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IMPLICATIONS OF FARMERS' PERCEPTION, LOCAL KNOWLEDGE AND CLIMATE CHANGE ON RICE PRODUCTION IN THE CENTRAL RIVER REGION, THE GAMBIA

DAWDA BADGIE

2018

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IMPLICATIONS OF FARMERS' PERCEPTION, LOCAL KNOWLEDGE AND CLIMATE CHANGE ON RICE PRODUCTION IN THE CENTRAL RIVER REGION, THE GAMBIA

BY

DAWDA BADGIE

Thesis submitted to the Department of Agricultural Economics & Extension of the School of Agriculture, College of Agriculture and Natural Sciences, University of Cape Coast, in Partial Fulfillment of the Requirements for the Award of Doctor of Philosophy Degree in Agricultural Extension

MAY 2018

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research work that no part has been presented for another degree in this University or elsewhere.

Candidate's Signature:…… Date…….

Name: Dawda Badgie

Supervisors' Declaration

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the university of Cape Coast.

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Name: Dr. Irit Eguavoen

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ABSTRACT

Rice production plays a critical role in food security of farmers in Central River Region (CRR), The Gambia. Over the past years, the region has experienced a reduction in yield due to perceived climate change negative impacts but limited studies were done in the area on how climate change affect rice production. This study assesses the implications of farmers' perceptions, local knowledge and climate change on rice production in the CRR. Two data collection methods namely quantitative and qualitative were used in this study. The quantitative data was obtained from a survey of 438 respondents while the qualitative data was collected from 58 focus group discussions with rice farming communities in all 11 districts of the region. In addition, 13 key informant interviews from relevant institutions were done. The results showed that rice farmers experienced changes in terms of inconsistent rainfall pattern, drought, high temperature, and floods which impacted negatively resulting in low yields, youth migration, food insecurity, and livestock death. Local knowledge was found to be useful in predicting climate and weather conditions and season performance by farmers. Adaptation measures; crop diversification, youth migration; early maturing varieties, livestock sale and remittance were used to address climate change impacts The study also found the inability of state institutions to effectively support the adaptive capacities of farmers, thus further increase rice farmers vulnerability. The study concludes that rice farmers acknowledged the existence and impacts of climate change, and therefore recommends availability of climate change ready- rice" to farmers to address climate change impact in the Central River Region.

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KEY WORDS

Climate Change

Rice farmers

Local knowledge

Climate change Impacts

Adaptation strategies

Support Systems

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DEDICATION

Dedicated to my family (mum Ya Adama), wife (Jainaba, Fatou), children (Yassin, Adama and Ramatoulie) and all rice farmers in CRR.

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CHAPTER SIX: SUMMARY,CONCLUSIONS AND RECOMMENDATIONS

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LIST OF ACRONYMS

ADF	Africa Development Fund
AfDB	African Development Bank
AGW	Anthropogenic Global Warming
ANR	Agriculture and Natural Resources
BCC	Banjul City Council
CBA	Community-Based Adaptation
CBA	Community-based Approach
CBOs	Community Based Organizations
CC	Climate Change
CRR	Central River Region
CRRN	Central River Region North
CRRS	Central River Region South
CSOs	Civil Society Organizations
CSR	Corporate Social Responsibility
CTS	Continental Terminal Soils
DRR	Disaster Risk Reduction
DWR	Department of Water Resources
EbA	Ecosystem-based Approach
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GBoS	Gambia Bureau of Statistics
GCM	Global Circulation Models
GEAP	Gambia Environment Action Plan
BMBF	German Federal Ministry of Science and Education

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GHG	Green House Gas
GNAIP	Gambia National Agricultural Investment Plan
GoTG	Government of The Gambia
HDR	The Human Development Report
IFAD	International Fund for Agricultural Development
IISD	International Institute for Sustainable Development
IPCC	Intergovermental Panel On Climate Change
ITC	International Trypanotolerance Centre
IUCN	International Union for Conservation of Nature
KMC	Kanifing Municipal Council
LDCs	Least Developing Countries
LGP	Length-of-Growing-Period
LRR	Lower River Region
LULCC	Land Use and Land Cover Change
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MOC	Meridional Overturning Circulation
MT	Metric Tonnes
NAMA	National Appropriate Mitigations Action
NAO	North Atlantic Oscillation
NAPA	National Adaptation Programme of Action
NASS	National Agricultural Sample Survey
NBR	North Bank Region
NCC	National Climate Committee
NDMA	National Disaster Management Agency
NEA	National Environment Agency

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NFA	National Forest Assessment
NGOs	Non-Governmental Organizations
NIB	National Investment Board
OECD	Organisation for Economic Cooperation and Development
PAGE	Programme for Accelerated Growth and Employment
PMT	Protection Motivation Theory
PPP	Public-Private Partnerships
PRSP	Poverty Reduction Strategy Paper
RCP	Representative Concentration Pathways
RAD	Regional Agricultural Directorate
SAS	Surrounding Antarctica Subsidence
SEI	Stockholm Environment Institute
SNC	Second National Communication
SSA	Sub Saharan Africa
THC	Thermohaline Circulation
UKDID	United Kingdom Department for International Development
UNFCCC	United Nation Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
URR	Upper River Region
USAID	United States Agency for International Development
VCA	Vulnerability Capacity Assessment
WAAPP	West Africa Agricultural Productivity Programme
WASCAL	West African Science Service Center on Climate Change and Adopted Land Use
WCR	West Coast Region
ZEF	Center for Development Research

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CHAPTER ONE

INTRODUCTION

Background to the Study

The Gambia's agricultural sector plays a vital role in the country's national economy given that more than seventy percent of the population depends on it for their livelihoods (Gambia National Agricultural Investment Plan (GNAIP), 2011 - 2015). However, the sector depends heavily on rainfall for crop production, particularly rice (Government of The Gambia National Communication to United Nations Framework Convention on Climate Change (GoTGSNC), 2012). This rain-fed rice production is under threat in The Gambia due to poor rainfall pattern emanating from weather variability and climate change. Interestingly, this phenomenon has received very limited research in The Gambia. To assess the implications of farmers' perceptions, local knowledge and climate change in the Central River Region, The Gambia, this introductory chapter provides a brief background to The Gambia situation in relation to climate change and weather variability. The research problem is defined and the purpose and objectives of the research are specified. The chapter also gives the significance of the research, the delimitations and limitations, definition of key terms and the broad outline of the entire research.

Scientifically, evidence that indicates that the climate has changed is being disputed. However, issues related to changes in climate are already being felt across all nations, and their impact is projected to increase (Intergovernmental Panel on Climate Change (IPCC), 2007).

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The impacts include, frequent and intense extreme events (floods, droughts, storms, cyclone, hurricanes, temperatures), unpredictability in rainfall patterns, and decrease or increase in the amount of rainfall in a particular region. Consequently, climate change put billions of people at risk worldwide. Climate change impedes social and economic development especially in the Least Developed Countries (LDCs) where communities mostly rely on rain-fed agriculture and natural resources for their survival. Climate Change (CC) has been identified as the leading human and environmental crisis of the 21st century (IPCC, 2007).

The IPCC (2007, 2013) reports indicated that the African continent is more likely to encounter adverse effects of climate change despite less Greenhouse Gases (GHG) emissions, the main cause of global warming. The IPCC's fifth report predictions affirm a high probability that whatever the mitigation measures taken to reduce emissions, the already increased temperature will highly impact Africa in the coming decades (IPCC, 2014). Thus the need for various adaptation strategies in Africa to withstand with the effects of weather variability and climate change is very necessary. Adaption strategies as classified by Clark *et al.* (2010) include soft (policy), (engineered) and ecosystem-based.

The soft adaptation approach has to do with enactment of policies in relation to appropriate adaptation responses from a multi-sectoral perspective including agriculture, hydropower, industry, environmental and ecosystem use, early warning and land-use planning. The policies are to guide the selection of appropriate responses and interventions, set priorities of these interventions and outline how these interventions are to be implemented.

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The hard approaches rely predominately on human-built infrastructure, which are complex and capital-intensive as a response to address climate change impacts such as dykes, sea defence walls, reinforced buildings and usually lack flexibility and adaptability to sudden changes in projections of climate change. The ecosystem-based approach uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels. This may involve the maintenance and enhancement of ecosystem services important for livelihoods and well-being of the people by designing ecosystem management initiatives that contribute to climate change mitigation. A typical example is reducing emissions from ecosystem loss and degradation, and enhancing carbon sequestration. These approaches in addressing climate change impacts are weak in The Gambia and Africa in general. The situation in Africa is further aggravated by the interaction of 'multiple stresses', occurring at various levels, and low adaptive capacity of the people (Boko, Niang, Nyong, Vogel, Githeko & Medany, 2007).

The weak adaptation mechanisms in The Gambia are exacerbated by endemic poverty and the fact that livelihoods in The Gambia and Africa in general are greatly tied to natural resources (forest and woodland ecosystem services). In addition, majority of the people in Sub Saharan Africa (SSA) including The Gambia depend on rain-fed agriculture for their livelihoods, with about 38% of the people living in drought prone dry lands (Olufunso, 2010). This implies that the agro-based livelihoods of such people and food security, in general, are threatened.

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SSA is noted to be the region most vulnerable to many adverse effects of climate change due to its high reliance on rain-fed agriculture for basic food security, economic growth and entrenched poverty (Dixon, Gulliver & Gibbon, 2001; IPCC, 2007; Cooper, Dimes, Rao, Shapiro, Shiferaw & Twomlow, 2008).

Livelihoods, especially in farming, depend on the capacity of ecosystems to provide the services vital for environmental balance without which food production and other productive activities cannot be sustainably executed (Agyemang-Bonsu, Dougherty, Penstil & Kemp-Benedict, 2008). To moderate and cope with the effects of climate change, livelihood trajectories are being changed or modified taking the changing climate into consideration (Bagchi, Blaikie, Cameron, Chattopadhyay, Gyawali & Seddon, 1998). Adaptation to climate change requires individuals to be aware of potential changes in the climate and to understand the implications of changes for their lives. It requires them to assess the risk such changes hold for their identity and to make informed decisions on how to adapt their livelihoods, homes and communities (Njie, Gomez, Callaway, Jallow & Droogers, 2009).

The Gambia is subjected to a number of climate change induced impacts (GoTGSNC, 2012). The recent changes in rainfall patterns and temperature over the past decade will presumably lead to sea level rise, droughts, increased surface evaporation, flooding, high risk of forest fires and insect attack among others (National Adaptation Programme of Action (NAPA), 2007; GoTGSNC, 2012).

It is projected that about 92 km² of land in the coastal zone of The Gambia will be inundated as a result of a 1m sea level rise, and the whole

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capital city of Banjul risks to disappear (Darboe & Bojang, 2005; Programme of Accelerated Growth and Employment (PAGE), 2012). Moreover, increased saline intrusion is leading to the loss of estuarine mangroves that provide a coastal defence and an important habitat for marine mammals. Again, the disappearance of freshwater swamps and soil salinization in lowland areas will result in the production of unsuitable field thus impacting negatively on crop production (Njie, 2006).

The impact of climate change could be significant in The Gambia since agricultural production is heavily dependent on climate, water resources and soil conditions (Njie, Gomez, Callaway, Jallow & Droogers, 2009). In addition, since agriculture is the second largest sector of the economy, climate change has the tendency of worsening food insecurity, unemployment and loss of livelihoods, thus increasing vulnerability to climate change in The Gambia cannot be neglected. Climate change can therefore be considered a threat to the achievement of the Millennium Development Goals (MDGs) and the recent Sustainable Development Goals (SDGs) to alleviate The Gambia from extreme poverty.

Two climate change modelling experiments for The Gambia were carried out by the University of Oxford in 2006 and 2012 (Darboe & Bojang, 2005), according to the reports, the temperature increases will be significant and that rain will reduce in the subsequent wet seasons. The projected impacts of climate change can be significant in The Gambia mainly in the agricultural sector, ecosystem services, and livelihoods which are very sensitive to changes in climate (Darboe & Bojang, 2005).

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A vulnerability assessment carried out for the Greater Banjul area revealed that salinity worsens in dry periods and in high temperatures, with the problem being severe in March to May. This negatively affects rice production along the river banks (Njie, Gomez, Callaway, Jallow & Droogers, 2009).

The IPCC Fifth Assessment Report concludes that projections of sea level rise are larger than previously projected primarily because of improved modelling of land-ice contributions. For the period 2081–2100, compared to 1986–2005, global mean sea level rise is likely to be 0.32 to 0.63m for RCP4.5, rising to 0.45 to 0.82m for RCP8.5, and rising to 0.52-0.98m by 2100.

This scenario especially is a serious risk for The Gambia considering that 30% of land is at or below sea level, 50% at or less than 20m above sea level and 10-20% seasonally flooded (Jallow, 1999). A 1m rise in sea level would inundate 60% of mangrove forests, 33% of swamp area and 20% of rice growing areas, assuming that no protection mechanisms are developed (Jallow, 1999). Areas in the upper end of the country would also be affected. Saline water would infiltrate ground water aquifers, especially considering that The Gambia sits on top of a shallow sand aquifer with depths of between 4 and 50m (Africa Development Fund report (ADF), 2005). In view of the current climate induce risk, climate change has the tendency of worsening food insecurity, unemployment and loss of livelihoods (ADF, 2005).

To mitigate the effects of climate change in The Gambia, farmers have adopted many strategies. According to Yaffa (2013), planting early maturing crops, drought resistant varieties, tree planting, soil and water conservation

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methods are being used by farmers to adapt to climate change in the North Bank Region of The Gambia.

Boko, Niang, Nyong, Vogel, Githeko and Medany, (2007) reported that despite farmers developing several adaptation measures to deal with current climate variability, such adaptations may not be sufficient for future changes of the climate. Most farmers in Africa and The Gambia in particular depend on their ecosystems to provide food, energy, water and medicine and also to renew fertility in the soil and purity in water (Agyemang-Bonsu, Dougherty, Penstil & Kemp-Benedict, 2008). Despite the adverse negative impacts of climate change, there is limited awareness on climate change in developing countries including The Gambia (Njie, 2006; IPCC, 1996).

The limited awareness affects their ability to make informed decisions to respond to the changing climate through the prevention and removal of mal-adaptive practices. IPCC (2007) defines mal-adaptation as adaptation measures that do not succeed in reducing vulnerability but increase it instead. Hence mal-adaptation of livelihood will only intensify the negative impacts of Climate Change on the livelihoods of individuals. In order to strengthen farmers' capacity to adapt to Climate Change, it is necessary to implement adaptation strategies through capacity building and educating farmers especially, the poor and vulnerable with tested methods (Ngigi, 2009).

One area that the government of The Gambia is focusing its effort on climate change effects is the rice production. Rice over the years has become the staple of the country. The national requirement for rice consumption does not meet the production thus most of the rice is imported to meet local needs.

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This imbalance in food security is a concern to the government of The Gambia in its drive for food self-sufficiency as stated in the vision 2020 blue print. Further to that, rice production has of recent times become an important cash and poverty reduction crop, as many farmers across the country are engaged in its production and sale (Njie, 2006).

Statement of the Problem

The Gambia's economy, domestic food supply and employment are largely dependent on rain-fed crop production and animal husbandry. Climate change assessments have confirmed that global warming will be more intense in Africa with up to +3.5^{o}C to +4^{o}C in parts of West Africa, particularly the Sahel region (including The Gambia), in the 21st century (IPCC, 2007). This was expected to affect agriculture as a sector in terms of low crop production and eventual food insecurity. In view of the significant role of agriculture in terms of food security, the Gambian government is seeking for possible adaptation options for mitigating the impacts of climate change on rice cultivation as a staple food for the entire Gambian populace. This is premised on the grounds that the issues of climate change and their associated implications are apparent and are here to stay at least for a while. Interestingly, The Gambia's national capacity to carry out scientific research on climate change is considered quite low (NAPA, 2007; Ozor, 2014). The organizational history and status of the National Metrological and Hydrological Services which is a non-research institution but given some research tasks on climate change have not contributed significantly to the generation of knowledge on climate change, socio-environmental

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vulnerabilities, mitigation science, or adaptation practices at the national level (Darboe & Bojang, 2005). The Gambia's First National Communication, aimed at addressing climate change impacts at the national level under the United Nations Framework Convention on Climate Change (UNFCCC) was published in 2003.

Research carried out by the organisation on global change had been mainly on the basis of researchers interests. Generally, pertinent research studies in the country have covered a range of topics including climate drivers, environmental and socioeconomic consequences of land use and land cover change; application of seasonal rainfall forecasts in decision-making; climate change impacts on trans-boundary water resources management; and cost and benefits of adaptation in The Gambian agricultural sector (Jallow, 1999). Other previous studies by Anyadike (1993) on climate change and variability in The Gambia have given valuable insights on some of the existing trends from a general perspective on the climate situation in the country. In general, little or no empirical research has been conducted on how weather variability and Climate Change impact on natural, agricultural and societal systems (Njie, 2006). Invariably, the assumptions about climate change related ramifications to farmers in The Gambia are to a greater extent based on perceived logic and anecdotal evidence thus falling short of the required information to support government initiative in mitigating the effects of climate change and weather variability in rice production.

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Purpose of this Study

The main purpose of this study was to assess the implications of farmers' perception, local knowledge and climate change on rice production in the Central River Region (CRR), The Gambia.

Specific Objectives

To achieve the main purpose of the study, the following specific objectives were set:

1. Describe rice farmers' perceptions of climate change and variability implications on rice production in CRR.
2. Determine the local knowledge of rice farmers' in predicting climate change and variability.
3. Determine the relationship between education level, income and age of rice farmers and adoption of adaptation strategies, knowledge of climate change, and use of adaptation measures of farmers.
4. Assess the adaptation strategies of rice farmers in response to weather variation and climate change implications.
5. Examine the availability of climate change and variability support system for rice farmers in CRR.

Research Questions

i. What are the perceptions of rice farmers on climate change and variability implications on rice production and household livelihoods in the Central River Region?

ii. What local knowledge do rice farmers possess with respect to climate

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change and variability?

iii. What adaptation strategies do rice farmers have in response to climate change and variability in Central River Region?

iv. What climate change and variability support system is available for rice production as perceived by rice farmers in Central River Region?

Research Hypotheses

I. H_o: There is no significant difference between respondents age, education level, income and adoption of adaptation strategies, knowledge and awareness of climate change and weather variability of rice farmers in the CRR.

II. $H_{1:}$ There is significant difference between respondents' age, education level, income and adoption of adaptation strategies, knowledge and awareness of climate change and weather variability of rice farmers in the CRR.

Significance of the Study

Addressing climate change related implication requires a holistic approach. It is never possible to conduct a controlled experiment by changing the global atmosphere to test the effects of changes on human beings and natural eco-systems (FAO, 2010). Research within the local communities can lead to a better understanding of the observed changes in climate and help to find more appropriate adaptation measures to deal with climate change related impacts.

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In view of this, it is envisaged that the findings of this study would be useful to policy and decision makers in the development of climate change policies and adaptation strategies that take into account local rice farming communities' perspective on climate change impacts for rice production in The Gambia. It would be relevant to extension training through increasing awareness, knowledge and skills on climate change and adopting appropriate mitigation measures relevant to rice production. Furthermore, the study findings would be relevant in academia as recommendations had been be made for further research on climate change related issues.

Delimitations of study

In The Gambia, rice cultivation is carried out in all the six agricultural regions of the country, under upland, lowland rain fed, irrigated and freshwater condition, and in mangrove swamps. The regions are West Coast, Lower River, North Bank, Central River – North, Central River –South and Upper River. This study concentrated on the Central River Region mainly on two reasons:

1. The CRR is the main rice producing region in the country and known as the bread basket of The Gambia.
2. It has similar ecological characteristics with other bothering regions and engaged in upland, lowland and irrigated rice production.

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Limitations of study

Key limitations were encountered the study were

1. All the data collection instruments, which were written in English, had to be translated into the different local languages of the respondent even though the instruments were validated. As such, it is possible that some vital information might have been lost during the translation process
2. The use of FGD technique in data collection has inherent tendencies of some dominant characters taking over discussion and others may not have a chance to express themselves thus loosing valuable information.

Definition of Terms

Climate Change: 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 or long period, typically decades or longer.

Climate Variability: It refers to the fluctuation or variation of the climate factors such as rainfall and temperature over seasons and years. It is shown by the occurrence of climate hazards such as drought, floods, heat wave and other extreme weather events.

Coping measures: They are techniques or practices used by farmers at the farm level when climate variability hazards occur to protect the crop. These are supposed to be for short term.

Adaptation: Means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise.

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Adaptation strategies: These are plans of action designed to achieve a long-term solution or overall aim and are needed at all levels of administration: at the local, regional and national levels due to the varying severity and nature of climate impacts between regions.

Adaptation Measures: It refers to techniques or practices used by farmers at the farm level to protect the crop against climate variability hazards. They are usually put in place before the disaster occurrence and are supposed to be for medium or long run measures.

Adaptive capacity: Refers to the potential or ability of a community to cope with, adapt to, or recover from the effects of an exposure.

Anticipatory Adaptation: Adaptation that takes place before impacts of climate change is observed. This is also referred to as proactive adaptation.

Autonomous Adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. This can be referred to as spontaneous adaptation.

Planned Adaptation: Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Local knowledge: It refers to the unique, traditional knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area and acquired from generation to generation.

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Vulnerability: Is defined by the IPCC as ″the degree, to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes.

Mal-adaptation: Action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups.

Organization of the Study

This thesis is presented in six chapters. Chapter one is devoted to the background of the study, statement of the problem, purpose of study, research objectives, research questions, hypothesis, significance of the study, delimitation of study, limitation of study, definition of terms and organization of the study. In Chapter two, a review of related literature on climate change such as the concept and science, the theories, vulnerability, climate change implications, local knowledge, agricultural sector impacts on climate change, perception, adaptation approaches, support systems and conceptual framework study on farmers perceptions of climate change and adaptation. The third chapter explains the research methods used. It presents the research design, data collection procedure, research instrument, data collection process, data processing and analysis and the reconnaissance visit. Chapter four describes the context of the study area. It includes the general perspective of the country background within the context of the study area on socio-economy, agro-ecology, climate, soils, vegetation and rice production. In addition, the role of the agricultural sector in The Gambia and the effects of climate change on agriculture in general and in particular on rice farming communities in the

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region was covered as well as the background characteristics of respondents. Chapter five focuses on the analysis, presentation, interpretation and discussion of the research findings. Finally, in Chapter six, the summary of the research findings, conclusions, recommendations and suggestions for further research were presented.

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CHAPTER TWO

LITERATURE REVIEW

Introduction

This study assessed the perception and local knowledge of rice farmers on climate change, and its related implications on rice production, vulnerability and adaptation in the Central River Region of The Gambia. To place the research problem in the context of the literature, the chapter is a review of the concept, science and theories of climate change and variability. It reviews the implications or effects of climate change and variability on agriculture and specifically rice production.

The review also considers the perceptions and local knowledge of rice farmers on climate change in relation to rice production, farmer vulnerabilities and adaptation strategies. Finally, approaches to climate change adaptation including key policies and support systems for climate change management were also reviewed. From the reviews, a conceptual framework was developed to guide the research.

The Concept and Science of Climate Change and Variability

According to Roesch, Miller, Yates and Stewart (2006), the climate system is dynamic and complex. While weather details changes over short periods of time, climate describes average conditions over longer intervals.

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Understanding this distinction and other basic concepts such as radiative forcing (measures the influence that climate-altering factors have on the energy balance of the Earth) and the enhanced greenhouse gas effect can clarify how the climate is changing and how humans have contributed to that change (Trenberth, Soden, Rusticucci, Renwick, Rahimzadeh, Parker, Klein, Easterling, Zhai , Jones, Ambenje & Bojariu, 2007).

Climate change according to IPCC (2001) could be defined as any change in climate over time, due to natural variability or as a result of anthropogenic activities. This definition considered climate change as observed and projected increases in average global temperature as well as associated impacts such as an increase in the frequency or intensity of extreme weather; melting icebergs, glaciers and permafrost; sea-level rise; and changes in the timing or amount of precipitation. According to IPCC report (2007), climate variability is the variation around the average climate, including seasonal variations as well as large-scale variations in atmospheric and ocean circulation such as the El Niño/Southern Oscillation (ENSO) or the North Atlantic Oscillation (NAO) and operates over decades or longer time-scales. The changes could be due to natural variability or as a result of human activity (IPCC, 2007). Naturally occurring greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3) are present in the atmosphere and are responsible for keeping the temperature on Earth at optimal levels to support life (IPCC, 2007).

The consensus that anthropogenic climate change according to Easterling *et al.* 2007; Meehl, Collins, Boville, Kiehl, Wigley and Arblaster (2000), is driven by an increase in the atmospheric concentration of GHGs that

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result from the burning of fossil fuels and certain land use practices. Easterling further explained that GHGs act to warm the atmosphere by absorbing long-wave radiation emitted from the earth's surface, which would otherwise escape through the atmosphere to space.

The IPCC (2001) report indicated that the primary contributor to anthropogenic warming is CO_2, with methane and nitrous oxide being of secondary importance. In this report, results of leading modeling groups around the world were published with an increase forecast in world average temperature within the range of 1·4–5·8°C by 2100. The increase will be greater at higher latitudes and over land. Global average annual rainfall will increase, although many mid latitude and lower latitude land regions will become drier, whereas elsewhere precipitation events could become more severe. The frequency and intensity of natural disasters are also growing rapidly worldwide according to Easterling *et al.* (2007).

A recent analysis of great natural catastrophes since 1960 shows an increase in the 1990s by a factor of three; this seems to be directly correlated with global warming and the economic losses adjusted for the inflation rose by a factor of nine (Easterling *et al.* 2007; Horton & DeCelles, 1997). This trend of climate change variation and implications, to greater extent, has greater implications to the Gambia as a nation and the CRR in particular whose livelihoods mainly depend on agricultural production which is influence by weather and climate parameters.

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Theories of Climate Change and Variability

Factors that influence the earth's climate have long been known to the scientific community which includes variations in the sun's brightness, magnetic field strength and the planet's orbit, the planet's movement through the galaxy, and changes in land use among others (Bast, 2010). Bast has given seven theories that may contribute to global warming as explained in the following sections:

1. *Anthropogenic Global Warming (AGW).*

The AGW is considered as the first theory and most accepted definition of climate change which suggests that human emissions of GHGs such as CO_2, methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism on how this happens is called the enhanced greenhouse effect and widely referred to as "anthropogenic global warming" (Gore, 2006; IPCC, 2007). In addition, Vardiman (2008) viewed the theory to be mostly familiar with the people who hold the argument that man-made greenhouse gases, particularly CO_2, are the predominant cause of the global warming that occurred over the past 50 years.

2. *Bio-thermostat*

The Bio-thermostat theory of climate change which is viewed as the second according to Idso & Singer, (2009); Niyogi, Chang, Saxena, Holt, Alapaty, Booker, Chen, Davis, Holben, , Matsui, Meyers, Oechel, Pielke, Wells, Wilson & Xue, (2004); Wingenter, Haase,, Zeigler, Blake, Rowland , Sive, Paulino, Thyrhaug, Larsen, Schulz, Meyerhofer & Riebesell, (2007). They argued that negative feedbacks from bio-logical and chemical processes entirely or almost entirely offset whatever positive feedbacks might be caused

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by rising CO_2. These processes act as a global bio-thermostat keeping temperatures in equilibrium. The scientific argument of such feedbacks as explained by Idso and Singer (2009) includes; Carbon Sequestration; in which the Sequestration offsets some of the temperature-increasing power of higher levels of CO_2, and Carbonyl Sulfide (COS); which is a biologically produced sulfur gas emitted from soils into the stratosphere where it is transformed into sulfate aerosol particles, which reflect solar radiation back into space, thus having a cooling effect on the earth's climate. In addition, the proponent of this theory also argued that diffuse Light and dimethyl sulfide emit greater amounts of gases converted into aerosols called "biosols." which in turn act as cloud condensation nuclei, helping to create new clouds that reflect more incoming solar radiation back to space, thereby cooling the planet. Bio-thermostat advocates further argued that Iodocompounds and Aerosols which are particles formed in sea air from iodine-containing vapors emitted by marine algae reduce the amount of solar radiation reaching the surface, and the aerosols increase the presence and reflect more solar radiation away from the planet's surface, causing it to cool.

3. *Cloud Formation and Albedo*

Another climate change theory considered to be the third suggests that changes in the formation and albedo of clouds create negative feedbacks that cancel out all or nearly all of the warming effect of higher levels of CO_2. This theory is based largely on observational data reported by a series of researchers, rather than computer models as in the case of the AGW theory Sud, Walker, & Lau, (1999); Spencer, George, Aiken-Kenna, Butler, Dornblaser, Striegl & Hernes, (2009); Lindzen & Choi, (2009).

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Lindzen and Choi (2010) reported that negative feedback by clouds in the tropics, which implies that the models are exaggerating climate sensitivity and justified that clouds act as a negative feedback to the warming that would otherwise be caused by man-made CO_2 emissions, eliminating any net warming.

4. Human Forcings

The fourth theory of climate change according to Matsui and Pielke (2006) reported that mankind's greatest influence on climate is not its greenhouse gas emissions, but its transformation of the Earth's surface by clearing forests, irrigating deserts, and building cities. Pielke (2009) stated that although the natural causes of climate variations and changes are undoubtedly important, the human influences are significant and involve a diverse range of first order climate forcings, which include but not limited to, the human input of carbon dioxide (CO_2). Some of these human forcings other than greenhouse gases according to Pielke (2009) include; Coastal Development, Urban Heat Islands, Jet Contrails, Aerosols and Ozone, and Deforestation.

5. *Ocean Currents*

The fifth theory of climate change according to Gray (2009), stated that global temperature variations over the past century and half, and particularly the past 30 years, were due to the slowdown of the ocean's Thermohaline Circulation (THC). This deep ocean circulation, called the Meridional Overturning Circulation (MOC), has two parts, the primary Atlantic THC and the secondary Surrounding Antarctica Subsidence (SAS).

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Gray (2009) further reported when the THC circulation is stronger than normal, the earth system experiences a slightly higher level of evaporation precipitation. Alternatively, when the THC is weaker than normal, as it is about half the time, global rainfall and surface evaporation are reduced about 2 percent.

THC conditions act together with the enhancement of the upwelling of deep ocean cold water into the tropical ocean upper level mixed region to bring about additional upper level ocean energy depletion (Gray, 2009). When the THC is relatively weak (for instance in the periods of 1910-1940 and 1970-1994), the earth system typically has lower net evaporation cooling and less deep ocean upwelling of cold water. During these periods, energy accumulates in the ocean's upper mixed layer and over a period of a decade or two, the global ocean begins to warm (Gray, 2009).

Gray further stated that changes of the Meridional Overturning Circulation (MOC) since 1995 led to the cessation of global warming since the 1998-2001 period and triggered the beginning of a weak global cooling trend since 2001. This weak cooling will continue for the next couple of decades and expects the start of a global cooling pattern thus discrediting most of the anthropogenic warming arguments.

6. *Planetary Motion*

The Planetary Motion is considered as the sixth theory of climate change (Bast, 2010). This theory supports the argument that most or all of the warming of the latter part of the twentieth century can be explained by natural gravitational and magnetic oscillations of the solar system induced by the planet's movement through space.

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These oscillations modulate solar variations and/or other extraterrestrial influences of Earth, which then drive climate change (Scafetta & West, 2009). According to Scafetta (2009), extraterrestrial influence on climate on a multi-millennial time scale associated with planetary motion was first suggested by a Serbian astrophysicist (Milutin Milankovitch), in his work published in 1941 and recent discoveries have enabled scientists to accurately measure these effects on climate. The coincidence of these cycles is known to lead with the help of positive climatic feedbacks such as water vapor, to the cooling and warming periods we recognize from historical data as Ice Ages and Interglacial Periods (Scafetta, 2010).

The climate models used by proponents of the AGW theory according to Scafetta (2010) are disgracefully unable to recreate past temperature variation without extensive alteration of the models to fit the data. Scafetta further reported that his model, without any deception, explains most of the warming of the twentieth century and result indicated the difference between his climate forecast showed cooling trend for the next two decades, while that of IPCC forecasts depicted a catastrophic warming trend over the same period.

7. *Solar Variability*

The seventh theory of climate change according to Soon (2009) is that of solar variability which accounts for most or all of the warming in the late twentieth century and will dominate climate in the twenty-first century regardless of man-made greenhouse gas emissions. Changes in the brightness of the sun are caused by sunspots bursts of energetic particles and radiation that vary in frequency in cycles of roughly 11, 87, and 210 years (Loehle,

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2004; Soon, 2005). The cycles cause changes in the amount of electromagnetic radiation also called “solar wind” and that reaches Earth and its atmosphere, which in turn affects Earth’s climate (Soon, 2009).

The proponents of the theory that solar variability drives changes in Earth’s climate argued that positive feedback occurs either by a process involving the influence of the solar wind on cosmic rays, which affects cloud formation, or on the oceans’ known as thermohaline circulation (THC), thus affects sea surface temperatures and wind patterns (Carslaw, Harrizon, & Kirkby, 2002). In a recent article entitled "Does Carbon Dioxide Drive Global Warming?" Vardiman (2008) argued that carbon dioxide is probably not the primary cause and stated that evidence gathered indicated that cosmic rays associated with fluctuations in the sun's electromagnetic field may be what drive global warming. Vardiman further reported that a new theory called cosmoclimatology that proposes a natural mechanism for climate fluctuations has been developed. A discovery by Henrik Svensmark in 1995 showed a startling connection between the cosmic ray flux from space and cloud cover. His discovery reported a complete chain of events that explains the variations in global temperature that have puzzled climatologists for so many years, and that has now led to an explanation for the recent global warming episode (Vardiman, 2008).

According to IPCC (2014), there is an increasing awareness and acknowledgement among the scientific community that the climate is changing. However, the debate concerning the projections and causes of climate change is inconclusive and the anthropogenic global warming theory now in disregard from the scientific community globally.

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In most of West Africa, some consensus seems to be emerging about the increasing frequency and intensity of extreme shocks and climate variability (Boko, Niang, Nyong, Vogel, Githeko, Medany, Osman-Elasha, Tabo & Yanda, 2007; Buontempo, Booth, & Moufouma-Okia, 2010; Kandji, Verchot, & Mackensen, 2006; Jung & Kunstmann, 2007; Hulme, 2001). These climate trends, shocks and seasonality affect food production, thus increasing livelihood and food insecurity (FAO, 2011).

Climate Change and Variability Effects on Agricultural Production

Climate change is a global environmental threat and development concern. Developing countries are the most adversely affected by the negative effects of climate-induced events because of their low level of adaptation (International Fund for Agricultural Development (IFAD) Report, 2010). Climate change 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 or long period, typically decades or longer (IPCC, 2007). On the other hand, climate variability according to IPCC (2007), refers to the fluctuation or variation of the climate factors such as rainfall and temperature over seasons and years. It is shown by the occurrence of climate hazards such as drought, floods, heat wave and other extreme weather events.

The agricultural sector has gone through evolution over the past decades when many new ideas were implemented and many new technologies were introduced. Agricultural production which include crop and pasture land, covers 40% of the globe and use 70% of the consumptive water and employs approximately 40% of the population worldwide. These ultimately necessitate

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the greater link between human, agriculture and environment (Kleinschmit, 2009).

According to IPCC report (2013), the average temperatures of the atmosphere and the ocean have increased, the sea level has risen, and the amount of snow and ices has diminished. Climate change is happening now and will continue in the future if nothing is done to stop the greenhouse gas emission.

Among the sources of greenhouse gas emissions are agriculture, forestry and other land uses. The report indicated that these sectors together contribute 24% of emission after the energy sector. The contribution of the agriculture sector to climate change is mainly in the area of land use (i.e. use of fertilizers and burning of farm residues) and livestock management (release of methane from livestock waste). However, climate change is predicted to affect agricultural and other related sectors in the following ways:

i. Crop production that depends mainly on rainfall will be affected in case of drought.
ii. The incidence of pests and diseases could increase.
iii. Sea level rise (40cm in the coming years) would submerge some vulnerable coastal agricultural lands especially rice fields
iv. Loss of biodiversity from some of the most fragile environments in tropical forests and mangroves.
v. It may make the day to day and medium term planning of farm operations more difficult.
vi. Livestock production and productivity could be reduced as a result of drought and heat stress

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Karrer (2012) study on farmers' perception and response to climate change stated that though agriculture is contributing to global warming, global warming is also affecting agriculture particularly in developing countries. Industrial mono cultural and fossil fuel-intensive is both a cause and victim of climate change (Kleinschmit, 2009).

Agricultural Sector Impacts on Climate Change

Globally, several discussions over the years have been focused more on the impact of climate change on agriculture sector and food security. However, what is obviously over sighted is the impact of agriculture on climate change (Dev, 2011).

Climate change is largely attributed to the outcome of GHG emissions. The human actions in production and consumption are mainly responsible for increase in GHG emissions and how the unsustainable production and consumption patterns in agriculture are responsible for the rise of these emissions. Agriculture alone contributed 13% of total global GHG emissions in 2000 0r 5729 Mt CO_2 equivalent. If the emissions due to deforestation, and agriculture's share are added, that would be 30 per cent to global emissions. Emissions from this sector are primarily CH_4 and N_20 making the agriculture sector the largest producer of non-CO_2 emissions, accounting for 60 percent of the world total in 2000 (World Resources Institute (WRI), 2008). The principal sources of emissions from agriculture are: 37% from Fertilizers (N_2O), 11% from rice (CH_4), 32% from livestock (CH_4), 13% from residue burning and/or forest clearing and, 7% from manure management (CH_4 and N_2O) (United States Environmental Protection Agency- USEPA, 2006).

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The production and consumption patterns in agriculture are not sustainable. Green revolution in agriculture benefited the farmers. However, it has neglected the problems relating to unsustainable exploitation of land and water, adoption of mono-culture and excessive use of mineral fertilizers and chemical pesticides (Dev, 2011).

Certain production practices in agriculture and forestry which is adding to GHG emissions are highlighted as thus: Overuse of fertilizers is one of the causes for rise in GHG emissions. Nitrous oxide (N_2O) emissions from soils are responsible for GHG emissions. N_2O is produced by microbial transformations of nitrogen in the soil, under both aerobic and anaerobic conditions.

The emissions, therefore, are often directly related to nutrients added to the soil in the form of mineral fertilizers and animal manure (Flynn, 2009). Some have argued that urea-based fertilizers lead to higher N_2O emissions than ammonia or nitrates. Flynn further reported that both environmental factors, such as soil conditions, climate, and management factors such as tillage also play important roles in determining the proportion of applied nitrogen lost as N_2O. Soil organic carbon has been depleted through (a) the long-term use of extractive farming practices and (2) the conversion of natural ecosystems (forest lands, prairie lands, and steppes) into croplands and grazing lands.

Lal (2009) reported that, most of agricultural soils have lost 30 to 40 mt of carbon per hectare, and their current reserves of soil organic carbon are much lower than their potential capacity. Lal further indicated that studies have revealed that rice cultivation is an important anthropogenic source of not

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only atmospheric methane but also of N_2O. 90 percent of the world's rice is produced and consumed in Asia, and 90 percent of rice land is –at least temporarily-flooded and it is one of the reasons for its emissions of one major GHG (methane).

The methane emissions from rice fields are determined mainly by water regime and organic inputs, but they are also influenced by soil type, weather, tillage management, residues, fertilizers, and rice cultivar (Wassmann, Hosen & Sumfleth, 2009).

Deforestation is another important source for increase in GHG emissions. The global forest cover is 3952 million ha, which is about 30 percent of world's land area. Most relevant for the carbon cycle is that between 2000 and 2005, gross deforestation continued at a rate of 12.9 million ha/yr. This is mainly as a result of converting forests to agricultural land, but also due to expansion of settlements, infrastructure, and unsustainable logging practices (FAO, 2006; Millennium Ecosystem Assessment (MEA), 2005). Due to afforestation, landscape restoration and natural expansion of forests, the most recent estimate of net loss of forest is 7.3 million hectares per year. The loss is still largest in South America, Africa and South East Asia. The MEA report further indicated that the decrease in forest area in the developing regions will increase from 200m to 490m hectares between year 2000 and 2050. In addition to the decreasing forest area globally, forests are severally affected by disturbances such as forest fires, pests and climatic events including drought, wind, snow, floods and all these factors have also carbon balance implications.

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Herrero and Thornton (2009) reported that livestock contribute 18% of global anthropogenic GHG emissions. The main sources and types of GHGs from livestock systems are methane production from animals (25 %), carbon dioxide (CO_2) from land use and its changes (32%), and nitrous oxide (N_2O) from manure and slurry management (31%).

Herrero & Thornton further indicated that the systems for producing different kinds of livestock are highly diverse. The rapidly expanding industrial livestock operations in Asia and those linked to deforestation in Latin America add more to GHG emissions than the small holder crop-livestock, agro-pastoral, and pastoral livestock systems.

The consumption patterns particularly of the developed countries and the rich are mostly responsible for rise in GHG emissions. The Human Development Report (HDR) (1998) indicated that the ever expanding consumption puts strains on the environment in that emissions, wastes generated tend to pollute the earth and destroy ecosystems. This to a greater extent enhances the depletion and degradation of renewable resources that undermine livelihoods according to the report. The inequalities in consumption are plain. For instance, the richest fifth consume 45% of all meat and fish and the poorest fifth only 5%. Similarly, richest fifth consume 58% of total energy, the poorest fifth only 4% (HDR, 1998).

The world‘s dominant consumers according to Dev (2011), are overwhelming and concentrated among the wealthy but the environmental damage from the world‘s consumption falls most severely on the poor and the vulnerable in societies. The distribution of current emissions points has an inverse relationship between climate change risk and responsibility. The poor

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countries need to accelerate their consumption growth but they need not follow the path taken by the rich and high growth economies. The developing countries can look at the supply chain of agricultural production and try to change their consumption patterns to reduce GHG emissions (Dev, 2011).

Vulnerability to Climate Change

Vulnerability is hypothesized in many diverse ways by scholars from different research communities, and even within the same (Fussel, 2004). The climate-related vulnerability assessments according to Fusses (2004) are built on the characteristics of the vulnerable system, the type and number of stressors and their root causes, their effects on the system, and the time horizon of the assessment. Vulnerability to climate change according to IPCC report (2001) showed the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

The importance of biophysical vulnerability is acknowledged as well. Many poor people are directly dependent on ecosystems for their livelihoods according to the International Union for Conservation of Nature (IUCN), Stockholm Environment Institute (SEI) & International Institute for Sustainable Development (IISD) report (2003). This report further stated that biodiversity is the foundation and mainstay of agriculture, forests and fisheries. Natural forests, freshwater and marine ecosystems maintain a wide

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range of ecosystem goods and services, including the provision and regulation of water flows and quality, timber and fisheries.

World Bank (2009) reported that the poorest of the poor are, often dependent on these goods and services for survival. The biophysical vulnerability to them means human livelihood vulnerability.

In dealing with vulnerability to climate change, there are key terminologies according to IPCC report (2001) that requires understanding. These include adaptive capacity, exposure, sensitivity, resilience, hazard and sustainable livelihood.

Adaptive Capacity is referred to as the ability of a system [human or natural] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. One of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over natural, human, social, physical and financial resources. Factors that affect adaptive capacity include: Human (Knowledge of climate risks, conservation techniques, agricultural skills, good health to enable labour), Social savings and loans groups, farmer-based organisations, traditional welfare and social support institutions), Physical (Irrigation infrastructure, seed and grain storage facilities), Natural (Reliable water sources, productive land, vegetation and trees) and micro-insurance.

In general, the world's poorest people according to United Nations Office for Disaster Risk Reduction (UNISDR) report (2009) often have limited access to those livelihood resources that would facilitate adaptation. Access to and control over these resources also varies within countries,

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communities and even households. The report further indicated that it is influenced by external factors such as policies, institutions and power structures. The approach to integration of climate change is grounded in the identification of vulnerable groups and targeting of adaptation strategies depending on both the human and natural ecosystem context.

Another important terminology with respect to climate change is exposure which is primarily a function of geography (UNISDR, 2009). For instance, coastal communities will have higher exposure to sea level rise and cyclones, while communities in semi-arid areas may be most exposed to drought**.**

Sensitivity is the degree to which a given community or ecosystem is affected by climatic stresses. A community dependent on rain-fed agriculture is much more sensitive to changing rainfall patterns than one where mining is the dominant livelihood. Likewise, a fragile, arid or semi-arid ecosystem will be more sensitive than a tropical one to a decrease in rainfall, due to the subsequent impact on water flows.

Resilience as climate change terminology refers to the ability of a system (human or natural) to resist, absorb and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structures, functions and identity (UNISDR, 2009). A resilient community is well-placed to manage hazards, to minimise their effects or to recover quickly from any negative impacts, resulting in a similar or improved state as compared to before the hazard occurred. There are strong linkages between resilience and adaptive capacity; consequently, resilience also varies greatly for different groups within a community (UNISDR, 2009).

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Hazard on the other hand refers to a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage and could be climate related (UNISDR, 2009).

The sustainable livelihoods from climate change perspective comprise the capabilities, assets and activities required for a means of living over long term. A livelihood is sustainable when it can cope with and recover from external shocks and stresses, and maintain or enhance its capabilities and assets available at present and in the future (Department for International Development (DFID), 2011).

Concept of Climate Change Adaptation

A concept by Oxford dictionary definition is an abstract, idea, notion, thought or impression representing the fundamental characteristics of a phenomenon. The climate change phenomenon according to (Rebetez, 1995; Gollier & Weitzman, 2009) is complex with vast spatial scale and its effects may generate negative consequences that will take decades to be realized. The perception of climate change threat by vulnerable group of our society is central to their attitude towards developing adaptation strategies (Arbuckle, Morton, & Hobbs, 2013). For instance, under the changing climate conditions, vulnerable groups like farmers' start to engage in adaptive behavior which is geared towards sustaining livelihood (Uddin, Bokelmann, & Entsminger, 2014).

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A study in Kenya revealed that farmers used some measures such as crop diversification, migration and sale of livestock as adaptation strategies to the changing climate (Ogalleh, Vogl, Eitzinger & Hauser, 2012). Therefore, climate change adaptation is mainly 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, 2007).

The adaptation as a process focused on reducing vulnerability, which usually involves building adaptive capacity, particularly of the most vulnerable people (WB, 2009). In developing adaptation strategies to climate change, reduction of exposure or sensitivity to impacts of climate change is more than reducing vulnerability of the society but taking cognizance of the fact that development initiatives should not inadvertently increase vulnerability (UNISDR, 2009).

In that perspective, reducing vulnerability is the foundation of adaptation, and therefore requires detailed understanding of who are the vulnerable of our society. This understanding will require both analysis of current exposure to climate shocks and stresses, and model-based analysis of future climate impacts (IPCC, 2007). The availability of this vital basic information would generate appropriate adaptation strategies that can be designed and implemented (Scoones, 2005). Scoones further reported that monitoring and evaluating the effectiveness of activities and outputs, as well as sharing knowledge and lessons learnt, are also critical components of the adaptation process.

In achieving successful adaptation strategies, it is important to support farmers' individual action to adapt to climate change and coordinate

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adaptation strategies at both local and national level for more synergy of actions and the success of any adaptation policies as well requires strong institutions particularly good governance of a country (Berrang-Ford, Ford, Lesnikowski, Poutiainen, Barrera & Heymann, 2014).

Approaches to Climate Change Adaptation

Climate change adaptation is increasingly on the agenda of researchers, policymakers, and program developers who are aware that climate change is real and threatens to undermine social and ecological sustainability (World Bank (WB), 2008). In agriculture, adaptation efforts should focus on implementing measures that help build rural livelihoods that are more resilient to climate variability and disaster. Climate change related impacts according IPCC report (2007) are multi-dimensional in nature and the need to design a comprehensive policy that includes multi-disciplinary and multi-sectorial approaches to overcome it related impacts is important.

In agriculture, adaptation efforts focus on implementing measures that help build rural livelihoods that would be more resilient to climate variability and disaster (Parry, Rosenzweig, Iglesias, Livermore & Fischer, 2004). Adaptation to climate change according to Futuyma (1979), generally refers to the development of genetic or behavioral characteristics which enable organisms or systems to cope with environmental changes in order to survive and reproduce. According to Ogalleh, Vogl, Eitzinger and Hauser (2012), approaches to climate change adaptation are essentially categorized into two, namely, short term and long term adaptations as explained in the following sections.

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Short-term adaptation

The short term adaptation measures mainly start and inspire urgent response measures to prevent or mitigate short-term impacts that are already occurring and likely to emanate from climate change (Perez &Yohe, 2005). The earth's climate also undergoes short-term climate change and these changes are usually natural and unexpected (drought, flooding), heat waves, La Niña or El Niño events), societies or ecosystems could have difficulties in adapting to the changes and require urgent solution (IPCC, 2007).

Medium and long-term adaptation:

Kurukulasuriya and Rosenthal (2003) considered the Medium and long-term adaptation approaches, as response strategies necessary to enhance adaptive capacity that contributes to prevention and mitigation of impacts, by assessing the risks of impacts that could occur in the medium and long term as well as controlling the impacts, reducing vulnerability, and strengthening resilience. Approaches to climate change adaptation under the medium and long term to address or mitigate climate related impacts have been discussed in the literature under four main headings as presented in the following sections according to Kurukulasuriya and Rosenthal (2003) include:

Policy driven or planned Approach

Planned adaptation is the result of policy decision by public agency or governments 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 and institutional arrangements for gathering, managing, and utilizing basic information on the target areas and sectors are fundamental for

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planning and implementation of adaptation measures (Kurukulasuriya & Rosenthal, 2003).

Individual or autonomous Approach

Autonomous adaptations are basically initiatives by private actors such as NGOs and CBOs rather than governments due to actual or foreseen climate change related impact. The measures are implemented with the intention of adapting to estimated impacts in specific sectors (Bass, 1993).

Ecosystem-based Approach (EbA)

The EbA adaptation involves people using biodiversity and ecosystem services to adapt to the adverse effects of climate change and promote sustainable development (Wertz-Kanounnikoff, Locatelli, Wunder & Brockhaus, 2011).

The EbA is synonymous to the community-based adaptation (CBA), as the people or communities are at the forefront in the process, and it uses participatory, culturally appropriate ways to address challenges, with stronger emphasis on ecological and natural solutions. However, it focuses more on the use of natural services to mitigate climate change negative impacts. The EbA has great potential to increase people's resilience and ability to adapt, but regrettably it is being overlooked in national and international policy processes (Leslie & McLeod, 2007).

Community-based Approach (CBA)

The CBA according to Van Aalst, Cannon and Burton (2008), presents a range of enhancement factors that must be in place at household, community and national levels in order for it to be effective or take place. These enhancement factors include: Promotion of climate-resilient livelihoods

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strategies; disaster risk reduction strategies to reduce the impact of hazards; capacity development for local civil society and even governmental institutions; Advocacy, social mobilisation and empowerment to address the underlying causes of vulnerability. It advocates for identifying adaptation strategies at different levels in order to build adaptive capacity of target populations (Van Aalst, Cannon & Burton, 2008).

Integrating Community and Ecosystem-based Approach

These approaches include integration of measures planned on a sectoral basis to a unified and effective adaptation plan, and enhancement of basic capacities of localities and sectors such as technologies and human resources (Spittlehouse, 2005). These should be implemented with a systematic and long-term perspective. It involves the identification of issues that require cross-sectoral approaches. It is important to raise the awareness and understanding of the people and government institutions responsible for adaptation and identify the responsibilities, roles and collaborations among organizations both at national and community or local levels (Reid, 2016). Research and technology development as stated by Kurukulasuriya and Rosenthal (2003) are important in areas such as monitoring and projections of climate change, measures for the short-term, and the medium- and long-term adaptation to effectively improve the resilience of local societies in terms of early warning systems requires serious attention and enhancement.

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Farmers' Perception and Adaptations Response to Climate Change and Variability

Urquijo and De Stefano (2015) referred to perceptions as range of judgments, beliefs and attitudes. From that it can be inferred that perception is neither universal nor static, rather a value-laden dynamic concept. What an individual considers as drought for instance depends on his or her environment and its characteristics (Heathcote, 1969). Therefore, to understand local perceptions of environmental challenges, it is pivotal according to Agnew and Warren, (1996) to link human to the environment.

People observe the world around them and act according to what they see (Slegens, 2008). Sonnenfeld (1972) further classified the physical environment, which he considers as human environment, into four levels (geographical, operational, perceptual and behavioural) based on the importance they have for the people. Burgers (2000) applied these four stages of the human environment to describe farmers' perceptions situations, not only in terms of their physical environment, but also of their social and political environment. In his classifications of human environment, the first level is the geographical environment, which is the same for every human being and could be viewed as the universe external to the farmer of which he is unaware.

The second stage is the operational environment, in which an individual operates and it include the natural characteristics of a farmer's area, and his or her social and political environment. The third level, is the perceptual environment, which is that part of the operational environment humans are conscious of through organic-sensory sensitivity, learning and experience, but towards which no observable behavior is directed.

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The fourth level is the behavioral environment. This is that part of the perceptual environment of which the individual is aware and to which he /she responds to. The interpretation of reality is an outcome of values and meanings that have been derived from the environment (Grossman, 1972). The geophysical and operational environment is objective environments as they have objectively measurable or quantifiable elements and this indicates that it can derive from nature itself such as temperature, but can also be given to it through values and culture (Sonnenfeld, 1972).

People do not just adapt to the environment but shape it both physically as well as from the possibilities they observed (Croll & Parkin, 1992). An individual builds up understanding of the environment that is closest to him or her to make decisions on how to respond and to behave in that environment (Park, 1999). Social, economic, political and cultural settings influence the way people perceive their environment and the way they react to it. These settings influence the goals of human environmental actions, the distributions of resources and the challenges people experience. Perception of a climate is based on the economic and social impact it has on the personal lives (Meze-Hausken, 2004).

The people who depend on their natural environment have resilient and adaptive capacities to cope with natural hazards (Oliver-Smith, 1996). However, not all people within a given locality or setting are equally vulnerable to environmental extremes such as drought. Assessing how farmers take notice of climate change and related risk and why they do or do not adopt an adaptation to climate change strategy in the agricultural practices at farm level, requires a deepened inspection of human perception (Karrer, 2012).

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A particular view of a single person or target group on particular issue such as climate change, its risk, and corresponding opportunity of behavioral change, is a social construct which does not meet objective reality. The term social construct refers to the concept of human perception as an individual as indicate in construction or reconstruction of the outer world. This construction and reconstruction may not reflect a holistic picture of an issue. Studies that dealt with farmers' perception of climate change were based on farmers experience in climate variation, whether farmers notice an increase or a decrease of the temperature, the rainfall; whether they experienced a decrease or an increase in frequency and density of climate events such as drought, flood and wind storm.

A study on farmers' perception in Bangladesh showed that 88% of the survey respondents have experienced climate variation in the past 20 years (Uddin, Bokelmann, & Entsminger, 2014). While most of the farmers perceived an increase in temperature, some perceived a decrease, 1.5% of the farmers in the Limpopo basin experienced a decrease in temperature (Gbetibouo, 2009). Akter and Bennett (2011), conducted a study in Australia which found that respondents' perception of climate change impact significantly influence their stated support for mitigation policies. According to Ogalleh, Vogl, Eitzinger and Hauser (2012) farmers have in-depth knowledge in climatic variability and their perception of drought is significantly linked to some adaptation measures such as migration and sale of animals.

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Farmers' Adaptations Response to Climate Change and Variability

The effects of climate change may generate negative consequences that will take decades to come. The gap is called the distance future (Gollier & Weitzman, 2009). Farmers' perception of climate change threat is central to their attitude towards adaptation (Arbuckle, Morton & Hobbs, 2013). Under the changing climatic conditions, majority of the farmers started to be engaged in adaptive behavior (Uddin, Akhi, Begum, Islam & Khatun, 2014).

According to Ogalleh, Vogl, Eitzinger and Hauser (2012), a study conducted in Kenya revealed that farmers do use some measures such as crop diversification, migration and sale of animal to adapt to the changing climate. Farmers' individual action to adapt to climate change need to be supported and coordinated at both national and local level for more synergy of actions (Berrang-Ford, Lesnikowski, Poutiainen, Barrera & Heymann, 2014).

Barnett and O'Neil (2010), identified various adaptations measures namely; anticipatory, autonomous, planned and mal adaptation as explained thus: Anticipatory adaptation takes place before impacts of climate change are observed. This is also referred to as proactive adaptation whereas the autonomous adaptations does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. This can be referred to as spontaneous adaptation. The planned adaptation is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

The mal adaptations are actions taken presumably to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the

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vulnerability of other systems, sectors or social groups. The Climate change adaptation policy is important and necessary, even the emission of the greenhouse gases are stop now, the negative impact of climate change is likely to occur due to the past emission of the greenhouse gas (IPCC, 2013).The adaptation policy should first answer these three questions: (i) adapt to what? (ii) Who and what to adapt? (iii) How will adaptation occur?

The adaptation policy should also be in line with the sustainable development goals .For instance a policy which increases the fuel prices will reduce the ability of poor people to access fuel. Therefore, this is not preferred compared to a policy of improving the ecosystem services that will create new jobs for farmers.

In response to the impacts of climate change and variability on their production, livelihoods, and environments, farmers resort to a range of adaptation strategies. The adaptation strategies reflect a combination of climate and non-climate factors since farming as an activity is driven by both dimensions rather than climate alone (Yaro, 2013). This is necessitated by the fact that climate change is a complex phenomenon with large temporal and vast spatial scale (Rebetez, 1995).

Adaptation decision making process of farmers

It is of particular interest to establish if farmers implement measures and why they do or do not, while assessing practicable measures to adapt to climate changes. In order to address these issues, the approach of a decision making model in the tradition of Rogers' (1983), protection motivation theory (PMT) has been chosen. It is a well-known concept from health psychology.

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The PMT was originally developed to explain people's response to fear arousing on health threat (Floyd, Prentice-Dunn, & Rogers, 2000; Sutton, 2002). Protection motivation corresponds to the motivation to protect oneself against health threat. In fact it refers to the intention to adopt a responsive action when facing health threat.

The PMT has been improved upon by Weinstein (1993) to include self-efficacy as a separate component.

A study on the protection motivation theory (PMT) by (Floyd, Prentice-Dunn, & Rogers, 2000) showed that the theory has been applied in diverse studies including political issues, environmental concerns and protecting others. In the environmental domain, according to Karrer (2012) has proven a strong relationship between the variables of the PMT such as the pro-environmental behavior, element of risk and the coping appraisal. The Figure 1 shows how the elements of the model interact.

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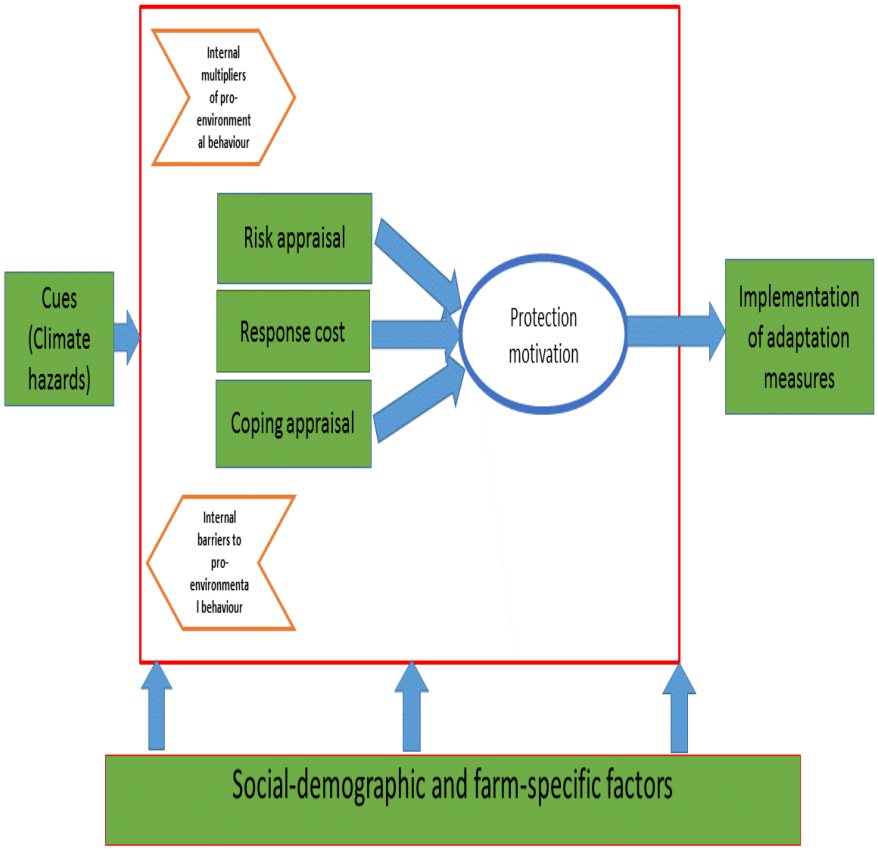

Figure 1: Descriptive model of farmers' adaptation decision making in the context of Climate variability & Change. Source: (Karrer, 2012)

Firstly, signals such as an observation or a question concerning climate change adaptation in agriculture for example activate both a risk and a coping appraisal. The risk appraisal assesses potential negative consequences of a risk that could hit the decision maker him/herself. The coping appraisal process evaluate the ability with avert, the threatened danger (Floyd, Prentice-Dunn & Rogers, 2000).

These two appraisals interact and lead to a protection motivation decision which, in turn, is influenced by barriers, that is, ideas and attitudes towards the feasibility and effects of a behavioral option that hinder the

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decision in favor of a particular option. The model's elements form a multi-layered processing system, which results in a stated decision output representing the dependent variables of the model, the implementation of climate change adaptation measure at the farm level. The socio-demographic and farm-specific factors have an overall effect on the elements of the model.

Fussel (2004) refers to vulnerability and severity to be the two main behavioral determinants of the model risk appraisal. The vulnerability is how the farmer perceives the degree of his exposure to the risk and the severity is the appraisal of the harmfulness of this risk. In this study vulnerability and severity are related to farm specific threat. Empirical studies showed that pro-environmental behavior is significantly better explained when these two main components of the risk appraisal are part of the predictors of the model (Karrer, 2012).

The only evaluative focus of risk perception, 'vulnerability and severity of rice farmers' risk appraisal would purely consist of anticipations. Thus, the descriptive of this study is rounded up with their individual observations of climate change consequences manifesting in their region, namely of extreme weather events and changes in natural production factors (length of the growing season). Although climate change is difficult to perceive, this has also been done successfully by other authors who report that farmers' observations are widely consistent with the meteorological data (Gbetibouo, 2009).

Rogers (1983) proposes two determinants for the coping appraisal namely: response efficacy and self-efficacy. Response efficacy refers to the assessment of options regarding to their effectiveness to reach a goal while

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Self-efficacy is termed as one's capability for coping with threatening situations. It is also the ability of the protective actions or measures to reduce or avoid existing risks, for instance will engaging in protective action actually reduce the risks (Bockarjova & Steg, 2014). Bockarjova and Steg further reported that self-efficacy comprises the extent to which one believes that he or she is able to perform protective measures or actions.

MacDonnell, Kinnard, Molg, Nicholson and Abermann (2013), reported that perceived self- efficacy is the ability to adopt a protective behavior, with internal responsibility judgment. Rogers (1983) study also found a positive link between self-efficacy and responsibility Judgment. Protection motivation, according to Milne, Sheeran and Orbell (2000) indicated that the mediator which is synonymous with the intention to perform protective health behavior.

In the case of The Gambia farmers 'decision making in terms of climate change adaptation, protection motivation denotes a judgment regarding the necessity of taking climate-protecting measures. It is the key mediator of the risk and the coping appraisal in the descriptive model. Nonetheless, response cost influences a pro-environmental behavior as external barriers. The cost here goes beyond the economic cost by taking into account the broader psychological sense that includes the behavioral cost like the time and effort needed to adopt a pro-environmental action (Karrer, 2012).

The response cost corresponds to the reported implementation of adaptation strategies on farm. The responses cost is originally part of the coping appraisal of the PMT. Dietz, Stern and Guagnano, (1998) set up the response cost as a mediator after their observation that social psychological

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factors explain more of the variance of stated behavioral intentions than of the variance of reported past behavior.

Floyd, Prentice-Dunn and Rogers (2000) further stated that response cost is the strongest predictors of action. For internal multipliers and barriers, the general environmental beliefs, value orientations or attitudes, have been proven to influence positively in a pro-environmental behavior in low-cost situations (Karrer, 2012).

Connectedness to nature is also correlated positively with a pro-environmental behavior. The above statements justify the inclusion of internal multipliers and barriers to pro-environmental behavior. .Connectedness to nature explains how an individual is linked to nature. The extent to which an individual think and feels that he or she is part of the nature impacts significantly on his or her willingness for pro-environmental commitment (Müller, Kals & Pansa, 2009).

According to Capaldi, Dopko and Zelenski (2014), connectedness to nature has a strong positive impact on pro-environmental behavior. Another factor for the internal multipliers is the attachment to place. The internal multipliers are contrasted with possible corresponding internal barriers to pro-environmental behaviour in order to maintain a balance in the model. Internal barriers refer to the negatives attitudes or beliefs that could hinder farmer's decision to adopt an adaptation measures (Karrer, 2012).

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Local Knowledge of Farmers in Response to Climate Change and Variability

Local knowledge is used synonymously with traditional and indigenous knowledge to differentiate the knowledge developed by a given community from the knowledge generated through universities, government research centres and private industry (Warren, 1992). Local knowledge refers to what people within a geographical location have known and done for generations – practices that evolved through trial and error and proved flexible enough to cope with change (Melchias, 2001). Johannes (1993) further referred it as a unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area.

The development of local knowledge systems, covering all aspects of life, including management of the natural environment, has been a matter of survival to the peoples who generated these systems. Such knowledge systems are cumulative, representing generations of experiences, careful observations, and trial-and-error experiments and in addition all members of a particular community (elders, women, men, and children) possessed some form of local knowledge (Grenier, 1998).

Grenier further reported that quantity and quality of the local knowledge that individuals possess vary in age, education, gender, social and economic status, daily experiences, outside influences, roles and responsibilities in the home and community, profession, available time, aptitude and intellectual capability, level of curiosity, observation skills and control over natural resources among others.

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These are some of the influencing factors and it is stored in peoples' memories and activities and is expressed in stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local language and taxonomy, agricultural practices, materials, plant species, and animal breeds (Ruddle,1993). Literature on the use of local knowledge to predict climate change and variability is found to be limited. However, the use of plants as a local weather indicator have reported by Slegers (2008), who discovered that when the flowers of a baobab three stay longer, it predicts a good rain season in Kondoa and Asfachew in Tanzania and Ethiopia.

Support Systems for Climate Change and Variability Management

The national support systems for managing the climate change related extremes and disasters in the context of changing climate according to Eriksen and Næss, (2003); and Klein, Eriksen, Næss, Hammill, Robledo and O'Brien (2007), can offer what they referred to as 'triple-win' solutions, as they can provide cost-effective risk reduction, support biodiversity conservation, and enable improvements in economic livelihoods and human well-being, particularly for the poor and vulnerable in societies.

Managing climate-related disaster risks is a concern of multiple actors, working across scales from international, national, and sub-national and community levels, and often in partnership, to ultimately help individuals, households, communities, and societies to reduce climate related risk (Twigg, 2004; Schipper, 2009; Wisner, 2011).

Effective national systems comprising national and subnational governments, the private sector, research bodies, civil society, and

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community-based organizations and communities, and would ideally have each actor performing to their accepted functions and capacities (Schipper, 2009; Miller, Osbahr, Boyd, Thomalla, Bharwani, Ziervogel, Walker, Birkmann, van der Leeuw, Rockström, Hinkel, Downing, Folke, &Nelson, 2010). Each actor would play differential but complementary roles across spatial and temporal scales and would draw on a mixture of scientific and local knowledge to shape their actions and their appreciation of the dynamic nature of risk (UNISDR, 2008).

The national support systems are at the center of a country's capacity to meet the challenges of observed and projected trends in exposure, vulnerability, and weather and climate extremes, the roles played by different actors working within such national systems (Organisation for Economic Cooperation and Development (OECD), 2009) are explained in the following headings:

National and local Governments level

The national and local government level according to McBean (2008), plays a key role in governing and managing support systems related to climate extremes and related disaster, governments are central to providing risk management-related for public good as they maintain organizational and financial authority in planning and providing such mandate. The National governments have the moral and legal responsibility to ensure economic and social well-being, including safety and security of their citizens to any climate related risk and disasters (UNISDR, 2004).

It is also argued that it is government's responsibility to protect the poorest and most vulnerable citizens from disasters, and to implement disaster

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risk management that reaches all (O'Brien, Sygna,, Leichenko, Adger, Barnett, Mitchell, Schipper, Tanner, Vogel, & Mortreux, 2008; OECD, 2009).

The national governments are often called 'insurers of last resort' as they are often the final entity that households and private sector turn to in case of need, although the degree of compliance and ability to honor those responsibilities by governments differs significantly across countries based on available capacities (Katz & Brown, 1992). Notwithstanding, in the context of climate change and variability, it is argued that governments have a particular critical role to play in relation to not only addressing the current gaps in climate risk management but also in response to uncertainties and changing needs due to increases in the frequency, magnitude, and duration of some climate extremes (Meehl, Zwiers, Evans, Knutson, Mearns & Whetton, 2000)

Private Sector Organizations

The private sector plays a small, but increasingly important role in climate change and disaster risk management and adaptation (Roeth, 2009). Roeth further stated that some aspects of climate risk management may be suitable for nongovernmental stakeholders to implement and this would often effectively be coordinated within a framework created and enabled by governments. Under such partnership, three private sector engagements may be identified, namely; public-private partnerships (PPP), corporate social responsibility (CSR) and business model approaches (Warhurst, 2006).

The PPPs focus on enhancing the provision of public properties for climate related disaster risk reduction in joint undertakings between public and private sector players. The CSR involves voluntary advocacy and raising awareness by the private sector on climate change and disaster risk reduction

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as well as involving funding support and contribution of helpers and expertise to implement risk management measures. The business model approach pursues the integration and alignment of climate change related risk reduction with operational and strategic goals of innovativeness (Warhurst, 2006; Roeth, 2009).

Civil Society and Community-Based Organizations

The civil society organizations (CSOs) and community based organizations (CBOs) play a significant role in developing initiatives to respond to climate change related impacts, reduction of associated risks and, adaptation to climate-related hazards at national level (CARE, 2008).

The CSOs and CBOs are wide range of associations, around which society voluntarily organizes itself as a humanitarian concern. These often evolve to embrace the broader challenge following community focused risk assessment. The activities usually target education and advocacy; environmental management; sustainable agriculture; infrastructural development; and increased livelihood diversification (McGray, Hammill, Bradley, Schipper & Parry, 2007; Oxfam America, 2008). For instance, in Central America, the experience is that advocacy on climate policy construction has become a new feature of such platforms since 2007 (CRGR, 2009).

In addition, Faith-based organizations are playing a critical and influential role in assisting local communities in climate change or disaster risk management, not only providing pastoral care in times of climate hazards but also playing an important role in raising awareness and training, with many international development partners often working with local church

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groups to build community resilience (Gero, Méheux, & Dominey-Howes, 2011; Tearfund, 2011).

Bilateral and Multilateral Agencies

In least Developing countries (LDCs), particularly where the government is weak and has limited resources, bilateral and multilateral agencies play a significant role in supplying financial, technical, and in some cases strategic support to government and nongovernment agencies to tackle the multifaceted challenges of disaster risk management and climate change adaptation in the framework of national development goals (AusAid, 2009; DFID, 2011).

Multilateral agencies according to Hammill and Tanner (2010) are international institutions with governmental membership that have a significant focus on development and aid recipient countries. Such agencies include United Nations agencies, regional groupings such as European Union agencies and multilateral development banks such as WB, AfDB, IFAD and Asian Development Bank. Other agencies include bilateral agencies which are national institutions that focus on the relationship between one government and another for instance UKDID, and USAID (Klein, Eriksen, Næss, Hammill, Robledo & O'Brien, 2007).

The relationship is based on a richer government providing support to a poorer government in addressing a particular concern with respect to the recipient. Bilateral and multilateral agencies have been key actors in advancing mainstreaming of climate change adaptation and disaster risk reduction into development planning (Eriksen & Næss, 2003; Klein, Eriksen, Næss, Hammill, Robledo & O'Brien, 2007). This has primarily been driven

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by a concern that development investments are increasingly exposed to climate- and disaster-related risks and that climate change poses livelihood security concerns (Harris, 2009; Persson & Klein, 2009). In this context, such agencies are influencing development policy and implementation at a national level of developing countries as they require climate and disaster risk assessments as well as environmental screening to be conducted at different points in the project approval process before projects starts (Hammill & Tanner, 2010).

Research and Communication

The effectiveness of national support systems for managing climate extremes and disaster risks is highly dependent on the availability and communication of robust and timely scientific data and information (Sperling & Szekely, 2005; Thomalla, Downing, Spanger-Siegfried, Han & Rockstrom 2006). The local knowledge according to Mercer, Dominey-Howes, Kelman & Lloyd (2007); and Kelman, Lewis, Gaillard & Mercer, (2011) is not meant only to inform and support community-based decisions and policymakers who manage national approaches to climate change adaptation and disaster risk but also researchers who provide further analytical information to support such decisions.

Scientific and research organizations according to Sperling and Szekely (2005) range from specialized research centers and universities, to regional organizations, to national research agencies and multilateral agencies playing differential roles, but generally continue to divide into climate change adaptation and disaster risk management on communities.

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Scientific research bodies play important roles in managing climate extremes and disaster risks by; supporting thematic programs to study the evolution and consequences of past hazard events (droughts, sandstorms, floods; cyclones), analyzing time-and-space dependency in patterns of weather-related risks, building cooperative networks for early warning systems, modeling and long-term prediction, actively engaging in technical capacity building and training, translating scientific evidence into adaptation practice, collating traditional knowledge and lessons learned for wider dissemination, and translating scientific information into user-friendly forms for community consumption (Thomalla, Downing, Spanger-Siegfried, Han & Rockstrom, 2006; Aldunce & González, 2006).

Thomalla et al. (2006) further reported that climate and disaster risk management practitioners largely focus on making use of short-term weather forecasting and effective dissemination and communication of hazard information and responses. This kind of climate change expertise can typically be found in meteorological agencies, environment or energy departments, and in academic institutions (Sperling & Szekely, 2005).

Chung (2009) reported that progress has been made in the communication and availability of scientific information, there is still a lack of sufficient local or sub-national data on hazards and risk assessments to reinforce area specific climate change and disaster risk management.

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Conceptual Framework for Study on Farmers' Perceptions of Climate Change and Adaptation

To understand the perception of rice farmers on climate change and variability and its implications on crop production, livelihoods, coping measures and adaptation strategies, in the CRR, The Gambia, the study adopted a conceptual framework presented in Figure 2. The Conceptual Framework of the study presents a range of "enabling factors" that must be in place at household, community and national levels in order to achieve an effective community-based adaptation approach. The Framework provides a guide in identifying adaptation strategies at different levels.

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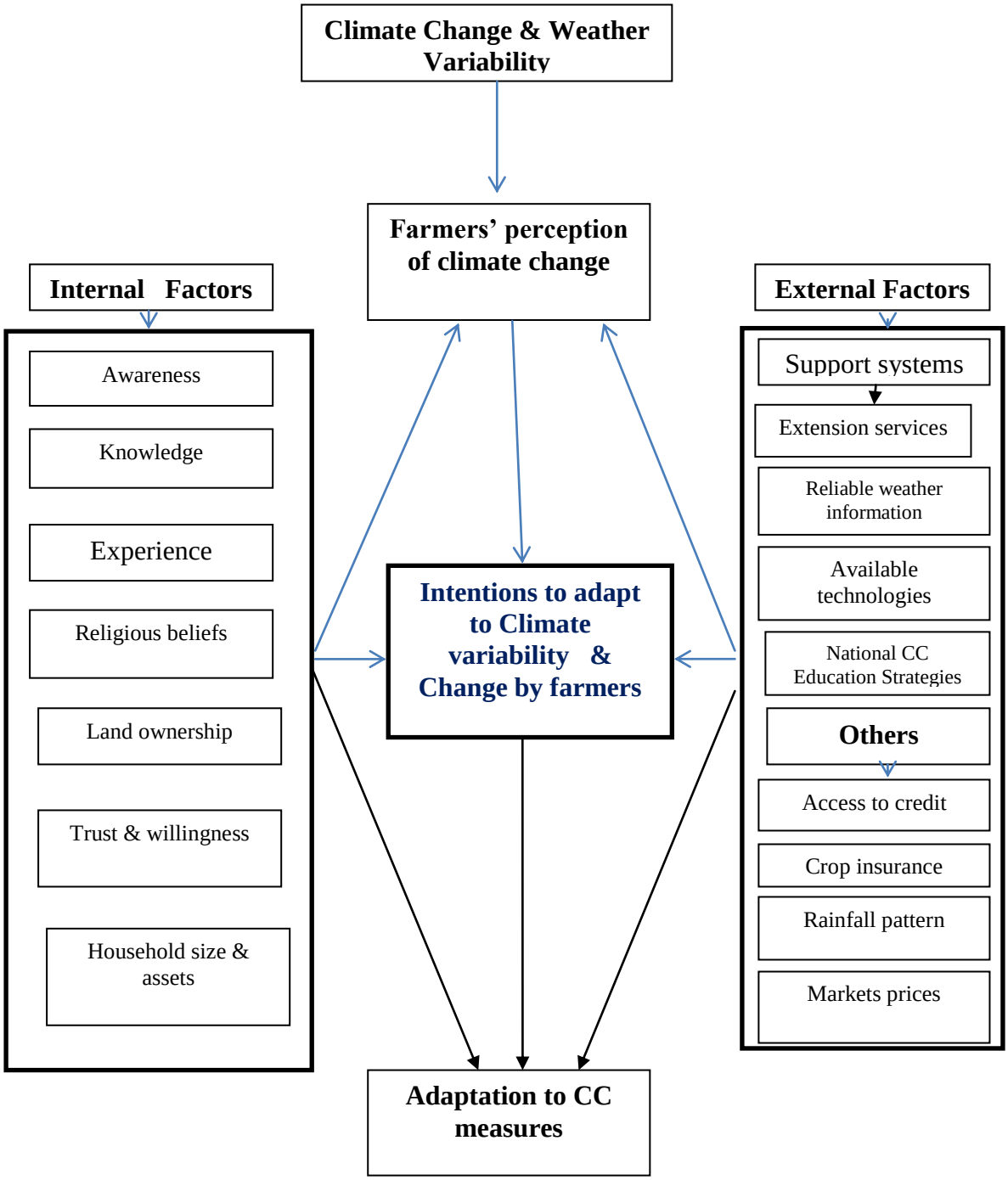

Figure 2: Schematic Conceptual framework of farmers' perceptions and adaptation of climate change and variability. Source: (Author's Field work, 2016).

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The framework indicates the interrelations between Farmers' perception of climate change and their internal and external factors. Internal factors here refer to factors that are largely under the control of farmers namely; knowledge, experience, willingness, trust, religious belief and awareness. Alternatively, external factors are those factors beyond the control of the farmers and include extension services, reliable weather information, rainfall pattern, available technologies .and support systems. The support systems which are connected to the external factors here include among others capacity building, national policies and action plans, on climate change. From the literature farmers' perception of climate change can be influenced by both internal and external factors.

The linkages according to Watson (2009), pose challenges to farmers, researchers and people working in the institutions of the agricultural sector and rural development. Watson (2009) further noted that climate change and other environmental concerns demand more on the specific nation's ability to address them on a coherent and sustainable manner.

In the framework, the description of farmers' perceptions of climate change and the adaptation process has been categorized into four main levels or stages. In the first level, climate change as a stand-alone issue and the second level is how farmers' perceive climate change and its adverse impacts on their agricultural production. These perceptions can be influenced by internal and external factors as explained earlier. The third stage is about how farmers exhibit their intentions to adopt some measures to adapt to climate change impacts which are also linked to both internal and external conditions.

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At the fourth level, farmers decide either to adapt or not to adapt to the perceived changes in climate. The farmers' decision to not adapt to climate change and variability could be explained by various constraints exhibited by the farmers even with intentions to adapt. This is not to suggest that any one project would be able to achieve all of these enabling factors but represents a range of different factors that aim to influence in order to build adaptive capacity of target populations

In identifying the limits on a farming system's vulnerability to changes in climate, the capacity to increase that resilience through management systems and the consequences of such changes, make useful contributions to the assessment of Climate Change impacts. The assessment of farmers' long-term adaptive capacity in the face of Climate Change, generate a significant contribution to the wider debate on the long term approach to sustainable steps in addressing the menace of climate change in the study area.

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CHAPTER THREE

RESEARCH METHODS

Introduction

This chapter discusses on how the study was carried out. The chapter concentrated on the research methods by providing the philosophical view justifying the approach used in the study. It covers an exploration concept form of the research design, the population under study, the sampling procedures, data collection instrument; data collection and data analysis procedures. It also described the suitability of the methods used thus strengthening the reliability and validity of the study findings.

The Research Design

Cameron and Price (2009) stated that the choice of research or data collection design is influenced by the individual's philosophical preferences. The study adopted the mixed method design which combines both quantitative and qualitative methods in research. The choice of the research design was guided by two philosophical views, constructivism and postpositivist research philosophies which the researcher shares. The constructivism philosophy is that individuals seek understanding of the world in which they live and work through subjective meanings of their experiences (Guba & Lincoln, 1994). These meanings are varied and multiple, leading the researcher to look for the complexity of views rather than narrowing meanings into a few categories or ideas (Guba, 1990).

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The goal of this study is to rely as much as possible on the participants' views of the situation being studied (Coyne, 1997). . This was on the basis that the phenomenon under study (climate change and variability) is an emerging issue and not well understood thus requires in-depth studies from the perspectives of those experiencing it. As such, it requires broad and general open-ended questions so that the participants can construct the meaning of their situation through discussions or interviews (Coyne, 1997).

In general, these subjective meanings are negotiated socially and historically through qualitative research, which Denzin and Lincoln (2005) describe as a method of studying things in their natural settings, by attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. Thus, the study largely used qualitative research and inductively generates meaning from the information or data collected in the field.

The postpositivism philosophy, which is sometimes called the scientific method, holds a deterministic philosophy in which causes probably determine effects or outcomes (Bryman & Bell, 2007). Thus, the problems studied by postpositivists reflect the need to identify and assess the causes that influence outcomes, as found in experiments. The knowledge that develops through a postpositivist is based on careful observation and measurement of the objective reality that exists in the world (Phillips & Burbules, 2000). Thus, quantitative research is a preferred method by postpositivists because it allows the researcher to get the facts about a phenomenon (Bryman & Bell, 2007).

Aliaga and Gunderson, (2002) further described quantitative research as an inquiry into a social problem to explain phenomena by gathering

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numerical data that are analysed using mathematically based methods. Therefore, developing numeric measures of observations in studying the behavior of individuals becomes paramount to a postpositivist.

According to Sufian (1998), the postpositivist philosophy can be applied to explore, describe and explain social phenomena involving human behaviour, which supports a view shared by the researcher that objectivity in a study can be obtained from both individuals understanding and experiences about a phenomenon being studied (Uddin & Hamiduzzaman, 2009). Thus, the two philosophical constructs (constructivism and postpositivist) have necessitated the choice of the mixed methods for this study. The justification for the mixed method was underpinned by key aspects as explained in the following paragraphs below:

Early thoughts about the value of multiple methods called mixed methods resided in the idea that all methods had bias and weaknesses, and the collection of quantitative and qualitative data neutralizes the weaknesses of each form of data (Jick, 1979). This type of method was chosen based on these key reasons: Firstly, it neutralized weaknesses of each method and secondly allows the researcher considers all available approaches to understand the problem as well using pluralistic approaches to derive knowledge about a phenomenon under study (Jick, 1979).

The quantitative data in this research allowed the researcher to measure and analyze data thus revealing the relationship between an independent and dependent variable such as awareness and use of adaptation strategies, education of climate change, income level against use of strategies, the frequency of rice farmers' use of available technologies in the study area

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This made the researcher more objective about the findings of the study. On the other hand, the use of qualitative data focused on subjective view of farmers' perception, local knowledge, and their implications on crop production, livelihoods, coping measures and adaptation strategies on climate change. These avail the researcher freedom to let the study unfold more naturally and gain detailed and rich data in the form of comprehensive and open discussion. Thus to a greater extent, the used of mixed methods clearly limit the weaknesses of a single method of data collection and enable greater understanding of the set objectives for the study. The quantitative and qualitative methods of data collection applied in this study are described in the following section.

Quantitative Methods Study Design

The study adopted a descriptive cross-sectional survey design for the quantitative method. Research design, according to Yin (2003), refers to the logical sequence that connects the empirical data to a study's initial research questions and eventually its conclusions. A descriptive study is one in which information is collected without changing the existing environment. The descriptive study research design was adopted since it does not allow for any manipulation of variables (Yin, 2003). In general, it involves collection of data to answer research questions or hypothesis of the subject being studied. It further determines and shows the current nature of the situations at the time of the study (Gay, 1992).

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Creswell (2003), considered a descriptive research design to be concerned with conditions or interrelationship that exist, processes that are ongoing, opinions that are held, effects that are evident and the trend that are emerging. According to Creswell and Plano-Clark (2011), descriptive research designs are appropriate in studying, documenting and analyzing phenomenon in natural settings.

Sapsford (2006) reported that descriptive research design is usually the most appropriate approach for collecting information that will demonstrate relationship and describe phenomenon as it exist. It is used to describe what is in existence with respect to conditions or variables that are found in a particular area. The cross-sectional survey design involves gathering information from a sample of the population of interest through personal interviews and/or impersonal (questionnaire, mails) means. For the purpose of this study, the survey design gave room for a group of respondents to be selected from a bigger population, which enhanced accurate inference about a bigger population of rice farmers in the study area. The survey methods allowed many respondents to be reached within a short period of time in view of size of the area and the resources needed.

Study Population

The target population in this study was all rice farmers in the Central River Region and key informants from the Regional Agriculture Directorates and development agencies in the region. The agricultural and development agencies were targeted as key informants because they are main objects of investigation with respect to the phenomena being studied. According to

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information received from the Regional Agriculture Directorates for both Central River Region South and Central River Region North personal communication regional agricultural directors (2014), there are 11 districts in the region, with a total of 626 villages, of which 98 produce rice and are spread within the districts. In that 70 villages produced rice under lowland production while 28 villages under upland production. All the districts were selected in order to give a wider coverage of the entire region. The combine population of rice producing household in the selected district was 20,559 (GBoS, 2013).

Sample Size Determination

In Central River Region, there were 98 villages involved in rice production with a combined population of 20,559 households (GBoS, 2013). To determine the appropriate sample size of the population, three criteria needed to be specified according to Miaoulis and Michener (1976); level of

To determine the appropriate sample size from the population of the study area, Yamane (1967) provides a simplified formula to calculate sample sizes as indicated thus and this was applied to determine the sample size for the study. At 95% confidence level and Level of Precision (P) = .05 is assumed for the equation.

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Equation:

$$n = \frac{N}{1 + N(e)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:

n = is the sample size,

N = is the population size,

e = is the level of precision.

$$n = \frac{N}{1 + N(e)^2} = \frac{20{,}559}{1 + 20{,}559\,(0.05)^2} = \frac{20,\,559}{52.397} = 392.369$$

From the above calculation, the minimum sample size needed from the population of the rice farmers in Central River Region was 392.369 (392) respondents. Israel (1992) noted that 10 – 30% is usually added to sample size to compensate for any unforeseen circumstances which depend on the available budget and time. In this study, a 10% was added the actual sample size of 392.369 making a total of 438 respondents which was used for the survey (Appendix) B.

With the sample size determination, the rice farmers for the study were selected through systematic random sampling technique. Systematic random sampling according to Ogula (2005) is the random sampling method that requires selecting samples based on a system of intervals in a known population and to ensure that all outcomes are given equal chance of getting selected in the sample.

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After the population of each village was established (Appendix A), then number of respondents was decided out of the total population to be included in the sample. This was followed by determining the interval for sampling which was standard distance between each sampled element in all the villages. The study adopted to sample every fourth compound in a given street within the village which means a rice farmer in every fourth compound in a given street was selected as respondents for the survey component in CRR.

Data Collection Instruments

The instrument of the survey was a structured questionnaire (Appendix 1). The set of questions was divided into Sections A – G under the following headings.

Section A: Personal data of respondents**.** This section mainly elicited information on the characteristics of respondents, which included gender, age, marital status, number of people in a household, education and income. **Section B**: Livelihood and farming activities: The main objective of this section was to obtain information on respondents' livelihood activities. It included farming practices and general knowledge on Climate Change and related issues in the study area.

Section C: Knowledge and perception of climate change**:** The key motive behind this section was to assess farmers' own knowledge about climate change and how their perception of the change with respect to rainfall and other related issues in the study area.

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Section D: Impacts, Responses, Coping and Adaptation of climate change related consequences by respondents- The main reason behind this section was to know from the farmers point of view the effects of climate change, their responses/ coping measures and adaptation strategies with particular attention to livelihoods and socio-economic implications.

Section E: This section was mainly meant to assess the farmers in different community own view and expectations of environmental and socio-economic changes in the future and vulnerability based on local observations and assessment of current trends in the study area.

Section F: This section mainly focus on the constraints the farmers face in terms of implementing adaptation strategies to reduce vulnerability in the study area.

Section G: This section was mainly meant to assess the available support system from both government and private partners in addressing climate change impacts in the study area.

Pre-testing of Instrument

Pre-testing of data collection instrument followed the reconnaissance survey. Research field assistants were recruited for the pre-testing of the instrument. The field assistants had at least Senior High School certificate and with working experience as agricultural extension agent and could read and communicate in English as well as two local languages widely spoken in the study area. All the research assistants had one day training for the pre-testing of the instrument and the questions that emanated with respect to the instrument were addressed accordingly.

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A pre-test for the reliability of the instrument was conducted on 30 rice farmer households which were randomly selected in neighbouring regions of NBR and URR between 20th – 23 October, 2015. After the pre-testing, some questions were reformulated and others completely removed in order to reduce the long average time spent on the interviews. Reliability analysis was run to determine internal consistency with regard to items measured on scale

Data Collection

Data collection commenced on 1st of December, 2015 and lasted for three weeks due to the relatively big sample size and the distance between the selected communities. Face to face interview was chosen for the data collection in this study. Ten (10) enumerators from the extension service in the region were hired to administer the survey questionnaires to the selected community households. Prior to the administration of the questionnaires, one day training for the hired enumerators was conducted. The training was done to limit chances of misunderstanding of the subject matter or certain terms in the questionnaires by the enumerators. The head of the villages (Alkali) were contacted to facilitate the process and to help build trust with the respondents. The interviews with the farmers were conducted the homes of the respondents. The average time for filling one questionnaire was between 15 -25 minutes.

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Analysis of Quantitative Data

The collected primary data for the survey component from the field work were carefully edited to remove all possible outliers or extreme values which could have affected the validity of the final result. The process involved scrutinizing the responses for the answered questions or ambiguous responses without necessarily changing the meaning of the responses.

The data were analyzed using Statistical Package for the Social Science (SPSS) version 19 software. Analyses for the quantitative data was done using a descriptive analysis for frequencies and percentages for the demographic variables (age, gender, level of education, income, and size of household)..

In addition, a Chi - Square Cross Tabulation statistical analysis was also done to assess the relationships between: education level of respondents and adoption of adaptation measures, education and knowledge of climate change and variability; income level of respondents and applying climate change adaptation measures; age of respondents and knowledge climate change. s intended to test how likely it is that an observed distribution is due to chance. The Chi-Square test helps you determine if two discrete variables are associated. If there's an association, the distribution of one variable will differ depending on the value of the second variable (Pallant, 2005).The results were presented in tables and charts.

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Qualitative Methods

The qualitative methods used in research were focus group discussion and key informants' interviews as presented in the following sections.

Focus Group Discussions (FGD) Approach for Rice Farmers

The FGD is an interview with a small group of people on specific topics (Patton 2002; Krueger & Casey, 2000). The group is composed of people who are specially selected based on their particular knowledge, experience, expertise or position in the community concern. This technique of data collection enables the researcher to gain information within a short period of time through wide ranging opinions and gives in-depth understanding of issues that are being discussed. However, the limitation of the FGD is that if the group dynamics are not well managed, some dominant characters may take over the discussion and others may not have a chance to express themselves. Possibility of conflict arising as a results of the group being too large and divisions formed within the group (Blackburn & Stokes, 2000).

Selection of Focus Groups

The total number of villages in CRR involved in both low and upland rice production according to the Regional Agricultural Directorate was 98 and is spread within the entire 11 districts. All the districts were selected in order to produce a wider coverage of the entire region. Composing the sample in qualitative research is different from the common sampling approach used in quantitative research. A carefully selected sample size could provide data representative of the population from which it is drawn (Patton 2002).

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For the FGDs consultation in this study, the selection of participants was done in stages as explained thus:

Stage 1: The first thing done in identifying the eligible communities was to seek the assistance of the Regional Agricultural Directorate to identify potential rice growing communities at district level across the region based on their interactions and knowledge of the area. A list of all rice growing communities in the study area in each district was provided.

Stage 2: The researcher through the guidance of District Agriculture Extension Supervisors and the Village Extension Agents conducted a reconnaissance visits to potential participating communities to further assess their suitability through first-hand information. During the visit, the purpose of the study was explained to the prospective participating communities through informal meetings organized with support of village heads. Furthermore, individuals who were willing and available to participate in subsequent discussion were identified through the support of the village heads (Alkali). Consequently, a list of all identified prospective participants of the rice growing communities in each district was developed (Appendix C).

Stage 3: The simple random sampling technique was applied in selecting rice growing communities from the total number in each district within the region because it gave all units of the target population an equal chance of being selected. A simple random sample according to Yates, Moore and Starnes, (2008) is a subset of a statistical population in which each member of the subset has an equal probability of being chosen.This technique was appropriate because the population of study was similar in characteristics and interest.

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A sampling frame was constructed in alphabetical order and numbered accordingly. The names of the communities listed were written and made to correspond with the numbers in the sample frame. The numbers were written on pieces of paper, folded and put into a glass container and mixed thoroughly. Subsequently, one piece of paper was removed by a volunteer and the process was carried out for all communities/villages in each of the 11 districts in the study area. The numbers were registered and the corresponding name of the village noted. The process continued until the required frames were selected and recorded. All the eventual numbers on the pieces of paper that were randomly picked and corresponded with written names of the villages were considered as villages to partake for the study.

In all, 58 rice growing villages were identified which also represented the number of FGDs. However, in each village, a certain number selected through the head of the village (Alkali) served as participants in that particular village and varies from a minimum of 5 to a maximum of 12 depending on the size of the community. Total number of participants for the FGD was 457 selected from all the rice farming communities and there were 257 males and 200 females' rice farmers, with a gender representation of 56.2% and 43.8% respectively (Appendix C). The rationale for choosing purposive sampling for the FGD was premise on the fact that the researcher was seeking knowledge

about the implication of farmers' perceptions, local knowledge and climate change phenomenon as well as adaptation strategies.

This required for the participating communities to provide valuable information by virtue of their experience, knowledge and ability to serve as in the discussion for the study. The eligible rice farming communities chosen to

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participate in this study were based on their knowledge, experience and historical background from their communities of origin.

Data Collection: Conducting Focus Group Discussion

The focus group discussion (FGD) was carried out from 4th of July to 28th August, 2015 for the Central River Region–South (CRRS) and from 15th October to 14th November, 2015 for Central River Region–North (CRRN). This was conducted by the researcher and four other hired field research assistants.

In each village visited, consultations were first carried out through the head of the village (Alkali) by the agricultural extension agent a few days before the set date. Upon arrival in each village community, the team first visited the head of the village in order to briefly explain the purpose of the mission. The head of the village (Alkali) then arranged to assemble the earlier identified participants at the village common square known as *Bantaba* for the FGD meeting.

During the discussion, questions were asked inductively, proceeding from general to specific using a semi-structured interview guide prepared before the session (Appendix D. The participants were asked to keep the discussion confidential. This discussion took the form of open discussion where a set of guided questions were asked on the rice farmers' general knowledge about climate change related issues.

This was followed by in-depth open questions related to weather variation, climate change, rice production, challenges, and involvement of stakeholders, local knowledge of climate change as well as its associated

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impacts, the coping measures and adaptation strategies. The map of the communities covered in the FGD is shown in Figure 3.

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Key Informants Interviews

Key informants Interviews (KII) according to McKillip (1987) is generally associated with qualitative research in which a researcher employs interviewing of knowledgeable participants as an important part of the method of investigation. The interviews are usually in-depth with people who know what is going on in the community and its environment (Kumar, 1987). The purpose of key informant interviews according to Carter and Beaulieu (1992) is to collect information from a wide range of people or professionals who have firsthand knowledge about phenomenon being studied and with their expertise and understanding on a particular issue can provide insight on the nature of problems and give recommendations for solutions. A key aspect of the study is to assess the local knowledge of the rice farmers in climate change which requires use of people with long term experience and in-depth knowledge in the subject, thus the choice of key informant interviews.

Selection of Key Informants

The section of informants was done through consultation with several knowledgeable persons in the Central River Region in order to prepare a list of possible informants. The list according to Kumar (1987) should be large enough to include substitutes in case some informants are not available. Ideally, 15 to 35 key informants are sufficient for most studies but if the study combines other data collection methods, such as surveys, even fewer key informants may suffice (Kumar, 1987). In this study 13 key informants from the agricultural sector and other related institutions were selected and 15 interviews were conducted (Table1).

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Table 1: Key informant Consulted in the study

Institutions	Key Informants Contacted	Selected	Interviews done
Agriculture office - CRRS	Regional Director	1	1
	Extension Specialists	1	3
	Agronomist (Rice Specialists)	1	1
	Extension Supervisors (DES)	2	2
Regional Environment Office	Regional Programme officer	1	1
Regional Disaster officer	Regional Coordinator	1	1
FAO – MDG1c Project office	M & Officer - CRRS	1	1
Agriculture office - CRRN	Deputy Regional Director	1	1
	Subject Matter Specialists	1	1
	Extension Agent (AEA)	1	1
FAO – MDG1c Project office	Project Director - CRRN	1	1
Regional Met office (CRR)	Meteorologist officer	1	1
Total		13	15

Source: Badgie, 2015.

Question Guide for Key Informant Interview

An interview guide made up of semi-structured questions was used for the key informant interviews (Appendix 5). The question guide for the key informants covered the following key issues areas:

I. Key informant perspective about climate change and variability phenomenon,

II. What general knowledge on climate change and variability

III. What services do their institutions offer to help the farmers in the region in addressing climate change related issues

IV. What kind of support is available at regional level for farmers in

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dealing with climate change in the CRR

V. From the informant perspective what available climate change adaptation strategies should be enhanced to reduce negative climate change implications?

Data Collection: Conducting Interviews of Key Informants

The interview with the key informant started from the 3rd – 29th of December, 2015 and after confirmation of the informants, contacts have been made and personal visit carried out to meet them at their various offices or base. The process took 26 days to complete due to busy schedules and availability of the officers in the region.

A brief explanation about the study background, and objective of the interview, and the possible uses of the information and ideas provided by the key informant was done to every participant. They should also necessary to assure that key informant of the confidentiality of information particularly key informants, government officials and other development agencies employees who expected fairly detailed descriptions of the study purpose.

Analysis of Qualitative Data

Qualitative research and, in particular, focus group discussions generate large amounts of data. Therefore, a central aim of data analysis, according to Robson (1993), is to reduce data.

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Yin (2009) pointed out that qualitative data analysis consists of a number of stages, which is examining, categorizing and tabulating or otherwise recombining the evidence, in order to address the initial goal of a study. The data gathered from the field for this study were examined, categorized and tabulated to collate the evidence aimed at addressing the set research objectives and questions of the study. The most common purpose of a focus group interview is to provide an in-depth exploration of an issue or topic of which little is known. The researcher used reflexivity, bracketing and intuition to lay aside the preconceptions regarding the phenomenon under investigation. According to Holloway and Wheeler (2002), data analysis occurs simultaneously with data collection. Field and Morse (1996) identified intellectual processes that play a role in data analysis of qualitative data:

I. Use of summary sheet which enables the researcher to reduce vast amounts of information into manageable themes that can be easily examined

II. Comprehending: The researcher wants to learn about what is going on. When comprehension is achieved, the researcher is able to prepare a detailed description of the phenomenon under study.

III. Use of descriptive code which involves a systematic recording of data. They are organized around relevant ideas, concepts, questions, or themes with respect to the issue and this was done when the interview is concluded.

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IV. Synthesizing: This involves sifting data and putting the pieces together. This enables the researcher to make sense of what is typical regarding the phenomenon. The researcher makes general statements regarding the phenomenon and participants.

V. Theorizing: This is the systematic sorting out of data. Alternative explanations of the phenomenon are developed by the researcher to determine their correlation with the data.

In this study, the meanings were formulated from extracted statements and then clustered manually into themes to provide full meaning of the experience. The participating rice farming communities were consulted to ensure or confirm the credibility of the description or the information provided in subsequent follow up visits. For exploratory research, a descriptive narrative approach was quite appropriate and often all that was necessary (Field & Morse, 1996).

The thematic approach was applied in the analysis of data acquired data for both key informants interviews and the focus groups discussions for the purpose of this study. The interview guides were transcribed and the recurring themes were selected and analyzed manually. The process involved drawing relationships between the categories of responses and the most recurring themes were considered for analysis.

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Ethical Consideration and Ensuring Quality of Data

Ethical Considerations

A balanced research relationship will encourage disclosure, trust, and awareness of potential ethical issues (Dresser, 1998). Ramos (1989) described three types of problems that may affect qualitative studies and they include; researcher-participant relationship, the researcher's subjective interpretations of data, and the research design.

Ethical considerations are critical and are the norms or standards for conduct that distinguish between right and wrong. It further helps to determine the difference between acceptable and unacceptable behaviors on the part of the researcher (Orb, Eisenhauer & Wynaden, 2000).

The ethical aspect of every research and how they are addressed are pivotal to narrate. This study took into consideration the issues of informed consent, confidentiality and anonymity (Appendix E). Norman, (2007) argued that researchers must not compel respondents into participating in any form of research and issues of anonymity were also assured. The guiding core ethical principles were primarily centered on protecting research participants during the study:

i. Respect for persons - Respect the autonomy, decision-making and dignity of participants.
ii. Justice - Participants should be selected from groups of people whom the research may benefit.
iii. Respect for communities - Protect and respect the values, cultural norms and interests of the community as a whole

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The respondents' anonymity was assured since their names and other personal details were not associated with the specific response given. In this study, respondents were assured of their confidentiality as the information they gave or provided was not to be disclosed to any third party other than its intended use, which is an academic exercise (Appendix D and E).

Ensuring Quality of Data and Research

The credibility of qualitative research generally is often questioned by postpositivists /positivists perhaps because their concepts of validity and reliability cannot be addressed in the same way in naturalistic work (Guba, 1981). Silverman (2001), have indicated that qualitative researchers can incorporate measures that deal with these issues of validity and reliability in a qualitative studies.

Guba (1981) proposed four key criteria that should be considered by qualitative researchers in pursuit of a trustworthy study and they are:

I. Credibility (validity);

II. Transferability (external validity);

III. Dependability (reliability);

IV. Confirmability (objectivity).

In this study the following steps were observed to ensure validity and reliability of the study as explained in the following headings:

Credibility

One of the key criteria addressed in this study was that of internal validity, in which the researcher ensured that the study measures or tests what was actually intended. Credibility, deals with the question, and how consistent are the findings with reality.

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In this study, the employed specific procedures such as the line of questioning pursued in the data gathering sessions which were consistent as the same questions where followed in all the FGDs and the methods of data analysis which were referenced from similar previous successful studies in the same domain.

Transferability

This was concerned with the extent to which the findings of one study can be applied to other situations (Shenton, 2004). In this regard, the researcher ensured that sufficient contextual information about the fieldwork sites is provided to enable the reader to make such a transfer. Another important aspect considered in this study to address transferability was the description of sufficient phenomenon provided under investigation which will allow readers to have a proper understanding of study and enabling those to compare the instances of the phenomenon described in the research report with that they have seen emerge in similar situation.

Dependability

In addressing the dependability issue more directly, the processes within the study were reported in detail to enable future researcher to repeat the work and achieved similar results. The in-depth coverage of relevant process also allow the reader to assess the extent to which proper research practices have been followed as these could guide readers of the study to develop a thorough understanding of the methods and their effectiveness. Furthermore, the use of overlapping methods (triangulation), such as Key informant, FGD and survey strengthened the reliability of this particular study.

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Confirmability

The concept of confirmability is the qualitative investigator's comparable concern to objectivity (Pitts, 1994). Patton (1990) reported that objectivity in science with the use of instruments that are not dependent on human skill and perception.

Patton further acknowledged the limitation of ensuring real objectivity, based on the fact that even tests and questionnaires are designed by humans, the intrusion of the researcher's biases is inevitable. Miles and Huberman (1994) considered key measures (triangulation to reduce researchers bias, recognition of study methods limitations and their potential effects and allow integrity of research results to be scrutinized) should be followed to ensure that the study findings to greater extent represent the results of the experiences and ideas of the informants and not the characteristics and preferences of the researcher.

In this study, the issues of triangulation, study methods challenges and in-depth description of the methods were observed by the researcher. The researcher recognized and respected the valuable in depth information and contribution of the participants and reflected it accordingly in the findings.

Reconnaissance visit to the study area

Prior to the data collection, the researcher conducted a reconnaissance recognizance in the study area from 15th August to 17th of September, 2014 with support of some agricultural extension agents in the region. The visit was carried out in areas where rice production is done in the community (Figures 4 & 5).

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A reconnaissance visit according to USAID report (2009) is a path on which one observes and evaluates environmental attributes in an area. During the visit, certain questions were asked of the farmers and some forms of adaptation measures to climate variability were observed and photos taken. Both lowland and upland ecologies for rice production were visited during the visit

The purpose of this activity was mainly to identify potential participants in each community, assess the available adaptation strategies used by farmers and to have an overview of the study area in order to fit the survey questionnaire to the reality of the situation in the study area concerned.

This was done at their various local communities to ensure correct using of the tape recorder and to listen to the researcher's problems with probing and verbal reactions. During the exercise attention was also given to body language and non-verbal responses as well as the manner in which questions were asked. There was no organized data collection procedure was employed to record the researcher's observations during the visit. However, detail notes information was taken on relevant issues with respect to the study interest. This enhanced the researcher's level of confidence, enhanced his experience of communication, and interpersonal skills. This further gave the researcher the opportunity to:

i. Meet possible potential participants in the communities.
ii. Approach the participants with sensitivity and open-mindedness.
iii. Avoid preconceived ideas and ensure reflexivity during field work
iv. Build in extra precautions to prevent errors in the discussion.

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Figure 3: Phot of the Lowland Rice Field in the Study Area. Source: Badgie, 2014

Figure 4: Phot of the Author Discussing with Rice Farmer in Upland Fields. Source: Badgie, 2014

The use of the qualitative method gave the researcher a good understanding on how the communities are governed through rules and norms and their social relations regarding the research phenomenon. The qualitative methods used in this study are key-informant interview of agriculture and development agencies officers and through focus group discussion with the rice farming communities in the region. These are discussed in the following sections.

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CHAPTER FOUR

CONTEXT OF THE STUDY

Introduction

Assessing the implication of farmers' perception, local knowledge, and climate change on rice production, in the Central River Region, The Gambia, requires an understanding of the context surrounding the study. This chapter describes the socio-cultural and economic, agro-ecological, and institutional conditions of the study area. It also highlighted the issue of climate change and variability, its impacts, and institutional support to reduce the impact in the study area. These are presented in the following sections.

Socio - economic and Cultural conditions

Socio-cultural conditions are associated with customs, lifestyles and values that characterize a society such as demographic, religion, attitudes, economic status, class and language (Noble, Chandler, & Clark, 2008). The 2013 Population and Housing Census showed that The Gambia has population of 1,882,450 with a density of 176 persons per km² (Gambia Bureua of Statistics (GBoS), 2013). It has seven administrative regions, five of which are rural based as shown in Figure 6.

The ethnicity composed of mainly eight officially recognized groups; Mandingoes (36%), Fullani (22%), Wollofs (15%), Jolas (11%), Sarahuley (8), Serer (2.5%), Manjago (1.7%), Aku (0.8%) and others 4% (GBoS, 2003).

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The country is situated between 13º and 14ºN and between 13.7º and 17ºW, occupies an area of about 11,300 km² of which 10% is covered by the River Gambia and another 20% by swampy land and flood plains. The country is a low-income, food-deficient nation where the primary sectors such as agriculture with example like crop production dominating the economy in terms of output, employment, revenue generation and foreign exchange earnings (GNAIP, 2011-2015).

Agriculture is an important driver of the country's economy accounting for more than one third of the country's GDP and employing about 75% of the work force. It is the principal source of livelihood for the rural population and for the majority of households below the poverty line (Bittaye, Jones & Drammeh, 2002).

The sector is characterized by small-scale, subsistence rain-fed dependent crop production mostly under taken in a single rainy season from May/June to October; traditional livestock rearing; semi-commercial groundnut and horticultural production; small cotton and a large artisanal fisheries sub-sector (Agriculture and Natural Resources (ANR), 2009). The economy heavy reliance on agriculture, dominated by groundnut production as the main export crop exposes the economy to extreme weather and climate change related implications (GNAIP, 2011-2015).

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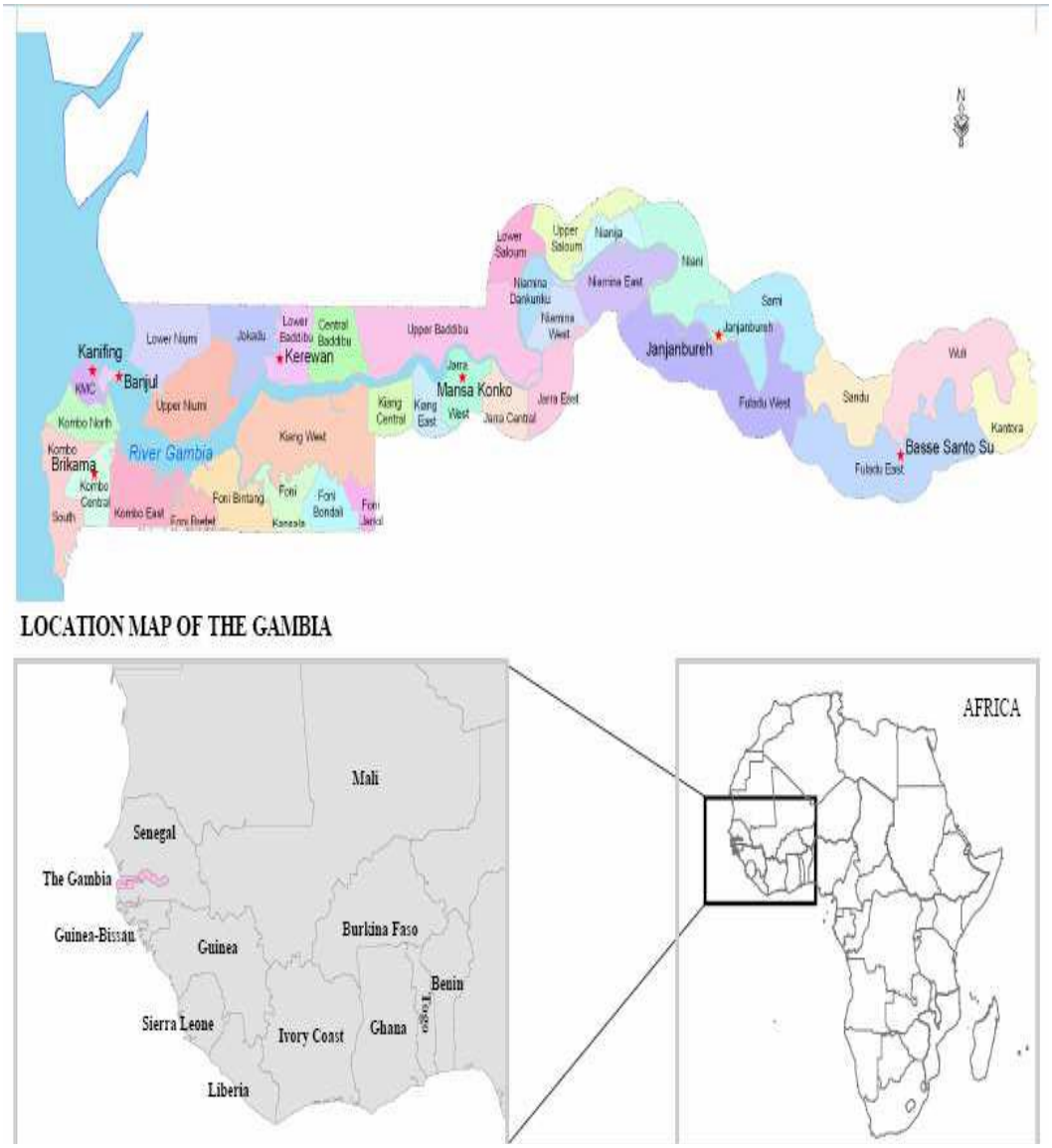

Figure 5: Map of Gambia Showing Major Towns & Villages. Source: Baganan, 2014.

The Central River Region (CRR) is situated in the eastern part of the country with a land area of 2,894.25 km² and a population of 226,018 of which 156,178 are farmers (69.1%), mainly living in dispersed settlements scattered across the region (GBoS, 2013).The region has 27,679 households with an average household size of 10.95 (GBoS, 2013). The region is divided into two by the River Gambia namely, CRR-North and CRR-South. CRR is administratively headed by a regional Governor appointed by the President of

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the Republic and serve as the center of power at the region. It consists of 11 districts namely; Lower Saloum, Upper Saloum, Nianja, Niani, Sami in CRR-North and, Niamina Dankunku, Niamina West, Niamina East, Fulladu West, Upper Fulladu and Janjanbureh in CRR-South (Figure 6).

The districts are headed by district chiefs locally known as *Seefolo*. Janjanbureh (formerly Georgetown) serves as the administrative headquarter. The major ethnic groups in CRR according to GBoS census report (2013) were Mandinkos (37%), Fulani (35%), Wolof (20%) and others (8%). The conventional literacy rate according to GBoS (2003) report is very low among the farming communities. However, madarasa (informal quranic schools) has greater influence as Islam is the major religion in the region.

In terms of religious affiliation, about 97% of the household heads in CRR are practicing Muslims, while the other constitutes 3% of household heads practice Christianity or traditional beliefs. The majority of the people in CRR depends heavily on agriculture for their livelihoods and mainly engages in groundnut, rice, coarse grains and livestock production at subsistence level (National Agricultural Sample Survey (NASS), 2013).

Rural households are typically organized into compounds occupied by extended families and farming systems are widely practiced. The majority of lands in the region are under a customary land tenure system, with land administration mainly under the community clan or village heads (Alkali), who supervise the land resources (West Africa Agricultural Productivity Programme (WAAPP) 1C, 2012). Land lease to households is done according to the needs of traditional households, with the clan or village head granting customary rights to the community members for free usage. However,

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ownership rights continue to be vested in the clan, thus preventing the granted land from being sold by the allocated families (Carney, 1988).

Crop production in the CRR is mainly rain-fed. The main crops cultivated (Groundnut, rice, millet, and sorghum, and maize) in the rainy season play an important role in household food security (Ceesay, 2004). Rice cultivation is mostly rain-fed in the upland. However, other areas along the river banks benefit from tidal irrigation schemes. The region has more suitable agricultural land and larger number of livestock compared to other regions thus being named "Food basket of The Gambia". The average land put under crop production estimated at 34,407 ha and the current land under rice production, in both uplands and lowlands is estimated to be 17,812 ha (NASS, 2013).

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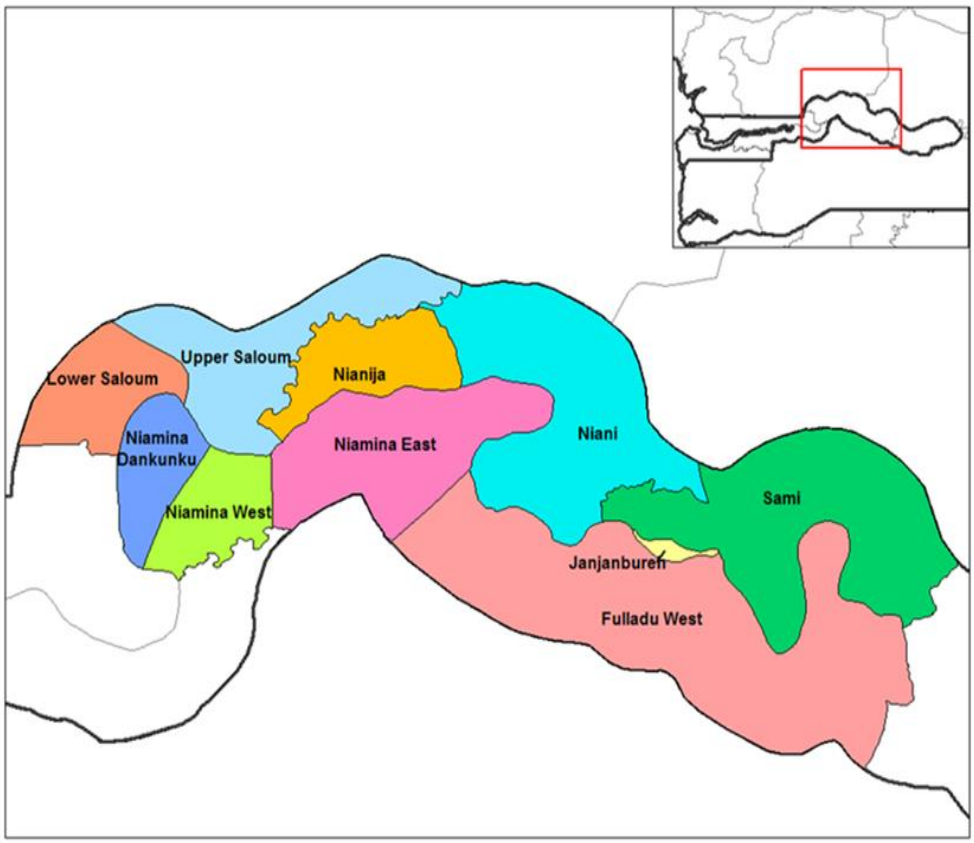

Figure 6: Map of the CRR showing districts Source: National Planning Commission 2014.

Agro-ecological Conditions

An agro-ecological condition constitutes a combination of a climatic and soil unit with homogeneous properties that can directly be matched with crop growth requirements (Food and Agriculture Organization of the United Nations (FAO), 1996). The climate of The Gambia is largely semi-arid and uniform across the country. There are two distinct seasons in the year; a rainy season from mid-June to early October and a dry season from mid-October to mid-June. Daily temperatures average 28.2°C across the country in the dry season and 28°C in the rainy season.

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The annual rainfall ranges from 850mm in the east to 1200mm along the coast (Jallow & Danso, 1997: National Forest Assessment report (NFA), 2008-2010). The country has three major agro-ecological zones that are not distinct as highlighted in the following section.

Sahelian Zone

This zone is characterized by open dry season savannah vegetation dominated by shrubs and herbaceous vegetation. Annual rainfall is usually less than 600mm and the effective length-of-growing-period (LGP) is less than 79 days. The soils generally have low water retention capacity and therefore, not very suitable for long-duration crops. The zone is mainly found across the northern strips of Central River, Upper River Regions and some parts in North Bank Region (NBR) respectively.

Sudano-Sahelian Zone

This zone has a longer LGP between 79 to 119 days and rainfall ranging from 600mm to 900mm rainfall area. The flood plains along The River Gambia and associated lowland valley systems, ideal rice cultivation, are all characterized under this zone.

It essentially also covers most of the others regions. Parts of this zone is found in Lower River and West Coast Regions along the River Gambia estuary but these areas are usually affected by salt intrusion due to tidal influence from the sea adjoining low lands at the peak of the dry season (Carney, 1993).

Sudan-Guinean Zone

The Sudan- Guinean Zone lies within the 900 to 1200 mm rainfall isohyets around the coastline and thus covers only the WCR and some part

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NBR. The vegetation is dominated by gallery forests, mangroves and tree species covering a great part of the estuary as well. The growing season is 120-150 days and in normal seasons full crop water requirements are met throughout the growing season. The principal crops cultivated in this agro-ecology are late millet, groundnut, rice (rain-fed upland and lowland) maize, vegetable, sesame and cowpea (Carney, 1993).

Rainfalls are usually heavy in the WCR and Greater Banjul Area. In the rainy season, temperatures vary between 29ºC and 32ºC, and from 15ºC to 23ºC dry season. However, the rainfall decreases as one move towards eastern part of the country while the temperature increases significantly as one move towards the same direction. In wet season, south-westerly monsoon winds combined with the continent northward movement of the wind give rise to the formation of thundery activities, which usually result to strong winds, heavy downpours and severe lightning (Jallow, 1997a).

Generally, the months of July, August and September receives the highest rainfall in the country. In dry season, North-easterly winds (Harmattan) blow from the Sahara towards the western coast of Africa resulting in the presence of dust particles in the air, and generally cloud free skies and dry air. This trend of temperature increase and reduction in rainfall has serious consequences on the agricultural sector hence it tends to constrain crop and livestock production (Jallow, 1997b; Cole, 2006). In addition to declining rainfall trends, The Gambia experiences high rainfall variability, with a larger than 25% coefficient of variation, above the global median of 21% (Hulme, 2001; Ericksen et al 2011; Barbier, Yacouba,., Karambiri, Zoromé, & Somé, 2009). This is further worsened by the erratic nature of the

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rains, characterized by late onset of the season, increased frequency of drought and/or dry spells, and high frequency of intensive rainfalls that result in severe floods and erosion. Figure 7 shows increasing annual rainfall variability since the late 1970s. Annual rainfall falling below the mean was more frequent beginning from the 1977, exhibiting not only a prolonged drought but recurrent variations between dry years and wet years, typical of the Sahelian climate (Kandji, Verchot, & Mackensen, 2006). The connection between rainfall variability, food production in developing countries such as The Gambia is quite strong (Boko et al 2007; Stern 2007). Often, when there are poor rainfall events, poor harvest and crop failure ensues. One recent example is that due to poor rainfall recorded in 2011, a crop failure of 70% was declared by the government of The Gambia (ECOWAS Commission Report, 2012).

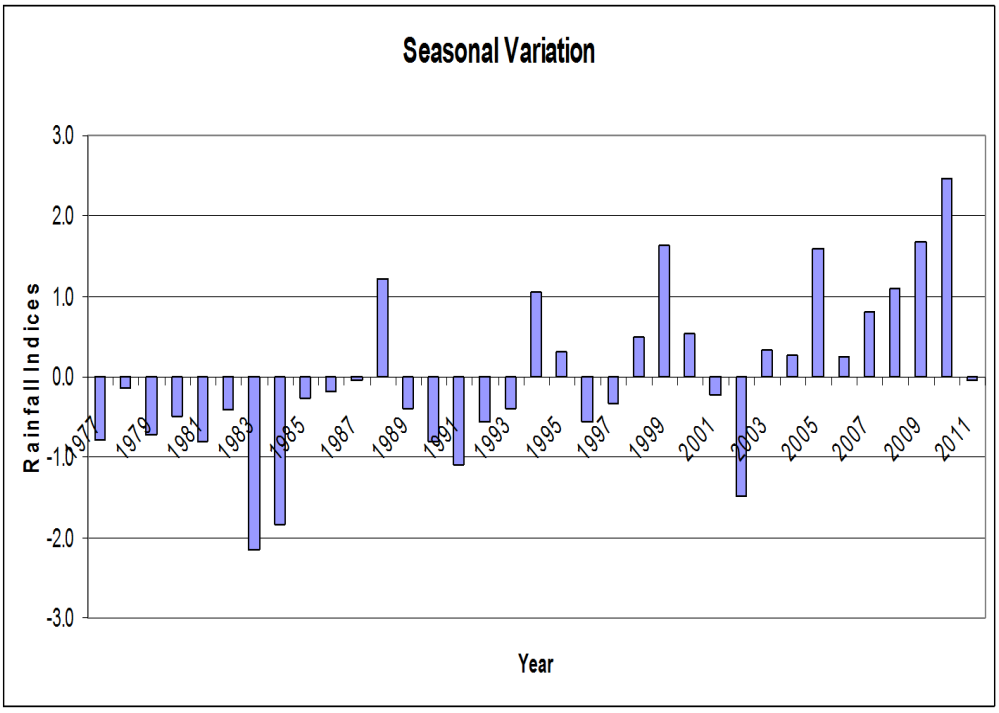

Figure 7: Seasonal Rainfall Variation for The Gambia from 1977 to 2011. Source: Bojang, 2012.

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In addition, average annual temperature taken from the Western, Central and Upper Regions of the country namely, Yundum, Janjangbureh and Basse from 1994-2014 also showed an increasing trend of temperature in recent past years in the country (Figure 8).

The current long term data on rainfall indicates a declining pattern over the years, the amount decreasing progressively from the mid-1940s corresponding to approximately 30 per cent in deficit (NAPA, 2007). In recent years (1994-2015), the annual rainfall experienced in these regions of the country has been erratic (Figure 9). This posed a serious threat to both crop and livestock production, and particularly rice which is mainly rain-fed under upland and lowland production (Njie, 2006).

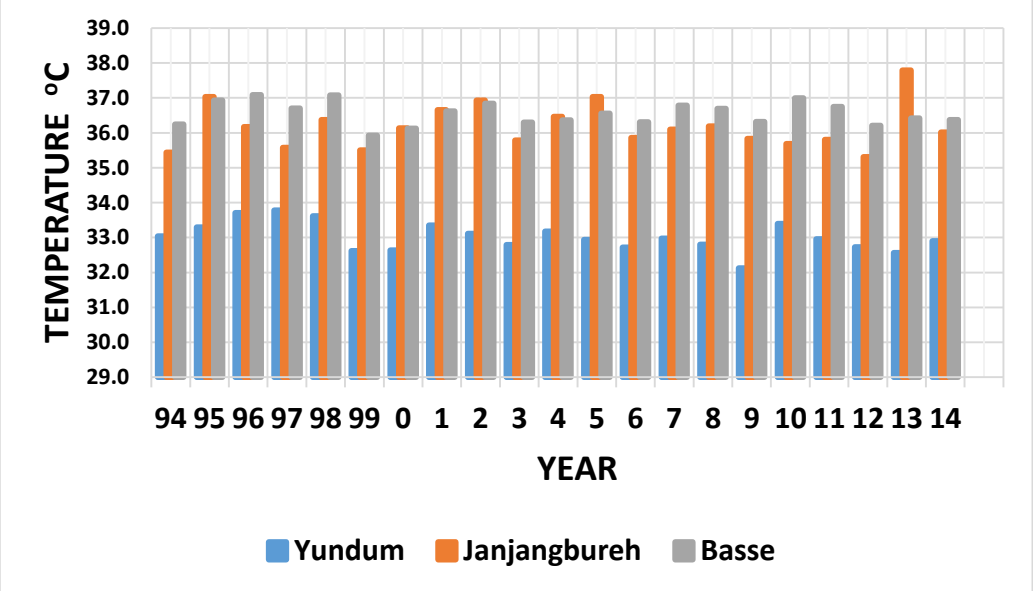

Figure 8: Average Annual Temperature For Yundum (WCR) /Jangjanbureh (CRR)/Basse (URR) from 1994 to 2014. Source: Department of Water Resources, 2015.

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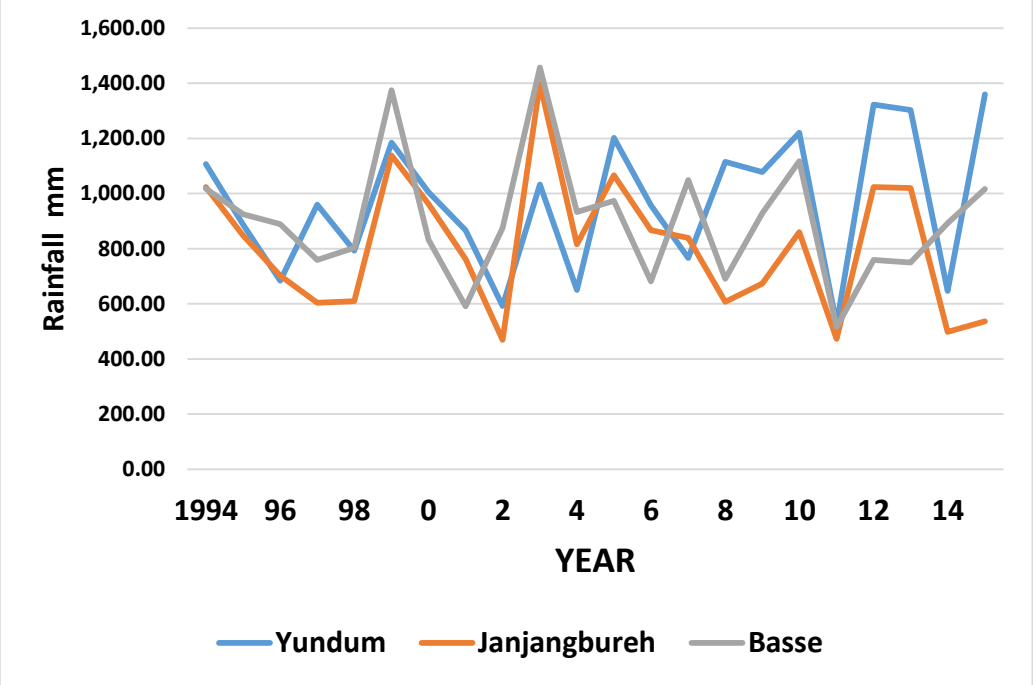

Figure 9: Annual Rainfall: 1994-2014 for Yundum, Janjangbureh, and Basse. Source: Department of Water Resources, 2015.

The soils of The Gambia can be subdivided into two main groups' namely Alluvial Soils and Continental Terminal Soils (CTS). The alluvial soils, covering approximately 30% of the country, are more dominant in the western part of the country reducing in extent as you move towards the east of the country (FAO, 1996). They are found in the lowlands along the river and its tributaries in the west, close to the sea. The soils are saline and dominated by mangrove vegetation. The CTS is more dominant and occupies the uplands. They are well drained and of low fertility compared to the alluvial soils. At the surface, CTSs are usually sandy and loamy sands while the subsoil horizons are generally sandy clays though loamy sand and clay frequently occur in some locations.

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Soils in The Gambia are subjected to various types of degradation attributed to soil erosion, land clearing, bush burning and limited incorporation of green manure as well as salinization from the main river and its estuaries. The most predominant soils are ferruginous and feralitic which are highly weakened tropical soils characterized by low cation exchange capacity, low inherent fertility, strong consistencies and poorly developed structures and medium to high base saturation.

The climate of the CRR is mainly semi-arid and uniform across the region as the study area. Daily temperatures average 28.2°C in the dry season and 26°C in the rainy season. This could be exceeded within the year depending on the prevailing condition. The annual rainfall ranges from 500 to 850mm. Weathered tropical soils are found on the upland plateaus. These soils have low intrinsic fertility and low water retention capacity, but their drainage conditions are good (FAO, 2010).

The soils of the lowlands are flat, fine textured and poorly drained. The climate dictates the natural vegetation and the type of crops that can be grown. The climate not only affects growth patterns, persistence, quality and yield, but also influences the response of each cultivar to different management practices (FAO, 1996). The Seasonal and Inter Annual analysis of rainfall from 1976 – 2013 in the CRR from three key weather stations in the study area namely Janjangbureh, Sapu and Kaur has a larger variance with a maximum ranging from around 250mm to 350m and the inter annual variation of 2000mm for the region as illustrated in Figures 10.

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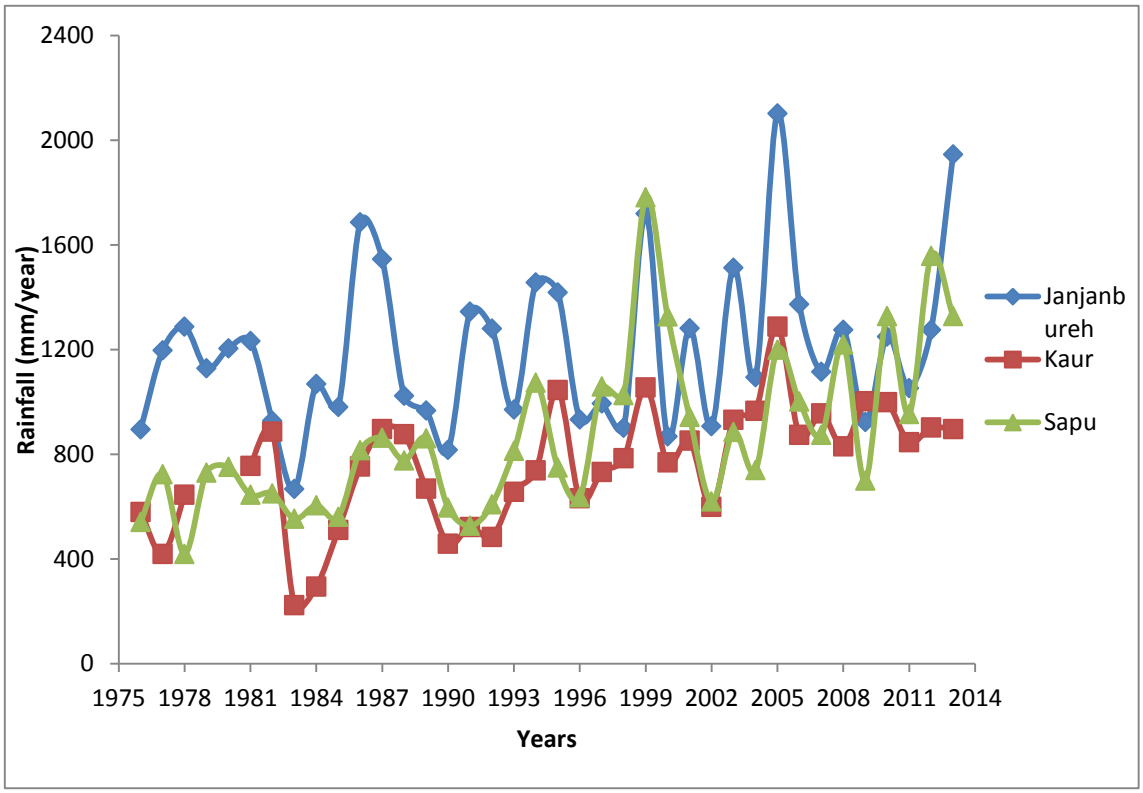

Figure 10: Historical Seasonal analysis of rainfall (1976 – 2013) in the CRR. Source: Department of Water Resources, 2015.

The temperature plays a major factor in the stimulation of biochemical processes in the plant. It can be expressed through a direct observation or measurement of the average, minimum or maximum temperatures registered over the day, the month or the year. The Seasonal analysis of Maximum Temperature from 1984 to 2012 in the CRR from three key weather station in the region indicated maximum temperature of 43ºC in the months of March, April May and June, which are considered hottest in all the three stations . The temperature gradually decreases into the 30s in July, August and September which are usually the peak of the raining season. In general, the temperatures in the region are generally high throughout the year (Figure 11).

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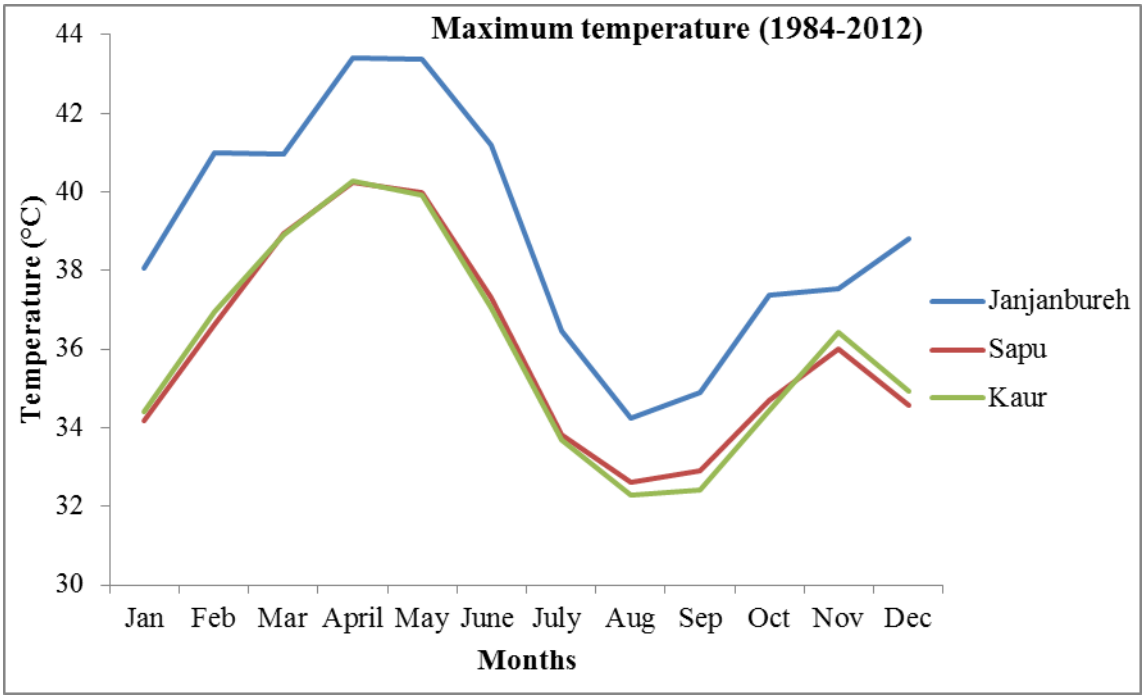

Figure 11: Seasonal analysis of Maximum Temperature (1984 – 2012) in CRR. Source: Department of Water Resources, 2015.

Minimum temperatures are more often a constraint, especially low temperatures which reduce physiological activities and might even become lethal for sensitive crops (FAO, 1996).The Seasonal analysis of Minimum Temperature from 1984 to 2012 in the CRR from three key weather stations in the region in contrast have high seasonal temperature in March, April, May through to September, and gradually drops in October, through to February (Figure 12).

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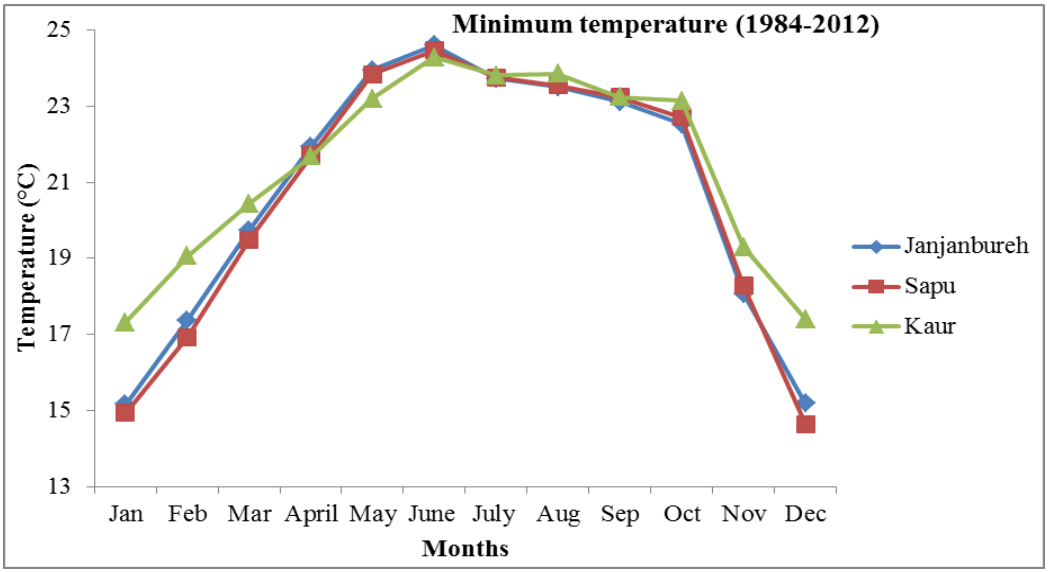

Figure 12: Seasonal analysis of Minimum Temperature (1984 – 2012) in CRR. Source: Department of Water Resources, 2015.

The soils in the CRR are dominated by alluvial soil along the bank of the river and inland valley. In general, the region has CTS dominance. The general topography and Altitude form of the CRR is generally flat, with typical pockets of average high ground levels of approximately 30m to 50m in certain areas. The area is predominantly grassland, shrubs and sparsely forest. In addition, there is a presence of wetland ecology along the riverine areas that are seasonally flooded by rain and run off and are outside the tidal influence. Seasonal saline tidal swamps are found at the Lower Central River and are situated on the fringes of mangroves where potential acid sulphate soils could be found. Figure 13 showed land use and land cover situation of the CRR.

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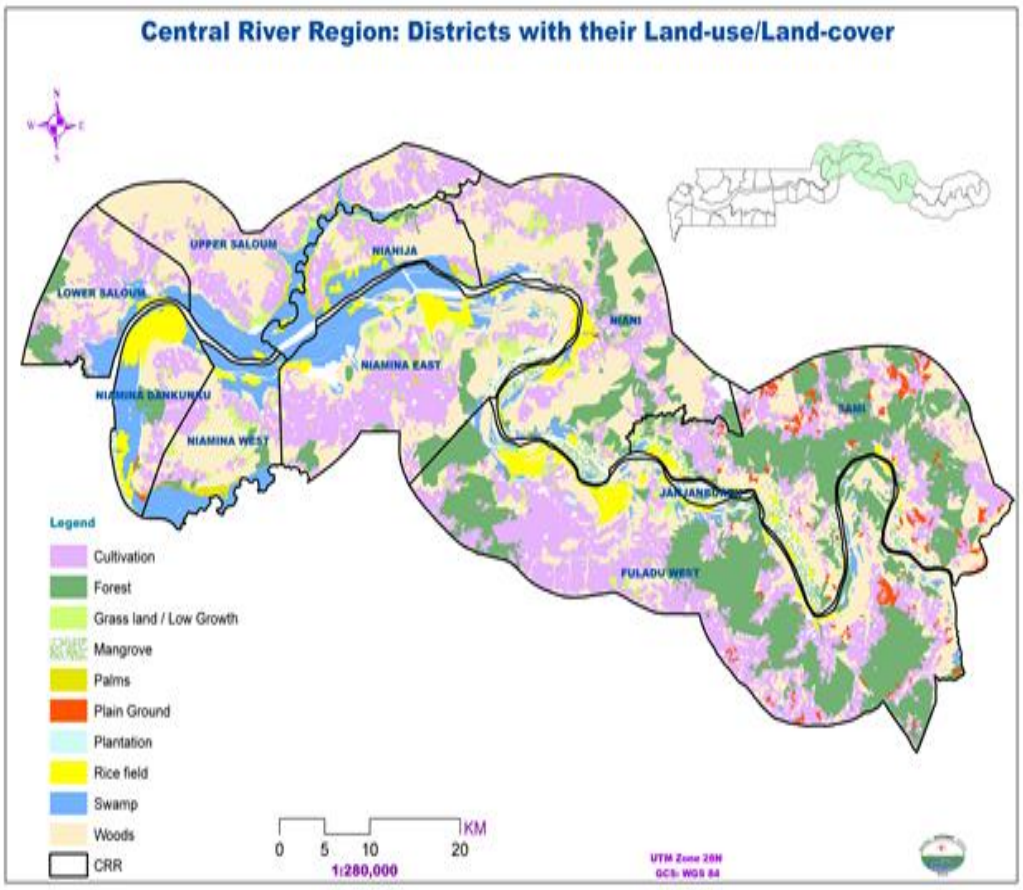

Figure 13: Map of CRR showing Land Use and Land Cover. Source: NEA, 2014.

Climate Change and Variability in The Gambia

The results of four Global Circulation Models (GCM) using local data have generally produced mixed results for The Gambia. The Models indicated that by 2075, the mean temperature in The Gambia is expected to increase between 3^{o}C and 4.5^{o}C. Estimates of annual rainfall patterns over the same time period are less consistent, varying between 59% and 29% of current levels (NAPA, 2007).

Since the mid-1960s, the country has experienced observed changes in the climate manifested by declining rainfall trends, increased frequency and

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length of drought spells and occasional catastrophic flashfloods (Jallow, 1997d). Analysis of long-term meteorological records according to Hutchinson (1982) showed a decline in both average rainfall levels and length of rainy season across the country. Norton (1989) reported that during the second half of this century, the country experienced erratic seasonal distribution of rainfall. It has been observed that the rainfall patterns over Banjul based on a 102-year period (1886−1987) established a consistently late onset of rainy seasons between 1968 and 1987, and an early end to the season between 1970 and 1976; and that on average, annual rainfall decreased by 3.54 mm per year (Hutchinson 1982; Anyadike, 1993). Anyadike further reported that long-term precipitation records in Banjul and Basse from 1886 to 1982 showed that 50% of the years between 1886 and 1968 had above average rainfall while only 25% of the years had precipitation below average. However, during the period 1968 and 1990 only 5% of the years had above average rainfall while 75% were dry.

Climate Change Related Impacts in The Gambia

Climate change is a global environmental threat and development concern. Developing countries are the most adversely affected by the negative effects of climate-induced events because of their low level of adaptation (Camara, 2013; Conteh & Njai 2005; Darboe & Bojang, 2005). The agricultural sector has gone through evolution over the past decades when many new ideas were implemented and new technologies introduced. However, despites the sector role in driving the economic growth, crop yields are low. The gap between production and consumption in The Gambia is filled

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by an expanding food import bill exceeding US$ 40m annually for rice as the staple food (NIB, 2008). The agriculture and fisheries are the two sectors of the economy that are highly sensitive to climate change (Jallow & Barrow, 1996; NAPA, 2007).

Crop production that depends mainly on rain-fed will be affected in case of drought, incidence of pests and diseases could increase, potential sea level rise that would submerge some vulnerable coastal agricultural lands especially rice fields, biodiversity losses from some of the most fragile environments in tropical forests and mangroves (Jallow,1999; Jaiteh & Saho, 2011). This may make the day to day and medium to long term planning of farm operations more difficult and livestock production and productivity could be reduced as result of drought and heat stress (PAGE, 2012; Sowe, 2015).

The projected impact of climate change on cereal yields strongly depends on the projected change in the rainfall pattern. According to Njie, Gomez, Callaway, Jallow and Droogers (2009), if the climate is warmer but not drier than the present, the simulated cereal yield would increase and generate economic profit in The Gambia. However, if the projected climate is warmer and drier than the present climate, yields would decrease and become more variable. The study opined that high temperatures are harmful during seed formation and between grain formation and grain maturity of crops.

Comparatively, to the Gambia situation, photosynthesis and respiration activities of crops and microbes according to Abrol and Ingram (1996), increases with temperature and verse versa. Furthermore, Travasso (2008) found that there is a significant correlation between changes in maize yield. An increase in temperature during the crop growing season for every 1ºC

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increase in temperature, there was a 5% reduction in yield in southwestern, South America. Similarly, a study in France by Velde and Tubiello (2012), found that crop yield was influenced by drought and extreme wet conditions in 2003 and 2007.

The NAPA report 2007 indicated that traditional adaptation methods may no longer be enough to protect against climate change related impacts in The Gambia. For instance, in 2007 total rice production dropped by about 68% (from 35,900 tonnes in 2002 to 11,395 tonnes. Similarly the drop in the production of coarse grains (Maize, Sorghum, Millet) was about 27% (from 248,400 tonnes in 2003 to 181,400 tonnes in 2007), mainly due to drought (Binnewerg, & Touray, 2009). In addition, other climate change related hazards in the country include flooding, salt water intrusion, wind storms, drought, heat stress, and unusual rains (NAPA, 2007). Poor intra-seasonal rainfall distribution also serves to increase food insecurity, rural poverty, and hardship (Njie, 2006; GoTG, 2009). Njie further reported that since the 1960s, large areas of freshwater swamps in western part of The Gambia have been replaced by salt pans or salt water marshes, as a result of reduced fresh water inflow from storm runoff. Also, over the last decade there were serious property and crop destructions in the North and East part of the country, notably in the North Bank Region and Upper River Region due to wind storms.

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Rice Production under Climate Change in The Gambia

Rice is the major staple food for millions of people in West Africa (FAO, 2011). The current annual demand for rice in the sub-region is estimated to be over 8 million metric tons (FAO, 2009).

Rapid population growth, increasing urbanization and the relative ease of preservation and cooking have influenced the growing trend in rice consumption (FAO, 2009). Currently, an estimated 4.1 million ha are under rice cultivation in West Africa. Total rice production in the sub-region is estimated to be about 6.2 million MT of paddy rice. The FAO further estimated that current rice imports into the sub-region have grown to more than 4 million metric tonnes per year costing over 1 billion US Dollars in each year. This has serious consequences for the balance of payments of these countries. Imports of this magnitude represent a major change on other broader development and poverty reduction efforts for the region (FAO, 2009).

In the Gambia, rice is generally grown as household food but with increased production it is becoming a cash crop because of price fluctuations for groundnut (Van Mele, Reece, Dalohoun, Drammeh, & Bah, 2011). The production systems can be categorized under upland, lowland, and irrigated. Bittaye, Jones and Drammeh (2002), reported that the potential for rice production is greater in the lowlands that accounts for roughly 65% of the total arable land for rice cultivation. Total area cultivated under upland rice has increased from 10,129 ha in 2006 to 65,056 ha in 2010. The total production of upland rice ranged from 4,633 metric tons in 2002 to 77,817 metric tons in 2010. A decline in upland rice production was observed in 2011 due to

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intermittent rainfall and drought conditions that prevailed in the country (NASS, 2011).

The major challenges to rice production in the country include: erratic and unreliable rainfall, inappropriate farm implements for women farmers to intensify production, difficulties in land preparation, inadequate inputs and high cost of fertilizers, poor access to improved varieties of rice, and heavy reliance on rain-fed production and poor access to credit for the purchase of inputs (Ceesay, 2004; WAAPP 1C, 2012). Other challenges include, inadequate extension services, land tenure system, high incidence of pests and diseases, low capacity building for rice farmers, high post-harvest losses, inadequate processing facilities, poor cooperatives systems to enhance marketing of rice and competition with cheaper imported rice on the domestic market (WAAPP 1C, 2012).

In addressing the aforementioned challenges, The Gambia government developed national development strategy called Vision 2020. The plan articulated intentions to transform the country to a dynamic middle-income through agriculture led economic growth over a 25-year period (NASS, 2009). In this plan, access to food and poverty reduction has therefore been a major consideration of the government especially in rural area with high incidence of food insecurity and abject poverty. The plan supports the earlier Poverty Reduction Strategy Paper II and the Sustainable Development Goals. In that it has proposed to expand and improve rice production from less than 20,000 ha in 2007 to 250,000 ha against the year 2015 and beyond (GNAIP, 2011-2015). It envisaged that increasing the productivity of the diverse rice growing

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environments, notably the uplands, is a central strategy in addressing the food security challenge in The Gambia.

The forest cover which includes forested areas and wooded land is estimated to cover about 37.5% (423,000) of the total area (Jallow,1997c; NFA report, 2010). In addition, livestock production is carried out nationwide by almost all rural households. Cattle population in the Gambia stands at about 300,000 heads closely followed by small ruminants comprising sheep (160,000) and goats (230,000) (GNAIP, 2011- 2015). All of which depend on the same land for their pasture and survival. In recognition of the important role of forest cover in term of serving as carbon sink, the clearing of the land for crop production will culminate severe consequent for our national drives to address the implications of climate change in the country over long term. In view of the land size, current degrading agricultural lands, diminishing forest cover, biodiversity consequences and ecosystem services among others, it is important for The Gambia to consider engaging more in agricultural intensification rather than agricultural expansion for the country future food needs.

National Climate Change Agreements, Policies and Action Plans

While the issue of climate change mitigation has received a significant amount of political and scholarly attention over the past two decades, engagement with climate change adaptation could be characterized as an infant occurrence (Eguavoen, Schulz, de Wit, Weisser, Müller-Mahn, 2013). The Gambia over the years has shown degree of commitment to address the effects

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of climate change nationally as reflected in the first national communication 2003.

Subsequently, several climate change policies and actions plans have been developed on adaptation and mitigation approaches as well as international climate change agreements that aim at enhancing the Gambians to better cope and adapt with the current and future climate impacts of all forms. A summary of relevant policies, actions, plans and commitment undertaken by the Government of the Gambia in addressing climate change related issues in that country (Table 2).

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Table 2: Commitments, Actions/ Plans and Policies relevant to Climate Change in The Gambia

AGREEMENTS	FOCAL POINT	FOCUS AREA
UN Framework Convention on Climate Change (UNFCC)	Department Water - Resources (DWR)	Climate change (reduce atmospheric concentrations of greenhouse gases)
Kyoto Protocol to the UN Convention on Climate Change (Kyoto Protocol) 1997	Department Water - Resources (**DWR**)	Climate Change (Reduce greenhouse gas emissions)
The Paris Agreement (2016)	Ministry of Environment, Climate Change, Parks and Wildlife	Climate Change (Reduction in greenhouse gases emissions mitigation and adaptation)
ACTIONS /PLANS		
National Climate Committee (NCC) created in 1992	Department Water Resources (**DWR**)	- Mandated to implement activities/programs under the UNFCCC
First National Communications (NC, 2003) Second National Communications (NC 2012)	Department Water Resources (**DWR**)	- As per requirement to update UNFCCC on the country activities in addressing CC
National Adaptation Programme of Action (NAPA, 2007)	Department Water Resources (**DWR**)	- Set of project profiles meant to mitigate the impacts of climate change (e.g coastal, water, agriculture, forestry, energy, health, livestock, fisheries) - capacity building to build/strengthen adaptive capacity through participatory planning/multi-stakeholder processes (IA, beneficiaries and extension workers)
National Appropriate Mitigations Action (NAMA 2011)	Department Water Resources (**DWR**)	- Contains information on the country can contribute to the global efforts in meeting goal of keeping global temperature to 2^{o}C
POLICIES		
Poverty Reduction Strategy Paper II (PRSP II 2007-2011),	Ministry of Finance	- Priority intervention identification to decrease vulnerability of key groups.
Gambia Environmental Action Plan (GEAP II 2009 - 2018)	National Environment Agency	- Developed synergy between MEAs on climate change, biodiversity and desertification
Programme for Accelerated Growth and Employment (PAGE, 2012 - 2015)	Ministry of Finance	- Established main drivers of economics growth (Agriculture & Tourism) and how CC impact on this vital sectors
National Climate Change Policy of The Gambia – 2016	Ministry of Environment, Climate Change, Parks and Wildlife	- Main policy directions to deal with climate change in The Gambia

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National Support System for Climate Change Extremes and Disaster Emergency Response in The Gambia

The Hazard Profile and Vulnerability Capacity Assessment (VCA) of The Gambia (2006) reported that drought, floods, wind storm, locust invasions and environmental degradation as the greatest threats to food security (GoTG, 2009). It was reported that from 2002 to 2006, there were 65 flash floods related incidents that affected almost 50,000 people; and 45 fire incidents across the country. According to Darboe and Bojang (2005), vulnerable areas to drought and flash floods.in the country are the uplands, low lands, water ways, and some unplanned settlements and these aspects cut across the seven administrative regions of the country, namely: Kanifing Municipal Council (KMC), Banjul City Council (BCC), West Coast Region (WCR), North Bank Region (NBR), Central River Region (CRR), Upper River Region (URR), and Lower River Region (LRR).

Against these recurrent circumstances, The Gambia's National Disaster Management Act and Policy (2008) was developed and outlined national support systems, strategies, response and preparedness. These provisions are meant to mitigate disasters and build community resilience to reduce the risk factors and impact of disasters on the affected communities. The National Disaster Management Agency (NDMA) was established to provide support and coordinate all emergence preparedness and response to all forms of disasters and related issues across the country (GoTG, 2009). The policy and Act mandated NDMA to coordinate the development of Disaster Management Contingency Plan, which will guide preparedness and responses to mitigate disasters at national level.

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The Gambia Hazard profile of 2006, identified five top hazards as extreme weathers as (floods, drought and wind storms), forest fires, oil spill, disease outbreak and population movement (GoTG, 2009). The establishment of The Gambia National Platform for Disaster Risk Reduction (DRR) in March 2011 reinforces the involvement of all stakeholders in DRR from the Governing Council to grassroots level across the country. This was further reflected in the establishment of Regional Disaster Management Committees, District, Ward, and Village Development Committees, supported by the Regional Disaster Coordinators (GoTG, 2009). This is a cohesive institutional framework which involves all stake holders, and requires capacity building. Partnerships, community ownership and sustainability formed the key ingredients to implementation of the contingency plan, which was preceded by the formulation of the sectoral and regional contingency plans (GoTG, 2009).

Key Stakeholders, Roles and Responsibilities in Emergency Response

Within the context of the National Contingency plan and its implementation, the National Disaster Management Governing Council served as the highest body responsible for advising the government and the coordination of emergency response and preparedness activities at national level (GoTG, 2009). They advise the President and executives' arm of government in the face of an imminent disaster and ensure accountability for all the resources received.

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The NDMA coordinates and monitors the implementation of the Contingency Plan in terms of emergency response and as well collaborates with other relevant government sectors, international agencies and NGOs in terms of need. The involvement of specific sectors of Government hinges on the emergency response at hand and the relevance of that sector in the contingency plan. For instance, in 2011, the Government of The Gambia declared a national crop failure due to severe drought.

The subsequent relief support for the affected communities such as food items, fertilizer and seeds for the following year production were distributed by the Ministry of Agriculture through its technical branch (Department of Agriculture), with the support from Regional Agricultural Directorate offices under the supervision of the NDMA. In this overlapping situation, there were obvious rivalries over responsibilities and funds allocation for the coordination of climate change related impacts and disaster response programme (Lauer, 2015). One fundamental mandate of the national climate change community was to build the capacity of the vulnerable people. However, this vital aspect is yet to be realized as the institution were engulfed in expanding their individual mandates in order to secure extra funding for their respective engagements in addressing climate change issues in The Gambia.

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CHAPTER FIVE

RESULTS AND DISCUSSION

Introduction

This chapter presents the results and discussion of the study. The main goal of this study was to assess the implication of farmers' perception, local knowledge and climate change on rice production in the Central River Region, The Gambia. First, the chapter discusses the results on the background characteristics of respondents in the study area which included the gender distribution, age category, education level, income, household size farming activities and livelihoods. This was followed the results discussion on the farmers' perceptions and knowledge of climate change and variability, and its implications in the study area.

Discussion on the available local knowledge of the farmers with respect to climate change and variability and examining how this local knowledge improves the rice farmer's adaptive capacities were done. Furthermore, the adaptation strategies of the rice farmers in response to climate change and variability as well as relationships were discussed. The availability of climate change support system for rice production as perceived by the rice farmers in the study area was presented and discussed. Finally, the result of key informants' interviews on climate change related issues were discussed

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Background characteristics of the research Participants in Central River Region

Description of the background characteristics of respondents in this research is pivotal for the interpretation of the research findings within the context of the study area. The key characteristics considered in the research include sex, age, educational background, income, size of household, type of crops cultivated and livelihoods. These characteristics are important in determining the context of the study at household level. The results showed that majority of respondents, were males represented by 53.7% (Figure 14). The rest (47.3%) were females (Figure 14). These in general indicated that most farmers in the study area are males.

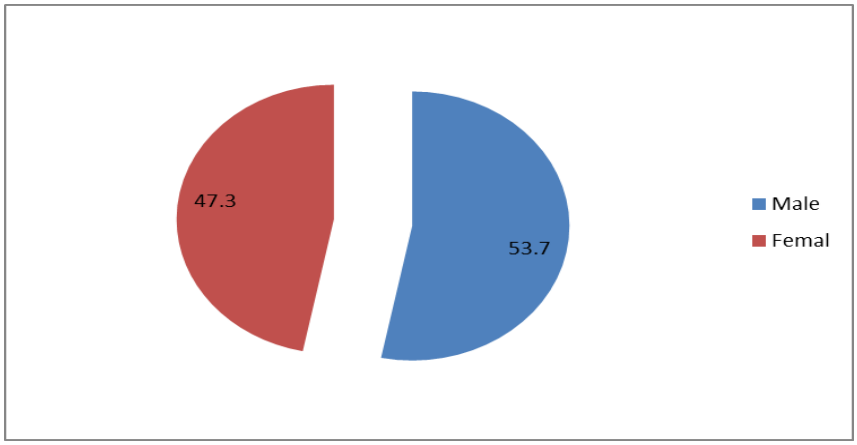

Figure 14: Sex distribution of respondents – Survey Results

Source: Badgie, 2015

The results as shown in Figure 15 indicate that 55.9% of the farmers in the study area were found to be within the age group of 31 – 54 years. Another 26.7% were in the age group of 15-30 years, and 17.4% within the age group of 55 years and above.

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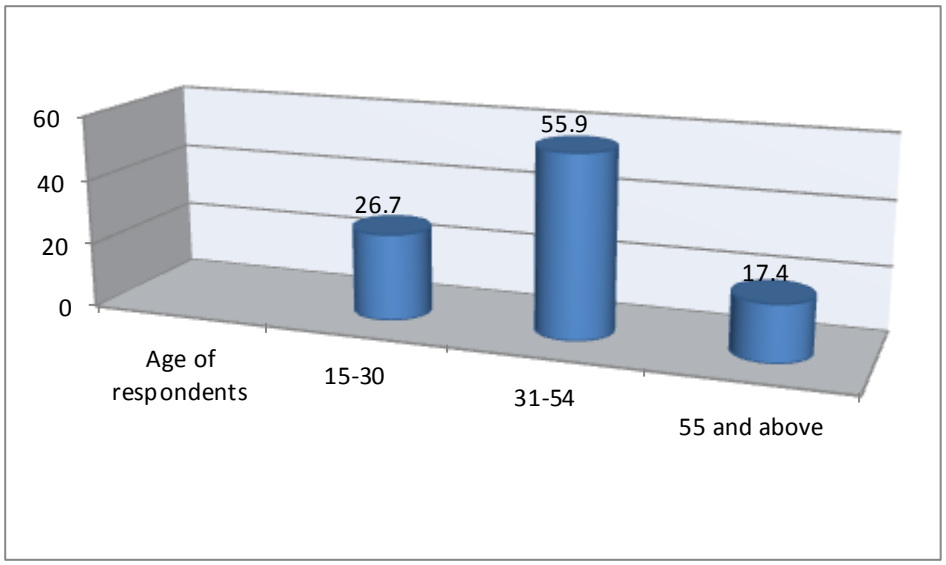

Figure 15: Age Category of Respondents. Source: Badgie, 2015.

On education levels, the results indicated that 62.6% of the respondents had no formal education (Table 3). The results further indicated that 10.3% and 6.8% of the respondents' attained primary and secondary level education respectively. In addition, only 3.2% of respondents attained college or University education. Interestingly, out of these respondents, 17.1% attained Kuranic education which is basically Islamic religious knowledge (Table 3). This indicated typical characteristics of farming communities in the study area in terms of education.

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Table 3: Background characteristics of respondents in Study Area (n=438)

Background characteristics	Frequency	Percentage
Educational Background		
Primary	45	10.3
Secondary	30	6.8
College & University	14	3.2
No Education	274	62.6
Others – Kuranic	75	17.1
Total	**438**	**100.0**
Income level per HH in Dalasi GMD)		
1000- 5000	207	47.3
5001-10000	100	22.8
10001 - 15000	82	18.7
15001 - 20000	36	8.2
20001 and above	13	3.0
Total	**438**	**100.0**
Household Size		
Two	32	7.3
Three	44	10.0
Four	107	24.4
Five and Above	255	58.2
Total	**438**	**100.0**

Source: Badgie, 2015

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In terms of income earnings, the results show that 47.3% of the respondents earned annual income of GMD 1000-5000. Moreover, 22.8% and 18.7% of the respondents earned annual income in the range of GMD5001 – 10,000 and 10,001 – 15,000 respectively. The findings indicated that only 8.2 % and 3.0% earned an annual income in the range of 15001 – 20,000 and 20,000 above respectively in the study area (Table 4).

The study revealed that 58.2% of the respondents had household size of five and above people. It also revealed that 24.4% and 10.0% of the respondents have a household size of four and three persons respectively. Only 7.3% has a household size of two people. With regards to number of people in a household, it plays a key role during crop cultivation. The size of the farm is usually determined by the number of helping hands available in a particular household.

Farming activities in the Central River Region

As part of the background characteristics, the type of crops cultivated and the livelihoods of the rice farmers were studied. The results revealed that 46.8% of respondents grow rice, 45.2% grow groundnut while 5.3% and 1.4% grow millet, maize or other crops respectively in the study area (Figure 16). The type of crops cultivated in the area, could probably be influenced by land suitability and more importantly the amount of rainfall received which mainly dictate the cropping system. Due to the agricultural potential in terms of arable land and vast agricultural activities, it is nicked name the “Food basket” of The Gambia.

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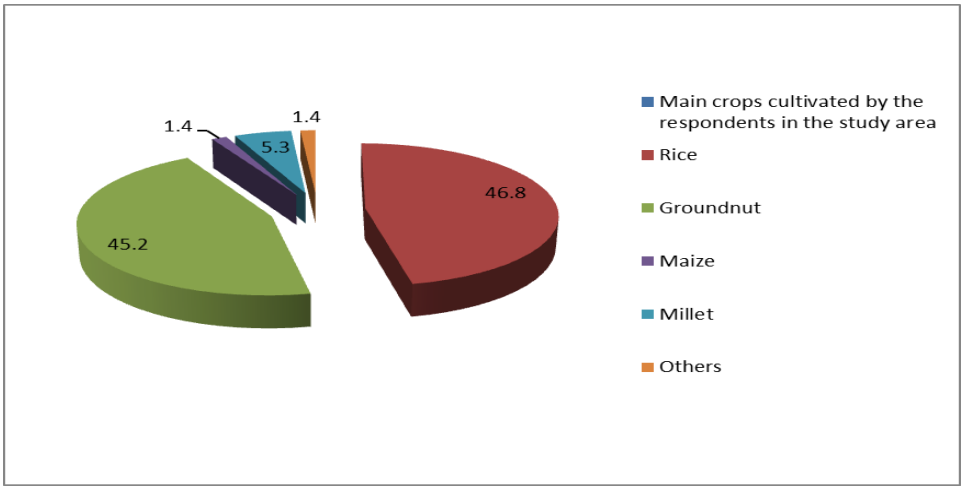

Figure 16: The main crops cultivated in the study area.
Source: Badgie, 2015.

Livelihoods in the Central River Region

A livelihood, according to Chambers and Conway (1991), comprises the capabilities, assets, income and activities required for a means of living. It is considered sustainable when it can cope with and recover from stresses and shocks as well as maintain or enhance its capabilities and assets both now and the future, while not undermining the natural resource base. The livelihoods of the respondents in the study area are indicated in Table 4.

The results revealed that 85.6% of respondents were actively involved in farming activities as their main sources of living while 14.4% considered farming as a secondary source of living in the study area (Table 4). On the type of farmlands, 43.8% of the respondents engaged in communal farming, 49.3% were individual farmers while 6.8% rented farms for their farming activities.

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Table 4: Livelihoods of Respondents in the study area

Category of Respondents	Frequency	Percentage
Actively in farming activities	375	85.6
Not active in farming activities	63	14.4
Total	**438**	**100.0**
Type of farmland		
Communal	192	43.8
Individual	216	49.3
Rented	30	6.8
Total	**438**	**100.0**
Change of Crops in past years		
Farmers who change crops	390	89.0
Farmers who do not change crops	48	11.0
Total	**438**	**100.0**
Reasons for change of crops		
Short rainfall duration	259	59.0
Drought	48	11.0
Low soil fertility	122	27.9
Pest & Disease	9	2.1
Total	**438**	**100.0**
Sources of energy needs		
National grid	22	5.0
Kerosene	60	13.6
Fuel wood	300	68.6
Solar	56	12.8
Total	**438**	**100.0**

Source: Badgie, 2015

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Furthermore, the results indicated that 89.0% of the respondents' change the crops over the years while 11% admitted that they stick to the crops they were using over the years. The reasons given for change of crops showed that 59.0% of respondents change the crops due to the short rain duration experienced over the years, while 27.9% asserted drought as the principal reason for the crop change. In addition, 11.0% stated low soil fertility, while 2.1% mentioned pests and diseases as the reasons for crop change. This findings support the earlier WAAPP1C (2012) study report which discovered that some of the predicament of farmers in the region are not only climate related but soil fertility issues and prevalence of pests and diseases.

The results further showed that 68.6% of the farmers derived their energy needs mainly from fuelwood, 13.6% from kerosene, while 12.8% and 5.0% derived from solar and the national grid respectively. The use of fuelwood was a major concern for both the region and the nation at large. This was on the premise that most of the vegetation are being cleared for domestic energy needs (firewood, charcoal), and this will invariably affect the natural balance of addressing climate change over the long term in the country.

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Perception and Knowledge of Climate Variability and Change from the Rice farmers' perspective in Central River Region (CRR)

In addressing objective one of this study, which was to assess rice farmers' perceptions of climate change and variability and their implications on rice production and livelihoods, the farmers were asked to give their general perspective about climate variability and change and its impacts on their livelihoods and crop production. Perception according to Taylor and Brown (1988) refers to a range of judgements, beliefs and attitudes from which people translate sensory impressions into a coherent and unified view of the situation or the world around them. The results on the perception of climate change and variability are presented in Table 5.

Table 5: Perception of Climate Change and Variability in CRR

Category of Respondents		Frequency	Percentage
Knowledge of Climate Change		352	80.4
No Knowledge of Climate Change		86	19.6
	Total	**438**	**100.0**
Observe change in rainfall pattern		431	98.4
Not observed change in rainfall		7	1.6
	Total	**438**	**100.0**
High Temperatures		285	65.1
Moderate Temperatures		114	26.0
Normal Temperatures		39	8.9
	Total	**438**	**100.0**

Source: Badgie, 2015.

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Results obtained from a focus group discussion in addition detailed out the communities' perceptions of climate variability and change, implications associated on rice production and livelihoods (Table 6).

Table 6: Focus Group Discussion Consensus on climate change and variability issues as perceived communities in CRR

Observed changes	Number of FGDs (n=58)	Percentage
High temperature	58	100
Less or erratic rainfall	58	100
Floods increase on farms	51	87.9
Late start of Rains	49	84.5
Less crops yield	44	75.9
More winds before rains	33	56.9
Land degradation or soil lost	21	36.2

Source: Badgie, 2015

The findings (Table 6) indicated that all the focus group (n=58) experienced changes in climate and weather changes with respect to increasing temperatures and erratic rainfall over the past years. This finding is similar to that of Fosu-Mensah, Vlek and MacCarthy (2012), who reported that 92% of respondents perceived increases in temperature, while 87% perceived decrease in rainfall over the years in Sekyedamase District of the Ashanti Region of Ghana.

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The results further indicated that a another sizeable number (n=51) of the groups agreed that there exist significant changes over the past two to three decades in occasional flash floods increase within their localities the region and the country as whole. This results is in agreement with earlier findings by Touray (2009) and IRRI (2013) who reported that submergence of crops due to extreme weather such as flash floods leads to several cultivated farmlands being flooded or washed away by run off in The Gambia and losses up to 4 million tons of rice in Bangladesh and India Another greater number (n=49) the focus groups indicated that they experienced late onset of rains in their areas. In addition, substantial number (n=44) of the focus group concluded that crop yields are low as result of the changes in climate change and variability. Another (n=33) of the focus group agreed and indicated they experienced strong winds before the rains. Relatively lower number of the focus group (n=21) indicated that they have experienced serious land degradation particularly soil erosion over the past two decades in their localities.

The results further established that most of the rice farmer in study area realized the fact that there exist drastic changes in the climate in terms of rainfall and temperature variation in their locality over the years and this could be linked to greater extent the implications faced in their farming activities.

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Climate Change and Variabilty Implications in Central River Region (CRR)

The results of the focus groups in the study area outlined the impacts of climate change and weather variability as depicted in Table 7.

Table 7: Perceived Impacts of Climate Change and Variability by the FGDs in CRR

Perceived Impacts	Number of FGDs (n=58)	Percentage
Increase migrations	57	98.3
Reduction in Crop	54	93.3
Food insecurity	54	93.3
Affects crop production	41	70.7
Low soil fertility	40	68.9
Affect livestock production	40	68.9
Less plants and wild animals	39	67.2
Malnutrition issues	28	48.3
Diseases related issues	20	34.5
Salt water intrusion issues	15	25.9
Increase drought	5	8.6

Source: Badgie, 2015

The results from the focus groups (Table 7) showed that 98.3% (n=57) of the rice growing communities linked impacts of climate change and weather variation with increase migration within and outside the country of able-bodied men and women from their localities.

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Furthermore, 93.1% (n=54) concluded that and associated it with reduction of crop yields and less food in household. In addition, 70.7% (n=41) of the focus groups agreed that it affected crop production while 68.9% (n=40) experienced lost in livestock production and soil fertility due to weather variability and climate changes.

Other issues of relevance highlighted by the communities over the past two decades includes; a decreasing fauna and flora 67.2% (n=39)), increase in malnutrition 48.3% (n=28)), diseases 34.5% (n=20)), salt water intrusion 25.9% (n=15)), and drought 8.6% (n=5)) which they associated with weather variability and climate change.

The study findings showed that rice farming communities through the FGDs, to a certain extent, attributed the challenges they faced as a direct result of climate change and variability. The communities reported that they experience a sharp reduction in youth population in the villages, low crop yields, household food insecurity, poor soils, reduction in livestock population and drastic reduction in fauna and flora within the locality. As simply put in Mandika local dialect "*Chosso Wullah Alhawwah lafalingfalingno Woyee Senelalu Mantoora Baakey"* (FGD 54). Literally means, the changes in weather has brought sufferings to the farmers. The results support the earlier findings of Njie (2006) and Njie *et al*. (2009) that discovered low crop yields, youth migration and loss of livestock as a major concern of climate and weather variability in The Gambia. This could lead to household food insecurity and low production at farm level These invariably according to the rice farmers have affected negatively on the fabric of their existence and household sustenance in terms of available food and income.

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Socio-economic Impacts of Climate Change and Variability in **Central River Region**

Socio-economic impacts of climate change according to Parry, Rosenzweig, Iglesias, Livermore and Fischer (2004), reported that the rural communities tend to be more vulnerable than urban communities due to factors such as demography, occupations, income, education, poverty incidence, and reliance on government support.

The results (Table 8) established that, 100% (n=58) of the focus groups agreed that the climate change and variability have impacted negatively on their income earning, 87.9% (n=50) linked it to reduction in social events (weddings, naming ceremonies, circumcision) occurrence, 72.4% (n=42) agreed that the change to low food reserve for the households while 70.7% (n=41) of the focus groups concluded that the phenomenon led to increased household instability. In addition, 55.2% (n=32) of the focus groups indicated that the changed with increasing their poverty level, 15.5% (n=9) and 8.6% (n=5) respectively connected it with enhancement of conflict with herders and reduction in labour force at the local level.

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Table 8: Socio-economic Impacts of Climate Change and Variability in CRR

Perceived Impacts	Number of FGDs (n=58)	Percentage
Decreasing Income earnings	58	100
Reduction in social events	50	87.9
low food reserve for the households	42	72.4
Increased household instability	41	70.7
Increasing their poverty level	32	55.2
Enhancement of conflict with herders	9	15.5
Reduction in labour force	5	8.6

Source: Badgie, 2015

To further expound on the results, income from farming related activities play a critical role in the lives of these communities. Indeed, poor harvest invariably reduces the power to sell the produce, thus reducing their income levels significantly as well as enhancing household food insecurity at community level. In addition, income generated from the farming activities is very key in carrying out other social event such as christening of children, cultural festivities such as circumcision and wedding ceremonies. The frequent occurrences of social events or festivities are mainly determined by the previous farming season and more importantly a good harvest.

A lot of these social gathering events or activities are usually observed or performed after a good rainy season and mostly done during the trade season when incomes are generated from crop sales. However, these entrenched festivals within communities are dwindling considerably due to

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losses from farming activities which are associated with changes in climate experienced over the years.

Another salient point attributed to the impact of climate variability and change by the rice farming communities was increased in household instability. From a cultural perspective, a household is principally headed by a man and he has general control over key decision relating to feeding, clothing, sheltering and provision of other basic needs of the members of the household. These powers are usually unquestionable when the leader can maintain the needs of the household. However, though the communities have been faced with the gradual erosion of such authority due to their inability to meet those demands of household heads adequately at rural level, culminating in divorce of marriages and social tension within households. Additional issue of importance highlighted by communities was that climate change and variability had increased their poverty status hence less income was available to them resulting to hardship. It has also increased conflict with livestock owners and farmers in terms of grazing sites and cultivated fields due to inadequate pastures for the animals. These are serious conflicts which can lead to physical attacks, serious injuries and deaths. There were also issues of losing the youths through migration from the rural communities to either urban areas or outside the country seeking for better lives or greener pastures. This consequently impact negatively on farm labour requirement as only the elders are left to carry out crop production at the community level.

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Main Causes of Climate Change and Variability from the Perspectives of the FGDs in Central River Region

The findings (Table 9) indicated that 98.3% (n=57) of the focus group in the study area associated the cause of climate change and weather variability to bad farming or agricultural practices. Another 93.1% (n=54) of the focus groups concluded that deforestation contribute to the changes in climate. In addition, 82.2% (n=48) of the focus group agreed that bush burning or fires also has a role to play in climate change and weather variability in the study area. Interestingly, 67.2% (n=39) of the focus groups concluded that climate change and weather variability is caused by Allah (God Creation). Furthermore, another 48.3% (n=28) and 29.3% (n=17) agreed that smoke emissions from industries and cars and population increase can lead to climate change and weather variability respectively.

Table 9: Main Causes of Climate Change and Variability as perceived by the focus groups in CRR

Perceived Causes	Number of FGDs (n=58)	Percentage
Bad agricultural practices	57	98.3
Deforestation	54	93.1
Bush burning	48	82.2
God (Allah) Creation	39	67.2
Smoke emission (Industries, cars)	28	43.3
Population increase	17	29.3

Source: Badgie, 2015

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The results from the focus groups discussion attributed the principal causes of climate change and variability to bad agricultural practices in which large areas were being cleared over the years which led to low vegetation and subsequently less rainfall. The FGDs further made reference by lamenting that areas with good vegetation tend to receive more rain compared to areas with less vegetation. This is simply put in the local dialect (Mandika) and I quote. "*Yerrow aning samageyoo la kummaya, kamuntakoo nyeewoo ning mankuyeroow beeynyoye nyameng*" (FGD 32), literally translated as: The importance of trees and rainfall are just like fish and the mangroves swamps relationship

The current farming practices according to the rice farmers are impacting negatively on their ability to grow crops and gain meaningful livelihoods. In addition, commercialization of the forest products has led to increase demand of wood and other forest products. The invasion by commercial lugging took precedence over conservation and this resulted in declining forest cover thus reducing rainfall. This result supports the finding of the WRI, (2008) that discovered that poor agricultural activities play a negative role in enhancing climate change across the globe.

The FGDs as well attributed the cause of climate change and weather variability to God's (Allah) creation based on their faith or biblical orientation. For instance, a statement that kept coming up in discussion as stated in local dialect (Mandika) was "*Jong ngoloo Mendangkenneeyaataa, Feengofeng Mengketa Nying Donniyaa, Issaa long koo Allah laa kerro dorong Lemme*" (FGD 19), literally meaning "anything that happen to mankind whether good or bad is from the creator (God) and nothing else".

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Another aspect that the FGDs associated as causes to climate change and variability were the smoke emissions from industrial activities, cars and other locomotive engines. Furthermore, the communities also agreed that increasing population has also caused climate change hence from experience, areas that were virgin lands before were currently cleared for either increasing settlements need or for agricultural activities.

Local Knowledge of Climate Change and Variability from the Community Perspective in Central River Region (CRR)

Local knowledge refers to what local people know and do, and what they have known and done for generations. In other words, practices that evolved through trial and error and proved flexible enough to cope with change (Melchias, 2001). Johannes (1993) further referred to it as a unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area.

In addressing the objective two, which was to determine the local knowledge of the rice farmers' with respect to climate change and variability in the study area? , the rice farmers were asked kind of local knowledge are available and known to them on climate change and where do they get it. The results of these findings are shown in Table 10.

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Table 10: Ways on how Local Knowledge of Climate change and Variability are predicted in in CRR

Perceived Causes	Number of FGDs (n=58)	Percentage
Local trees and Shrubs	57	98.3
Creatures (birds, Worms, insects)	45	77.3
Non-living objects	22	37.9
No idea	1	1.7

Source: Badgie, 2015

The results (Table10) of the FGDs indicated that the rice farmers relates the issues of climate change and weather variability through several local indicators. The findings of the FGDs showed that almost all (98.3%; n=57) of the rice farmers do predict the nature of a particular seasons based on features exhibited by certain local trees or shrubs. Another 77.3% (n=45) predict climate and weather related issues through the behavoiur or presence of certain living creatures (birds, insects, worms) within their locality.

Climate change and variability could be predicted through the used non-living indicators such as orientation of stars, emergence of rainbows at the onset of the rains, unusual flooding of lowland fields before the rains begins in a season as agreed by FGDs 37.9% (n=22). The results demonstrated the importance of objects in predicting not only the onset of rains but whether it will be a successful farming season or not within a given community. In addition, 1.7% (n=1) of the FGDs indicated that they have no idea on local knowledge with respect to climate change and variability hence they viewed what ever change to be from God.

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Local Trees/shrubs used by Local Communities to Predict Climate Change and Variability

The local communities in CRR identified ten (10) local trees or shrubs whose characteristics served as local indicators for predicting the climate change and variabilty (Table 11).

Table 11: Type of Trees/shrubs with Characteristics used as Local weather indicators for Predictions in CRR

Type of Tree	FGDs (# =58)	% of #
Adansonia digitata (Baobab)	50	86.2
Lannea acida /macroptera	26	44.8
Maytenus senegalensis	22	37.9
Cordyla pinnata	22	37.9
Parkia Biglobosa	15	25.9
Saba senegalensis	11	18.9
Acacia faidherbia	9	15.5
Cola cordifolia	4	6.9
Mangifera indica (Mango)	1	1.7
Khaya senegalensis	1	1.7

Source: Badgie, 2015

Characteristics Observed from Local Trees/Shrubs and used as Local Indicators of Weather Variability and Change.

The local trees or shrubs within the communities play a significant role in determining the weather conditions and prediction of yields through exhibition of certain characteristics. The communities frequently used the features of local trees from generation to generation as local weather indicators.

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These local indicators could be observed from different plants within their environment and they vary from one community to another. These are done through repeated observations of signs from the plant to predict the onset of rains and prospect of the season in terms of crop yields. It is salient to note that number per group has nothing to do with order of importance but each community has peculiar local climate indicator widely used within that locality (Figure 17).

Figure 17: A picture of Baobab trees. Source: Badgie, 2015

The baobab tree known local dialect as *sitoo* was considered a very important tree in almost all the rice farming communities consulted during the study as 86.2% (n=50) used it as local weather indicator. The communities observed the following local signs or indicators from the baobab tree to predict weather and further use to plan for the farming season:

1. *Sprouting of the leaves*: The local communities determine the onset of rains observing the sprouting of the baobab leaves which always occur prior to the rains onset in particular season. It was observed over time that when the

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new sprouting leaves on the baobab tree almost cover a vulture that anchored on the branches, it is an indication that rain will commence within a week.

2. *The Pattern of flowering and fruiting*: This is another indicator use to predict the length of rainy season and the kind of crops that could perform well in that season. Prediction of flowering and fruiting According to farmers r observations, when the baobab trees start flowering and fruiting from the base branches upwards, this is an indication that the rainy season will not be long enough and the advice is to plant early maturing varieties to achieve good yields. Further to that, when the fruiting starts from the top branches of the baobab , this is an indication that the rainy season will be long and can support long duration varieties such as sorghum, late millet and other rice varieties for that season.

3. *Uniform flowering*: This is another local weather indicator used to predict the cropping seasons by the community. The local communities viewed the uniform fruiting of the baobab tree as a complete rainy season that could be successful as it can support all kinds of crops and the rainfall could be adequate for their life cycle. However, the uniform fruiting of the baobab seldom achieved, considering the current situation of the climate change and variation being experienced. The study finding is in agreement with the findings of Slegers (2008) who discovered that when the flowers of a baobab tree stay longer, it predicts a good rain season in Kondoa district and Asfachew in Tanzania and Ethiopia.

The Lannea Lannea acida /macroptera shrubs locally known as *Singola* were another important indicators used by the farming communities to predict climate variability and change. It Lannea has two species; acida species

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identified with dark back (Figure 18) and the macroptera species identified with greyish bark. The results showed (Table 11) that 44.8% (n=26) of the FGDs concluded that the fruiting of the lamea shrub is used to predict the onset of the rains and crop performance in a particular season. In a season when lannea shrubs produce a lot of fruits prior to the onset of the rainy season, this is an indication that the season is predicted to be good in terms of rainfall sufficiency and crop performance (good yields). Another important that could be predicted was the type of grain crops that could perform better when cultivated in that particular season by observing the nature of the fruiting of the shrub. In addition, local communities also stated that the bark and phloem (inner bark) is important as is used as a local herb to treat diarrhea and anaemic patients when soaked in water or boiled and taken as a solution respectively.

Figure 18: A Photo of Lannea acida (dark bark) Plant. Source: Badgie, 2015

The results showed that 37.9% (n=22) of the FGDs in the study area used Maytenus senegalensis trees as local climate variation indicators for several years. The local communities' observations are made through the nature of fruit production before the onset of the rains.

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In a year when the communities observed these shrubs produce a lot of fruits prior to the rainy season, the year could be predicted to be potentially good as the rainfall would be sustained for crop production.

The Cordyla pinnata tree was also an important local weather indicator for some of the rice farming communities consulted as they indicated that 37.9% (n=22) of FGDs used it to predict rain and season performance. The people use the sprouting of the leaves to predict the onset of the rains and also the fruiting pattern to forecast, length and success of the season. When the sprouting leaves of the *tree* covers a dove anchoring in it, it is an indication of the onset of rains. Moreover, in year where the communities observed the trees produce a lot of fruits prior to the rainy season, this is a prediction that the season ahead has prospects and potential good crop performance in terms of yields.

The finding showed that 25.9% (n=15) used *Parkia biglobosa* (Figure 19) as another local weather indicator by the communities to predict weather through the pattern of fruiting prior to the rainy season. In a particular year when the community observed before the onset of rains when this tree produce a lot of fruits, the season ahead is predicted to be potential good. However, in a season when the tree fruit production is observed to be low, then the subsequent rainy season, the indication are the rainfall would not be adequate or good as well as crop performance and yields. The observations and predictions also allows the local communities to diversify into other alternative source of income such as hired labor or cultivate crops that could be suitable.

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Figure 19: A photo of Parkia biglobosa tree. Source: Badgie, 2015

The results indicated that 18.9% (n=11) of the communities identified *Saba senegalensis*, a creeping plant known locally as Kabaa as local weather indicator. These observations are done through the flowing pattern of the plant to predict the nature of the rain and season performance. The communities reported that prior to the onset of the rains, when the plant produce a lot of flowers; the prediction from the local communities is that the upcoming rain season would be good as there will be enough water for the plants.

The Acacia faidherbia shrub was another important local weather indicator for some of the rice farming communities consulted. The results indicated that 15.5% (n=9) of the local communities used the shrubs to predict the length of the raining season and crop performance. It was agreed that the community predict the onset of the rains and the duration through the fruiting nature of the acacia. In a season when the community observed the acacia shrub to produce fruits heavily to a point the branches rest on the ground, the coming raining season was usually predicted to be potentially good as there will be enough rain and also prospect for good harvest.

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Another important local climate variability indicator for some of the rice farming communities consulted was the Cola cordifolia tree. The findings showed that 6.9% (n=4) of the communities used it to predict their weather condition for rainy season performance. The observation on this tree is made through the flowering and fruiting nature of the plant. In a season when the tree produce a lot flowers and fruits, the community prediction in that particular year could be potentially good based on the favorable signs as this also invariable suggest prospects of good crop yields.

The mango tree (*Mangifera indica*) is mainly known in the Gambia for it fruits use. However, FGD results indicated that 1.7% (n=1) of the community also used the mango tree as an important local climate variability indicator for the predicting onset of rains. The sprouting of the leaves is used by the community to predict the onset of rains and this helps them to prepare their farmlands on time before planting start.

The khaya tree (*Khaya Senegalensis*) is widely known in The Gambia for it commercial values in terms of quality timber that can be obtained from it as well as some medical value through the use of it bark. Besides that the study findings indicated that 1.7% (n=1) of the rice farming communities used the khaya tree to predict and determined the start of the rains through its leaf production prior to the onset of rain. The spouting of the leaves helped to predict the onset of the rains thus creating time for land preparation for the upcoming farming seasons.

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Insects and Annelids used by Local Communities to Predict the Climate Variability in Central River Region

Insects, earthworm and birds were found to play important roles for the rice farming communities in serving as local weather indicators (Table 12).

Table 12: Local climate variability indicators Observed from Insects and earthworms in CRR

Observations	# of FGDs (N=58)	Percentages
Ants removal of grains at the start of rains	30	51.7
Plenty of Mosquitoes before the rainy season	12	20.7
Red velvet mite (Trombidiformes) appears	8	13.8
Emergency of earthworm in a seasons	2	3.4

Source: Badgie, 2015

From the results (Table12), 51.7% (n=30) of the FGDs indicated that rice farmers used life behaviour of ants (Figure 20) to predict climate and weather conditions for the coming season .

According to the groups, when ants are seen removing the stored grains from their holes prior to the onset of the rains. The grains that were removed would be predicted to be successful for that particularly season when planted. For instance in a particular season, if the ants remove more of coarse grain such as rice, millet, sorghum and maize, the communities prediction would be for these crops to be cultivated in that particular season as there is high hope for good crop yields.

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Figure 20: A photo of grains grains removed from holes by Ants. Source: Badgie, 2015.

Mosquitoes in The Gambia and globally are generally known to be pests and a medium for the malaria disease transmission. However, they also serve as local climate variability indictor for certain communities particularly those living around river banks and swamp areas. From the results 20.7% (n=12) of FGDs concord that in a particular year, when the community experience high prevalence of mosquitoes in the area prior to the rains, this indicate a clear prediction that there will be enough rainfall for the season ahead but cannot determine whether the season would be good enough or not.

The red velvet mite (Figure 21) served as local climate variability indictors for certain communities consulted during the study. The results indicated that 13.8% (n=8) of the communities said that in a particular year, the emergence of the red insects during the first week of the rainy season, this give an indication of a good season in terms of water availability and crop performance. However, they were quick to mention that this kind of insect is

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rarely seen could not determine when they last observed the appearance of the red insects in their locality.

Figure 21: A photo of Red Velvet mite Insects. Source: The Plant Protection Services, The Gambia, 2016

The earthworm (*Lumbrucis terrestris*) (Figure 22) are consider as farmers' friend play critical roles in enhancing soil nutrients in terms of improvement of soil structure and pores for air and water percolation within the soil. The findings showed that 3.7% (n=2) of the communities predict a particular year raining season performance by observations of the emergence of numerous earthworms at the first week of rains. The local communities concord that in a season where the plenty earthworms emerged in season that season would be predicted to be a good terms of water availability and crop performance.

Figure 22: A photo of Earthworm. Source: Plant Protection Services, The Gambia, 2016

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Birds and Amphibians

Certain local birds and amphibians play key roles in serving as local weather indicators for the rice farming communities in some communities in the study area (Table 13).

Table 13: Birds and Amphibians with characteristics used by local communities as weather Indicator in CRR

Birds/Amphibians	# of FGDs (N=58)	Percentages
Weaver birds (placement of nets)	19	32.8
Senegal Coucal (running after another)	12	20.7
Frogs (high emergence in a season)	7	12.1
Hawks (making noise)	4	6.9

Source: Badgie, 2015

The weaver bird (Figure 23) is generally known for being a pest of cereals. The results of the study demonstrated that 32.8% (n=19) of the rice farming communities in CRR, stated the importance of this bird as a local climate variability indicator for the onset of rains and success of that particular season. According to the result of the focus groups, the changing of the colours by the weaver birds to complete yellow is an indication of the onset of the rainy season. In addition, the placement of the nests predicts the duration of the season and what types of crops could perform well in that season. The local communities indicated that when the weaver birds nest are placed around the base of the trees, the prediction is that the rains will be short and therefore, early maturing varieties are suggested for that season. Alternatively, when the nests are place far up the branches of the trees, this implied that the rains will be long and could sustain late maturing crops in that particular rainy season.

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Figure 23: Photos of Weaver bird and nests on the Palm trees. Source: Badgie, 2015

Another important bird that served as a local climate variability indicator to predict the situation of the incoming farming season for the rice local farming communities was the Senegal Coucal (Figure 24) locally known as “Goutot”. The communities according to the findings depicted that 20.7% (n=12) that whenever, the the “Goutot” bird are observed chasing one another, it is predicted that the rainy season is about to start and could be a good season as well. The used of the “Goutot” according to them have been a local knowledge that were inherited from their great grandparents and still served as an important indicator for prediction of rainfall and the nature of the season for crop production.

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Figure 24: A photo of Senegal Coucal bird. Source: Badgie, 2015.

Frogs and toads also serve as an important local climate variability indicator for some local communities in CRR. The FGDs result showed that 12.1% (n=7) there is a consensus on the emergency of plenty toads at the beginning the rainy season to predict enough rains in that particular season and good crop performance.

The Hawk (Figure 25) according the local communities make different sounds to communicate between each other such as females to the males for food during the nesting period and also a distinctive hoarse screech often described as a scream. The hawk is another important bird that served as a local climate variability indicator to predict the situation of the incoming farming season for the local farming communities though known for being a pest of local chicks. The study findings depicted that 6.9% (n=4) of the focus groups consciously agreed that whenever the hawks are heard making sounds demonstrated as "*Dookwo, Dookwo*" at the beginning of the rains, it predicted that the rain season is about to start

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Figure 25: A Photo of Hawk. Source: Sullivan, undated photo

Non-living objects used by local communities to predict the weather

Other sources of local climate indicators observed by communities besides living organisms were natural signs (Table 14).

Table 14: Non-living objects with characteristic used by Local communities to predict weather conditions

Non-living objects	Number of FGDs (n=58)	Percentage
Stars	21	36.2
Unusual floods in rice field before the rains	10	17.2
Rainbow	7	12.1
Cold wind blowing at the start of season	3	5.2

Source: Badgie, 2015

The research findings indicated that 36.2% (n=21) of the local communities affirmed that at the beginning of the rainy season, they could predict the nature of the climatic factors such as rainfall in terms of good or bad through alignment of stars. The communities observed that when seven (7) stars are aligned together in a straight line within the first week of the raining season, this gave a prediction that the season could be successful in

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terms of crop performance because there would be enough rains. On the other hand, when three stars are seen aligned together on a straight line within the week of the rains, that particular cropping season will not be good enough in terms adequate rainfall and crop performance**.**

Unusual flooding of lowland rice fields also served as a local weather indicator for some of the focus groups in the CRR of The Gambia. From the study, 17.2% (n=10) of the FGs indicated that unusual flooding of the rice fields before the rains are indication of predicted good raining season. The communities based on experience observed and agreed that normal flooding has a particular bench mark or limit. When this normal bench mark is exceeded in a particular rainy season, the prediction is that there will be sustained rain to support crop production in that locality. This local weather indicator is unique to communities around the rivers banks with high tidal influence in their rice fields. This result is in agreement with the findings of Slegers (2008) who discovered that the flooding at the onset of the rain season, predicts a good rainfall season in Kondoa district and Asfachew in Tanzania and Ethiopia.

The rainbow is another local weather indicator for used by the rice farmers in CRR. The study result showed that 12.1% (n=7) in some of the rice farming communities in the study area, used rainbow emergence as local weather indicator. According to the focus groups, local people could predict the performance of the preceding raining season based on the direction of the emerging rainbow prior to the onset of the rains.

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For instance, it has been observed and agreed that they can predict the duration and success of the season through observing the direction of the emerging rainbow at the beginning of the season.

According to the focus groups, whenever they observed the rainbow emerges from the south towards the north direction, the upcoming season is predicted to be good in terms of rainfall adequacy and crop performance. On the other hand, if the rainbow emerges from the north towards the south direction, that particular incoming season is predicted not to be good in terms of adequate rainfall to support crop production in that locality.

The blowing of the cold wind at the onset of the raining season is another local weather indicator for some of the rice focus groups. The results indicated that 5.2% (n=3) of the rice farmers in the study area believed and agreed that whenever the raining season begins with cold wind blowing, it is an indication of insufficient rainfall for crop production in that particular raining season.

Adaptation Strategies to Alleviate Adverse Impacts of Climate Change and Variability in Central River Region

Adaptation strategies are needed at all levels from the local, regional, national and also the international levels due to the severe implications of climate change and variability impacts. The objective three of this study was to assess the adaptation strategies of the rice farmers in response to climate variability and change implications in the CRR.

In this section, the communities discussion focus on the measures used to adapt or cope with the perceived implications of climate variability and

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change in the area. According to the communities, several measures have been used by rice farmers in area to improve their coping and adaptation capacities to climate change and variability. The results (Table 15) indicated that the focus groups employed local weather indicators and prediction to adapt to climate change and weather variation. The results further showed that the capacity to cope and adapt also varies across one focus group to another, economic status and available technologies within the region. The vital information on predictions according to the groups supported them in adapting to weather and climate related variation to reduce its negative impacts on crop production and livelihoods. In addition, the local weather indicators according to the focus groups are used by the rice farmers to raise alarm on the potential crop failures for a particular season and to solicit or seek support from government and other national and international agencies to alleviate the perceived problems.

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Table 15: Rice Farmers adaptations measures to climate change and variability in CRR

Strategies	Number of FGDs (n=58)	Percent age
Use of early maturing varieties	54	93.1
Sale of livestock as alternatives	54	93.1
Crop production diversification	37	63.8
Remittance from Travelers	32	55.2
Good resource management (reserve keeping)	29	50
Government or NGO's Support	28	48.2
Garden production	26	44.8
Use of unskilled or hired labor	26	44.8
Skill work (Masonry. Carpentry. Fishing)	14	24.1
Petty trading	12	20.7
Lowland rice production	9	15.5
Orchard (Fruit trees) development	2	3.4

Source: Badgie, 2015

The findings (Table15) of the focus group indicated that rice farmers in the study area adaptation measures and key among these strategies were the use of early maturing crop varieties such as *NERICA* which a new rice variety developed by Africa Rice. The study revealed that 93.1% (n=54) of the focus groups used crops with short duration considering the short spell of the raining seasons. This is particularly very relevant for upland rice cultivation which completely depends on rainfall. This was pivotal with the fact that rice farmers that are far away from water sheds usually face bigger challenges in terms of water availability compared to those around water sheds or river banks.

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The finding disagreed with the discovery by Westengen and Brysting (2014) in Semi-arid Zone of Tanzania which reported that growing of local crop varieties of drought tolerance with longer cycle were preferred by farmers' than growing improved varieties with short growing cycle because the households' farmers distinguish the benefits between drought-tolerance and drought-avoidance traits to adapt to climate change stresses. However, the research findings were in agreement with the result of Huang et al. (2014) and Fosu-Mensah et al. (2012) who discovered that farmers respond to extreme weather events by increasing crop diversification in China and Sekyedumase district of Ghana.

Livestock sale according to focus group have been used by the rice farmers in the study area as adaptation strategy to reduce the adverse effects of climate change and variation. The findings indicated that, 93.1% (n=54) of the communities sell their livestock to compensate for losses resulting from seasons crop failure due to climate related adverse effects. The income generated through livestock sale is used to buy households needs particularly food stuff and other social needs within a household. Another adaptation strategy used by rice farmers in the study area according to the focus group is the crop production diversification. In this, 63.8% (n=37) of the group agreed that they cultivate different crop in a planting season to limit total loss as a result of adverse weather and climate impacts. Despite the relatively small farm sizes, the practice usually pay dividend to communities in terms of avoiding total crop failures. The type of crops to be cultivated in a particular season is gained from the local knowledge or signs prior to the onset of the rains and helped farmers to follow that pattern of cultivation in a season.

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The focus groups in addressing negative effects of climate variability and change indicated that they also used another adaptation measure which was largely relying on remittances from family members in and out of the country. The results indicated a 55.2% (n=32) of the focus group agreed that they benefited from remittances and it played a key role in alleviating challenges of crop failures due to climate related negative effects. In general, the remittances are in two folds. Remittances received from relatives and children who are within the country but are working in other urban settlements and usually send out money for family use periodically or from those family members or children who in foreign countries supporting their families back home.

The decision for youths to migrate both within and outside the country from the rural area is influence by the relatively poor yields from farming activities, inadequate amenities at the rural level, lack of job opportunities and assumptions that things are always better outside home. Consequently, it has become imperative that households encourage their children to migrate in search of greener pastures to safeguard the family in future when they succeed. This invariably led to most communities being inhabited by mainly the elderly men, women and little children to work on the farms.

Another important adaptation measure alluded to by the communities was the proper resource management (reserve keeping). The results showed that 50% (n=29) of the focus indicated that they practice good resource management in terms of judicious use of farm produce.

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The communities have to sacrifices or limit other social festivals such as traditional wedding, circumcision, lavish naming ceremonies that would require large gatherings and consumed a lot of food and resources. This, to them, was another adaptation measure that is meant to save limited food produce for only household use and has worked well over the past years.

The communities also indicated that there were other measures that assist them to adapt or cope with climate change and variability adverse effects These strategies included support from government and NGOs (48.2%; n=28), gardening (vegetable) (44.8%; n=26), use of unskilled or hired labour (44.8%; n=26), skilled work (carpentry, masonry, fishing) (24.1%; n=14), petty trading (20.7%; n=12), lowland rice production (15.5%; n=9), and orchard development (3.4%; n=2).

To further elaborate on the aforementioned strategies, the communities agreed that support from government and NGOs when climate change and variability induced challenges such as inadequate rainfall or drought help them to alleviate crop losses and sufferings. These kind of interventions are not frequent and mostly do not arrived at the right time when needed due to logistics involved and the political situation. They include food supplies, planting seeds, fertilizers, chemicals and clothing material. The other important strategy employed by the communities was gardening or vegetable production. These are done to limit total losses from field crops as a result of climate related impacts. Produce from the gardens such as vegetables are sold at weekly market for household income as well as consumed at household level to supplement diets.

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Use of unskilled or hired labour is another measure applied by some the communities to address climate change and variability adverse effects or stresses. Some communities indicated that they usually engaged in unskilled or hired labour to earn income particularly during the dry season to support their households. When there are crop failures, alternative must be sought to address or reduce the problem because they have to survive and it means doing other physical work to earn money. The local community's members in the region engaged in petty trading to alleviate the negative effects of climate change and variability. The results also have indicated that the rice farmers in the study area undertake petty trading to supplement their income (Table 15). This is usually done through visiting weekly markets locally called "Lumos" to sell merchandise and this, to them supports them immensely in supplementing loss in income from failed farms.

The lowland rice production according to some communities was another measure some farmers in the region adopt to address the climate change related impacts. The results indicated that 15.5% of the communities from predominantly upland rice cultivating areas moved to other areas to rented rice fields to cultivate around the river banks with of tidal irrigation infrastructure. This is usually expensive and mostly generates conflicts as payment is normally done after harvest and in situation when the farm yields becomes poor.

Orchard development is another strategy used by farmers to adapt to climate change in some of the communities. The findings indicated that the rice farmers also engaged in orchard development as strategies to reduce losses from the usual crop production activities. These involved planting of

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cashew plants, mangoes, bananas and oranges and other fruit trees which usually earned them enough money to sustain their household needs.

Constraints to the use of adaptation measures to climate change and weather variability as perceived by the communities

Under this section, the focus groups were asked about the limitation faced in adapting (Table16) to climate change and variability related issues in the study area.

Table 16: Constraints to the implementation of adaptation strategies in CRR

Constraints	Number of FGD(n=58)	Percentage
Low knowledge of adaptation strategies	58	100
Less support government	50	86.2
Reluctance to accept the strategies	42	72.4
Refusal of climate change (God destine)	22	37.9

Source: Author's Fieldwork, 2015

The results of the focus group (Table16) indicated that all the groups (100%; n=58) highlighted the inadequate knowledge or information on the adaptation measures that usually hampers their ability to adapt to climate change related impacts. This result supports the findings of Antwi-Agyei et al. (2015) who discovered that lack of information on climate change and variability characteristics posed a barrier to successful adaptation process in Northeast Ghana. Furthermore, other communities during FGDs (86.2%; n=50) indicated that inadequate support from government on climate change related challenges impedes ability to comprehensively address climate change

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challenges in the region. Interestingly, substantial number of the communities (72.4%; n=42) stated that farmers' own unwillingness to accept adaption measures affects the prospects of addressing the climate change related problems in the area.

Another aspect that limit the use of adaptation measure in the study area according to the focus groups was the refusal to accept climate change issues as they based the phenomenon on God / Allah creation (37.9%; n= 32). The argument was premised in the ground that the situation is from God and no one can do anything to address it, except Allah or God himself. The result is in agreement with a study by Patt and Schroter (2008) and Meze-Hausken (2004) who found that farmers considered that God and Ancestors were the main cause of observed changes in climate change and variability in Mozambique and Northern Ethiopia. Furthermore, the findings, support earlier discoveries by Cuni-Sanchez et al., (2012), and Ajibade and Shokemi (2003) of Benin Republic and Kwara State of Nigeria who found that farmers approach to climate concerns were governed by the notion that climate is a divine phenomenon that they were not in control.

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Assessing the Differences between the Background Characteristic of respondents (education, age, income) and the Adoption of Adaptation Measures, Knowledge of Climate Change and use of Adaptation Measures in CRR

In addressing objective four of the study, an aspect of the study was to determine the differences between background characteristics of respondents such as education level and the adoption of adaptation measures, education and knowledge of climate change, income level and use of adaptation measure, and age and knowledge of climate change and variability in CRR. The background characteristics of respondents in the area are an important measure to assess on how they related to knowledge and the adoption of adaptation measures on climate change and variability related implications. Chi-square test was used to analyse the data collected in order to determine whether there are differences between the responses among rice farmers were significant or not. Differences were considered significant at $p < 0.05$. The findings are presented in the following sections.

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The assessing the relationship between Education levels of respondents and the Adoption of climate Change Adaptation Strategies in CRR

The differences between the education levels of respondents and adoption of adaptation strategies in the study area are presented in Table 17.

Table 17: Cross - Tabulation between education levels of respondents and adoption of climate change adaptation strategies in CRR

Education and adoption of strategies			n=438
P-Value ≤ 0.05			
	YES	**NO**	**Total**
Very Important	95%	5.0%	100.0
Important	89.6%	10.4%	100.0
Less important	66.7%	33.3%	100.0
Not important	50.0%	50.0%	100.0
Total	**75.3%**	**24.7%**	**100.0**

Pearson Chi – square =12.878 (Sig. = 0.005); Source: Badgie, 2015

The findings indicated a significant difference exist between education level of respondents and adoption of adaptation strategies in CRR. The differences between education level and adoption of adaptation strategies proved to be statistically significant (Pearson Chi-square significance = 0.005). Most of the respondents considered an educated society very important to address climate change related challenges. In contrast, the percentage of the respondents considering education level and adoption of adaptation measures not important is very low. The findings is in support of the result of Bagagnan (2015) who discovered that farmers are more likely to adopt to climate change adaptation strategies when they are fully educated about them and aware of the available strategies.

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The assessing the relationship between Education levels of respondents and Knowledge of Climate Change and variability in CRR

The findings revealed that there is a significant difference between educational levels of respondents and knowledge of climate change and variability among respondents in CRR (Table 18). The difference between the knowledge of climate change and educational level of respondents at various levels demonstrated significant differences (Pearson Chi – square = 0.001). This implied that rice farmers, with no education who knew about the climate change related issues was low (22.9%) compared to those who attained a certain level of education ranging from primary, secondary and college or university level 67.1% and 75.4% respectively.

Table 18: Cross-Tabulation between education level and knowledge of climate change among the respondents in CRR

	Educational level and Knowledge of climate change (n=438)		
P-Value ≤ 0.05			
	Yes	**No**	**Total**
No Education	22.9%	77.1	100.0
Primary & Secondary	67.1%	32.9	100.0
College & University	95.4%	4.6	100.0
Total	**61.8%**	**38.2**	**100.0**

Pearson Chi – square = 14.375 (Sig. = 0.001); Source: Badgie, 2015

The findings confirm the results of Cole (2006) on the Vulnerability and adaptation assessment of the agricultural sector of The Gambia to climate change who reported that the more educated a society is, the likely is to know more about climate change and variability related issues.

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Assessing the relationship between Income levels and Application of Climate Change Adaptation Strategies in CRR

The results (Table 19) indicated that no significant difference existed y between the respondents' income levels and the application of climate change adaptation measures (Pearson Chi – square = .785). Interestingly enough, the percentage shows increase of non-application of adaptation measures as the income levels increase in CRR. This could possibly be attributed to either low awareness on available climate change adaptation measures or the cost on the available adaptation measures are beyond the respondent's means and the religions belief that climate change phenomenon is Allah's (God) creation and only God can address it.

Table 19: Cross- Tabulation between Income Level and applying climate change adaptation strategies in CRR

Income level and CC Adaptation Application			**(n= 438)**
P-Value ≤ 0.05			
	Yes	No	Total
Income level			
1,000-5,000	7.3%	92.7%	100.0%
5,001- 10,000	3.8%	92.2%	100.0%
10,001- 15000	5.7%	94.3%	100.0%
15,001 – 20000	4.0%	96.0%	100.0%
20,001 and above	4.0%	96.0%	100.0%
Total	**6.1%**	**93.9**	**100.0%**

Pearson Chi – square = .785 (Sig. P = .946). Source: Badgie, 2015

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Assessing the relationship between Age of Respondents and Knowledge of Climate Change and Variability in CRR

The results on the relationship between age of respondents and knowledge of climate change and variability showed no significant differences (P>0.005) (Table 20). This finding implies that age has no influence on the farmers' knowledge of climate change and variability in the study area. This could possibly be attributed to low literacy and awareness levels of climate change and variability related issues among respondents' in the study area.

Table 20: The cross- tabulation between age and knowledge of climate change and variability of respondents in CRR

Temperature Variability and Age (n=438) P-Value ≤ 0.05				
	15-30	**31-54**	**55&Above**	**Total**
Very Hot	15.9%	40.4%	43.7%	100.0%
Hot	18.4%	38.7%	42.9%	100.0%
No Idea	47.7%	24.3%	32%	100.0%
Total	**25.6%**	**34.4%**	**39.5%**	**100.0%**

Pearson Chi – square = 9.605 (Sig. P = .651; Source: Badgie, 2015

The findings provided evidence to reject the null hypothesis (H_o) which stated that there is no significance difference between background characteristics of respondents (age, education level, income) and adoption of adaptation strategies, knowledge of climate change and variability among rice farmers in the CRR. The study results are in accordance with the findings of Bagagnan (2015) who found that farmers are more likely to adopt to climate change adaptation measures when educated about the measures and aware of the available strategies.

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Available Support Systems to Alleviate Climate Change and Variability Implications from Rice Farmers' Perspective in CRR

Managing climate-related disaster risks is a concern of multiple actors, working across scales from international, national, and sub-national and community levels, and often in partnership, to ultimately help individuals, households, communities, and societies to reduce climate related risk (Twigg, 2004; Schipper, 2009; Wisner, 2011). The objective five of this study was to examine the available climate change support for rice production as perceived by the rice farmers in the study area. Here, the focus groups were asked about the available support to alleviate the negative effects of climate change and variability and the results are shown in Table 21.

Table 21: Available Support to Rice Farmers on Climate Change related extremes events from the FGDs perspective in CRR

Available Support to Farmers	Number of FGDs(# =58)	Percentage
Emergency Seeds Supply	54	93.1
Subsidized Fertilizer Sales	47	81.0
Emergency Relief (food, clothes &Shelter)	37	63.8
Water Conservation Practices (dykes & bonds)	29	50.0
General extension Services	28	48.3

Source: Badgie, 2015

The results from the focus groups (93.1%; n=54) revealed that the rice farmers do received emergency seed supply as a results of crop failure mainly from government support to cope with climate change related impacts.

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Furthermore, 81.0% (n=47) of the local communities indicated that subsidized fertilizer sales were introduced to as support from government to address soil infertility due to climate change and variability implications. In addition, 63.8% (n=37) indicated that climate change and other climate extreme events such as drought and floods which leads to total crop failure, the communities do receive relief supplies such as food, clothing, medical and shelter in the region. Another 50% (n=29), of the local communities had benefited from water conservation techniques such as dyke and bond construction through government or NGOs funded intervention projects over the years. Additionally, 48.3% (n= 28) of the local communities in the region indicated that general extension services were provided sometimes by department of agriculture on basic agronomic practices in the region.

Types of support needed to alleviate the issues of climate change impacts as perceived by the local communities in Study Area

During the focus group consultations, the local communities were further asked on what types of support they would need from government or development partners to address or mitigate climate change and variability related extremes events in the study area. The communities agreed on the these issues (provision of early maturing crop varieties, training on water conservation methods, capacity building on climate change adaptation measure and provision of accurate and timely weather information for the season) as priority areas. These points are further explained in the following sections.

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Provision of early maturing crop varieties

The local communities during FGDs agreed that considering the short and erratic rainfall pattern, the availability of early maturing crop varieties to rice farmers was considered as very important (n=57) to alleviate the menace of climate change and variability. The point to greater extent could require support from government and other established institution to supply the necessary planting materials that would produce good yields within the short rainy season. The support should be given out on time when needed for the farming to proceed otherwise it has no meaning. According to the communities, acquiring the right early maturing varieties of planting material at the right time would serve as encouragement to farm.

Training on water conservation methods

Another important issue highlighted by the local communities in CRR was conducting training on appropriate water conservation techniques (n=48), such dykes, bonds, and zai methods to effectively deal with climate change and variability related impacts particularly inadequate rainfall.. According to FGDs, the water conservation training techniques are usually carried out by government with high level use of equipment or machinery through donor funded projects. The measures of conservation are usually very expensive and unsustainable in terms of maintaining the structures at community level after the project phased out. Therefore, the communities in the region suggested that training of farmers on appropriate water conservation measures which are less expensive to maintain could enhance their efforts in addressing climate change and variability induced effects over the long term on rice production in CRR.

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Capacity building on adaptation measures

The capacity building on available climate change adaptation measures was another important element that has been emphasized by the communities in the study area (n=30).

According to the local communities in CRR, the adoption of climate change and variability adaptation strategies needs the proper understanding of those measures for continued use at the local level. The communities indicated that in most cases, rice farmers are faced with less awareness on the climate change adaptation strategies resulting to their limited use in the region. They also wonder whether the extension service agents themselves to assist them have the knowledge about the strategies either.

Provision of accurate and timely weather information

Provision of accurate and timely weather information to farmers is another important issues underscored by the local communities in the CRR prior to the raining seasons (n= 20) in addition to their local knowledge. The groups indicated the rice farmers in the study area also needs accurate and timely weather information served as a planning tool to farmers for the subsequent seasons. However, this very important weather prediction information is either not available on time or mostly inaccurate. This limitation in weather prediction has generated some level of unreliability within the communities on the information and mostly do not adhered to when given.

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Results of the Key Informant Interview on Climate Change and Variability in the Central River Region

The results of the key informants interviews are summarized into four categories: General perspective of climate change and variability (issues and concerns, challenges, causes and the way forward), the Institutional roles on climate change related issue at regional (service offered in climate change related extremes), adaptations measures to address climate change related extremes (available adaptations, their own assessment on the use of this measures, challenges on the measures and the way forward), and available support at regional level to deal with climate change and weather variability extremes (support available, own assessment on this available support, challenges and the way forward). These are discussed in the following sections.

Key Informants General perspective of climate change and variability in CRR

The results of the interview from all the key informants indicated that the issues related to climate change and variability highly of a national concern which needs urgent attention particular at rural areas like this region that depend main on farm produce to survive. According to results of the interview, there have been remarkable changes in climate relate events over the past years in the region such as reduce and unreliable rainfall, increasing temperatures, frequent floods and drought in the region (n=13). Based on their perspective, the change could be associated with the changing climate that is being experienced over the years.

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On the implications associated with climate change and variability, the result from the interview showed that (n=13), the climate change particularly in reduce rainfall led to low crop production, which ultimately leads to low yields, hunger, food insecurity and death of livestock. In addition, income levels of the people in the region are affected and the economy of the country as whole which depends more on export of agricultural produce. According to the informants, the climate change and weather variability extremes impacts are multi-faceted in nature and links to so many sectoral issues of a nation when it occur

The result of the interview offered a logical explanation on the linkage of climate change related negative impacts as: *"In 2011, the Government of The Gambia declared a national disaster of crop failure as a result of drought. In that year prior to the next rainy season, the government spent GMD 20 million to buy seeds and GMD 89 million to buy fertilizer to support famers for the subsequent season across the country. That money from Government would have been used for other development purposes if there was no crop failure due to insufficient rainfall or drought"*.

On the causes of climate change, the result indicated that (n=11) associated the causes of climate change and variability mainly to a multitude of factors which include emissions from industries and locomotive engines, deforestation, poor agricultural practices and landfills which they claimed are all human related. Furthermore, the participant also highlighted that the causes from emissions are mainly from developed countries with numerous factories and automobiles. However, others (n=2), indicated that God is responsible for the climate change in The Gambia.

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It was argued that anything that occurs onto mankind on this earth should be link to God (Allah) first then other things could follow.

On the possible ways to mitigate or address the causes of climate change and weather variability, number of participant (n=11) suggested that the causes could be reduced or addressed by reducing industrial emissions particularly industrialized countries, afforestation, improvement in agricultural practices, use of solar energy as alternatives and proper waste management systems.

To further buttress, the result of informants indicated that the principal causes of the climate change are CO_2 emissions which can only be reduced mainly by industrialized nations. On the other hand, developing countries could also involve in afforestation projects, as trees attract rainfall, use of more organic fertilizers as opposed to synthetic in agricultural production. It was further stated by the participants that use of solar energy as alternatives should be encouraged the country have sunlight all year around even though the initial cost is high but it can save our environment. In addition, the issues of waste management in the developing countries are a big challenge including The Gambia. The emissions from landfills are also substantial and in the case of the Gambia, there is also burning of refuse at waste dumps which emit smoke into the atmosphere which could cause climate change according to the participants. On the other hand, informants (n=2) during the interview argued that this is God created phenomenon therefore needs divine intervention through prayers and seek for forgiveness from God to change the situation.

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Institutional Services on climate change related issues at regional level from Key Informants Perspective

The institutional roles with regard to climate change and weather extremes events vary from one institution to another in accordance with respective mandates at regional and national level. The results showed that (n=10), the prevalent feeling was rendering general agriculture services at farm level such as extension advice, farmer field schools training, innovation plat forms and dissemination of production related information.

In addition, (n=3) highlighted that in line with their institutional mandate, the service they offer for the general public at the region in particular are mainly giving out weather information, assessing disaster related events and coordinating relief distribution and environmental safeguards compliance and capacity building on environmental issues at regional level.

To further elaborate on some of the services, most participants agreed that the services offered to farmers are mainly routine extension services but not necessary specific to climate change related issues. Services include advising farmers on the use of early crop varieties, basic water conservation measures trainings through farmer field schools and development of key groups among farmers to serve as innovations platforms who serves as training of trainers (TOTs) in the region. The informant are with the opinion that issues of climate change are not mainstreamed at the grassroots in the region since is handled by different institutions not dealing with farmers at all. This as well also impede prospect of addressing climate change related issues in the study area.

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Other informant participants indicated that they have a limited role in terms of giving field support to farmers on climate change related issues in the region in view of the institution specific mandates. However, in emergency situation, the institutions are part of Regional Technical Advisory Committee (TAC), with key mandate of advising the regional governor on all issues of development at regional level.

Available Adaptations Measures to Address Climate Change related extremes from Key Informants Perspective in CRR

The key informants view on the available adaptation measures for the farmers to ease climate change negative impacts in the region. The results indicated that majority of participants (n=9) agreed that the available adaptation measures that are used to adapt to climate change related negative impacts include; use of early maturing crop varieties, crop diversification, mixed farming, water conservation measures through crop residue retention, use of reliable climate forecasting information and livestock production. In addition, (n=4) of key informants felt that other available adaptation measures that could be used by farmers to limit the climate related implications include; agro forestry farming practices, farmers education and awareness on climate change, provision of credits to farmers, crop insurance and vegetable production.

The use of climate change available measures in the region, the majority of the key informants who participated in the discussion agreed that some level of adaptation measures are being applied by farmers mainly use of early maturing crop varieties, crop diversification and livestock productions. However, some of the available adaptation measures are not been used due to

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farmers reluctance or inaccessibility of the measures. According to the participant, the way forward to fill the gap would be building capacities of farmers on the available adaptation measures and necessary support through government and other development partners to enhance production in the region.

Available support at regional level to deal with climate change and variability extremes from Key Informants point of view

On the available climate related extremes event support in the region, most of the participants (n=10) indicated that the support given to the farmers are mainly farm input supplies (seeds, subsidized fertilizer and other agro chemicals), emergency relief supply to needy in terms disasters and development of water conservation infrastructures for both upland and lowland fields (bond, dykes and irrigation systems) to enhance crop production particularly rice. However, the latter according to the participants are high capital intensive and are executed mainly by government funded projects and other development partners in the region. Such include; National Land and Water Management Development Project (Nema), Gambia Food and Agriculture Sector Development Project (FASDEP), FAO European Union Millennium Development Goal– 1c Initiative Project (MDG1c), West African Agricultural Productivity Programme (WAAPP 1C). In addition, (n=3) of the key informant that participated in the discussion concluded that the only support available to the farmers in the region are mainly coordinating the relief supply in climate extremes events and other disasters. The relief supports to the farmers are coordinated through NDMA in collaboration with stakeholders

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and international relief agencies operating in the country. The participants however noted the existence of national development projects in the region but have no clue on their operation.

The perceive challenges associated with the available support, according the key informants (n=13), were the existence of conflict of interest among institutions mandated for such operations and grasp for resources with regard to climate change which created inefficiency in the system. Secondly, the support system is not readily available in some instances when the needed. Thirdly, the political interference on the available support to the farmers tends to focus on the country leadership sympathizers, meaning communities that votes for the president and assembly members received support first. In addition, addressing climate change and variability issues in the region are done on a top - bottom approach, all the initiative are done higher level and consequently affected the mainstreaming of climate change issues at grassroots level.

On the way forward, the key informants cited proper cooperation and coordination among institutions, development of a readily available support mechanism for the region, and political party affiliation should take a back seat when comes to national development and assisting people as Gambians irrespective their political affiliation at national, regional and district levels.

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CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Climate change is expected to have serious environmental, economic, and social impacts on The Gambia, particularly on rural farmers whose livelihoods depend largely on rainfall. Agriculture, primarily in subsistence scale, is the backbone of The Gambia's economy with the Central River Region being one of the major food producing regions. Agriculture contributes about 35% of The Gambia's GDP, and employs about 75% of the population. Despite its high contribution to the overall economy, this sector is challenged by many factors of which climate-related disasters like drought, erratic rains, and floods and high temperatures.

In recent years, adaptation to climate change has become a major concern to rice farmers, researchers and policy makers alike. To enhance national efforts towards confronting challenges posed by climate change to rice farmers in the study area, it is important to know the implication of rice farmers' perception, local knowledge and climate change on rice production in the Central River Region, The Gambia. The Central River Region situated in eastern part of the Gambia is one of the major food production areas of the country. To continue high food production in this region, rice farmers would have to adapt to climate change related stresses.

There is however, little known local knowledge on climate change and have adopted adaptation measures from the local communities in CRR.

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Therefore this study seeks to explore on the existing of local knowledge on climate change and it implication on crop production in CRR.

The study adopted the mixed method approach which combines quantitative and qualitative procedures in research. This was based on the premise that all methods had bias and weaknesses, and the collection of both quantitative and qualitative data neutralized the weaknesses of each form of data. The quantitative component was designed to collect information on livelihoods, farming systems, perception of climate variability and change, coping measures, capacities of farmers to adapt and the available support in the study area. In total, 438 questionnaires were administered in 11 districts of the CRR through face-face interview with the rice farmers. Data from the survey were first coded in the Microsoft Excel and then analysed using descriptive statistics. In order to further assess the relationship between variables, a chi-square also refer to as goodness of fit test was used to test whether the observed proportions for a categorical variable differ from hypothesized proportions from the Statistical Package for Social Science (SPSS) software.

For the qualitative component, 58 focus group discussion and 13 key informant interviews were conducted in the CRR targeting rice farmers and personnel from related government institutions and development agencies. The data was grouped as per focus group and key informants based on conscientious and consequently served as the main unit of analyses. Thematic analysis approach was used to identify principal themes of the discussion. Structuring of the themes allowed the classification and identification of

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responses which were further separated from the general themes based set research objective.

The results on perceptions on climate change and variability showed that the rice farming communities consulted during the focus group discussion and survey as well the key informant interview experienced changes in weather and climate changes with respect to erratic rainfall, drought and increased temperature. The findings further indicated that the communities agreed that there was significant changes over the past two to three decades in terms of flash floods increase, low crop yields, heavy wind storms before the rains seasons and serious soil infertility. The recognition climate change and variability shown by the communities could be attributed to long term observation of events and activities which were linked to the current situation. The linkage between farmers' perceptions and obtainable scientific climate and variability data in the area, supports the impression that when meteorological records are inadequate or not available, local knowledge on climate change and variability could be applied to supplement scientific climate or weather report.

The findings revealed that climate change and variability effects were attributed to several implications and which included low rice yields, migration of youths, food insecurity, soil infertility, reduction of livestock and frequent flash flood occurrence among others. The communities in the study area mainly depended on subsistence farming principally on farm produce for household food supply and income generation. The implications of climate change lead to household food insecurity, low income and poverty. The findings on the negative implication of climate change and variability results

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to youth migration from local communities in search of better lives. The climate change induced problems also contributed to reduction in livestock which were considered as alternative sources of income to offset farm losses.

The reduction of income due to poor farm produce as a result of climate change has also contributed significantly to the sharp reduction of social events or festivities such as weddings, naming ceremonies /christenings, circumcision and wrestling contest which combined them together due to loss income from farming activities linked to changes in climate experienced over the years.

The finding on local knowledge of climate change and variability indicted that local communities derived immense importance from plants, birds and objects as local weather indicators. The local knowledge on climate change and variability assisted not only for predicting the onset of a particular rainy season but also the possible outcome of the season in terms of being good or not. The aspect of dynamic signs could be reflected generally as many communities shared the same doctrine, nevertheless they were also distinctive to a certain communities depending on the locality. Based on the observations from local weather indicators, the communities over generations used this important information to plan for the farming activities in every season and the predictions supported them in adapting climate related variation to reduce its negative impacts on crop production and livelihoods. The study revealed that some of the limitations in enhancing this unique local knowledge could be linked to western education, low mastery of traditional knowledge practices by younger generation, religious beliefs among others.

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The findings on the adaptation measures of climate change and variability in the study area showed that the communities adopted several on-farm and non-farm adaptation strategies to address climate change impacts which included crop diversification, migration in search of labour, planting of early maturing crops, livestock sale and remittance from travelers. In addition, vegetable production, petty trading, lowland rice production and orchard farming to reduce farm activity losses were stated. These measures were applied by the local communities to offset low rainfall which could not support crop production in some years.

The study also revealed fundamental restrictions experienced by the local communities in applying adaptation measures, such as; insufficient knowledge or consciousness of the strategies, religious beliefs, reluctance to adopt the strategies, little institutional support and unreliable and untimely weather and climate change related information.

The results on the difference between age, education level, income and adoption of adaptation strategies, knowledge of climate change and weather variability resulted to the rejection of the null hypothesis (Ho) which indicated that there is no significance difference between background characteristics of respondents (age, education level, income) and adoption of adaptation strategies, knowledge of climate change and weather variability between rice farmers in the central river region.

Preferably, the national support systems on climate change and variability should help to address climate variability and change over the years in the study area. The results showed that key aspects which the communities highlighted as limited or none existence included provision of early maturing

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crop varieties, training on water conservation skills, capacity building on available adaptation measures through extension service, farm input supply, access to credits and provision of accurate and reliable weather information in a timely manner.

Conclusion

Climate change and variability is an impediment to the accomplishment of self-food security in The Gambia. It is an obvious menace to the agricultural sector. Rice farmers in CRR experienced changes in the climate patterns and adopt measures to deal with the changing climate with inadequate knowledge of climate change and variability as a scientific theory.

The study findings indicated that the rice farmers are well aware of climate change and variability in terms increasing temperature and a decreasing rainfall trend as it has impacted on their livelihoods. Nonetheless, only a few seem to be actively taken steps toward adjusting their farming activities in the study area to address the challenges of climate change in CRR.

The main adaptation strategies of farmers identified include change in crop types, used short season varieties, crop diversification, migrant work, sale of livestock and remittances. The results of determinants of adaptation strategies suggest that low knowledge, limited government support in terms of access to extension service and credit, input availability and religious beliefs are the most noteworthy factors affecting the adaptation capacity of rice farmers in the region.

Local knowledge used in adapting to climate change were perceived to be successful as the communities have relied on them for long to endure the

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negative effects of climate variability and change on their livelihoods in the study area. The results further indicated that the communities' documentation of major climatic events over the past years were in agreement with the empirical data on temperature and rainfall of the region. The present concept of the communities showed that existing scientific climate and weather forecasts in the study area were not that useful at local level because they do not incorporate available customary knowledge. Therefore, to preserve such a significant form of local knowledge on climate change and variability, the need to reinforce the dissemination of local knowledge and incorporate with modern methods that enhance climate change adaptation strategies is required in addressing long term climate change implications in CRR.

The national support system for climate change and variability highlighted limited provision of emergency seeds, training on water conservation techniques through projects among others. Interestingly, the level of government support was either inadequate or not forthcoming and some point political based on the findings. Government policies in terms of addressing climate related extremes events should therefore ensure that capacity building of farmers is sustained on water conservation methods, adaptation and input supply (seeds, fertilizer) and access to affordable credit conducive enough to enhance farmers. This will steadily increase the ability of rice farmers to change crop, managed soil infertility and adopt suitable strategies in response to climate variability and change. In addition, given the insufficient extension services coverage in the study area as highlighted by the focus groups, enhancing the extension service in those affected could possibly yield positively on the climate change adaptation programme in the region.

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Recommendations

Based on the findings, the followings recommendations were drawn:

1. To mitigate the negative effects of climate change and variability in the CRR, The Gambia, it is recommended that rice farmers be supported with "climate change ready- rice" varieties such as drought, submergence, heat, salt and poor soils tolerance cultivars, by Department of Agriculture and other development partners.
2. Given the low capacity of rice farmers on climate change adaptation measures in the region, it is recommended that the Department of Agriculture and other key stakeholders to plan and embark on capacity building programmes for rice farmers on the emerging appropriate climate change adaptation strategies in order to realize their usefulness in crop production and by extension retrain extension service agents on recurrent adaptation measures.
3. Cognizance of the significant role of Local knowledge in predicting climate change and variability conditions under changing climate in terms of the season and crop performance, the study recommends dissemination and integration of the local knowledge on weather predictions with modern methods that will enhance climate change adaptation and resilience in the region for the farming communities
4. Given that climate change related issues are virtually not mainstreamed at grassroots level in the study area, it is recommended that Agriculture stakeholders and relevant institution including development partners in The Gambia country to adopt the bottom-top approach with farmers in order to mainstreamed and address climate change impacts in CRR.

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5. Acquiring accurate and timely weather information to rice farmers was critical in addressing climate change negative implication in the study area, it is recommended that the government through the aligned Ministries and departments of Meteorological Services should invest into and enhance the current early warning weather station infrastructure systems in the region to make it more capable of supplying reliable and accurate weather information for the farming communities for better planning.
6. To improve the national support systems for climate change and related emergency response, it is recommended that proper cooperation and coordination among all stakeholders be enhanced for effective and efficient service delivery in climate change response programmes to the farming communities.
7. Given that awareness on basic elements of CC and weather related issues for the rice farmers is critical in the study area, it is recommended that awareness creation in all forms focusing on basic knowledge on climate change science, climate change risk management, coping and adaptation measures be embarked upon by the Department of Agriculture and other relevant institutions.
8. Given that religious beliefs contribute significantly in the denial of climate change and variability events, the study recommends the involvement of religious and community leaders to relate climate change issues in their usual sermons in mosques/churches and community's gatherings which requires their presence.

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Suggestions for further research

The following areas have been suggested as potential future research areas:

I. Evaluation of economic impact of climate variability and change on farming communities in the Central River Region through on farm experimental trials. In that respect, a set of measures that could give a maximal yield under a given climate condition using different parameters**.** This kind of study is expected to give out real impact of climate change on rice production through on farm trials with objective measurements.

II. Assessment of performance and role of Extension Services in addressing climate variability within the context of the NAPA (2007) Provisions in The Gambia.

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APPENDIX A: SURVEY QUESTIONNAIRES FOR 2015

Rice Farmers' Perception, Local Knowledge of Climate Change and Variation, Implications on Rice Production and Adaptations Strategies in the Central River Region (CRR) – The Gambia

PURPOSE:

The information obtained from this study will under no circumstances be used to evaluate any respondent. Basically, it is to be used by the researcher in writing thesis research project to fulfill the requirement of an award of Doctorate Degree in Climate Change & Agriculture as well inform policy makers and the media about the challenges of rice farmers and suggest solutions and make them heard.

Start of interview:----------

End of interview:----------

Name of Interviewer:……

Date:……

Namer of respondent:……..

Section A: Information on the informant and the household

1. Sex of respondent: 1= Male 2= Female

2. Marital status: 1= Single 3=.Married 3= Widow 4= Divorced

3. No of people in household: 1= Two 2= Three 3= Four 4= Five & above

4. Age of respondent: 1= 15 - 35 (Youth) 2= 36 – 56 (adult) 3= 56 and above (elder)

5. Education level: 1= Primary 2= Secondary 3= College & University 4= No education 5= Kuranic

6. Income level per annum (dalasi).

1= 1, 000 – 5,000 2= 5, 001 – 10,000 3= 10,001- 15,000 4= 15, 001 – 20,000 5= 20,001+

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SECTION B: Livelihood and farming activities

The main objective of this section is to determine the respondents' farming practices and livelihood activities. related issues in the study area.

7. **Are you actively involved in Farming activities:** 1= Yes 2= No

8. **What are the main crop (s) you grow**: 1= Rice 2= G/nut 3= Maize 4= Millet 5=Others

9. **Type of farmland**: 1=Communal (family) 2= Individual 3= Rent

10. **Have you changed crops:** 1 = yes 2= no

11. **If yes why**: 1= Short rainfall duration 2= Drought 3= Low fertility 4= Pests & diseases

12. **What was previous crop:** 1= Rice 2= Millet, 3= G/Nut 4= Maize 5= Sorghum

13. Have you noticed any changes in the planting season: 1 = Yes 2= No

14. **If yes, how:** 1= earlier 2= Late

15. **How long have you noticed change:** 1= 5yrs 2= 10yrs 3= 15 yrs 4= 20 yrs 5=.30 yrs+

16. **Do you use chemicals on your produce:** 1= Yes 2= No

17. **If yes, which type**: 1 = Fertilizers 2= Pesticides 3= Herbicides 4= Both

18. **Have you noticed any changes in the harvest season:** 1= Yes 2= No

19. **If yes, what are the changes:** 1= Yield Increase 2= Low Yields 3= Average 4=Poor

20. **Sources of your energy needs**: 1= National grid 2=. Kerosene 3= Fuel wood 4= Solar

21. **What is power manly used for**: 1=.Lighting 2= Cooking 3=. Heating 4=Warming

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22. **What do you use in cooking:** 1.= Charcoal 2= Firewood 3= Gas 4= Electricity 5=Both

SECTION C: Knowledge and perception of climate change

The idea behind this section is to determine Farmers Knowledge and Perception of Weather variability and Change with respect to rainfall and other related issues

23. Do you know anything call climate Change: 1= Yes 2= No

24. Do you observed any rainfall change: 1= Yes 2= No

25. If yes, how would describe the changes over the past years:

1= No changed 2= Minimal Changes 3= Drastic changes 4= No idea

26. Do you feel temperature variation: 1= Yes 2= No

27. If yes, how would you describe the variation over the past years?

1= Very hot 2= Hot 3= Cold 4= Normal

28. Do you observed flood occurrence in your area? 1. Yes 2. No

29. If Yes? How frequent does the floods occur in your area?

1= Frequent 2.= Rare 3= Constant 4=.Little

30. Do you observed any drought occurrence in your area? 1= Yes 2= No

31. If Yes? How frequent does the drought occur in your area?

1= Frequent. 2= Rare 3= Severe 4= None

32. Do you observe any pest outbreak in this area? 1= Yes 2= No

33. If Yes? How frequent does the pest outbreak occur in your area?

1= Very Frequent. 2= Frequent 3=. Rare 4=.None

34**. Do you observed any salt intrusion in this area?** 1= Yes 2= No

35**. If Yes? How frequent does the salt occur in your area?**

1= Frequent. 2= Rare 3=.Severe 4=. None

36- How do you assess the productivity of your Agricultural lands?

1= Unchanged 2= Diminishing 3=Sterile 4= Slightly Changed

37**. In this area, is the soil degradation obvious**? 1. Yes 2. No

38. **If yes, what do you think is responsible**?

1= Nature 2 = Deforestation 3= Poor Farming Practices 4 = Weather Variability &Change

39**. Does the changes have any impact on your livelihood**? 1= Yes 2= No

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SECTION D: Impacts, Responses, Coping and Adaptation of respondents on the consequences of climate related changes

The objective behind this section is to determine the consequence of climate related changes, responses and adaptation mechanisms – with particular attention to livelihoods and socio-economic impacts

40- What are the impacts of the climate related changes on your livelihoods over the years?

1= High 2= Medium 3= Low 4= Normal

41. Do you experience changes in terms of overall food stock and the reserved during hard period of production season?

1= Empty 2= Diminishing 3= Stable 4= Increasing

42. When do you experience changes in terms of income-generating activities over the years: from farming related activities?

1= 5year ago 2= 10years ago 3= 20 years 4= 30years ago

Risk appraisal

43. Evolution of extreme weather events and factors of plan

Please rate your observation during the past 30 years of the following items in table A below on a 7-points scale in the space provided in the table 1.

1= High decrease, 2= Medium decrease, 3 Low decrease, 4= No decrease, 5=little increase, 6= increase, 7= very strong increase, N.I = No Idea

Table 1

n	Issues	1	2	3	4	5	6	7	NI
Extreme weather events									
1	Heavy precipitation								
2	Storms								
3	Heat wave								
4	Longer precipitation period								
5	Longer period of drought								
Factors of plant growth									
6	Quality of soil surface structure								
7	Soil water storage capacity								
8	Length of growing season								

44. How hard do you estimate a possible negative consequence of climate variability? The likelihood and the lost associated. Please rate the following climate variability-related production risks on two 6-point scales as shown in Table 2.

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Vulnerability:1=Not at all 2= Highly unlikely, 3= unlikely, 4 = likely, 5= Medium likely, 6= Highly likely, N.I = No Idea
Severity: 1=Not at all, 2= less than 10%, 3= 10% to 20% loss, 4= 20% to 30% loss, 5= 30% to 45% loss, 6= 45% and above, NI = No Idea

Table 2

n	Issues	1	2	3	4	5	6	NI
	Vulnerability							
1	more yield losses due to dryness							
2	more yield losses due to heat stress							
3	increase of animal diseases							
4	increase of plant diseases							
	Severity							
5	more yield losses due to dryness							
6	more yield losses due to heat stress							
7	increase of plant diseases							
8	increase of animal diseases							

Coping Mechanism

45. How do you see your own ability to do something about climate change?

Please rate the following items on a 6-pointscale as indicated in table 3 below.

Table 3

Strongly disagree=1	**Disagree=2**	**Somewhat disagree=3**	**Somewhat agree=4**	**Agree=5**	**Strongly agree=6**	**NI.= No Idea**

n	Issues	1	2	3	4	5	6	NI
1	'I feel I am in the position to make an important contribution to my farm protection							
2	I feel I am in the position to withstand the effects of a drought in case it occurs							
3	I feel I am in the position to withstand the effects of a flood in case it occurs							
4	I feel I am in the position to withstand the effect of heat wave in case it occurs							
5	I feel I am in the position to withstand to heavy storm in case it occurs							
6	The protection of my farm depends mainly on me							

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46. Who is responsible for the adoption of adaptation Measure?

Please rate all the following items using a 6-point rating scale as indicated in Table 3 above in the previous question.

Table 4

n	Issues	1	2	3	4	5	6	NI
1	I am responsible myself.							
2	Every one of us is responsible.							
3	Consumers are responsible.							
4	Extension workers are responsible							
5	Government is responsible.							
6	The NGO's are responsible							

Protection motivation, response cost, stated preference and implementation

Please complete the following sentences in questions 47 by rating a 6-point scale as indicated below

47. Measures to protect rice farm against climate variability i usually take.

1= Never, 2= Very Rarely, 3= Rarely, 4= Occasionally, 5= Frequently6= Always

Table 5

	Measures	Description
A	Use of Improved varieties	Use of varieties that have been breed to be Pest resistant, Drought tolerant, Salt tolerant, early maturing or more palatable.
B	Crop Rotation system	Growing of different crops in succession on a piece of land to avoid exhausting the soil.
C	Use of Chemical fertilizers	Use of Chemical substance added to the soil to increase its fertility
D	Water conservation techniques	Techniques of managing fresh water to use efficiently for farming activities
E	Water Diversion techniques	Techniques used to change the water way or to reduce the speed of the ranoff to avoid erosion.
F	Use of natural fertilizers	Applying compound residues and animal waste at the farm to increase soil fertility

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48. Rank the following measures according to their estimated cost from **1= least costly, 2=Moderately costly 3= Costly, 4= Most Costly 5= No cost 6= Project support**

	Measures	Rank
A	Use of Improved varieties	
B	Crop Rotation system	
C	Use of Chemical fertilizers	
D	Water conservation techniques	
E	Water Diversion techniques	
F	Use of natural fertilizers	

After reading a short description about measures to adapt to climate variability in the table above, answer the following questions:

49. Why is it difficult to implement that measure on your rice farm?

1= No Technology available 2= Cost involve 3= Not interested 4= No appropriate technologies 5= No trainings on technology use

50. 'Do you think this Measure would be effective or not?' please rate it on a 6-points scale as indicated in Table 6 below.

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Table 7

1=Completely not effective	2= not effective	3= Somehow not effective	4= Somehow effective	5= effective	6= Very effective	NI= No Idea

	Measures	Reasons why it is difficult to implement
A	Use of Improved varieties	
B	Crops rotation system	
C	Use of Chemical fertilizers	
D	Water conservation technics	
E	Water Diversion technics	
F	Use of natural fertilizers	

	Measures	1	2	3	4	5	6	NI
A	Use of Improved varieties							
B	Crop Rotation system							
C	Use of Chemical fertilizers							
D	Water conservation techniques							
E	Water Diversion techniques							
F	Use of natural fertilizers							

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Read the measures provided in the table below and answer the question for each measure in the space provided using the following scale**1= Never, 2= Very rare, 3= Rarely,4= Occasionally, 5=Frequently, 6=Always NI = No Idea**

51. How often do you implement this measure?

	Measures	1	2	3	4	5	6	NI
A	Use of Improved varieties							
B	Crop Rotation system							
C	Use of Chemical fertilizers							
D	Water conservation techniques							
E	Water Diversion techniques							
F	Use of natural fertilizers							

Read the measures provided in the table below and answer the question below for each of the measure in the space provided in the table using the following scale:**1= Definitely Not, 2=Probably Not, 3= Possibly, 4= Probably, 5= Very Probably, 6=Definitely, NI= No Idea**

52. Would you like to implement this measure

	Measures	1	2	3	4	5	6	NI
A	Use of Improved varieties							
B	Crop Rotation system							
C	Use of Chemical fertilizers							
D	Water conservation techniques							
E	Water Diversion techniques							
F	Use of natural fertilizers							

53. Do you prefer the implementation of this measure or not? 'Please rate on 6-point-scale **from as follow: 1= I don't prefer it at all, 2= I moderately prefer it, 3= I somehow prefer it, 4= I prefer it, 5= I strongly prefer it, 6= I very strongly prefer it**.

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	Measure	1	2	3	4	5	6	NI
A	Use of Improved varieties							
B	Crop Rotation system							
C	Use of Chemical fertilizers							
D	Water conservation techniques							
E	Water Diversion techniques							
F	Use of natural fertilizers							

SECTION E: Farming community expectations of environmental and socio-economic changes in the future and perceptions of vulnerability based on local observations and assessment of current trends in the study area

54- In your opinion, how would be the rainfall and the temperature in the future?

1= drastic change 2= Moderate Change 3= Less Change 4= No Change 5= No idea

55- In your opinion, how would flood and drought occur in the future?

1= More floods &Drought 2= Medium floods & drought 3= Less floods &drought 4= No Change 5= No idea

56- How do you perceive your livelihoods in the future with these climate changes in terms of Food insufficiency, health, income, standard of living

1= Hunger 2= Diseases 3= Malnutrition 4= Migration 5= Less income 6= all are applicable

57**.** In your own point of view, what may be the origins of such climate changes or variation? **1= Nature(God) 2= Developed Countries 3= Developing Countries 4= Individual 5= None** 6=Both

58- Apart from climate changes, what may be the other reasons which can negatively influence the earning of living, nutrition, standard of living and health?

1= Pest attack (Hippos) 2= Low Inputs 3= Low Income 4= Less extension contact 5= Less government support 6= Both

59. What are the consequences of the climate changes on the sustainable use of natural resources and environment protection?

1= Hunger 2= Diseases 3= Malnutrition 4= Migration 5= Less income 6= all are applicable

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60. Apart from climate changes, what may be the other reasons which can negatively influence the sustainable use of natural resources and environment protection? (e.g; forest, water, aquatic resources, and living creatures) **1= Bad farming practices 2= Cutting down of trees 3= Poor water management 4= all are applicable 5= It is a natural**

SECTION F: **Observation on the constraints to adaptation to climate change and the implementation of the intervention to reduce vulnerability in the study area**

60. What are the basic strategies for reducing the challenges of weather variation & climate changes in your own point of view as a farmer?

1= Water Conservation technologies 2= Availability of early crop varieties 3= Capacity building on adaptation measures 4= Replanting of Trees 5= None

61. What may be the constraints to the implementation of these strategies**?**

1= Lack of Knowledge 2= Acceptance of Technologies 3= Less support 4= Refusal to accept climate change issues

SECTION G: Assess the support from both government and private institution in addressing possible climate change impacts in the study area

62. What sort of support do you get from the community in case of drought or crop failure?

1= Seeds 2= Fertilizer 3= Food supply 4= Capacity Building 5= None

63. Do you think the community has a role to play in effectively addressing issues related to climate variation and change? **1= Yes 2= Yes**

64. What important role does the community play in when the situation believed to be associated with climate variation & change in this area?

1= Tree planting 2= Water conservation Techniques 3= Support each other 4= Nothing

65. What do you think should be in place to mitigate or adapt to issues related to climate change in this area?

1= Capacity Building on adaptation 2= Water conservation Techniques 3= Government food Support 4= Early Maturing Crop Varieties 5= Nothing.

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66. What important role does the community play in when the issues believed to be associated with climate variation & change in this area?

1= Tree planting 2= Water conservation Techniques 3= Support each other 4= Nothing

THANK YOU VERY MUCH FOR THE SUPPORT

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APPENDIX B: DISCUSSION GUIDE FOR THE FOCUS GROUP DISCUSSION 2015

Purpose of the survey

The focus of this survey is to assess the perception of rice farmers on climate change, their indigenous knowledge of weather variation and climate change and how it affects crop production, livelihoods and what cooping measures and adaptation strategies to adapt to the current situation, The information obtained from this study will under no circumstances be used to evaluate any respondent.

Approach

Qualitative methods of data collection were employed during field work, targeting farmer groups established and women through a focus group discussion approach engaging farmers at the village "Bantaba" was adopted and as well visits some fields. In addition, relevant mapping information such as of selected communities were collected with GPS coordinates for the production of site maps. Basically, the area of focus of discussion aimed at assessing the perception of weather variability and climate change and how it relates to their rice production, environmental and social life during the survey were mainly centered on but not limited to the following themes:-

1. Perception of climate change by rice farmers

1. Do you know what Climate Change is?
2. Do you experience any changes in the Weather or Climate compare to the past?(frequency and severity) If yes give some evidences
3. Current conditions weather variability compared to some 30 – 40 years ago
4. What are the impacts that you associate with Climate variability?
5. What Socio-economic implications do the changes?
6. What are your coping mechanisms when they occur?
7. Who do you think is responsible for the change and what are the main causes of weather variability climate change?

2. Indigenous knowledge about weather variability & climate change

1. From an indigenous knowledge what is consider as climate change
2. Traditionally, what signs do know which predicts drought or inadequate rainfall
3. How do these predictions help to mitigate the situation at local level
4. Local knowledge on weather variation & Climate change

3. Adaptation measures

1. What adaptive measures are being used address weather variation or climatic change issue in your this area
2. What technologies are being used to reduce the effects of weather variations or climate change in your production in case they occur? If yes, mention some of them, if no why not?
3. Why do you use them?
4. What prevents you from protect your farm against weather variability and Climate Change effects?
5. What are your training needs that could help you to better protect your rice production from climate related impacts?

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4. Available Support for climate change and weather extreme events in the this area

1. Do you receive any support in addressing related climate change induce problems?
2. What types of support do you receive?
3. Where do your supports on climate extremes related come from?
4. What is your opinion on the support in terms of effectives and adequacy?
5. What would be your needs in addressing climate change impacts incase the supports are available

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Appendix C: Guided Questions for Key informant Interviews in CRR – The Gambia, 2015

Purpose

I want to thank you for taking the time to meet with me today. My name is Dawda Badgie. I would like to talk to you about on issues relate to climate change and weather variability more so in the CRR. I would to discuss with you on your of climate change and how it impacts on the livelihoods in the region, what is your institution doing, as well as the available adaptation and support for the people you are serving in this region.

The interview will not be long at most an hour and I will be recording the session for ease of reference incase i miss any of your comments while taking notes.

Note that all responses will be kept confidential. This means that your interview responses will only be used by the researcher and will ensure that any information included the report does not identify you as the respondent. Please you need to talk about anything you do not want to and you may end the interview at your discretion. Are there any questions about what I have just explained? Are you willing to participate in this interview?

1. **Perception of climate change and weather variability**

- What is your understanding about climate change and variability in general?

- What are your experiences in the current climate compare to the past? if any you please give further evidence on the experience ?

- What do you think are the impacts associated with Climate change and variability?

- In your view, what do you think are the main causes of climate variability and change

- How do you think these causes could be addressed?

2. **Intuitional role on climate change issue in the region**

- What services do you institutions offer to help the people in the region in addressing climate change related issues particularly farmers,

- If any, could elaborate on the services give to the people

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3. Adaptations strategies to address climate change and weather variability

- From your perspective, are the available adaptation strategies for the people particularly farmers to ease climate change related challenges in the region?

- What is your own assessment of the use of this adaptation measures for the communities

- Are there any challenges associated with the use from your own perspectives

- How could those challenges be resolved from you own point of view

4. Available support at regional level to deal with climate change related extremes in the CRR

- From your point of view, what support is available at the regional level to reduce negative climate change impacts?

- In your view, what are the challenges with regard to the support system if any and what do you think is the way forward.

5. Is there anything more you would like to add on the interview?

I will be please to share with you a copy to review at any time, if you are interested.

Thank you for your time and support.

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Appendix D: Sample Populations per Village for the Survey Field work in Central River Region of The Gambia.

No	Name of the Villages	Name of District	Actual Population	Sample Population
1	SARUJA	LOWER FULLADU	234	4
2	WELLINGARA	"	168	4
3	MADINA	"	150	4
4	JAHALLY	"	182	4
5	KEREWAN SAMBA-SIRA	"	151	4
6	PACHARI SANA	"	132	4
7	TABANANI	"	102	4
8	DARSILAMEH	"	172	4
9	BRIKAMA -BA	"	742	9
10	FULLA-BANTANG	"	331	5
11	BOIRAM	"	312	5
12	TABANDING	"	123	4
13	NJOBEN	"	105	4
14	FASS- ABDOU	"	125	4
15	BRIKAMA NDING	"	108	4
16	KORRUPT	"	41	4
17	SANKULAY KUNDA	"	154	4
18	GALLEH MANDA	"	221	4
19	MADINA TUNJANG	"	132	4
20	MISIRA	UPPER FULLADU	121	4
21	SARE SOFFIE	"	203	4
22	CHA- KUNDA	"	201	4
23	SUKUTA	"	211	4
24	DARRU -ANGLAIS	"	223	4
25	KESSERE KUNDA	"	171	4
26	BANTANTU	"	142	4
27	DOBON KUNDA	"	357	5
28	BANSANG	"	741	9
29	KUDANG	NIAMINA EAST	598	6
30	KEREWAN DEMBA	"	149	4
31	KUNUNKU	"	133	4
32	KARANTABA	"	172	4
33	SAMBELLY KUNDA	"	243	4
34	SUTOKOI	"	591	6
35	JARENG	"	704	9
36	TOUBA DEMBA	"	149	4
37	DARSILAMEH	"	211	4
38	BAATI-NJOLL	"	383	5
39	MAMUDU FANNA	"	473	5
40	MBAYEN	"	83	4
41	MACCA	"	61	4

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42	**NJIEKUNDA**	"	58	4
43	**KERR BIRAN**	"	47	4
44	**SAMBANG MANDINKA**	**NIAMINA WEST**	68	4
45	**SAMABANG FULLA**	"	71	4
46	**PENIAYE FULA**	"	88	4
47	**JAWULA-BA**	"	102	4
48	**PAPPA**	"	133	4
49	**CHOYA**	"	143	4
50	**PINIAYE**	"	213	4
51	**KATAMINA**	"	183	4
52	**DALABA**	"	77	4
53	**DANKUNKU**	**NIAMINA DANKUNKU**	677	9
54	**BUNIADU**	"	133	4
55	**JAKOTO**	"	150	4
56	**SINCHU JUKARI**	"	102	4
57	**GISSADI**	"	207	4
58	**BARO KUNDA**	"	255	4
59	**SI-KUNDA**	"	142	4
60	**SAMBANG WOLLOF**	"	39	4
61	**JANJANBUREH**	**JANJANBUREH**	957	12
62	**TANKONG KUNDA**	**SAMI**	321	5
63	**KUNTING**	"	309	5
64	**YONNA**	"	311	5
65	**KURAW**	"	198	4
66	**BANNI**	"	207	4
67	**LAMIN KOTO**	"	209	4
68	**JARUMEH KOTO**	"	547	6
69	**MANNAH**	"	75	4
70	**SALIKENNE**	"	67	4
71	**JARUMEH KUTA**	**NIANNI**	243	4
72	**KAYAI**	"	437	5
73	**SUKUTA**	"	331	5
74	**TOUBA KOUTA**	"	102	4
75	**BARAJALLY SUBA**	"	280	4
76	**FULLA KUNDA**	"	272	4
77	**JAKABBA**	"	255	4
78	**KUNTAUR**	"	225	4
79	**WASSU**	"	288	4
80	**DOCKEY**	"	34	4
81	**MANJUMBA**	"	52	4
82	**KASS WOLOF**	"	301	1
83	**MADINA**	"	248	4
84	**JELLAN**	**NIANIJA**	170	4
85	**BAKADAJI**	"	213	4
86	**SAFFALU**	"	43	4
87	**SANHULAY**	"	37	4

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88	**BUDDUKE**	"	201	4
89	**SITA KOTA**	"	241	4
90	**CHAMEN**	"	488	5
91	**BATI NDARR**	**UPPER SALOUM**	301	5
92	**BANTANTU KERR SULLAY**	"	147	4
93	**KENYEKENN**	"	47	4
94	**FASS**	"	211	4
95	**KAUR JANNEH KUNDA**	**LOWER SALOUM**	307	5
96	**BALANGHAR KER NDERY**	"	89	4
97	**JAHURU**	"	172	4
98	**BALANGHAR BANTENI**	"	75	4
TOTAL		**11**	**20,559**	**438**

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Appendix E: Number of Participant per FGD and Rice Communities Covered during the Consultation in the study area.

No	Name of rice Communities/ Villages	District	# of Male	# of Female	Total
1	Brikama Ba	Lower Fulladu West	5	7	12
2	Fulla Bantang	Lower Fulladu West	4	3	7
3	Njoben	Lower Fulladu West	3	5	8
4	Tabanding	Lower Fulladu West	2	4	6
5	Fass Abdou	Lower Fulladu West	5	6	11
6	Boiram	Lower Fulladu West	4	3	7
7	Galleh Manda	Upper Fulladu	8	5	13
8	Madina Tunja	Upper Fulladu	4	3	7
9	Kerseri Kunda	Upper Fulladu	3	2	5
10	Korrupt	Upper Fulladu	3	4	7
11	Cha Kunda	Upper Fulladu	4	5	9
12	Sare Sofie	Upper Fulladu	6	5	11
13	Sukuta	Upper Fulladu	4	3	7
14	Daru Anglais	Upper Fulladu	6	3	9
15	Dobong Kunda	Upper Fulladu	3	5	8
16	Pacharr	Lower Fulladu West	3	5	8
17	George Town/Janjangbureh	Janjang bureh	4	3	7
18	Jahally	Lower Fulladu West	6	2	8
19	Saruja	Lower Fulladu West	3	4	7
20	Si – Kunda	Niamina Dankunko	5	3	8
21	Jakoto	Niamina Dankunko	6	4	10
22	Gissadi	Niamina Dankunko	4	2	6
23	Sambang Wolof	Niamina Dankunko	3	2	5
24	Piniaye	Niamina West	4	5	9
25	Touba Demba	Niamina East	5	3	8
26	Kerewan Demba	Niamina East	5	4	9
27	Sotokoi	Niamina East	5	3	8
28	Mamud Fana	Niamina East	8	4	12
29	Jareng	Niamina East	6	3	9
30	Dalaba	Niamina West	4	3	7
31	Papa	Niamina West	5	2	7
32	Choya	Niamian West	3	2	5
33	Banni	Sami	6	3	9
34	Kujew	Sami	5	3	8
35	Kunting	Sami	6	4	10
36	Tankong kunda	Sami	4	2	6
37	Yonna	Sami	5	4	9
38	Salikenni	Sami	3	2	5
39	Jarumeh Koto	Sami	4	5	9
40	Jahuru	Lower Saloum	6	4	10
41	Kaur	Lower Saloum	3	4	7
42	Fass	Upper Saloum	5	4	9
43	Bati -Ndarr	Nianija	5	2	7

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44	Bantantu Kerr Sulay	Nianija	3	5	8
45	Chamen	Nianija	5	6	11
46	Sita koto	Nianija	6	2	8
47	Buduck	Nianija	3	2	5
48	Jellan	Nianija	3	2	5
49	Sanhulay	Nianija	3	3	6
50	Safallu	Nianija	4	4	8
51	Kass Wolof	Niani	6	3	9
52	Manjumba	Niani	3	2	5
53	Kayai	Niani	5	3	8
54	Barajally Suba	Niani	4	2	6
55	Sukuta	Niani	6	4	10
56	Touba Suta	Niani	4	3	7
57	Jakaba	Niani	3	3	6
58	Wassu	Niani	4	3	7
			257	**200**	**457**
			56.2%	**43.8%**	**100%**

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Appendix F: Student Curriculum Vitae

Brief Student Vitae

Dawda Badgie was born on the 30th of October 1973 in Brikama New Town, WCR, The Gambia, His primary and secondary education took him around the country from Brikama, (WCR), Kayai (CRR) and Basse (URR) respectively..He obtained Higher Diploma in Agriculture and Life Science (HDA) in 1997 (Gambia College), B.Sc (Hons) Degree in Agriculture and Environment in 2005 (University of The Gambia), Diploma in Management Studies in 2011 (Management Diploma Institute) and M.Sc Degree in Environmental Science in 2011 (Universiti Putra Malaysia). The benefitted several short capacity building training courses on environmental, nuclear and chemical related over the years both national and overseas. He served in different capacities in both private and public sectors; as supervisor Quality Assurance Unit Radville Farms, National Project Coordinator, Ozone Project (NEA), Senior Programme Officer and Head EIA (NEA) and currently Ag. Director, Directorate of Technical Services of the National Environment Agency, The Gambia.

Mr. Badgie has authored a book; co-authored book chapters as well as published some environmental related articles in journals, written and presented in several conference proceedings. The author is the current national liaison officer for International Atomic Energy Agency (IAEA) for The Gambia among other responsibilities.

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Appendix G: List of related study Conference Publication

1. The Impact of Climate Change on Rice Farming Communities in the Central River Region (CRR) of The Gambia. A Socio-Economic Study: Badgie, Dawda,[1] Okorley, Ernest L[2], Eguavoen, Irit [3], CISSE, Youssouf [4] Poster Presentation at the International Symposium on Weather and Climate Extremes, Food Security and Biodiversity at George Mason University, Virginia, USA from the 20 – 24 October, 2014.

2. Augmenting Climate Change adaptation Strategies in The Gambia; Evaluating the Contributions of National Institutions in Central River Region (CRR). Badgie, D[1], Okorley, EL[2], Sam-Amoah, LK[2], Eguavoen, I[3]. Accepted Paper submission for Oral Presentation at the World Symposium on Climate Change and Biodiversity (WSCCB) 2018, at Manchester Metropolitan University´s Business School, Manchester, UK, 3rd-5th April 2018.

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