shuffled. Thus, for the study the three districts were randomly selected from the box. In the third stage, since communities in the various districts of Kaffrine Region share similar characteristics, three communities were randomly selected from each selected district in the region using the lottery method of simple random sampling. For the last stage, simple random sampling technique was used to select households from each community for the entire study as households serve as the sampling units for the study. In each selected house one household head was interviewed for the study but in the absence of the household head, any adult member (more than 18 years which is mostly considered as mature age) was interviewed. For the entire study 204 household heads were interviewed.

A key informant interview session was held with the individuals responsible for the sources of climate change information in the region. In fact, purposive sampling was used to select 2 farmers preferred source of climate change information in each selected district of the region. In addition, 3 main farmers preferred source of climatic change information were purposively selected for the entire region. This is because the study is specifically focusing only sources from which farmers' access climatic change information from Kaffrine Region which is the study area.

3.5.1 Sample Size

The study population was considered as all the households in the selected communities for the study. All farmer household heads with the sampling units being farmer households were considered as the sample frame for the study. Thus, household heads were considered as the target respondents for the study.

Krejcie & Morgan (1970) sample size formula (Equation 1) was used in computing the sample size for the study. In all 204 household heads were interviewed for the entire research.

Equation 1: Sample Size Formula

S = X2NP (1-P) /d2 (N-1) + X2 P (1-P) ……………………………………………… **[1]**

Where: S = required sample size

X2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841) that is 1.96 *1.96 = 3.841

N = the population size.

P = the population proportion (assumed to be 0.50 since this would provide the maximum Sample size)

d= the degree of accuracy expressed as a proportion (0.05)

From this formula a sample of 204 farmer household heads was obtained. To have the number of respondents from each village, the total number of households in each community was divided by the total households for the study (432) and the result value multiplied by 204. Table 3.1 shows the sample size interviewed in each selected community. This sample size formula has been widely used in research (Denkyirah *et a*l., 2016; Kutir, 2015; Ommani, 2011; Trede & Whitaker, 2000). Okumu (2013) used this formula in selecting the sample size in his study on small- scale farmers' perceptions and adaptation measures to climate change in Kitui County, Kenya. Also, Mburu *et al*. (2015) used this method in their study to compute the sample size of their study Climate change adaptation strategies on small-scale farmers in Yatta District, Kenya.

Table 3.1: Sample for the study

Region	*District*	Communities	Total households	Sampled households	Percentage (%)
Kaffrine Region	*Birkelane*	Keur Elhadji Mor Coumba	29	11	6
		Gama	74	31	15
		Hamdallaye Wolof	12	7	3
	Malèm Hoddar	Medina Dianke	59	26	13
		Mbarocounda	146	73	36
		Passy Mbelbouck	46	21	10
	Koungheul	Diokoul Wadene	10	8	4
		Taiba Nguebanene	12	7	3
		Tawfekh Saloum	44	20	10
Total	**3 districts**	**9 communities**	**432**	**204**	**100**

3.5.2 Research Data and Sources

The qualitative and quantitative data used in the research were primary and secondary data. The demographic characteristic of farmers, their awareness of climate change, farmers' sources of climate information, farmers' response strategies, and the challenges farmers faced in their response to climatic change were the primary data collected for the study. The secondary data collected were the relevant information obtained from published books and publications, newspapers, journals, internet, and reports from the Inter-governmental Panel on Climate Change (IPCC), United Nations Framework Convention on Climate Change (UNFCCC), World Meteorological Organization (WMO), National Adaptation Programme of Action (NAPA) of

Senegal, National Agency of Statistic and Demography (ANSD) of Senegal, National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), Direction of Analysis and Prevision of Agricultural Statistics (DAPSA), Regional Agency of Development (ARD) of Kaffrine, Food and Agriculture Organization (FAO) among others.

3.6 Research Instrument

3.6.1 Questionnaire

A semi structured questionnaire was used with both closed ended and open questions that were administered directly by the researcher to the sampled farmers. The questionnaire was structured in five sections with section A representing the demographic information of the respondents; section B consisting of questions in line with farmers' awareness of climatic change. The sections C, D and E of the questionnaire represent respectively response to climate change, farmers' sources of climatic information, and challenges associated with response to the changing climate. This questionnaire was used to gather data on farmers' demographic information as well as their awareness to climatic change, their adaptation strategies, and challenges limiting farmers' response to climate change, and farmers' communication channels and sources of climate change.

3.6.2 Focus Group Discussion

To guide the focus group discussion (FGD) a focus group guide was employed. Information on the consent process, rational of the focus group discussion and some rules for the discussion comprised the focus group discussion guide. The tool consisted of questions pertaining to farmers' awareness, farmers' source of climate information as well as farmers' preference source of climate information and also response and challenges farmers faced in their response process. The FGD guide was used to gather further explanations on data obtained from the individual farmer interview.

3.6.3 Key Informant Interview Guide

To guide the key informant interview session an interview guide was used. A series of open ended questions on the source of climatic change information of farmers preferred source of climatic change information as well as the challenges they face in educating farmers on the changing climate consisted the interview guide. The key informant interview guide was adopted to interview a journalist and an extension officer from each selected district in the region. This method was also adopted to interview a regional extension officer and 2 journalists from Kaffrine community radio and Nganda community radio in order to understand climate change information dissemination throughout the region. These people had experience and in depth knowledge in the study on climate change awareness creation. In addition, during the individual interview and focus group discussion sessions farmers indicated that radio and extension service as their most preferred source of climate change information. During the field study, nine key informants were interviewed.

3.6.4 Pilot- Testing of Instrument

A pilot-testing of the research questionnaire and guides was done at Nioro district which was closer to the study area in order to ensure accuracy and reliability of the research instrument. Nioro district was selected for the pilot-testing because of the shared socioeconomic characteristics it has with those communities selected for the study. It was administered to 20 respondents, who were selected randomly. The purpose of the pilot-testing was to know the suitability of the questionnaire and to reformulate some questions if necessary in order to guarantee the validity and reliability of the instruments.

3.7 Data Collection Procedure

3.7.1 Reconnaissance Survey

A community entry was conducted through a day visit to each study village. The purpose of the visit was to inform the village chief and elders of the aim of the study and to solicit their permission and support during the data collection process. The visit was also to get a contact person in the village that the researcher would correspond with for the period of the field research. It was also an occasion for the researcher to familiarize with the social and geographical conditions of the study site.

3.7.2 Interview

Plate 2.1 shows a face-to-face interview with the aid of a questionnaire which is administered to the sampled farmer household head. Here, the questions were asked to the interviewee and the answers recorded in order to access easily to the information needed since majority of the respondents could not read or write.

Plate 2.1: Farmer interview Session (source: author's photography)

3.7.3 Focus Group Discussions

Focus group discussion is a method in which the moderator keeps a small group of people to discuss the research topic (Gresehover *et al*., 2007). A focus group method of 7 to 10 farmers' household heads was held in each selected community (Plate 2.2). A total of 9 focus group discussions were held for the entire study, one in each village. Purpose sampling technique was used. Specific farmers were target in order to ensure the representativeness of the entire village in term of knowledge and gender among others. The discussion was chair by the researcher following the focus group guide. All the process was recorded. The method provided the opportunity to affirm some responses and serve as a cross check on the answers from the interview. It was also adopted to provide more detailed explanations on the data that was collected during farmers' individual interviews.

Plate 2.2: Focus group discussion (source: author's photography)

3.7.4 Key Informant Interview

A key informant interview session was held with individuals responsible for farmers preferred source of climatic change information (Plate 2.3). In fact, an extension officer and a journalist from the community radio were interviewed for each selected district. Also, a regional extension officer and 2 journalists from respectively Kaffrine community radio and Nganda community radio were interviewed as well. At the end 9 key informant interviews were conducted in the study area. An in-depth knowledge on their source of climatic change information and the challenges they face in educating farmers on climate change and adaptation strategies were provided during the key informant interview session.

Plate 2.3: Key informant interview (source: author's photography)

3.8 Data Analysis Procedure

The quantitative data from the individual interviews was analysed with the aid of statistical software STATA 14.0 and Statistical Package for Social Sciences (SPSS) version 23. The qualitative information obtained through key informant interview and focus group discussion sessions were processed to supplement the quantitative data. To analyze farmers' demographic and socioeconomic characteristics, frequencies, means, modals, standard deviations, maximum, minimum values and percentages (descriptive statistics) were used during the procedure. This process was also used to analyze data on farmers' awareness, adaptation strategies to climatic change, and source of climatic change information. Furthermore, an awareness index was also calculated for the sample in order to assess climate change awareness of the sampled farmers. This study adopted the calculation technique of climate change awareness used by Kutir (2015). Thus, climate change awareness was estimated as a composite of three indicators: i) ***conceptual awareness***; ii) ***experiential awareness***; and iii) ***engagement***. According to Gbetibouo & Mills (2012) conceptual awareness is about the individual' knowledge on the human causes of climatic change and their impacts whiles experiential awareness refers to experiencing and knowing long term changes in climate and their impacts. The last indicator, engagement, is also defined by Gbetibouo & Mills (2012) as the frequency with which an individual talks or hears about climatic change, but also spreads his/her acquired knowledge on awareness among the community.

The answers from the questions in the awareness section of the questionnaire were assigned a numerical score which were summed up for each respondent in order to compute the awareness index for each participant. To compute a climate change awareness index, the responses to the nine questions were used. Therefore, the index was calculated as follows: the scores from the nine questions were summed up and the minimum and maximum total scores a participant obtained was between 0 and 17 respectively to get an index between 0 and 1, and the total score that a participant got was then divided by 17. Climate change awareness scores were further normalised to range between 0 – 100% by dividing the scores with the highest possible score (17) and multiplying the quotient by 100 as shown in Equation 2 below.

Equation 2: Climate Change Awareness Index Formula……… [2]

$$CCAI = AS/MS*100$$

Where;

CCAI refers to Climate Change Awareness Index

AS means Awareness Score

MS refers to Maximum Score

Empirical model

To examine the factors that affect a farmers' response to the changing climate, a logistic regression model was used to determine the farm and socioeconomic characteristics that influence a farmers' response to climatic change. The main objective was to investigate the factors that affect farmers' decision to adapt or not to climate change. In the literature numerous studies have indicated that a number of farm characteristics such as soil fertility and size of farm among others and socioeconomic characteristics such as gender, age, formal educational status, awareness about climate change, household size affect a farmers' response to the changing climate (Denkyirah *et al*., 2016; Mudombi, 2011; Bryan *et al*., 2009; Gbetibouo, 2009; McConnell *et al*., 2009; Okoffo *et al.,* 2016). The lack of response measures to climatic change will adversely affect agricultural production with the consequential implication of making farmers more vulnerable to the changing climate (Mabe *et al*., 2014; Smit & Skinner, 2002). Therefore, Mabe *et al*. (2014) assert that farmers' response to climatic change is based on their expectations about the possible benefits that may be obtained in the future. Denkyirah *et al.* (2017) argued that farmers have a level of utility they want to meet and therefore make choices based on that.

The binary logistic model falls in the group of qualitative response models which have the dependent variable as an indicator of a discrete choice (Greene, 2003). According to Deressa *et al.* (2009) the main advantage of the binary logistic regression model over other models of discrete and limited dependent variables is that it allows the analysis of decisions across two categories, allowing the determination of choice probabilities from different categories. In addition, its likelihood function, which is globally concave, makes it easy to compute. However, the main limitation is the independence of irrelevant alternative properties, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternatives in the available choice selections (Deressa *et al.*, 2009; Greene, 2003). The binary logistic is represented as shown below.

$$\Pr(y=1 \mid x') = \frac{\exp(x'\beta)}{1+\exp(x'\beta)} = \Lambda(x'\beta) \qquad \textbf{(3)}$$

Where;

Pr (y =1| x') represents the probability of an event happening, the dependent variable takes a value of 1 given an independent variable x'. The x' represents vectors of all the independent variables. The explanatory power of the independent variable is explained by the coefficient β. The dependent variable is the probability of a household responding to climate change by adapting to variations in climate. This dependent variable takes two discrete values which are: 1= at least one adaptation strategy or 0=no adaptation.

The model predicts the maximum likelihood of a household being an adapter versus being a non-adapter. The coefficient β in the model depicts a relationship of how variations in the independent regressors affect the predicted log of odds of a household being an adapter versus being a non-adapter. This relationship between the dependent and the independent variable can be depicted using the antilog of the β (exp β) which is the odds ratio. The formula of the odds ratio is presented below.

$$\frac{P_i}{1-P_i} = \frac{1+e^{\Lambda(x'\beta)}}{1+e^{-\Lambda(x'\beta)}} = e^{\Lambda(x'\beta)} \qquad \textbf{(4)}$$

Where Pi is the probability of adapting (Pr(y =1| x') in equation (3) and 1− Pi is the probability of no adaptation (Pr(y = 0 | x')). Equation (4) represents the odds ratio in favor of adapting to variations in climate which is the ratio of the probability that a farmer adapts to the probability of not adapting. An odds ratio that is greater than 1 implies that a unit increase in the continuous variable or discrete change in the categorical variable in the regressors leads to a decrease in the odds of a household being an adapter versus being a non-adapter (Mandleni, 2011; Long, 1997).

In summary, to estimate the factors influencing farmers' adaptation to climate change in this study the logistic regression model was employed by using the STATA software version 14.0. Thus, The logistic model for "*k*" independent variables (*X*1, *X*2, *X*3, …., *Xk*) is given by

$$\text{Logit}P(x) = \alpha + \sum_{i=1}^{k} \beta_i x_i \qquad \textbf{(5)}$$

Where α denotes a constant and βi denotes the regression coefficient.

The logistic regression model could be specified for this study as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \varepsilon \quad \textbf{(6)}$$

where Y denotes whether to adapt or not, X_1 denotes gender, X_2 denotes age of farmer, X_3 denotes marital status, X_4 denotes household size, X_5 denotes awareness about climate change, X_6 denotes education of the farmer, X_7 denotes years of farming experience, X_8 denotes farm size, X_9 denotes access to extension, X_{10} denotes member of farmer organization, X_{11} denotes access to credit. These 11 Xi chosen correspond to the 11 independent variables which were hypothesized to influence a farmers' response to climate change based on literature review. To envisage the probability of farmers' response to the changing climate in Kaffrine Region, the logistic regression model uses a number of independent variables that are mentioned above. The Description statistics of variables hypothesized to influence farmers' response to climatic change is presented in Table 3.2.

Table 3.2: Explanatory variables for logistic regression model

Variable	Mean	Standard Deviation	Minimum	Maximum	A *priori* expectation on R
Gender (male=1 female=0)	1.25	0.437	0	1	+/-
Age	46	1.412	18	81	+/-
Marital status (yes=1 no=0)	1.07	0.403	0	1	+
Household size	10	0.695	2	33	+
Awareness about climate change (yes=1 no=0)	0.96	0.195	0	1	+
Educational level (educated=1 not educated=0)	4.67	1.010	0	1	+
Farming experience	18	1.124	3	73	+
Farm land size (hectares)	1.36	0.828	1	33	+/-
Access to extension service (yes=1 no=0)	0.67	0.473	0	1	+
Member of farmer organization (yes=1 no=0)	0.08	0.270	0	1	+
Access to credit (yes=1 no=0)	0.05	0.227	0	1	+

The independent variables for the logistic regression model are statistically described in the table 3.2 in order to give a general overview of the factors that are expected to influence a farmer's response to the changing climate in the study area.

3.9 Ethical Considerations

The permission to administer household questionnaires and conduct key informant interviews was consensual in this study. In fact, permission from the Governor of Kaffrine Region was obtained through the help of the administration of Climate change and Education programme by explaining the purpose of the research and how it was going to benefit the region. After that the village chiefs of the selected communities were informed in order to get their approval for the study. A community entry was then conducted to meet the members of the community in which the village chief informed them of the present and purpose of the researcher as well as seek their support during the data collection procedure. Prior arrangements with the respondents were made in order to avoid any eventual inconvenience during questionnaire administration. The researcher also assured the respondents anonymity, that information given will be treated confidentially, professionally and for only the purpose of the research. Respondent's approval to participate in the study prior to administering the questionnaire was also sought by the researcher. Also, the option to withdraw from the study at any point during the research was fully given to the participants.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter contains a detailed presentation and discussion of the results of the study. The presentation of the results is done concurrently with the discussion. These include demographic characteristic of the respondents, farmers' awareness of climate change, and farmers' source of climate change information. Afterwards, the chapter discusses the farmers' perception about climatic change and their response to climate change, the challenges associated with responding to the effects of climatic change, and the results of the logit regression model on the factors affecting farmers' response to the changing climate.

4.1 Demographic Characteristic of Respondent

A large part of respondents (74.5%) were males while the remaining 25.5% were females (Table 4.1). The relative domination by male respondents among the farmers could be the result of males having greater access to farm land than female farmers. Also, this could be due to the fact that farming activities are usually labour-intensive. Thus, women in the study area seem more focusing on domestic work among others rather than making effort to have their own land, although they effectively participate to the farming activities of the household. This result is similar to the general *census* of Senegalese's population conducted by ANSD (2015) in which it has been stated that males are relatively more numerous than females in Malem Hodar and Koungheul districts. Also, the findings of this study are in conformity with that of Denkyirah *et al.* (2017) in which they found that the number of female farmers was relatively low in Brong-Ahafo Region of Ghana.

Table 4.1: Age, Gender, and Years of farming experience, Household size, Farm land size, and Educational level of respondents

Variables	Description	Frequency	Percentage (%)
Age	between 18 and 30	39	19.1
	between 31 and 40	49	24.0
	between 41 and 50	36	17.6
	between 51 and 60	40	19.6
	over 60	40	19.6
	Total	204	100.0
Gender	Male	152	74.5
	Female	52	25.5
	Total	204	100.0
Years of farming experience	between 1and 5	4	2.0
	between 6 and 10	22	10.8
	between 11 and 15	19	9.3
	between 16 and 20	33	16.2
	21 or more	126	61.8
	Total	204	100.0
Household size	between 1 and 3	3	1.5
	between 4 and 6	16	7.8
	between 7 and 9	37	18.1
	10 or more	148	72.5
	Total	204	100.0
Farm land size	between 1 and 10	162	79.4
	between 11 and 20	24	11.8
	between 21 and 30	4	2.0
	31 or more	14	6.9
	Total	204	100.0
Educational level	primary education	11	5.4
	secondary education	5	2.5
	no formal education	8	3.9
	Quaranic education	180	88.2
	Total	204	100.0

Figure 4.1 also showed that the majority (96.5%) of the farmer household heads were married while 1.5% was observed to be single. It also showed that 0.5% of the respondents were divorced

whilst 1.5% was reported to be widows. This means that most farmers who engage in farming in the study area are married. It could be an advantage for the household as married farmers could be a considerable support for farming activities compared to single farmers who could hire individuals for labour among others. The finding is in line with that of ANSD (2015) in which it has been reported that majority of the population in Kaffrine Region was married. This result is also consistent with Bammeke (2003) who stated that individuals who undertake agricultural activities are married. In addition, as married farmers engage in supportive efforts in their farming activities, thus, their spouse could be a source of support in terms of labor and also help supplement the income needed to acquire agricultural inputs and consequently increase crop production (Kutir, 2015).

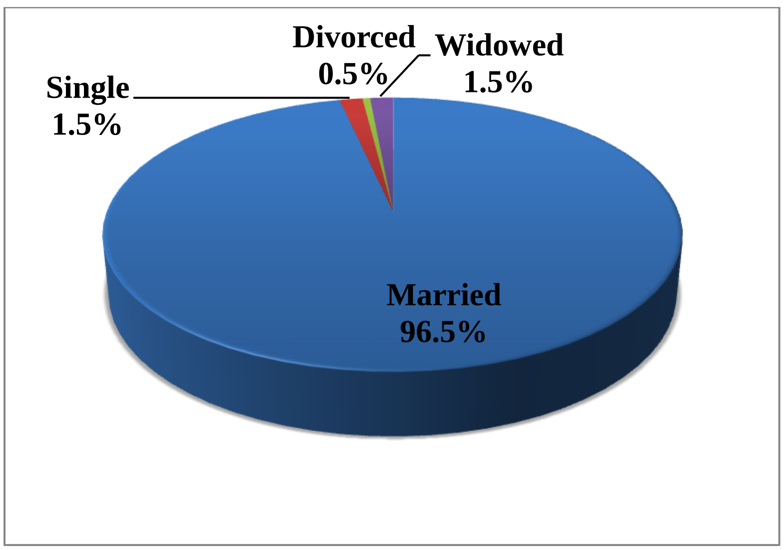

Figure 4.1: Marital status of farmer households heads

The others socio-economic characteristics of the respondents are also presented in Table 4.1. It is indicated that the proportion of farmers whose ages ranged between 18–30 years was 19.1%, 31–40 years was 24.0%, 41–50 years was 17.6%, 51–60 years was 19.6 and over 60 years was 19.6%. The youngest and oldest ages of farmer household heads were 18 and 81 years respectively with the mean age of 46 years. The majority (24.0%) of farmers were within the age bracket of 31-40 years old. This means that farmers in the study area are relatively young. It could be predicted that farmers in the study area would have more interest and incentives in tackling climate change issues since they are relatively young and active. This result agrees with the findings of Luka & Yahaya (2012) and Yusuf (2005) that most farmers are within their active years and can make positive contribution to agricultural production since they were predominantly in their middle ages hence are economically active and thus can undergo stress and have the manpower to carry out labor intensive response strategies. The majority (72.5%) of the farmers had household size of 10 or more persons. Proportion of farmers who had household size between 7 and 9 persons was 18.1%, household size between 4 and 6 persons was 7.8% and household size between 1 and 3 persons was 1.5%. The mean household size was 10 persons per household with the highest and lowest household size being 33 and 2 members respectively. This is an indication of large family size in the study area. This also means that farmers have a source of cheap labour from their large household size. Furthermore, to supply the labour necessary for crop production large sized rural households would be a considerable support in agricultural system and this would have a positive repercussion for crop production. Very few (2.0%) farmers had farming experience between 1 and 5 years while the majority (61.8%) of the farmers had farming experience 21 or more years with a mean of 18 years of experience. This means that majority of the farmers are experienced in farming in the study area and this is important in climate change adaptation. Also, farmers' experience in the study area could be crucial for Government and NGOs which are doing programs on climate change in the area. Thus, one must effectively consider farmers' experience in taking climate change adaptation measures in the study area. This result is in line with the findings of Danso-Abbeam *et al*. (2014) which stated that a good farming experience could help farmers in making good decisions and choices in their crop production process hence, has a positive implication for crop productivity. On farm land size the results indicated that majority representing 79.4% of the farmers had farm land size between 1 and 10 hectares with 6.9% having a land size equal or more than 31 hectares (Table 4.1). This means that farmers in the study area were relatively subsistence farmers making them vulnerable to the changing climate. In addition, farmers in the study area seem to be greatly weak to handle a large farm size under the threat of the changing climate and consequently they are still farming in the small size of land in order to survive in general. These findings are in agreement with that of Idrisa *et al*. (2012) in which they found in their study area Borno State of Nigeria, that famers were generally vulnerable to climate change because of their subsistence farming activities which are probably linked to small land size.

In terms of education, 5.4% of farmers in the study area had education up to primary, 2.5% had education up to secondary, majority (88.2%) had Quaranic education and only 3.9% had no formal education. This shows that literacy level in the study area is very low, thus inhibiting farmers' understanding and use of crop technologies. Low educational level of farmers in the study area has implication for climate awareness and response to climatic change as well as the adoption of new agricultural innovations and technologies. It is suggested that educated farmers tend to be more efficient in production and readily accept new innovation when compared to uneducated ones that rely on their experience (Martey *et al*., 2013; Enete & Igbokwe, 2009). This means that adaptation to climate change would not be a major challenge in relation to education. Furthermore, farmers should be more educated and trained on improved and sustainable response strategies for crop production due to its capacity to increase crop yields and food security (Tesfay, 2014). In addition, Maddison (2007) asserted that educated and experienced farmers are expected to have information and knowledge about climatic change and adaptation measures to use in response to the changing climate. Also, Idrisa *et al*. (2012) argued that a minimum threshold in terms of educational qualification is necessary for understanding the technical and scientific nature of modern agriculture. The result of the study agrees with the findings of Yegbemey *et al*. (2014) that educational level of farmers was low in their study area Northern Benin.

As shown in Table 4.2, majority (94.6%) of farmers lack access to credit in the study area whilst only 5.4 % had access to credit from banks, cooperative unions, and farmer organizations. This has repercussion for crop production as credit is needed to acquire farm inputs such as fertilizers, seeds, and efficient farm tools and machines for production. This can also hinder adoption of new technologies and climate change adaptation. This lack of access to credit for farmers was confirmed during the focus group discussions and key informant interviews which revealed that many farmers are not even aware of the existence of financial institutions for agriculture in the area or to have access to those existing institutions remains a challenge for them. The result corroborates the findings of Marchetta (2011); and Ansoglenang (2006) who asserted that access to credit by rural farm households is out of reach.

Table 4.2: Access to credit, Access to other forms of support, Access to extension service, and Organizational membership

Variables	Description	Frequency	Percentage (%)
Access to credit	No access to credit	193	94.6
	Access to credit	11	5.4
	Total	204	100.0
Access to other forms of support	No access to support	118	57.8
	Access to support	86	42.2
	Total	204	100.0
Access to extension service	No access to extension	68	33.3
	Have access to extension	136	66.7
	Total	204	100.0
Farmers organizational membership	Not a member	188	92.2
	A member	16	7.8
	Total	204	100.0

The findings also revealed that 92.2% of the respondents did not belong to any farmer organization whilst 7.8 % were members of farmer organizations. This could be an obstacle for the farmers in the study area to deal with climate change impacts properly (Table 4.2). This finding was confirmed during the focus group discussions in which many farmers argued that the main problem with the existing farmer organizations in the study area is the monitoring process and the practical aspects. That is the principal raisons why majority of farmers in the study area prefer do not belong to any farmer organization because they hardly get benefits from it. Thus, these farmer organizations could adopt participatory approach in which each member could build his or her local and personal ownership leading to sustainable development programs on climate change issues among others and consequently this could improve relationship among partners and attract social volunteers for the organizational membership. In terms of access to other form of support, 42.2% of the respondents had access to seeds, fertilizers, and other farm machines and tools from the Ministry of Agriculture of Senegal, and others NGOs for their crop productions whilst the majority (57.8%) did not have access to any other form of support for their farming (Table 4.2). This means that the adaptive capacity of farmers in the study area would be decreased if they do not have access to credit, enough farm inputs, and organizational membership. In addition, the inability of farmers to be member in a farmer organization in the study area could be a disadvantageous as many at times organizations who support farmers prefer to deal with them in groups. Thus, access to resources (human and physical) and credit are considered as key determinants of adaptive capacity (Gbetibouo & Mills, 2012). Table 4.2 also illustrated that 33.3% of the farmers had never had any extension contact whilst a large percentage of farmers (66.7%) had access to extension service in the study area. This lack of extension service by most farmers have adverse implication for farmers climate awareness and sustainable adaptation as they are deprived climate change information and appropriate response strategies needed to increase productivity in the study area. Moreover, the lack of access to extension service for farmers as revealed in the study area will likely affect farmers' adaptation to climate change. In addition, extension officers are responsible for educating and training farmers on climate and agricultural issues especially on how farmers can sustainably respond to climate change to increase crop yields. The result of this study is similar to the findings of Okumu (2013) and Mudombi (2011) who revealed that a large percentage of farmers had access to extension service in their study areas in Kitui County of Kenya and Seke and Murewa districts of Zimbabwe respectively. Furthermore, Maddison (2006) reported that farmers who have access to extension service are more likely to adapt to climate change. However, the 33.3% of farmers in the study area without access to extension service might not be adequately informed about improved adaptation methods to climate change, although they might be aware of long-term changes in climatic variables. In addition, during the focus group discussions farmers argued that they rarely understand the message on climate change and agricultural issues that is often delivered by extension services and that represents a challenge for them to effectively tackle the changing climate. This could explain the considerable percentage of farmers who did not access to extension services. Also, during the key informant sessions journalists and extension officers claimed a need for them to be more trained and educated in climate change field so that they could effectively deliver climate change information to the farmers in their local language.

4.2 Awareness of Climate Change in Kaffrine Region

Farmers' awareness of climate change is presented in Figure 4.2. Out of the 204 respondents, 154 (64.7%) indicated they have heard of climate change or have an idea of what climate change is, while 35.3% indicated they had never heard of climate change. This result indicates that farmers in the study area are relatively aware of climate change. These findings could be explained by the fact that a large part of the farmers in the study area had access to extension services and daily listen to radio broadcast which could be probably their sources of climate change information, coupled with their farming experience which is relatively high. Also, numerous programs on climate change awareness and agricultural issues have been launched in Kaffrine Region by the Government and NGOs like ied Afrique which could be considered as factor that contributed in increasing farmers' awareness in climate change in the study area. This would help farmers adapt to climate change mitigation measures and help create awareness among fellow farmers. Fosu-Mensah *et al*. (2012); Gbetibouo (2009) and Mertz *et al*. (2009) reported similar results on farmers' awareness of climate change in their different studies areas Sekyedumase district of Ghana, Limpopo Basin of South Africa and in rural Sahel respectively.

To further assess farmers' awareness on climate change, an awareness index was computed. The average awareness index for the study was 0.5903 (59.03%). The awareness index for this study implies that farmers in Kaffrine Region are aware of the changing climate. In addition, Gbetibouo (2009) reported that climate change awareness/perception is a prerequisite first step to response. Thus, this considerable average awareness index in the study has positive implications for food security and sufficiency since farmers have adequate knowledge about the changing climate and can therefore respond sustainably to it.

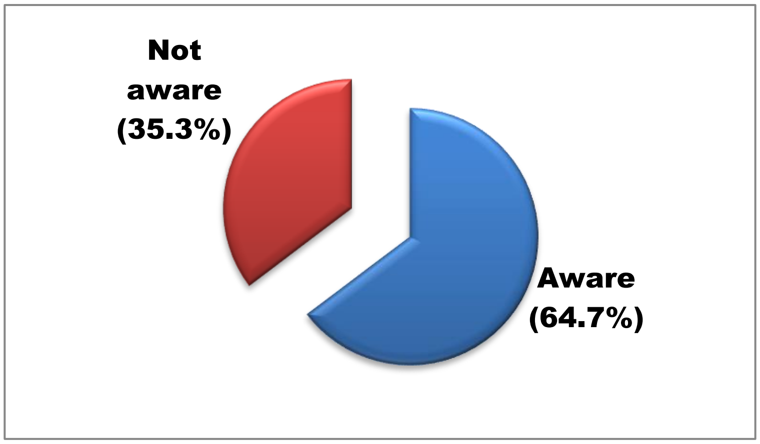

Figure 4.2: Farmers climate change awareness

As shown in Table 4.3, a comparison of farmers' awareness of climate change was done between the three selected districts for the study. Thus, Birkelane and Malem Hodar had an awareness index of 0.5601 (56.01%) and 0.562 (56.20%) respectively. This shows that the average awareness index computed among sampled farmers in Birkelane and Malem Hodar districts are relatively equal. Farmers in Koungheul district had the highest awareness index of 0.709 (70.90%) for the entire study because the interviewed farmers in this district relatively have more access to extension services and programs on climate change awareness and education. Therefore, the finding revealed that the least aware farmers were found in Birkelane and Malem Hodar whilst the most aware farmers were in Koungheul district.

Table 4.3: Climate change awareness index according to selected districts

District	Average awareness index (%)	Minimum	Maximum
Birkelane	0.5601 (56.01%)	0.234 (23.40%)	0.887 (88.70%)
Malem Hodar	0.562 (56.20%)	0.236 (23.60%)	0.852 (85.20%)
Koungheul	0.709 (70.95)	0.323 (32.30%)	0.926 (92.60%)

4.3 Gender and Climate Change Awareness

Table 4.4 presents gender distribution of the respondents with respect to the awareness level according to the selected districts. Out of the 50 females sampled for the study, 12.5% of the females from Malem Hodar district were not aware of the changing climate. Whilst all the sampled males in Koungheul district representing 80% were aware of climatic change. In

Birkelane district, majority of the respondents were aware with 18.36% males and 4.08% females who were not aware of climate change. As shown in table 4.4, the awareness score of 1 which indicated an awareness of climate change reveals that out of 154 males sampled for the study, all the males in Koungheul district were aware of climate change (80%) as compared to the males in Malem Hodar and Birkelane districts which recorded 51.6% and 73.4% respectively. In the female category, Malem Hodar district had the highest percentage of females who were aware of climate change (20%) with Birkelane having the least with 4.08% of females who were aware of the changing climate. These results thus indicated that male farmers were relatively more aware of climate change compared to females in all the three districts since male have more access to agricultural and climate information through their *daathiaya* (shade for relaxing/community center) meetings which are strictly for them and where they discuss about issues such as agriculture and climate. This means that males have a higher likelihood of receiving information on new farming technologies and climate in the study area. Therefore, women are relatively denied equal access to climatic change information from some sources and consequently that could negatively affect their awareness level. This relative low awareness of climate change of female farmers in the study area could be due to the fact that during their meetings (called *Tour*) women in the selected villages probably discuss about other topics rather than climate change issues. Also, although, women in the selected communities do listen to the radio broadcast but it seems they do not effectively understand the programs on climate change that are broadcasting by community radios. Hence, their level of awareness of climate change is observed to be relatively low. The findings of this study are in line with the studies of Asfaw & Admassie (2004) and Tenge & Hella (2004) who reported that female have restricted access to information, land, and other resources due to traditional social barriers in Ethiopia and West Usambara highlands in Tanzania respectively. This relative low awareness of climate change of female farmers in the study could have a negative implication for food production in those selected communities since climate change awareness is a crucial step to sustainable response to the changing climate.

Table 4.4: Gender and climate change awareness

Awareness index	Gender	Birkelane	Malem Hodar	Koungheul
Not aware of climatic change	Male	18.3%	15.8%	0%
	Female	4.08%	12.5%	14.3%
Aware of climatic change	Male	73.4%	51.6%	80%
	Female	4.08%	20%	5.7%
Grand total		100%	100%	100%

4.4 Source of Climatic Change Information

The results revealed that most of the respondents received climatic change information from diverse sources with majority representing 63.23% received climate change information from radio broadcast, whilst 18.13% received climatic change information from colleague farmers, and radio broadcast (Table 4.5). The findings also indicated that 0.49% of the farmers received climate change information from both colleague farmers and extension services, whilst 9.80% received climate change information from their colleague farmers alone and 1.47% of the respondents received climatic change information from extension workers. However, 6.4% of the farmers indicated that they have ever heard about climatic change from any source. Furthermore, farmers also indicated during the focus group discussion sessions that mobile phones and their community meetings which are mostly used to be held in their *daathiaya* (community center/shade for relaxing) were some sources of climatic change information. In fact, during their community meetings farmers discuss and share ideas about agricultural and climate issues. In the study area farmers have many sources both interpersonal and media sources of climate information and they would be equipped with diverse knowledge on adaptation strategies to climatic change to increase productivity, ensure food security and sustain their livelihoods. The findings of the study are in accordance with Oduniyi (2013) who found that a large part of the respondents received climate change information from radio in Mpumalanga Province of South Africa, whilst they contradicted with the findings of Denkyirah *et al.* (2017) in which it has been suggested that the majority of farmers in Brong-Ahafo Region of Ghana indicated that own experience/ observations were their main sources of climate change information. Thus, farmers' access to information on climate change and innovations through extension contact is a major challenge in the study area and that farmers rely mostly on radio broadcast and colleague farmers in adopting innovations. In addition, Tessema *et al*. (2013) revealed that extension service was the least source of information on climate change to farmers. Also, Maponya & Mpandeli (2013) found that most farmers in rural areas did not have access to other sources of information such as flyers, magazines and the internet and getting information remains a challenge. They were only able to access limited climate change information through local chiefs and the tribal authority.

Table 4.5: Farmers source of climatic change information

Source of climatic change information	Frequency	Percent
Never heard of climate change from any source	13	6.37
Radio broadcast	129	63.23
Colleague farmers and radio	37	18.13
Colleague farmers and extension services	1	0.49
Colleague farmers	20	9.80
Radio, colleague farmers, and extension services	1	0.49
Extension services	3	1.47
Total	**204**	**100**

As shown in Table 4.6, a considerable part (36.8%) of the respondents preferred radio broadcast as their source of climate change information, whilst 28.4% preferred extension services and 26.4% of them preferred researchers and project/NGOs as source of climate change information. The raisons behind of this preference of radio broadcast as farmers' source of climate change information was that farmers have trust and confidence in the climatic change information from the radio broadcast because radio broadcast was their only source of climate change information and for its capacity to reach uneducated farmers with matters associated to crop production in comprehensible language. Also, farmers indicated that they preferred radio broadcast as source of climate change information because experts in climate and agricultural field discuss on the radio and that could be a benefit for them in order to deal with climate change and agricultural issues. The results are similar to the findings of Churi *et al*. (2012) in which it has been revealed that majority of the farmers preferred radio broadcast as their source of climate and agricultural market information in Tanzania. In the study area, the justification of 28.4% preferred extension services and 26.4% preferred researchers and project/NGOs for sources of climate change information by farmers was that they consider extension workers and researchers among others have the knowledge and the responsibility to educate, train and advise farmers on farming and climate issues. Also, the Table 4.6 presented that 4.41% of the farmers indicated that neighbour farmers were their source of climate change information, whilst the least preferred source of climate change information for the study was farmer association representing 3.92%. This means that farmers in the study area would like to have an effective access to extension services and researchers and project/NGOs as sources of climate change information instead of relying only on their colleague farmers among others to be informed about the changing climate. Furthermore, it is established in the literature that the more number of contact farmers have with extension personnel and services the better their production, productivity, and the more efficient the farmers in the use of resources, and invariably the more the profits (Otitoju, 2013). In addition, the justification about the minority of the respondents (3.92%) that preferred farmer associations as their source of climate change information could be attributed to the fact that majority of the sampled farmers were not members of any farmer association. Thus, the diffusion of climatic change information and agricultural innovations has to be done through appropriate communication channels which will be based on the different preferences of communication sources of farmers.

Table 4.6: Preferred source of climatic change information for farmers

Preferred source of climatic change information	Frequency	Percent
Radio broadcast	75	36.8
Extension services	58	28.4
Researchers	27	13.2
Project/NGOs	27	13.2
Neighbor farmers	9	4.4
Farmer association	8	3.9
Total	204	100

4.5 Farmers' Perceptions of Changes in Temperature and Rainfall

Farmers' perception on climate change is important for climate change adaptation. Table 4.7 shows that 96.07% of the farmers in the study area had experienced changes in climatic factors with 88.23% of them perceiving changes in both rainfall and temperature, whilst 2.94% perceived changes in only rainfall and 4.9% perceived changes in only temperature. However, 3.92% of the respondents perceived no changes in temperature and rainfall at all for the same period. A considerable part of the sampled farmers attributed these changes in climatic factors (temperature and rainfall) to continuous deforestation (depletion of forest resources), bush fires, atmospheric pollution, and increased population but some of them linked these changes to Allah (God). The results on perceived changes in temperature and rainfall by farmers are in line with the findings of Oluwatusin (2014); Fosu-Mensah *et al*. (2012); Oyekale & Oladele (2012) and Hassan & Nhemachena (2008) in Ondo State of Nigeria, Sekyedumase district of Ghana, Southwest of Nigeria, and African countries respectively.

Table 4.7: Farmers' perceptions of changes in temperature and rainfall

Perception	**Frequency**	**Percent**
No changes in climate factors	8	3.92
Changes in climate factors	196	96.07
Total	**204**	**100**
Perceived changes in climatic factors	**Frequency**	**Percent**
Change in temperature only	10	4.9
Change both temperature and rainfall	180	88.23
Change in rainfall only	6	2.94
Total	**204**	**100**

Majority of farmers representing 95.09% in the study area have perceived a decreased in the amount of rainfall, early cessation and late start of raining season for the past 3 years, whilst 3.92% of them perceived increased in rainfall, late start and short length of the raining season and 0.98% of the respondents could not give any argument about these changes in rainfall (Appendix 1). Furthermore, farmers indicated that during the FGD, the rainfall pattern had been changing with continuous decreasing, early cessation and late onset for the past 30 years with each succeeding year having a slightly higher or lower amount of rainfall than the preceding year. Moreover, Figure 4.3 shows the meteorological trends of the rainfall pattern in the region for the past 3 years which revealed a decrease in amount of rainfall during this period (2014, 2015, and 2016). During these 3 observed years there was no evidence of an early interruption of rainfall. However, there was a late onset of the rains to the month of June instead of May as experienced in 2014 and 2015. Thus, the late onset and decrease in amount of rainfall perceived by farmers for the past 3 years are relatively confirmed by the meteorological trends. Since the main activity in the study area is rain-fed agriculture then these changes in rainfall have considerable implications for crop production, food security and sufficiency which have been experienced by the farmers through low crop yields, and loss of entire crop yields during their farming activities.

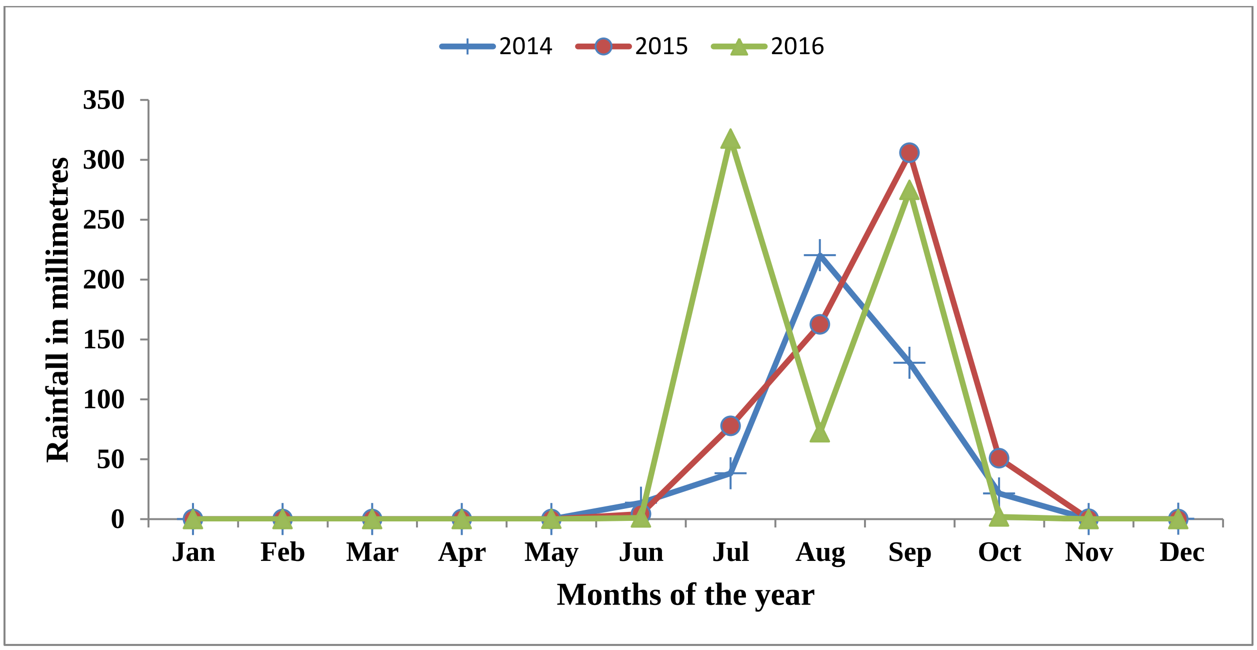

Figure 4.3: Rainfall pattern in Kaffrine Region for the past 3 years

Source: National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), 2017

In addition, farmers' perceptions of climatic change and variability do not relatively correspond with the climatic data records in the study area for the past 30 years (Figure 4.4). In fact, during the Focus Group Discussion farmers indicated that rainfall was continuously decreasing over the past 30 years. This is not in agreement with results obtained by the climatology data recorded in the region for the past 30 years, where it showed a relative increase in rainfall. From Figure 4.4, the R^2 (0.1212) indicates a weak relationship in the trend of rainfall over the years, whiles the gradient (0.458x) shows that the trend of rainfall has being marginally increasing over the past 30 years. Furthermore, farmers' perceptions about the early interruption and late start of the rainy seasons for the past 30 years was not in line with the climatic data records in the region as presented in Table 4.8. Indeed, the meteorological data recorded in the region for the past 30 years revealed that there has not being significant changes in the interruption and onset of the raining seasons. Also, the climatic data records revealed that the interruption of the rainfall for the past 30 years was absolutely in October whiles it was only in the years 1993 and 2015 where there was a delay in the onset to July instead of May/June. In summary, farmers' perceptions about the trend of the rainfall pattern, the interruption and onset of the raining season in the region for the past 30 years were not in accordance with the meteorological data that have been recorded.

These findings could be seen in two angles. Firstly, ATPS (as cited in Kutir, 2015) reports that 'farmers know precise days or weeks within a critical crop growth period when a crop demand for water is peak; hence if it does not rain adequately in those critical growth period, farmers might perceive it as decrease in rainfall amount'. (p. 58). This could explain the relative contrast between the farmers' perception of changes in rainfall and statistical analyses of meteorological data in the study area. Kutir (2015) argued that farmers relate crops harvest to the rainy season, as such if other environment and climate factors result to a low harvest they tend to perceive the season as bad season of low rains since rainfall is a crucial factor to their crop production. Furthermore, farmers may be observing generally rainfall decline, which could be attributed to temperature increases (Moyo *et al*., 2012). Also, temperature increase results to increased evapotranspiration rates, which eventually lead to faster soil water depletion (Osbahr *et al*., 2011). Secondly, the contrast between farmers' perceptions on onset and interruption of the rainfall over the past 30 years could be explained by the fact that farmers' remembrance of past events could be relatively faulty in terms of accurate remember about the changes in onset and cessation of the raining season for the past 30 years. Moyo *et al*. (2012) reported that farmers' inability to vividly remember long time climate events makes it challenging when investigating climate change as farmers may need to use personal experience, which could be unreliable. It has been suggested that farmers choose to learn from experience instead of statistical descriptions, which may lead to flawed interpretation or remembrance (Moyo *et al*., 2012). The results of this study are not in accordance with the finding of Alam *et al*. (2017) and Lemma (2016) in which household perceptions about rainfall pattern were supported by the observed scientific data in their respective study sites of riverbank erosion-prone areas in Bangladesh, and Western Amhara Region of Ethiopia. However the findings of this study are similar to the findings of Moyo *et al*. (2012) and Maddison (2006) in which farmers' perceptions about rainfall pattern contrast the meteorological data over a long period of time in their respective studies in areas of Zimbabwe, and Africa. In addition, in terms of farmers' perceptions about onset and interruption of the rainfall, the results of this study are in line with of the results of Dhanya & Ramachandran (2015) and Mulenga & Wineman (2014) in which it has been suggested that there was no agreement in climatology data and the farmers' perceptions about the interruption and onset of the raining season in their studies areas in India and Zambia respectively. Farmers' perceptions of how rainfall is changing is crucial in anticipating the effects of climate change, as only farmers who perceive it as a problem will adapt to it. Thus, there is a considerable need to align farmers' perceptions and meteorological observations about the changing climate in the study area in particular and Senegal in general.

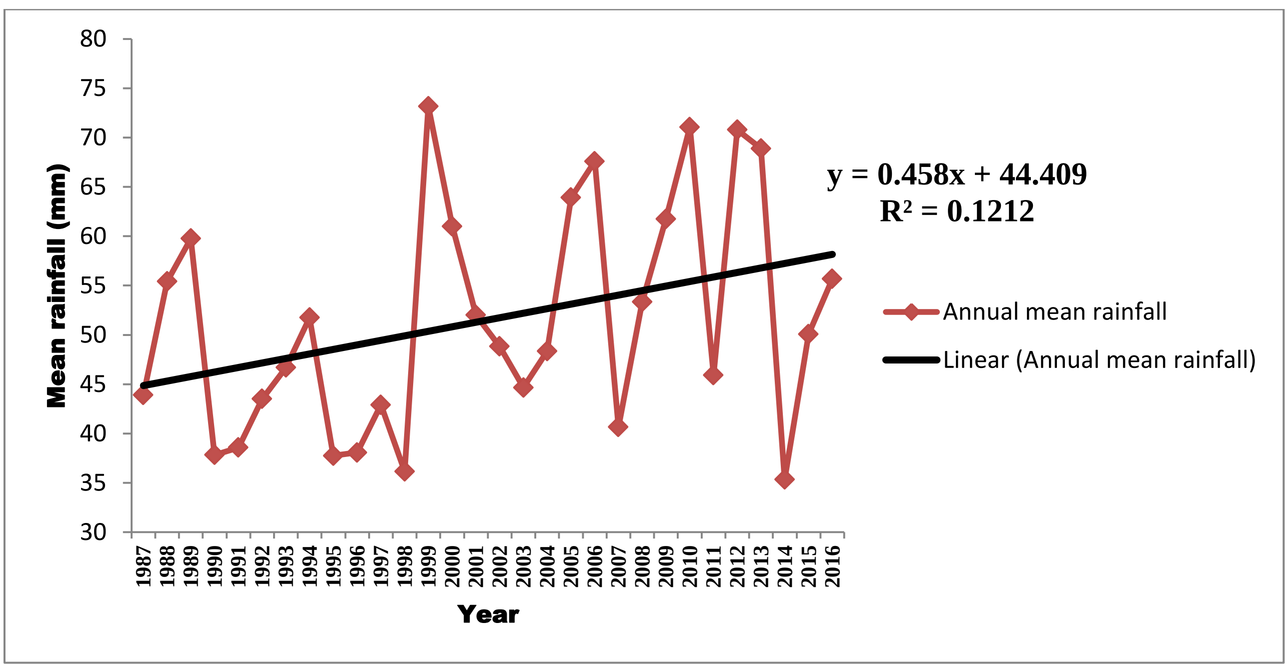

Figure 4.4: Trend of rainfall in Kaffrine Region for the past 30 years

Source: National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), 2017

Table 4.8: Interruption and onset of the rainy season in Kaffrine Region for the past 30 years

Year	Month of onset of rainy season	Cessation month of rainy season	Year	Month of onset of rainy season	Cessation month of rain season
1987	June	October	2002	May	October
1988	May	October	2003	June	October
1989	June	October	2004	May	October
1990	June	October	2005	June	October
1991	June	October	2006	June	October
1992	June	October	2007	June	October
1993	July	October	2008	May	October
1994	June	October	2009	June	October
1995	June	October	2010	June	October
1996	June	October	2011	June	October
1997	June	October	2012	May	October
1998	June	October	2013	May	October
1999	June	October	2014	June	October
2000	June	October	2015	July	October
2001	June	October	2016	May	October

Source: National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), 2017

In terms of changes in temperature for the past 3 years, 89.70% of the farmers perceived an increase in temperature over the past 3 years whiles 2.94% indicated a decrease in temperature (Appendix 2). These results are in accordance with the findings of Alam *et al*. (2017); Oruonye (2014) and Adebayo *et al*. (2011) in which it has been reported that farmers perceived an increase in temperature in riverbank erosion-prone areas of Bangladesh, Taraba and Adamawa states of Nigeria. In addition, during the Focus Group Discussion farmers indicated that yearly temperature had been increasing for the past 30 years with each succeeding year having a relatively higher temperature than the preceding year due to increased population, bush fires, and deforestation. Also, farmers indicated that reduced grain production of crops and reduction in the maturity period of crops have been experienced in the study area as the effects of increased temperature on their crop production. The observations made by farmers about the changes in temperature were confirmed by the meteorological data on maximum temperature in Kaffrine

Region for the past 3 years in which an increase in temperature has been recorded as presented in Figure 4.5.

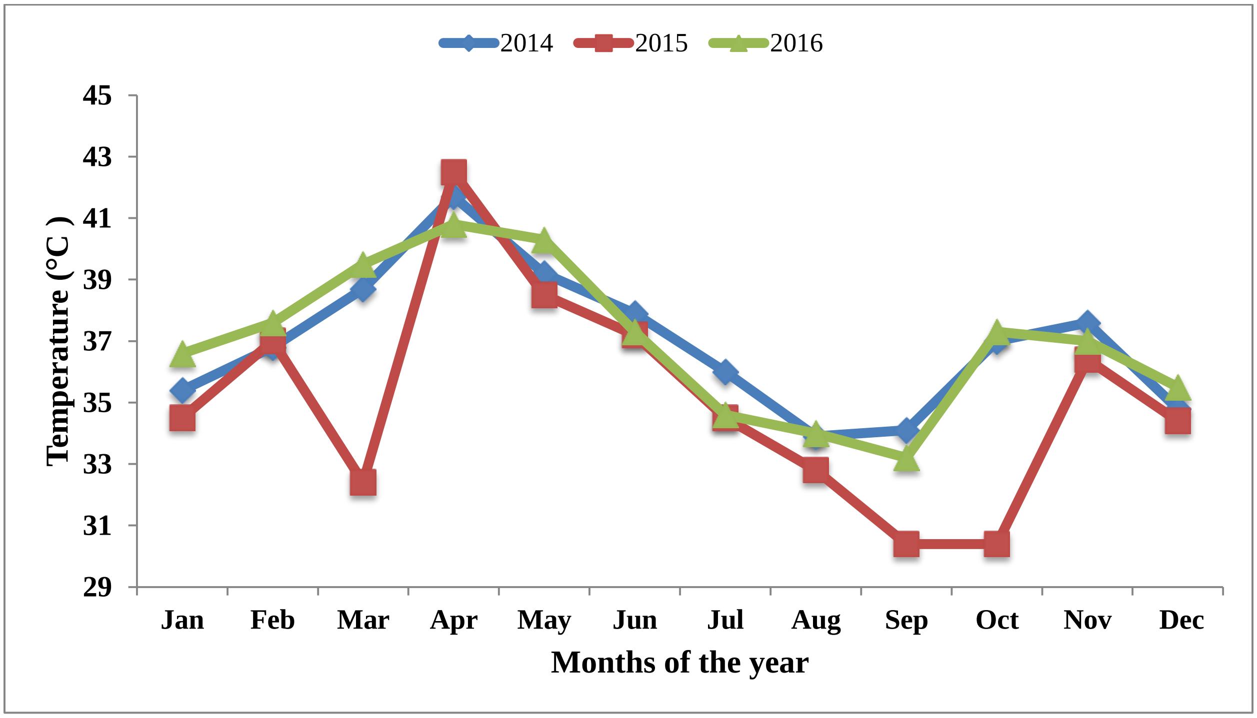

Figure 4.5: Changes in temperature in Kaffrine Region for the past 3 years

Source: National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), 2017

In the study area the meteorological trends in both minimum and maximum temperatures for the past 30 years present an increase in minimum temperatures and a weak decrease in maximum temperatures (Figure 4.6 and 4.7). This is not similar to the observations made by farmers. From Figure 4.6 the gradient (0.0315x) indicates a marginally increasing trend in minimum temperatures over the past 30 years, whiles the R^2 (0.6111) reveals that the association in the trend of minimum temperature over the years is relatively significant. However, the trend in maximum temperatures has being decreasing slightly over the past 30 years as indicated by the negative gradient value (-0.0018x) with the R^2 (0.0011) revealing a weak relationship between the changes in maximum temperature and the considered years (Figure 4.7).

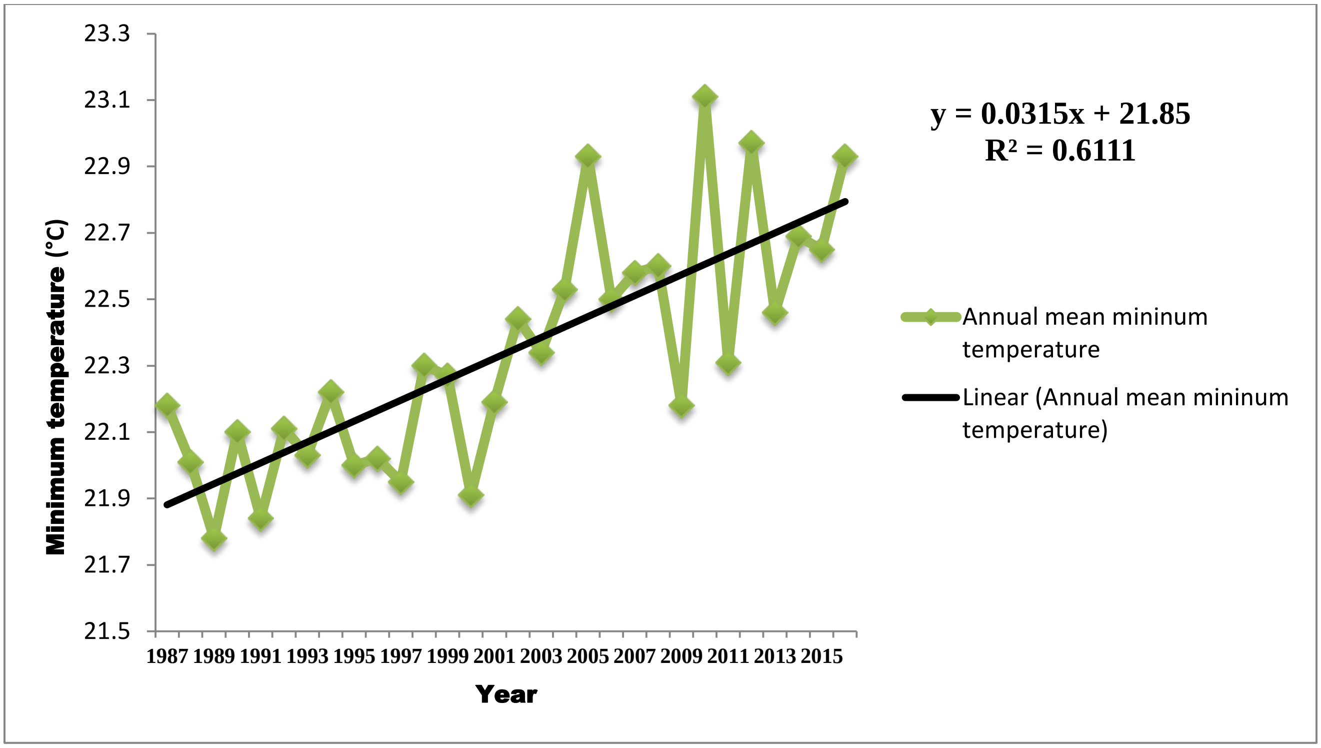

Figure 4.6: Annual mean minimum temperature of Kaffrine Region for the past 30 years.

Source: National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), 2017

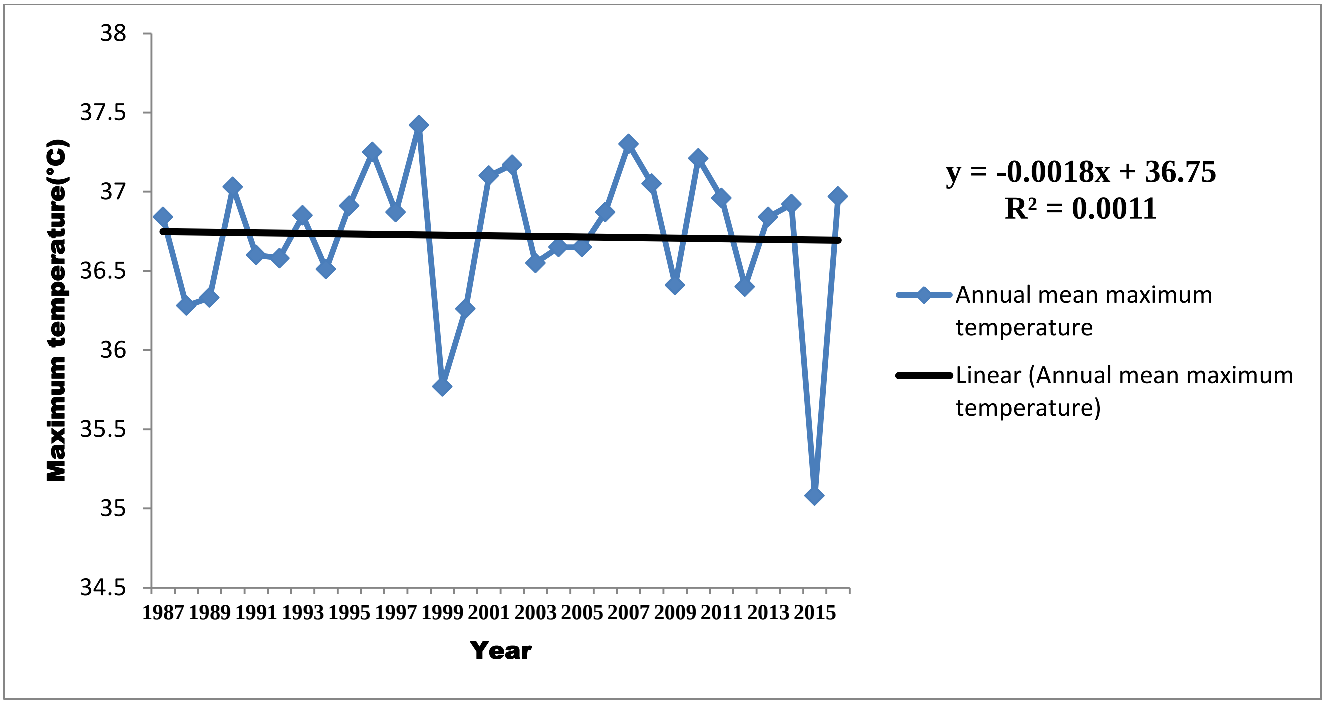

Figure 4.7: Annual mean maximum temperature of Kaffrine Region for the past 30 years

Source: National Agency of Civil Aviation and Meteorology of Senegal (ANACIM), 2017

Moreover, in the study area the farmers have indicated the perceived effects of climate change such as reduction of grain production and crop maturing, low crop yields among others. These farmers' observations could be supported by the annual production trends of groundnut and maize which show a considerable decrease in quantity of these crops (groundnut and maize) during the years 2002 and 2007 in the region as presented in Figure 4.8.

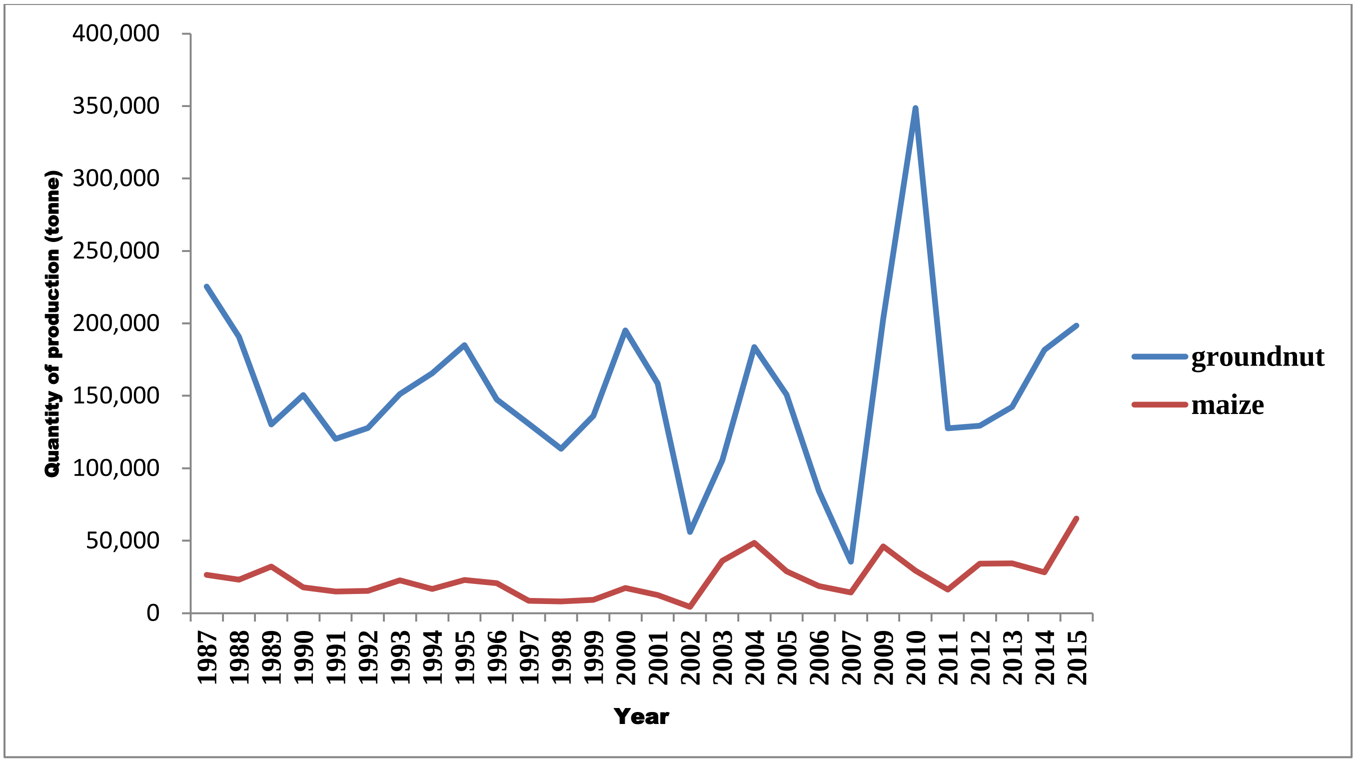

Figure 4.8: Evolution of the annual production of groundnut, and maize in Kaffrine Region for a period of 28 years

Source: Direction of Analysis and Prevision of Agricultural Statistics (DAPSA), 2017

4.6 Response Mechanism to the Changing Climate

Adaptation to climatic change is extensively recognized as a vital element of any policy response to climate change. It has been suggested that without adaptation, climate change is generally detrimental to the agricultural sector; but with adaptation vulnerability can largely be reduced. Out of the 204 respondents in the study area, 184 (90.2%) responded to the changing climate by adopting one or more adaptation strategies to increase their crop production and reduce vulnerability to climate change. These findings are in accordance with the results of Alam *et al.* (2017) in which majority of the respondents adapted to the changing climate in Bangladesh. However, 9.8% of the respondents did not adopt any adaptation strategy to climatic change despite its negative effects on their crop production. Indeed, these farmers argued that Allah (God) was solely responsible for the changing climate and yields in production hence when

Allah decided to bless them they will get good rainy season and good yields. Thus, this has a negative implication for crop production since such farmers would not response to the changing climate and consequently increase their vulnerability to the changing climate.

The response to climatic change differs from farmer to farmer since the preference of adaptation strategies depends on a farmer's perception and willingness to respond to it. The results of this study on the response strategies employed by farmers to adapt to the changing climate indicated that farmers implement diverse response measures to cope with the changing climate and increase their crop production. As shown in Figure 4.9, majority of the respondents (69.7%) employed Strategy I as a response to climatic change for the past 3 years, whilst 12.35% of the farmers used Strategy IV as an adaptation strategy. In addition, 9.83% of the respondents also used Strategy II as response to the changing climate and 8.12% used Strategy III as an adaptation strategy to climatic change. However, 9.8% of the sampled farmers never responded to the changing climate. In fact, apart from prayers they have never changed their farming activities or crop as a way of responding to the changing climate. They argued that God is the only one that can bring rains and increase their crop production.

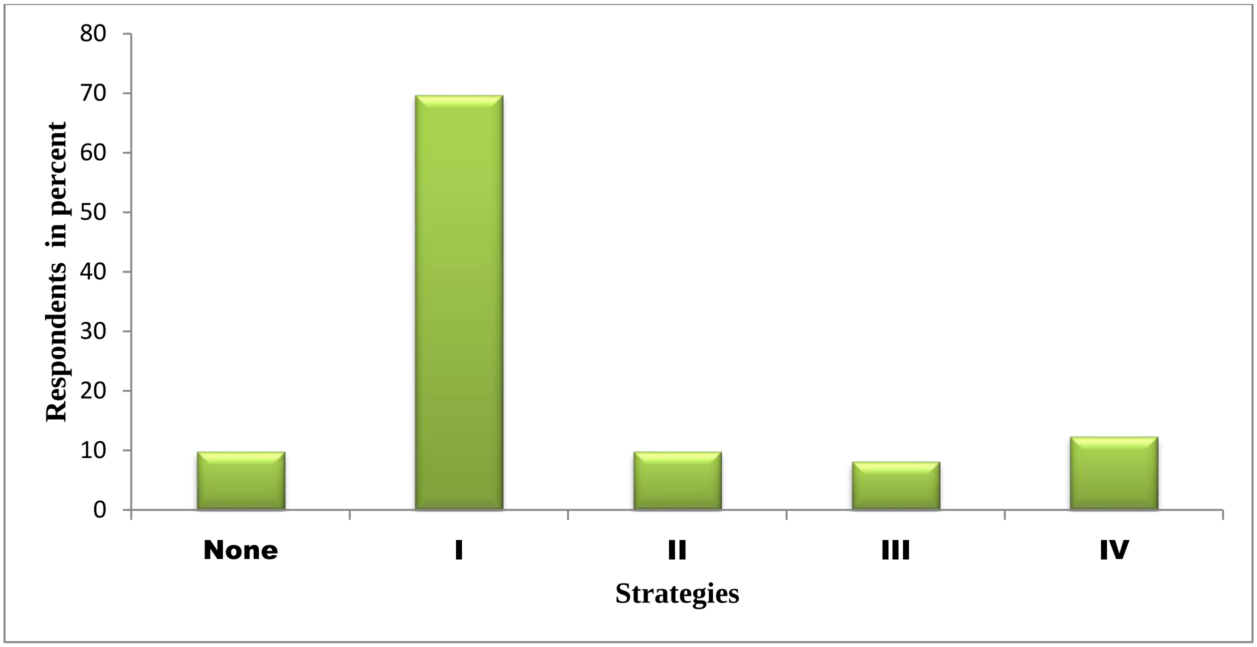

Figure 4.9: Farmers' adaptation strategies to climatic change

Note: None *means farmers who never responded to climatic change*

Strategy I: *Adaptation strategy that involved the using different planting dates, using drought resistant crops, practicing of crop diversification, practicing crop rotation, growing early maturing varieties, using chemical fertilizers, performing prayer/ritual offerings, and implementing soil and water conservation methods.*

Strategy II: *Response strategy that involved the changing area/size of farm land, practicing crop diversification, using drought resistant crops, using different planting dates, and practicing crop rotation.*

Strategy III*: Adaptation strategy that involved migrating to different locations, acquiring credit, growing early maturing crop varieties, practising crop rotation, and applying chemical fertilizers*.

Section IV : *Response strategy that involved using early maturing crop varieties, using different planting dates, growing drought resistant crops, performing prayers/ ritual offerings, and applying chemical fertilizers.*

Furthermore, out of 184 respondents who responded to the changing climate in the study area, 154 (83.69%) indicated that the response strategies they implemented were effective whilst 16.31% of them indicated that even though they responded by implementing diverse adaptation strategies and these strategies were ineffective as they still experienced low crop yields due to the increased temperatures coupled with low amounts of rainfall (Appendix 3).

As shown in Figure 4.10, out of 154 farmers who claimed that their adaptation strategies were effective, 58.8% of them realized an increase in crop production, 2.9% of them crops matured early and 12.7% of the farmers indicated that their adaptation strategies were effective because diversification provided an alternative for them whilst 19.32% farmers indicated that with the adaptation strategies their production and early crop maturity also increased. Also, 4.22% of the respondents indicated that an increase in early crop maturity with diversified alternatives and 2.06% of them realized an increase in crop production with diversified alternatives. Improving adaptation to current climate variability is not an alternative to preparing for adaptation to longer term changes in climate; it is rather an adjunct, a useful first and preparatory step that strengthens capacity now to deal with future circumstances (Tesfay, 2014). Therefore, since crop production is highly linked to food sufficiency and security it is crucial to educate and train farmers on improved and sustainable response strategies to the changing climate.

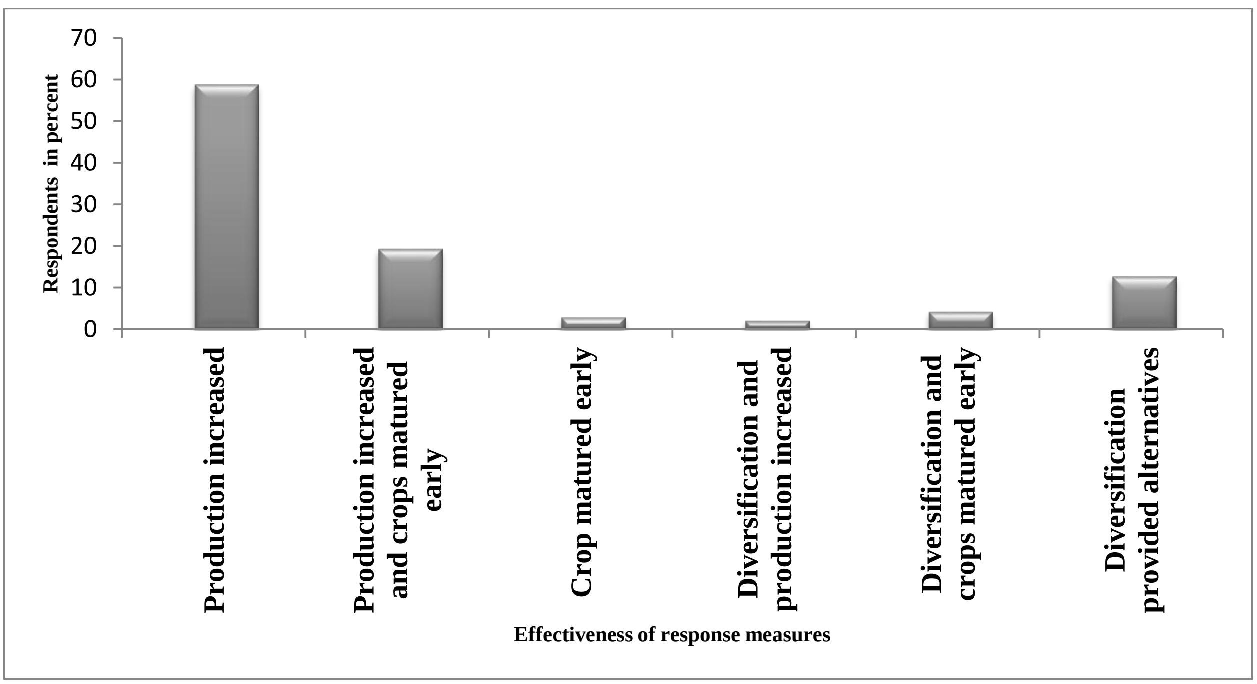

Figure 4.10: Effectiveness of farmers' adaptation strategies

4.7 Factors Influencing Farmers' Response to Climatic Change

The logistic regression model showed the best fitness of the model at 1% significant level (LR chi2 (11) = 137.04; Prob > chi2 = 0.0000). The model had adjusted R^2 of 0.7208, signifying that about 72.08% of the variation in farmers' response to climate change is appropriately predicted by the explanatory variables (Table 4.9).

Table 4.9: Results of logistic regression model on factors influencing farmers' response to climate change

Number of obs = 204
LR chi2 (11) = 137.04
Prob > chi2 = 0.0000
Pseudo R^2 = 0.7208
Log likelihood = -26.545473

[95% C.I]

Variable	Odds Ratio	Std. error	*z*	*p*-value
Gender	0.6597058	0.6462399	-0.42	0.671
Age	0.918929	0.0339873	-2.29	0.022**
Marital status	2.145998	4.756358	0.34	0.730
Household size	0.8324787	0.0923425	-1.65	0.098*
Awareness of climate change	21.61431	19.219	3.46	0.001***
Educational level	12.11672	18.31207	1.65	0.099*
Farming experience	1.123755	0.050109	2.62	0.009***
Farm land size	2.585097	0.5866185	4.19	0.000***
Access to extension service	4.017437	3.556949	1.57	0.116
Member of farmer organi.	3.731006	9.706512	0.51	0.613
Access to credit	0.0855943	0.1295118	-1.62	0.104
_cons	0.0931338	0.2356899	-0.94	0.348

*Significance level at 10%.
**Significance level at 5%.
***Significance level at 1%.

Post estimation of logistic regression model

On the predictions of the model the performance shows overall rate of correct classification of 96.57% with 91.67% specificity and 97.62% sensitivity as shown in Table (4.10).

Table 4.10: Classification table and summary statistics

True			
Classified	D	~D	Total
+	164	3	167
-	4	33	37
Total	168	36	204
Classified + if predicted Pr(D) >=0.5 True D defined as Response to Climate change != 0			
Sensitivity	Pr (+| D)		97.62%
Specificity	Pr (-|~D)		91.67%
Positive predictive value	Pr (D| +)		98.20%
Negative predictive value	Pr (~D| -)		89.19%
False + rate for true ~D	Pr (+|~D)		8.33%
False - rate for true D	Pr (-| D)		2.38%
False + rate for classified +	Pr (~D| +)		1.80%
False - rate for classified -	Pr (D| -)		10.81%
Correctly classified			96.57%

In addition, the Homsmer-Lemeshow test is used for the goodness fit of the model. This test is an important parameter test that assumes that there is no difference between the observed and the predicted result. Therefore, Homsmer-Lemeshow test of the model (Prob > chi2 = 0.9960) failed to reject the null hypothesis. This suggests that the observed and expected cell frequencies are generally in good agreement and the model is a good fit.

Furthermore, for the model to make 100% correct predictions, it would make about 12% wrong predictions as indicated by the Receiver Operating Characteristics (ROC) curve (Figure 4.11).

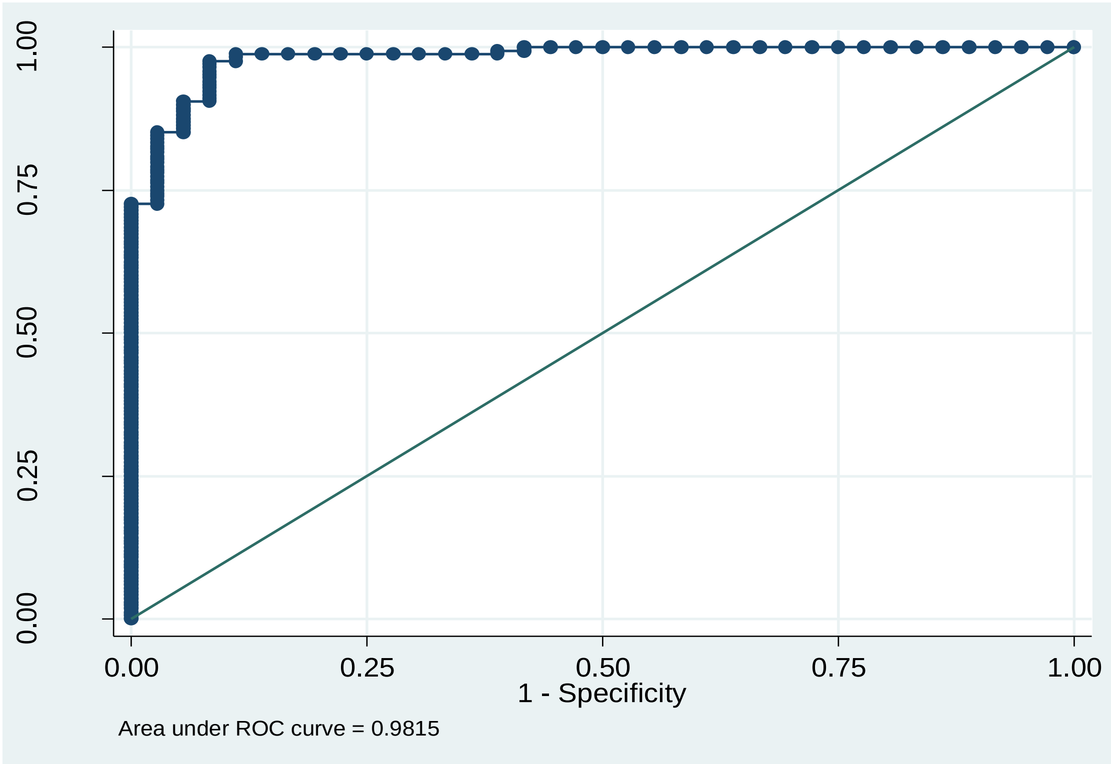

Figure 4.11: Receiver Operating Characteristics (ROC) curve

In addition, an excellent predictive power was obtained as indicated by the area under the curve which is 0.9815 as shown in Figure 4.11. This predictive power is coupled with the optimum cutoff probability of about 0.78 (78%) which separates the farmers who responded to climate change and those who did not respond (Figure 4.12). This results show that the farmers' adaptation to climate change are correctly predicted by the independent variables in the model.

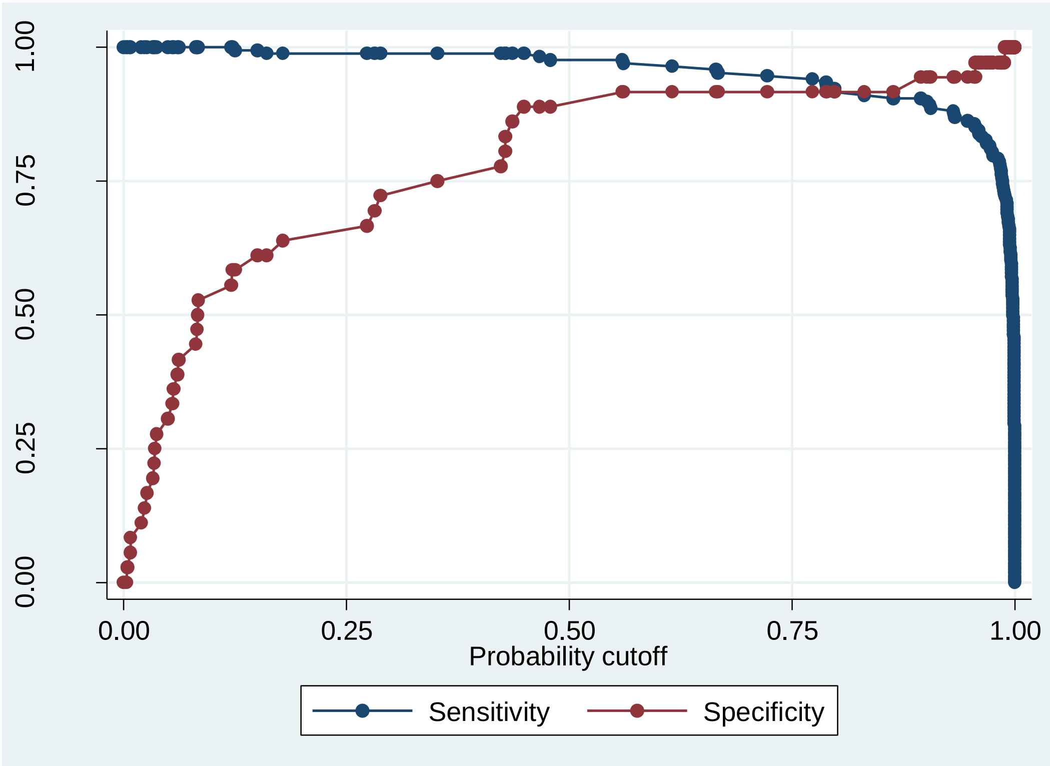

Figure 4.12: Probability cutoff graph

As expected, the findings from the logistic regression model indicate that farm land size, awareness of climate change and farming experience were significant factors at 1% significant level whilst age of the household head was significant factor at 5%. Also, household size and educational level were significant at 10%. However, gender, marital status, access to extension services, member of farmer organization and access to credit were not significant in influencing a farmers' response to the changing climate (Table 4.9).

Farm size was statistically significant at 1% and positively influenced a farmer's response to climate change. This indicates that as the farm size of a farmer increase by one hectare, he or she is more likely to adapt to climate change. A farmer would adapt to climate change as his or her farm size increases because he perceives to be at a greater risk and would lose a large portion of farmland in case of a negative impact of climate change on his or her farm. This result is in line with recent findings (Denkyirah *et al*., 2017; Oluwatusin, 2014). However, it contradicts the findings of Uddin *et al*. (2014) and De-Graft (2011) in which it has been revealed that farm land size negatively and significantly influenced farmers' response to the changing climate in Bangladesh and Ghana respectively.

Awareness about climate change was statistically significant at 1% and positively influenced a farmer's adaptation to climate change. This indicates that the more a farmer is aware about the causes and effects of climate change, the more likely he or she responds to it in order to increase productivity. Furthermore, in the model awareness of climate change variable has an odd ratio of 21.61431, meaning that farmers at a given level of awareness of climate change is 21.61431 times more likely to have adapted to the changing climate than the farmers in the next lower level of awareness of climate change. This follows the hypothesis of the study which stated that awareness about climate change is positively expected to influence a farmer's response to climatic change.

Farming experience had a positive influence on adaptation to climate change and was statistically significant at 1%. This indicates that as the farming experience of a farmer increase by one year, he or she is more likely to adapt to climate change. Therefore, a farmer who has more farming experience is more likely to make good decisions in adapting to climate change than a farmer who has less farming experience. This follows the *a-priori* expectation which shows that years of farming experience positively influence climate change adaptation. The result is in line with the findings of Denkyirah *et al*. (2017) and Oluwatusin (2014) in which it has been found that a farmer's adaptation to climatic change was positively and significantly influenced by the number of years of farming experience in Brong-Ahafo Region of Ghana and in Ondo State of Nigeria respectively.

Age of a farmer was statistically significant at 5% and negatively influenced a farmer's adaptation to climate change. This shows that younger famers are more likely to adapt to climate change. Also, younger farmers have probably more interest or more incentives in taking climate change adaptation measures. Perhaps older farmers do not see the necessity to adapt to climate change effects. This could be due to the fact that older farmers invest their resources in non-farming activities than climate change adaptation activities. This result is in agreement with that of the findings of Uddin *et al*. (2014) and Acquah-de Graft & Onumah (2011) in which it has been revealed that the age of farmers negatively affected their response to the changing climate in Bangladesh and western Ghana respectively. However, the result contradicts with the findings of Tazeze *et al*. (2012) in which it has been reported that age of household head, which represents experience, affected adaptation to climate change positively and significantly in Ethiopia. As the age of the household head increases, the person is expected to acquire more experience in weather forecasting and that helps increase the likelihood of practicing different adaptation strategies to climate change (Tazeze *et al*., 2012).

Household size is negative and significantly (at 10% level) related to farmers' adaptation strategies to climate change effects. This indicates that with increasing size of the family, the probability of farmers' adoption of an adaptive strategy decreases. The result could be explained by the fact that subsistence farming is predominant among the households in the sample, and then the same labor shortages assumed to be inhibiting adoption in income-generating agricultural activity may not be considerable. In addition, subsistence households are resource poor, larger family size may not contribute considerably in increasing the resource pool of the farm family. Also, a majority of the additional family members are children and/or the elderly, therefore we may assume an overestimate of labor availability using household size, and, in fact, the distribution of household members and their endowments may be a contributing factor to the risk acceptance-aversion factor of a farm household, leading them to view adaptive strategy adoption as "too risky" given their circumstances (Moser & Barrett, 2003). The result does not follow the *a-priori* expectation which assumed that household size positively influences climate change adaptation for the study but it is in agreement with some previous findings (Uddin *et al*., 2014; Moser & Barrett, 2003; Neil & Lee, 1999) in which it has been found that family size negatively influenced a farmers' adaptation to climatic change in Bangladesh, Madagascar, and Northern Honduras respectively. However, the finding is not similar to the results of Mignouna *et al.* (2011); Deressa *et al.* (2009) in which it has been reported that household size positively and significantly influenced a farmer's adaptation to climate change in the Nile Basin of Ethiopia and Western Kenya respectively. They argued that large family size makes available more labor which can enable them to be actively engage in work, thus better facilitating the adoption of adaptive measures against climate change effects.

Educational level had a positive influence on adaptation to climate change and was statistically significant at 10%.This indicates that the probability of adaptation to climatic change is greater for those who have higher educational attainment compared to less-educated or illiterate farmers. It is obvious that educated farmers have more knowledge, a greater ability to understand and respond to anticipated changes, are better able to forecast future scenarios and, overall, have greater access to information and opportunities than others, which might encourage adaptation to changing climate. The result is consistent with the findings of Tazeze *et al*. (2012); Quayum & Ali (2012) in which it has been revealed that educational level positively and significantly affected the response of farmers to climate change in Ethiopia and Bangladesh respectively.

4.8 Barriers Facing Farmers in their Response to Climatic Change

The Figure 4.13 presents the challenges associated with farmers' response to climatic change that they are faced with in the study area. Majority of the respondents representing 70.19% were affected by Constraint A, whiles 15.44% were challenged by Constraint C. Also, 12.79% of the farmers were affected by Constraint B, whilst 1.58% of the respondents were challenged by Constraint D in their response to climate change. Also, during the focus group discussions farmers argued about many challenges that they are facing in responding to the changing climate in the study area such as lack of access to extension services, inadequate access to credit, insufficient access to farm inputs and materials, inadequate access to climate change information among others. These findings are similar to the results of Denkyirah *et al.* (2017); Kutir (2015); Munhande *et al*. (2013) and Idrisa *et al.* (2012) in which it has been suggested that inadequate access to extension services, inadequate access to credit, lack of information on climate change and adaptation strategies, poor access to technology necessary for adaptation, inadequate access to efficient agricultural inputs, and inadequate access to market among others were the constraints inhibiting farmers' response to climate change in their respective studies areas in Ghana, The Gambia, Zimbabwe, and Nigeria.

Moreover, during the key informant interview sessions with farmers preferred sources of climatic change information such as extension officers and radio broadcast among others indicated some challenges in responding to climate change. In fact, the journalists at the community radio stations in Kaffrine Region indicated that inadequate access to experts on climatic change and agriculture, lack of modern and quality broadcasting equipment, and lack of logistics were the barriers inhibiting their programmes on climate change and agriculture. Whiles, lack of equipment and transportation for accessibility to rural areas, logistical constraints in the form of financial support for income farmers, and lack of monitoring programmes on climate change were asserted by extension officers in the study area.

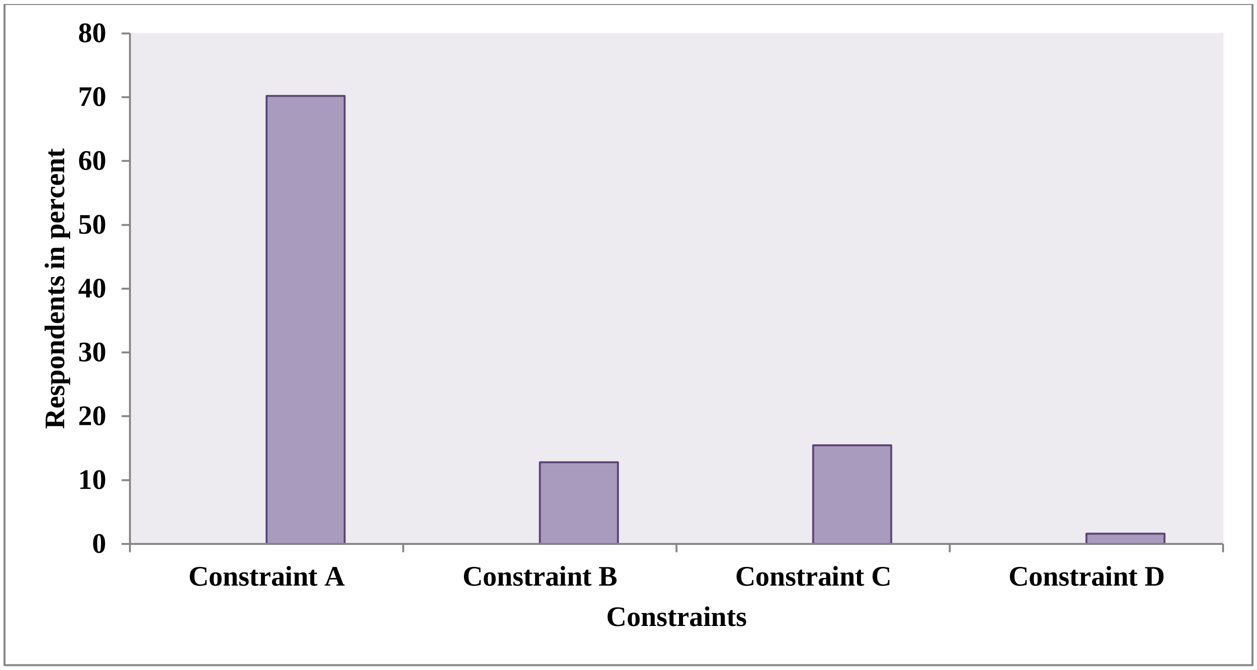

Figure 4.13: Constraints inhibiting farmers' adaptation to climatic change

Note:

Constraint A: *Labor constraint, inadequate credit, inadequate access to information and poor skills, inadequate access to efficient inputs, and inadequate access to land*

Constraint B: *Inadequate access to information and poor skills, inadequate access to land, inadequate credit*

Constraint C: *Inadequate access to efficient inputs, inadequate information and poor skills, inadequate credit, and labor constraints*

Constraints D: *Inadequate credit, inadequate access to market, inadequate water and irrigation facilities*

On the possible solutions to these barriers inhibiting farmers' adaptations to climatic change majority of the farmers representing 80.88% specified that government support in the form of credit and farm inputs would help to increase their crop production and solve their challenges, whilst 5.88% of the respondents asserted that apart from government other stakeholder could help supply credit and farm inputs as well as stabilize the market for agricultural good as they lack ready market and hence, sometimes selling their produce at cheaper prices due to the perishable nature of their produce. Also, 4.41% of the respondents indicated that their crop productions could be increased through awareness on climate change and adaptation measures combined together with provision of farm inputs, whiles 3.92% proposed good cooperative unions to provide credit and farm inputs and buy farm produce as solutions to these challenges. Lastly, 2.45% of the respondents recommended agroforestry as solution and 2.46% indicated preference for conservation agriculture, including creation of adequate water harvesting system for agricultural activities during the dry season. The results of this study on farmers proposed solutions to their barriers are shown in Table 4.11.

Table 4.11: Farmers proposed solutions to their barriers

Solutions to barriers	Frequency	Percent
Government support in a form of credit and farm inputs	165	80.88
Preservative means to preserve perishable agricultural goods and creation adequate water harvesting for agricultural activities during the dry season	5	2.45
Agroforestry	5	2.45
Good cooperative unions to provide credit and buy farm produce	8	3.92
Create climate change and adaptation measures awareness among farmers and provide farm inputs	9	4.41
Government and other stakeholders should help provide inputs and information, stabilize the market for agricultural goods	12	5.88
Total	**204**	**100**

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

The dissertation dealt with studying farmers' awareness and response to climatic change. In this chapter, the major findings of the study based on the research questions, objectives, theories, and reviewed literature have been summarized. This chapter therefore attempts to integrate and synthesize the major findings, and then provides conclusion and recommendations and also proposes issues requiring further research.

5.1 Summary

The main goal of the study was to assess farmers' awareness and response to the changing climate of selected areas of Kaffrine Region (Senegal). The objectives of the study are clearly stated in Chapter 1 of the dissertation. Therefore, the first objective was to evaluate farmers' awareness about climatic change. In the second objective, sources from which farmers' access to climate change information were identified. The third and fourth objectives were to assess farmers' perceptions about climate change and to identify factors that affect farmers' adaptation strategies to climate change respectively. In the last objective, challenges associated with climate change response of farmers were identified.

The reviewed literature on climatic change and adaptation strategies was done in order to achieve the stated objectives of the study. It focused on the concept of climate change and climate variability, climate change and agriculture, adaptation policies, farmers' adaptation response to climatic change, barriers affecting farmers' response to climatic change, agricultural mitigation to the changing climate. Then the study observed in depth the determinants of farmers' decisions to adapt to climate change, the climate change awareness, the sources of information on climate change among farmers as well as methods of assessing farmers' awareness. Also, literature was reviewed on the theoretical framework of the research which comprises the diffusion of innovation theory by Roger (1995) and the extension theory by Rolling (1988). The literature was finally reviewed on the empirical model employed in the study.

The descriptive design was adopted and all farmer household heads in Kaffrine Region were the target population for this study. Through simple random and purposive sampling procedures two hundred and four (204) household heads from the nine selected communities, four extension workers and five journalists from different community radio in Kaffrine Region were selected for the study.

The key instruments of the study consisted questionnaires and interview guides; and the questionnaires were first pilot tested in order to establish their validity and reliability before their use for data collection. To analyze the data the statistical packages STATA 14.0 and SPSS version 23 were used for the study. Findings of the study were presented in a form of both inferential and descriptive statistics such as percentages, means, standard deviations, awareness index, minimum, maximum, and summations. Also, figures, tables, and charts were used to summarize the results of the study. A logistic regression model was also estimated for the research.

5.2 Major Findings

The major results for the research included:

For the first objective majority of the farmers representing 64.7% were aware of the changing climate. The average awareness index for the research was (0.5903) 59.03%. This means that a relative level of climatic change awareness among farmers of Kaffrine Region of Senegal. Comparing the awareness among the three selected districts farmers in Koungheul district had the highest awareness index of 0.709 (70.9%) for the entire study followed by Birkelane and Malem Hodar districts with awareness index of 0.5601 (56.01%) and 0.562 (56.2%) respectively. Because the interviewed farmers in Koungheul district relatively have more access to extension services and projects on climate change awareness and education. The results also indicated that male farmers were relatively more aware of climate change compared to females in all the three selected districts.

1. On the second objective, most of the farmers had diverse sources of climatic change information with majority representing 63.23% having received climate change information from radio broadcast whiles 6.4% of the farmers indicated that they have never heard about climatic change from any source. However, majority of the farmers representing 36.8% preferred radio broadcast as their source of climate change information among all the others

sources. Farmer association representing 3.92% was the least preferred source of climatic change information of farmers for the study.

2. The third objective was to assess farmers' perceptions about climate change. Majority of farmers representing 96.07% perceived changes in climate factors in their area for the past 3 years with most (88.23%) of them perceived changes in both temperature and rainfall. Decrease in the amount of rainfall, early interruption and late start of rainy season was perceived by 95.09% of farmers for the past 3 years. And 89.70% of the farmers perceived an increased in temperature over the past 3 years. These farmers' perceptions were validated by the temperature and rainfall data from the National Agency of Civil Aviation and Meteorology which showed an increase in temperature, a late onset, and a decrease in rainfall for the past 3 years but deviates from the early cessation of rainfall perceived by farmers. Furthermore, the perceptions of farmers about temperature and rainfall pattern for the past 30 years were not in line with the meteorological data.

3. A logistic regression model was estimated in order to determine the factors that influence a farmers' response to climatic change. From the binary logistic model in Chapter 4 empirical results revealed that farm land size, awareness of climate change, farming experience, age, household size and educational level were the only socio economic factors that significantly influence a farmers' response to climate change. Other factors such as access to credit, access to extension services, gender, member of farmer organization and marital status correlated with response but were not significant.

5. On the barriers inhibiting farmers' response to climatic change majority representing 70.19% of the farmers indicated that their response to climate change was inhibited by constraint A which consisted labor constraint, inadequate credit, inadequate access to information and poor skills, inadequate access to efficient inputs, and inadequate access to land. On the possible solution to these barriers inhibiting farmers' adaptations to climatic change, majority of the farmers representing 80.88% specified that government support in the form of credit and farm inputs would help to increase their crop production and solve their challenges.

5.3 Conclusion

Climate Change is a real threat to the agricultural sector of Senegal. Farmers in Kaffrine Region are aware of climate change but the average awareness index is relatively inadequate since it is slightly above average (59.03%). Awareness about climatic change is crucial for farmers' response to the changing climate as explained by empirical model of the study.

It can be concluded that farmers have a wide pool of sources through which they access climatic change information from. Hence, climate change awareness of farmers could be attributed to their different source of climatic information. In Kaffrine Region, radio broadcast, colleague farmers and extension services were the most sources of climatic information for farmers.

Farmers have adequate knowledge on the changes in temperature and rainfall through their experiences and personal observations for the past 3 years. This was confirmed by the climatology data recorded for the past 3 years. There was a clear contradiction between farmers' perceptions of rainfall and temperature and the climatology data recorded for the past 30 years. Since crop production is considerably rain-fed in Senegal in general and Kaffrine Region in particular then, the livelihoods of farmers in the study area solely depend on temperature and rainfall patterns. And this has negative impact for crop production in the study area.

An adaptation strategy to the changing climate differs from one location to another. Results from the empirical models showed that there are combinations of factors influencing a farmers' response to climatic change. Thus, farm land size, farming experience, awareness of climate change, age, educational level and household size influence farmers' response to climate change in Kaffrine Region.

Diverse challenges that inhibit the ability of farmers in Kaffrine Region to increase their crop productions have been identified. These barriers include but not limited to inadequate access to information and poor skills, labor constraints, inadequate credit, inadequate access to efficient inputs, and inadequate access to land. Thus, the ability of farmers to adapt to climatic change has been affected by these challenges like lack of farm inputs, materials and resources which has led to some poor farmers unable to adapt to the changing climate in the study area.

5.4 Recommendations

The recommendations included here are presented as suggestions on how initiatives on climatic change could be more effective. Recommendations also stress the various stakeholders involved in climate change in the region and how the country at large should organize their role to increase the effectiveness and sustainability of climatic change adaptation interventions.

The study recommends that climate change information, agricultural innovations and other issues should be communicated through farmer preferred sources such as radio, colleagues, and extension workers in order to educate and train farmers on climate change science, climate risk, measures to cope with and adapt to the changing climate. The rate of acceptability and dissemination of innovation or information would be increased through farmers accepted and trusted sources. To help increase farmers' knowledge and shape their perceptions Government and NGOs should facilitate the broadcasting of seasonal climate forecast information.

Also, Government should provide adequate modern broadcasting machines and logistics, and equipment to the community radios to enable them improve and carry out more climatic change education programmes and projects.

The research also recommends that extension agents and journalist' knowledge should be broadened on climate change issues in order to equip them with the skills to effectively communicate complex and scientific climatic change information into simple language for farmers' comprehension. Also, Government and others partners should organize in-service training programmes such as seminars and workshops for journalists in the community radios.

It is also recommended that since climatic change is multi-sectorial and the priority of sub-Saharan countries is on adaptation measures then Government and other stakeholders need to make climatic change adaptation as a priority area of their political agenda. Also, since agriculture is predominantly rain-fed policies to reduce poverty, hunger and ensure food security and sufficiency have to address issues of the changing climate.

The research also recommends that during the implementation of programmes and projects on response to climatic change among farmers one must consider and enhance the positive and significant socioeconomic factors that influence farmer' response to climatic change in the study area such as farming experience, farm land size, awareness to climate change, age, household size and educational level.

It is also recommended that to improve their knowledge on climatic change and enhance their adaptive capacity to the changing climate farmers have to collaborate more and form farm associations which could enable them have easy access to farm inputs and training from donor and Government agencies.

In the study area, the contact between farmers and extension officers is considerably low. Since extension agents play a crucial role in creating climate change awareness and adaptation strategies to farmers, it is thus, recommended that Government should establish more agricultural training colleges to train more extension agents on agricultural innovations and response measures to climate change in the country in general.

The study also recommended that to enable extension officers perform their duties Government should provide for them with transportation logistics for accessibility to all villages and fuel allowances among others. Also, it is important that the ministries of Environment and Agriculture, agencies among other organize in-service training regularly on awareness and sustainable response to climate change for extension workers through field visits, seminars, and workshops in order to increase their knowledge-base to better offer extension services in climatic change.

To increase crop production, sustain farmers' livelihoods and ensure food security in the country it is important that Government and other NGOs such as ied Afrique should help provide credit and efficient farm inputs such as fertilizers seeds, and tools to farmers as these pose a major challenge to rural farmers.

It is also recommended that price fluctuation for agricultural goods have to be stabilized by the Government in order to help farmers to adapt sustainably to the changing climate.

5.5 Suggestions for Further Study

From the research it is suggested that further study to be conducted to include:

1. A comparative research of farmers' awareness and responsiveness to climatic variability in different agro ecological zones of Senegal
2. Farmers' perceptions and indigenous adaptation measures to climatic change and variability in Senegal.
3. The role of agricultural extension services in farmers' awareness and response to the changing climate in Senegal.
4. The role of communication in enhancing farmers' climatic change awareness in Senegal.

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Appendices

Appendix 1

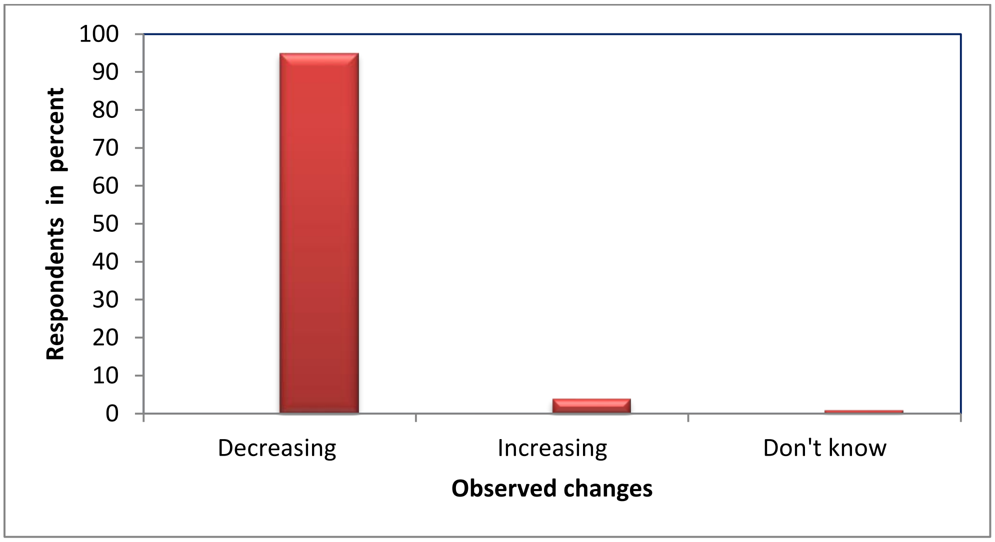

Figure 7.1: Farmers perceived changes in rainfall pattern for the past 3 years

Appendix 2

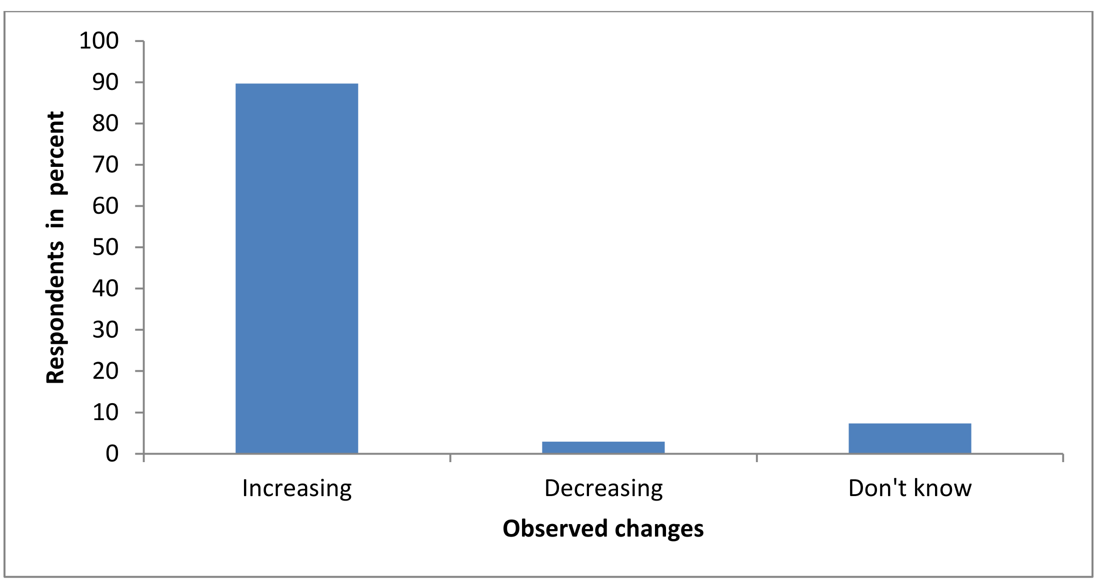

Figure 7.2: Farmers perceived changes in temperature for the past 3 years

Appendix 3

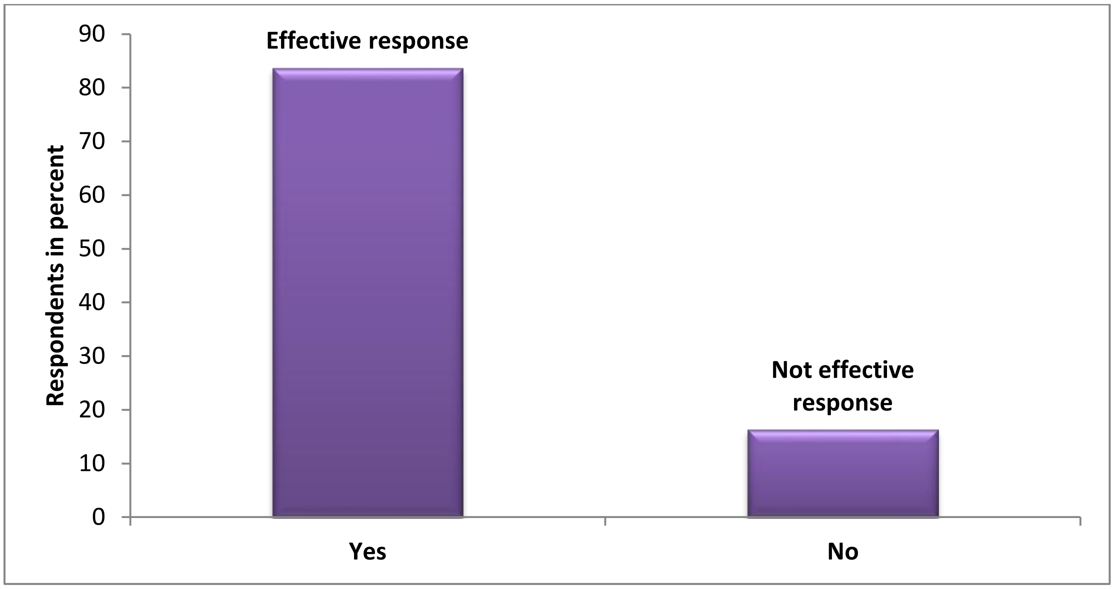

Figure 7.3: Effectiveness of farmers' adaptation strategies

Appendix 4

RESEARCH TOPIC:

FARMERS' AWARENESS AND RESPONSE TO CLIMATE CHANGE IN KAFFRINE REGION, SENEGAL

QUESTIONNAIRE

My name is Baba Libasse Sow; I am a student of The University of The Gambia. My research topic is entitled *"Farmers' Awareness and Response to Climate Change in Kaffrine Region, Senegal"*. This research is in partial fulfilment of the requirements for Master of Science degree in Climate Change and Education under the WASCAL (West African Science Service Center on Climate Change and Adapted Land Use) program. Your participation in this research, by providing relevant information, will be helpful in the achievement of its objectives and will be greatly appreciated. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Approval by Director of WASCAL

Assoc. Prof. Dr. Sedat Yaffa

Sign: -----------------------

District: ____________

Questionnaire #: ____________

Farmer code: ____________

INSTRUCTIONS:

- Tick marks in space provided for closed-ended questions and write your response on the space provided for open ended questions.

- This survey is an individual questionnaire to be addressed to each farmer (Household head) sampled.

<u>SECTION A:</u> Socio-demographic characteristics of respondents

1. Gender of the household head: Male[ ] Female [ ]
2. Age of head of farmer household (years):
   (a) 18–30 [ ] (b) 31–40 [ ] (c) 41–50 [ ] (d) 51–60 [ ] (e) Over 60 [ ]
3. Marital status of household head: (a) Married [ ] (b) Single [ ] (c) Divorced [ ]
   (d) Widowed [ ] (e) other (specify)……………………………..
4. Farmer education level (a) Primary [ ] (b) Secondary [ ] (c) Tertiary [ ] (d) No formal education [ ] (f) other (specify)……………………………..
5. Size of household:
   (a) 1-3 [ ] (b) 4-6 [ ] (c) 7-9 [ ] (d) 10 or more [ ]
6. Number of years of experience in farming:
   (a) 1-5 [ ] (b) 6-10 [ ] (c) 11-15 [ ] (d) 16-20 [ ] (e) 21 or more
7. Are you a member of any farmer organization group?
   (a) Yes [ ] (b) No [ ]
   If yes, what is the name of your farmer organization/group? ....
8. Primary occupation?
   (a) Farming [ ] (b) Civil service [ ] (c) Trading [ ] (d) others (specify)…………………..
9. Do you have access to credit for crop production? (a) Yes [ ] (b) No [ ]
10. If yes from where? ………………………………………………………
11. Do you have access to other forms of support? (a) Yes [ ] (b) No[ ]
    In what form? ……………………………………………………………….
12. Do you have access to extension service?
    (a) Yes [ ] (b) No [ ]
13. What crop(s) do you normally grow?
    (a) Cereals [ ] (b) Vegetables [ ] (c) Tuber crops [ ] (d) Cash/tree crops [ ] (e) Leguminous crops [ ]
14. What is the approximate size of your farm in acres?
    (a) 1-10 [ ] (b) 11-20 [ ] (c) 21-30[ ] (d) 31 or more

SECTION B: **Farmers' observations on climate change**

15	Do you know what climate change is? a) [ ] Yes b) [ ] No
16	If yes what is it……………………………………………
17	State 2 possible human causes of climate change? Human causes:………………………………………

Code	Questions
18	Have you observed any changes in climate factors for the past 3 years? a) [ ] Yes b) [ ] No
	If No, do you have any comments?
If yes, go to the next questions	
19	In which factor(s) have you observed the changes? a) [ ] Rainfall only b) [ ] Temperature only c) [ ] Both rainfall and temperature d) [ ] Others (specify)……………………………………

Code	Questions
20	What changes in rainfall have you observed in the past 3 years? Tick all the options below that apply to you a) [ ] Decreased b) [ ] Increased c) [ ] Late start of the raining season d) [ ] Short Length of seasons e) [ ] Do not know f) [ ] Other (specify)…………………………
21	What changes in the distribution of rainfall have you observed in the past 3 years? a) [ ] Evenly distributed b) [ ] Unevenly distributed c) [ ] I do not know d) [ ] Others (specify)…………………………………
22	How have the changes in rainfall affected your crop production? a) [ ] Low crop yields b) [ ] Loss of entire farm produce c) [ ] I don't know d) [ ] Others (specify)…………………………

23	What are the changes you have observed in temperature in the past 3 years? a) [ ] Increased b) [ ] Decreased c) [ ] Do not know d) [ ] Others (specify)……………………….…………………..
24	How have the changes in temperature affected your crop production? a) [ ] Reduce the maturing period of crops b) [ ] Reduce grain production c) [ ] I don't know d) [ ] Others (specify)………………..

<u>SECTION C:</u> Farmers' adaptation to climate change

Code	Questions
25	Have you ever changed your farming practices in order to adapt to the pervious changes in rainfall patterns and/or temperature in the past 3 years? a) [ ] Yes b) [ ] No
If No, why not?	
If Yes, go to the next questions	
26	Why did you decide to adapt? a) [ ] I was advised b) [ ] I noticed my crop yield decreased c) [ ] My neighbouring farmers changed d) [ ] Others (specify)…………………………
27	What adaptation strategies did you implement? Choose **ANY** of the following which may apply. You may have more than one choice. a) [ ] Implemented crop diversification b) [ ] Used different planting dates c) [ ] Used droughts resistant crops d) [ ] Changed area/size of land e) [ ] Changed from crops to livestock f) [ ] Changed from farming to non-farming activities g) [ ] Increased irrigation of farm h) [ ] Used chemical fertilizers more i) [ ] Implemented soil and water conservation methods j) [ ] Used prayer or ritual offering k) [ ] Acquired credit l) [ ] Migrated to a different location m) [ ] Practiced crop rotation

	n) [ ] Others (specify)……………………………
28	Were these measures effective in reducing the effects of climate change on your crop production? a) [ ] Yes b) [ ] No
29	If yes how effective are they? a) [ ] Crop production increased b) [ ] Crop matured early c) [ ] Diversification provided alternatives d) [ ] Others (specify)……………………………

<u>SECTION D:</u> Sources from which farmers access climate change information

Code	Questions
30	How often have you receive information (or training) to cope with climate change in the past 3 years? a) [ ] Never b) [ ] Once (received information once) c) [ ] Sometimes (received information/training intermittently) d) [ ] Often (receives information/training more than once a year e) [ ] Other (specify)……………………………
31	How often do you talk about climate change with other farmers, family and/or extension workers? a) [ ] Never b) [ ] Rarely (one a month) c) [ ] Sometimes (once a week) d) [ ] Often (more than one a week) e) [ ] Other (specify)……………………………
32	What is your current source of climate change information? Tick all the options below that apply to you a) [ ] Radio/Mass-media b) [ ] Extension services c) [ ] Neighbor farmers d) [ ] farmers association e) [ ] Researchers f) [ ] Project/NGO/Program ( ) g) [ ] Other (specify)……………………………
33	How often have you heard about climate change from these sources in the past 3 years? a) [ ] Daily b) [ ] Weekly c) [ ] Monthly d) [ ] Once in a yearly e) [ ] Other (specify)……………………………

34	What is your preferred climate change source of information? a) [ ] Radio/Mass-media b) [ ] Extension services c) [ ] Neighbor farmers d) [ ] farmers association e) [ ] Researchers f) [ ] Project/NGO/Program( ) g) [ ] Other (specify)……………………………….
35	Why do you prefer the above mentioned climate change information source? ………………………………………………………….. …………………………………………………………..

<u>SECTION E:</u> Challenges associated with adapting to the effects of climate change

36	What challenges do you encounter in adapting to climate change? Tick all the options below that apply to you a) [ ] Inadequate/shortage of land b) [ ] Inadequate credit c) [ ] Inadequate access to more efficient inputs d) [ ] Inadequate access to information and poor skills e) [ ] Inadequate water and irrigation facilities f) [ ] Labor constraints g) [ ] Inadequate access to markets h) [ ] Others specify

37) In your opinion what can be done to solve these challenges and increase your crop yields?

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….

End of the questionnaire

Thank you very much for your time and participation

FOCUS GROUP DISCUSSION GUIDE

How do farmers perceive climate change?

1. Based on your experience, have you observed any changes in the rainfall pattern for the past 3 years?
2. What are the causes of climate change changes?
3. Did you observe any change in temperature over the past 3 years in your area?
4. State how these changes affect crop production in your farm?
5. What negative experiences have you had due to change in rainfall pattern and temperature?

Sources from which farmers' access climate change information in the Region?

6. List all the sources through which you access climate change information in your area.
7. Which source do you prefer and why?
8. State some of the information you learnt from the above sources with respect to climate change?
9. How is the information you learnt from these sources different from what you perceived before?

How farmers' awareness of climate change influence their response to climate change in the region?

10. What influenced your decision to adopt an adaptation measure to climate change?
11. What adaptation measures are you applying in dealing with climate change issues and then mention the one you think is most important and why?

Challenges that farmers' encounter in responding to climatic uncertainties in the study area?

12. List all the challenges you face in adapting to climate change.
13. How in your opinion can these problems be addressed?
14. What can you do, individually, to solve these problems to increase productivity?

KEY INFORMANT INTERVIEW GUIDE FOR CLIMATE CHANGE EDUCATION FACILITATOR

Baba Libasse Sow is my name, a student of University of The Gambia. My research topic is entitled *Farmers' Awareness and to Response to Climate Change in Kaffrine Region, Senegal* in partial fulfillment of the requirements for Master of Science degree in Climate Change and Education under the WASCAL (West African Science Service Center on Climate Change and Adapted Land Use) program. Therefore, your valid contribution by giving adequate information is highly valuable in achieving the objectives of this research. The information I will collect from you will serve only for academic purposes and it will be kept confidential. Thus, feel free to convey the required information honestly. Thank you in advanced for your cooperation.

FARMERS' AWARENESS AND RESPONSE TO CLIMATE CHANGE IN KAFFRINE REGION, SENEGAL

Part I: Supportive information

i. Name of the interviewer………………………………………………………………
ii. Date: ……/……./………..Time spent for interview: From………..to……………….
iii. Profession…………………………………………………………………..

1. How long have you being educating farmers on climate change?
2. What is your motivation behind this climate change education?
3. What is your source of climate change information?
4. Can you describe how you go about your climate change education among farmers?
5. What aspect (content) of climate change do you educate the farmers on and why?
6. How often do you carry out this education program/activities?
7. In your opinion do you think your education efforts are helping farmers to adapt sustainably (please explain with evidence and examples)
8. What are the challenges that you face in educating farmers on climate change?
9. Do you get any support from the government/NGOs?
10. Please, do you have anything to say?