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IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON SMALLHOLDER FARMERS AND ADAPTATION STRATEGIES IN SOUTHWEST NIGERIA

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DECLARATION

I declare that this thesis is my original work and has not been submitted elsewhere as a research thesis. Where other people's work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements

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DEDICATION

To God Almighty from whom all blessings and wisdom comes is this work dedicated;

To Serah Ogallah, Victor Ogallah and Samuel Ogallah for your sacrifices, prayers, support and encouragement. This feat is also yours.

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ABSTRACT

The overall objective of this study was to design effective adaptation response strategy based on improved knowledge of climate variability and change for smallholder farmers in South-west Nigeria. The study had three specific objectives, namely: to assess the trends of climate variability and change, profiles and perceptions of smallholder famers in South West of Nigeria; to examine the impacts of climate variability and change on the smallholder farmers and; to evaluate the adaptation strategies implemented by the smallholder farmers. The study relied on primary data from a sample of 411 household heads. The study also used Social Analysis System (SAS^2), multi-stage sampling techniques, household survey, focused group discussion and key informant interview. Secondary data were obtained from credible publications and the Nigerian Meteorological Agency (NiMet). The Meteorological data from 1985 to 2015 comprising of rainfall, temperature, wind speed, relative humidity and sunshine were collected from NiMet. The Statistical Package for Social Sciences, MS Excel, SAS^2 tool, Instat and Standardized Anomaly Index (SAI) were used to process the data. The Coefficient of variation (CV), Multi Criteria Analysis (MCA) and Adaptation Decision Matrix (ADM) were the key inferential statistics employed for analysis, while the graphs, charts and tables were used to present the data in descriptive statistics such as frequencies and percentages. The findings showed that though the duration of rainfall decreased, the intensity had increased by 2.1mm per annum with high degree of variability and these trends are likely to continue. It further showed an erratic rainfall pattern which resulted in late onset and early cessation. The average maximum temperature (T_{Max}) and minimum temperature (T_{Min}) increased by 0.04^0C and 0.03^0C per annum, respectively, with less variability but high intensity; relative humidity increased by 0.01% per annum with less variability; and the wind speed also increased by 2.14mph per annum, with high variability; while a decrease of -0.035W/m^2 per annum was recorded for solar irradiation with high degree of variability. The perception of farmers varied on what caused the observed changes. The perceptions ranged from an act of God, sin of mankind and climate change. The findings also showed a gap in climate information services. From the findings, decreased crop yield, increased poverty level and a general downward trend in agricultural productivity were the negative impacts of climate change among the smallholder farmers. The results also showed that smallholder farmers practiced planting of different crop varieties, land fragmentation, minimum tillage, varied planting dates, irrigation practice, crop diversification, off-farm activities, mulching, cover cropping, use of inorganic fertilizer and change in farmland as adaptation strategies. From the results it was concluded that multi-stakeholders' engagement was necessary during planning, designing and implementation of adaptation actions to ensure effective adoption and sustainability of such initiatives. Furthermore the Integrated Community-Based Planned Adaptation Strategy (ICPAS) model designed in this study provides an important framework that will contribute to reduce vulnerability, build adaptive capacity and resilience of smallholder farmers to the impacts of climate variability and change.

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ACRONYMS AND LIST OF ABBREVIATIONS

ACCOYS	Agricultural Credit Corporation of Oyo State
ADM	Adaptation Decision Matrix
AR	Assessment Report
ATPS	Africa Technology Policy Studies Network
BAU	Business as Usual
BNRCC	Building Nigeria's Response to Climate Change
BoA	Bank of Agriculture
BoI	Bank of Industry
CAADP	Comprehensive Africa Agriculture Development Programme
CBA	Community Based Adaptation
CBPAR	Community Based Participatory Action Research
CoP	Community of Practice
COP	Conference of Parties
CUTS	Consumer Unity and Trust Society
CV	Coefficient of Variation
EAC	East African Community
ETL	Extract, Transform, Load
FAO	Food and Agriculture Organisation
FGN	Federal Government of Nigeria
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoK	Government of Kenya
ICPAS	Integrated Community-based Planned Adaption Strategy
IGR	Internally Generated Revenue
IITA	International Institute for Tropical Agriculture
IK	Indigenous Knowledge
IPCC	Intergovernmental Panel on Climate Change
KS	Knowledge Sharing
LVB	Lake Victoria Basin
LGA	Local Government Area
MCA	Multi Criteria Analysis

MDGs	Millennium Development Goals
MoANRRD	Ministry of Agriculture, Natural Resources, Rural Development, Oyo State
NAIC	Nigerian Agricultural Insurance Cooperation
NASC	National Agricultural Seeds Council
NASPA-CCN	National Adaptation Strategy and Plan of Action on Climate Change for Nigeria
NBS	National Bureau of Statistics
NEST	Nigerian Environmental Study/Action Team
NGO	Non-Governmental Organization
NiHORT	National Horticultural Research Institute
NIMET	Nigerian Meteorological Agency
NPC	National Population Commission
OYSADEP	Oyo State Agricultural Development Programme
PA	Paris Agreement
PPP	Public Private Partnership
RAI	Rainfall Anomaly Index
RMAFC	Revenue Mobilization Allocation and Fiscal Commission
ROI	Return on Investment
RUAF	Resource Centres on Urban Agriculture and Food Security Foundation
SAI	Standardized Anomaly Index
SAS^2	Social Analysis Systems –Second Generation
SDGs	Sustainable Development Goals
SIDs	Small Island Developing States
SPSS	Statistical Package for Social Sciences
SSA	Sub- Sahara Africa
TD	Transdisciplinary
UCH	University College Hospital
UI	University of Ibadan
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WANEP	West Africa Network for Peace Building
WB	World Bank
WMO	World Meteorological Organization

GLOSSARY OF TERMS

Adaptation: "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC 2014).

Anticipatory adaptation: "adaptation that takes place before impacts of climate change are observed. This type is also referred to as proactive adaptation (AMCEN, 2011).

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. It is also referred to as spontaneous adaptation (IPCC, 2007). This adaptation involves changes that systems will undergo in response to changing climate, irrespective of any policy, plan or decision. It can be represented by the reaction of, for example, a household to a reduced water supply by storing water or by economizing its use. Natural systems such as plant communities usually develop autonomous adaptation i.e. adapt reactively (AMCEN, 2011).

Climate change: According to IPCC "climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes." (UNFCCC, 1992; IPCC 2014).

Climate system: "The totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions." (UNFCCC, 1992).

Climate variability: "Variations in the mean state and other statistics (e.g. standard deviations or the occurrence of extreme events) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural external processes outside the earth system or natural or anthropogenic internal forcings" (AMCEN, 2011; UNFCCC, 1992).

Conference of the Parties (COP): "The Conference of the Parties to the Convention" (UNFCCC,1992).

Convention: "The United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992." (UNFCCC, 1992).

Emissions: "The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time." (UNFCCC, 1992).

Exposure: "The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected." (IPCC, 2014).

Greenhouse gases: "Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation." (UNFCCC, 1992).

Hazard: "The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources." (IPCC, 2014).

Impacts: "Effects on natural and human systems. The term *impacts* are used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as *consequences* and *outcomes*. Floods, droughts, and sea level rise are a subset of impacts called physical impacts" (IPCC, 2014).

Maladaptation: "an action or process that increases vulnerability to climate change-related hazards. It can refer to 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 while maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term" (Barnett and O'Neill 2009; AMCEN, 2011).

Party: "A Party to the Convention or/and Paris Agreement" (UNFCCC, 1992; UNFCCC, 2015).

Perception: Detection of information from the environment which could involve an intervention of memory images and representation based on the inputs from the stimuli in the nervous system involving a complex interpretation of such inputs received and processed (Michaels and Carello, 1981).

Planned adaptation: "the result of a deliberate policy decision, based on awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state" (IPCC, 2007).

Reactive adaptation: "reactive adaptation takes place after the initial impacts of climate change have occurred. Unlike planned adaptation which takes place prior to the events, the reactive adaptation is triggered by the events and starts after the impacts have been felt" (AMCEN, 2011).

Reservoir: "A component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored" (UNFCCC, 1992).

Resilience: "The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation" (IPCC, 2014).

Risk: "The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard" (IPCC, 2014).

Sink: "Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere" (UNFCCC, 1992).

Source: "Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere" (UNFCCC, 1992).

Transformation: "A change in the fundamental attributes of natural and human systems. It also could reflect strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction" (IPCC, 2014).

Vulnerability: "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2014).

CHAPTER ONE

INTRODUCTION

1.1 Background

The term climate change means the variability in the mean state of climate that extends for a comparable period of time attributable to human activities which may be direct or indirect together with natural variability over a longer period of time ranging from decades and beyond (UNFCCC, 1992; NEST and Woodley, 2011a; IPCC, 2014).

Climate variability and change will continue globally to undermine and erode the development gains made by communities and countries over the years. The impacts are observed in almost every sector, be it socio-economic or environment. The heightened impacts of this changing climate will continue to intensify in the coming years and will be increasingly felt in Nigeria and other countries in the developing world especially in Africa, a continent recognised to be very vulnerable to the effects of the variability in climate and its changes (NEST and Tegler, 2011b, UNEP, 2014).

Some critical sectors like agriculture, infrastructure, transport, human health and settlements, education, communications, commerce and industries and natural resource will all be impacted by the changing climate. Agriculture will be particularly affected because most of the agricultural practices in Nigeria and other countries in Sub-Saharan Africa are rain-fed and dependent on other climate sensitive variables. Stern (2007), IPCC (2014), UNEP (2014) alluded to this fact that the impacts of this changing climate will even be greater in Africa leading to substantial decline in crop yield.

Climate change and food insecurity are both closely linked. The two pose one of the greatest threats to human, animal and plant survival in the 21st century. To underscore the importance of the inter-link of these two variables, the Paris Climate Agreement (known as the Paris Agreement) adopted on 12th December, 2015 that came into force on 4th November, 2016 explicitly "Recognized the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change".

Agriculture and smallholder farmers in many developing countries are front and centre and at the heart of climate impacts putting them at the receiving end of the effects of climate variability and change. In Nigeria, small scale farmers account for approximately 95 percent of total agricultural output with crop yields that are in the range of 0.6 to 1.5 tons per hectare against the expected yield of 1.44 tons per hectares (NEST and Tegler, 2011b). Smallholder farmers constitute majority of the food producers in the Nigerian agriculture sector. Unfortunately, food production in Nigeria is on the decline and documented evidence shows that the food production (supply) in Nigeria has not matched the food consumption (demand) of Nigerians thereby giving rise to increase in food importation worth US$1.4 billion in 1990 (NEST and Tegler, 2011b) and the value rose to US$7.665 billion worth of food imports by 2011 (Vaughan *et al.*, 2014). This trend is likely to continue if nothing is done to address climate change and its impacts globally, nationally and locally. Effective response solution and adaptation measures to the changing climate will therefore require a Community of Practice (CoP) where science and the society interface to draw up a strategy that will provide a solution to this problem and risk multiplier called climate change. In Africa and other developing countries, the impacts of climate change are exacerbated by weak adaptive structures as confirmed by many literature and studies.

1.2 Problem Statement

The global change in the climate system has in recent times become the most devastating problem the world faces. It represents a huge challenge to every sector of the economy and the solution will require collective actions at all levels by all stakeholders and actors in the field to take urgent action to combat this threat (Stern, 2007; Ogallah, 2016). Climate change has been suggested to be more of a global threat compared to terrorism and it is also the most significant challenge of the 21st century (Ayinde *et al.*, 2011; WANEP, 2014). In the words of the United Nations Secretary General, António Guterres "The headlines are naturally dominated by the escalation of tensions and conflicts, or high-level political events but the truth is that the most systemic threat to humankind remains climate change and I believe it is my duty to remind the whole of the international community" (United Nations, 2018).

The agricultural sector on which food security is anchored and which represents 30 percent of Africa's GDP has over the years been plagued by the changing climate and its associated drivers such as rise in temperature, precipitation, sea-level rise and incidence of extreme events in weather patterns (Chidumayo, 2011). In Nigeria, available evidences have shown that the country is currently faced with grievous ecological and food insecurity threats, conflicts and insurgencies posed by different factors which are directly or indirectly linked to climate variability and change and all these need to be considered (NEST and Tegler, 2011b; Bello *et al.*, 2012). All the four aspects of food security (availability, stability, utilization and access) will be severely impacted by climate change (FAO, 2013). This comes with huge implications on the cost of adaptation. The economic cost of climate change in Nigeria if no adaptation is implemented according to NASPA-CCN (2011) report could amount to a loss of between 2 percent and 11 percent in the Gross Domestic Product of Nigeria by the year 2020 and could increase to about 6 percent to 30 percent in 2050. This loss could approximately be around US$100 billion and US$460 billion, respectively.

The irregularity coupled with unpredictability of the rainfall pattern that currently characterises Southwest Nigeria which previously was known for its high and stable rainfall pattern (Ayinde *et al.*, 2011) has affected crop production and smallholder farming in the area. The impacts of changing climate patterns in southwest Nigeria especially with the smallholder farmers in the target localities have in recent years manifested in low crops yield leading to reduced income, socio-economic hardship, increase in poverty level, malnutrition, high rate of school drop-outs due to inadequate resources to support schooling beyond secondary level, increased level of lawlessness and other social vices among youths (Zabbey, 2007; Abiodun *et al*., 2011; Olajide, 2014). Furthermore, conflicts as experienced in Nigeria, poverty, environmental disruptions, and a growing population in addition to climate change have also added to the decline in food production (UNDESA, 2017).

To tackle hunger, African continent needs to find new integrated approaches. Some of these approaches which were discussed during the 9th Harvard University conference in 2017 on Annual Nutrition and Global Health Symposium: Agriculture, Nutrition, Health, and the

Environment in Africa, must increase crop yield, enhance the nutritional content of people's diets, improve people's health, and promote sustainability[1].

1.3 Research questions

1: What is the profile and perception of the smallholder farmers on climate variability and change and are there scientific evidences that show that the climate is changing in Southwest Nigeria?

2: What impact does climate variability and change have on the smallholder farmers in Southwest Nigeria?

3: Which adaptation strategies and options are smallholder farmers in Southwest Nigeria practicing to cope and adjust to climate variability and change?

1.3.1 Research objective

To design effective adaptation response strategy based on improved knowledge on the impacts of climate variability and change for the smallholder farmers in Southwest Nigeria.

1.3.2 Specific objectives

1: To assess smallholder farmers' socio-economic profile and perception with regard to climate and its variability and change trends;

2: To examine the effects of climate variability and change among smallholder farmers; and

3: To evaluate smallholder farmers' adaptation strategies and options to climate variability and change.

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[1] https://www.hsph.harvard.edu/nutrition-and-global-health/lecture-seminar-series/agriculture-nutrition-health-and-the-environment-in-africa/.

1.4 Justification and Significance of the study

1.4.1 Justification

There is no doubt that agriculture continues to contribute to the global, Africa and Nigeria's GDP. Negotiations on matters relating to agriculture have also been ongoing since the United Nations Summit at its Seventeenth Conference of Parties on Climate (COP 17) held in South Africa with the aim of finding a lasting solution to the problem posed by climate change to agriculture. However, these negotiations are yet to produce the expected results or solution to the problem (Ogallah and Rapando, 2018).

In Nigeria, in the non-oil sector for instance, agriculture contributed 26 percent to the real GDP in the fourth quarter of 2016 (NBS, 2017). This sector is also contributing to poverty reduction and employment generation and holds some elements of helping vulnerable groups to escape poverty and adapt to climate variability and change impacts (Tesie *et al*., 2015) yet the sector continues to be heavily impacted by climate change. Food security and climate change is a great concern to Nigeria in the face of declining crop and livestock production, increased hunger, high level of poverty rate and inequalities, low income, conflicts, insurgencies, increasing incidences of climate related diseases, pest infestation, mal-adaptation etc. Responding to the challenges of climate variability and change trend has also become a major priority and of urgent importance to the global community (UNEP, 2011; FAO, 2013).

Previous study reports (e.g. Robert and Chinenye, 2015) showed that some studies have been carried out in Southeast Nigeria to gain insights into farmers' perception on climate change and its trends. This group of studies, however, failed to compare and match information of whether the farmers rightly understand the change and the selection of their adaptation strategies. Similarly, the study did not cover Southwest Nigeria and as such leaves a gap in literature and more research on perception and trends in climate variability and change patterns needs to be conducted.

Nigeria's ability to cope with climate related adverse impacts and also feed its growing population of 182 million which is projected to hit 210 million by 2021 at the current growth rate of 3.5 percent annually (NPC, 2017) is coming under intense scrutiny and call for urgent action with the present decline in agricultural production. The non-oil sector comes second to the oil sector which is the backbone of the country's economy. Both the oil and non-oil sectors are experiencing decline in growth rate and their contribution to Nigeria's GDP. According to the NBS (2017) report, a look at the real GDP share of oil contribution to the economy showed a drop from 9.61 percent in 2015 to 8.42 percent in 2016 while the non-oil sector which includes agriculture in 2016 declined by -0.22 percent compared to the growth rate experienced in 2015 of 3.75 percent leading to a huge points difference of 3.97 percent. This has partly been caused by climate change and other non-climatic drivers in the environment.

Similarly, the ever increasing climate change impacts and its related costs especially among smallholder farmers in Nigeria will require accurate information supported by transdisciplinary research approach and thorough assessment of smallholder famers' adaptive capacity to climate variability and change. There are emerging studies on the subject of climate change carried out in Nigeria but only few have been carried out on the impacts of climate variability and change on smallholder farmers in southwest Nigeria, hence the timeliness of this research.

Furthermore, the smallholder farmers are confused on the best adaptation option to adopt in the current changing climate, thereby trying out different adaptation strategies to adapt and with varying degree of such adaptation practices. These efforts in some cases results in mal-adaptation. Scientists, non-governmental organizations, research institutions, universities, government and communities all over the world including Nigeria are also struggling with the best approach to solve this problem. In Southwest Nigeria, the selected study region was chosen because of its roles and geographical advantages in agriculture and in Nigeria with the projected impacts on agricultural production and smallholder farmers' livelihoods.

1.4.2 Significance of the study

In view of the current situation of declining crop production globally, in Africa and also in Nigeria, urgent need is required with further research on these impacts of climate variability and change on agricultural productivity. There is also an urgent need for research on smallholder farmers and their perception with regard to changing climate given its impacts on the changing livelihood pattern and adaptation strategies as well as its negative socio-economic impacts on the people (AMCEN, 2011; Abiodun *et al.*, 2011; NASPA-CCN, 2011; Bello *et al.,* 2012*;* Ademola, 2012*;* Olajide, 2014).

So far, only few studies on climate variability and change with regard to smallholder farmers have been undertaken in southwest Nigeria and particularly in Oyo State. More so, there still exist gaps in identifying effective solutions to the problems of variability and change in climate as well as perceptions about this change; these gaps require further location specific research and studies in the subject area (Bello *et al.,* 2012*;* Olajide, 2014). This study was designed to contribute to addressing such gap, hence, its significance in this aspect.

This study will contribute to increasing adaptive capacity and resilience of smallholder farmers in the target region through improved knowledge as well as possibly help in the adoption of new and improved adaptation strategies. It will also add new insights to the body of knowledge with regards to climate variability, climate change, perceptions of the variability and change in climate, impacts and adaptation strategies. The study has the potential to serve as a springboard for other communities and regions across Nigeria, Africa and other developing countries with similar climatic characteristics and climate change impacts. It is envisaged that the research will inform decision making on the effective and appropriate strategies to solving the problem of climate variability and change by government, other decision makers and relevant stakeholders.

1.5 Scope of the research

The thematic area of this study is Climate Risk Management and Food Security. The research topic for this study is “The impacts of climate variability and change on the adaptation strategies adopted by smallholder farmers in Southwest Nigeria”. The research work was confined to Southwest Nigeria and focused on smallholder farmers in the region, the climate trends, variability, perceptions with regard to climate change, their exposure to the impacts of climate variability and change including adaptation strategies practice within the region by the farmers. The study covered a period of 31 years from 1985 to 2015. The scope was also defined by the limited budget, time and other resources required to carry out the study. Other stakeholders within the scope of the study and the region were also engaged in the course of the research. Some of these stakeholders included but not limited to Oyo State Agricultural Development Programme (OYSADEP), International Institute for Tropical Agriculture (IITA), National Horticultural Research Institute (NiHORT), Nigerian Environmental Study/Action Team (NEST), Department of Climate Change of the Federal Ministry of Environment, Nigerian Meteorological Agency (NiMet), University of Ibadan (UI) and the National Agricultural Seeds Council (NASC).

1.6 Overview of the methodological approach

The research used a Transdisciplinary (TD) methods comprising of Social Analysis System (SAS^2), Multi Criteria Analysis (MCA), Adaptation Decision Matrix (ADM) and Timeline-force-field applications.

From March to May 2016, primary data was collected through interviews, household surveys, FGDs, oral history and observation methods. Secondary data was obtained from the meteorological department and various publications. The data were analysed using Statistical Package for Social Sciences (SPSS), Social Analysis System (SAS^2) tool, Adaptation Decision Matrix (ADM), Multi Criteria Analysis (MCA), Standardized Anomaly Index (SAI), Coefficient of variation (CV) and MS excel.

Descriptive statistics such as frequencies, means and percentages were also employed. The data were presented in charts, graphs and tables Because of lack of adequate gender disaggregated records of smallholder famers in the communities, the disproportionate sampling was done based on the principle provided by Rubin and Babbie (2008) to select smallholder farmers especially between male and female headed farming households within the communities.

Secondary data were obtained from institutions such as International Institute for Tropical Agriculture (IITA), National Horticulture Research Institute (NiHORT), OYSADEP, National Agricultural Seeds Council (NASC), National Bureau of Statistics (NBS), Ministry of Agriculture, Natural Resources and Rural Development (MoANRRD), University of Ibadan (UI) and the Nigerian Environmental Study/Action Team (NEST).

At all the stages of data analysis, triangulation was made for the primary data and secondary data. Social Analysis System (SAS^2) was used in the analysis stage of the primary data. SAS^2 is an approach which is widely used for participatory research where action, learning and social engagements with different stakeholders helps to find solution to a complex problem through Knowledge Sharing (KS) (Chevalier *et al*., 2008). The SAS^2 tool resonates with the "Knowledge Democracy" of the Community-Based Participatory Action Research (CBPAR) advocated by Openjuru *et al*. (2015).

Also used were the Multi Criteria Analysis (MCA) and Adaptation Decision Matrix (ADM) tools. These tools provided a systematic approach for decision making using a variety of adaptation strategies and options provided by target stakeholders and helping to narrow down options for implementation of realistic adaptation strategies (UNFCCC, 2005; Aarjan and Heather, 2013).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Over the years, several studies and research such as the first to fifth Assessment Reports (AR1-5) of the Intergovernmental Panel on Climate Change (IPCC) have been commissioned and many bodies including IPCC, World Meteorological Organization (WMO), and United Nations Environment Programme (UNEP) have been established by different international, regional and national governments and inter-governmental bodies to provide the required information on the vulnerabilities, resilience, adaptations, mitigation and the impacts of climate change at different levels and regions though with little or no attention given to the concept of climate variability and change and its perception to local communities. The efforts by the global community, however, have not been able to deal adequately with the ever evolving dynamic challenges posed by climate variability and change especially to smallholder farmers in rural communities in many developing countries. Climate change continues to remain a risk multiplier in addition to the already competing challenges to sustainable development in this century.

2.1.1 The perceptions and trends of climate variability and change

The IPCC (2014) report confirms the increasing trends in global average temperature and predicted decreasing rainfall in many parts of the world especially in Africa which is the most vulnerable continent to climate change (Figures 2.1 and 2.2). These trends are likely to continue if actions are not urgently taken to reduce the concentration of greenhouse gases in the atmosphere and further mitigation action carried out in this century. Several reports (Stern, 2007; AMCEN, 2011; Abiodun *et al*., 2011; UNEP, 2014; Ogallah *et al*., 2017a) and as shown in Figures 2.3, 2.4 and 2.5 alluded to these increasing trends leading to further global warming and climate change with its attendant consequences for the planet.

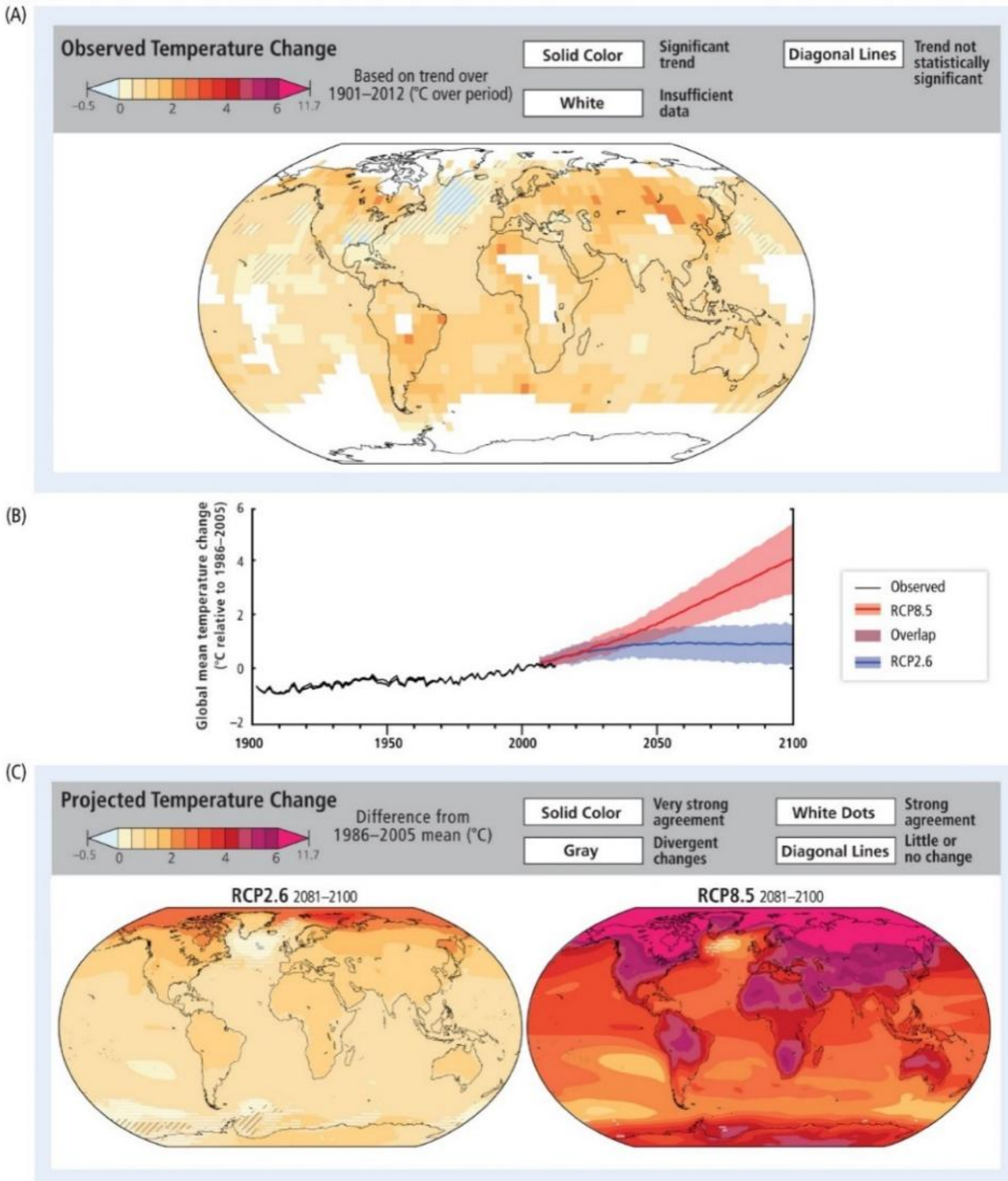

Figure 2.1: Observed and projected global mean temperature changes (1900-2100)
Source: IPCC, 2013

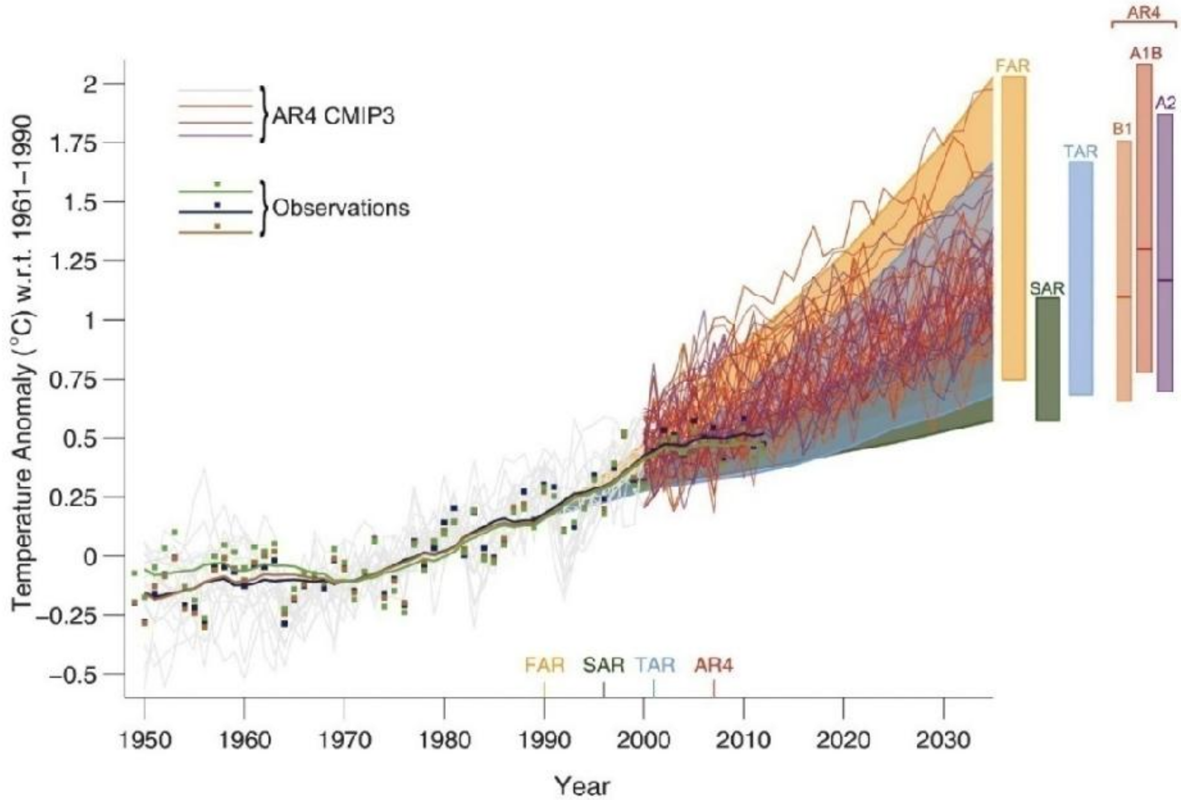

Figure 2.2: Observed and projected global temperature anomaly (1950-2030)
Source: IPCC, 2013

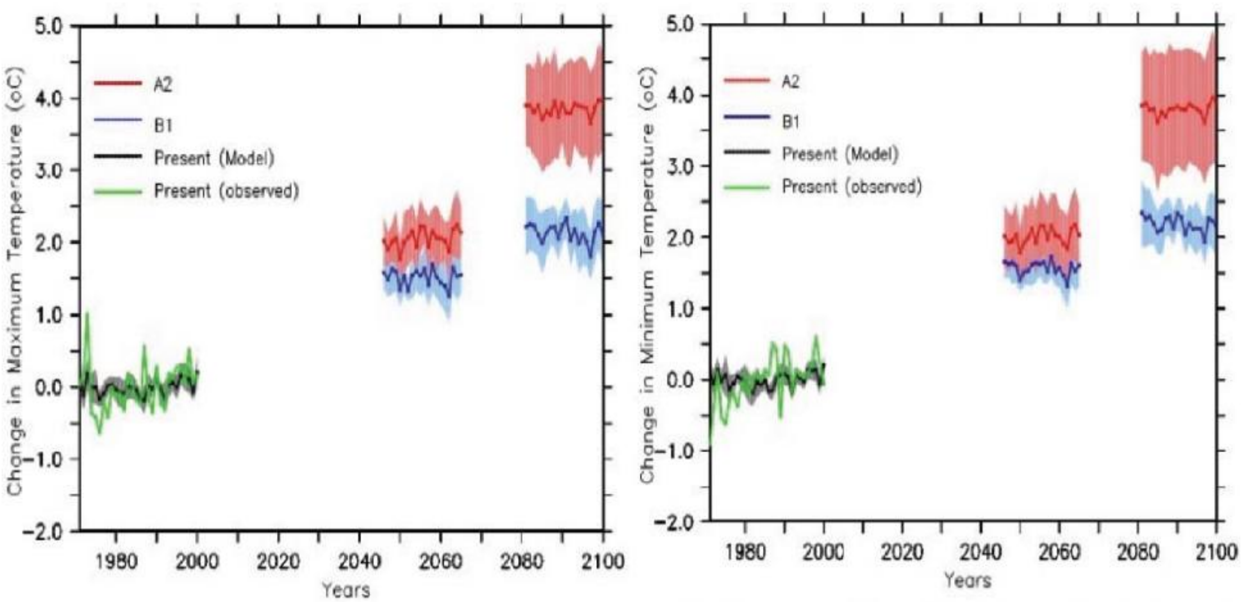

Figure 2.3: Time series in maximum and minimum temperature changes for past and future climate in Nigeria
Source: Abiodun *et al.* (2011)

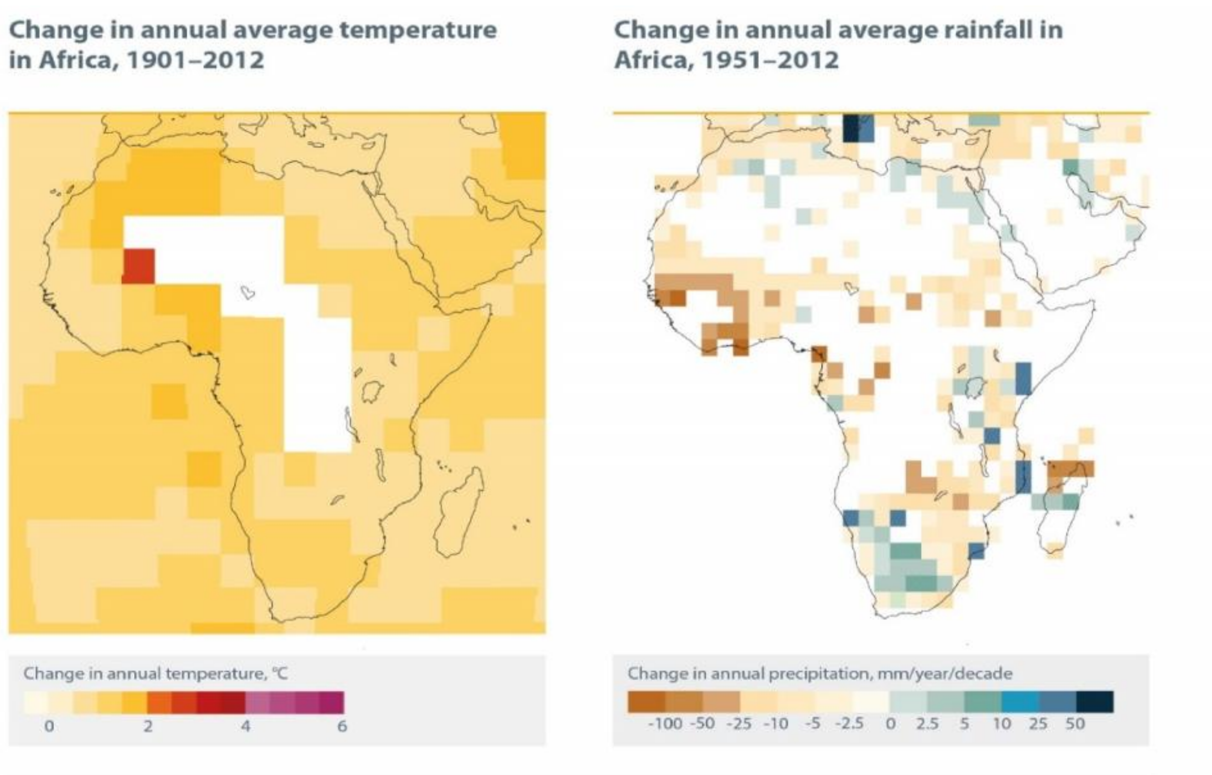

Figure 2.4: Changes in annual average temperature and rainfall in Africa (1901-2012)
Source: IPCC, 2014

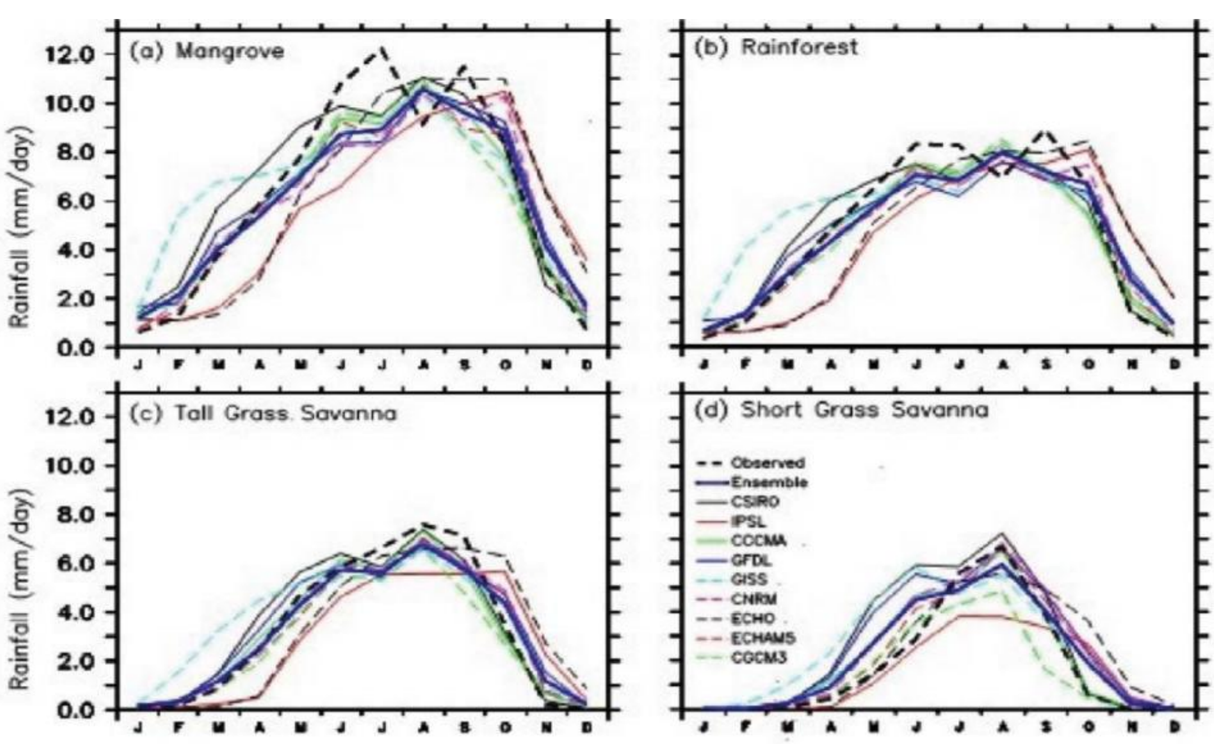

Figure 2. 5: Observed and stimulated mean monthly rainfall variation for Nigeria (1971-2000)
Source: Abiodun *et al.* (2011)

In the West Africa country of Ghana, Emmanuel *et al.* (2014) assessed the perceptions together with the views of Ghanaian policy makers on the impact of climate change within smallholder agriculture and productivity in Ghana. The result of this study confirmed that despite Ghana's policy on climate change, most of the policy makers were not aware of the content of this document. The study also asserted that to improve productivity in agriculture through smallholding farming approach in Ghana, there is need for a national dialogue on climate change adaptation and mitigation to ensure that agricultural productions are driven by available scientifically backed data.

Considering the relevance of perceptions in climate change by smallholder farmers, different players involved in addressing climate change challenges often give little or no attention to smallholders' perceptions about climate variability and change. In a study carried out on the smallholder farmers' perception of climate change and conservation agriculture (Progress *et al.* 2011), it was found that even in conservation agriculture as one of the strategies for adaptation to climate change, most practitioners and researchers often ignore this vital aspect of the perception of most farmers to climate change in the adaptation strategies. Paying less attention therefore to the farmers' perception of these climatic changes can hamper effective strategies for adaptation to variability and change in climate in the long run (Progress *et al.*, 2011).

In the study on climate change and adaptation in Nigeria in the rural farming system economics, Nwajiuba (2008) and Ayanlande *et al*. (2016) found that when it comes to addressing some of the challenges of climate change, most research has not adequately given attention to the smallholder famers' perception on some of the climatic changes as well as their employment and income status as it relates to adaptation to the climate variability and change impacts.

2.1.2 The impacts of climate change on agriculture and smallholder farmers

Sivakumar *et al.* (2005) and Stern (2007) confirmed that climate variability and change will continue globally and would have significant impacts on agriculture and smallholder farmers in many developing countries through fluctuations in food production and this is in addition to other impacts in other sectors of the economy. This trend would likely continue in the absence of appropriate adaptation measures. While in the agriculture sector some countries with higher altitude in the developed north may likely experience positive impacts of climate variability and change as a result of increased temperature on their agricultural produce, the global south and especially Africa will continue to be impacted negatively by the same climate factor thereby leading to decline in agricultural yield because of weak adaptive systems and low topography (Stern, 2007).

The African continent is host to many developing countries and some Small Island Developing States (SIDs) which are very prone to the impacts of climate variability and change. According to Africa's Adaptation Gap Report (2014) and The Stern Review, a total of 97 percent of the crop land in Sub-Sahara Africa is rain-fed (climate sensitive) and this agriculture sector employs a labour force of about 60 to 65 percent compared to other sectors (Stern, 2007; UNEP, 2014). The reports also indicated that the farming conditions present in the continent are further compounded with the population growth, climate and other non-climatic factors such as lack of quality seeds, degraded soils, and market opportunities. All these factors put together determine the failure of the smallholder agriculture farmers on agricultural productivity (those operating a farm land of 2 hectares or less and on a small scale).

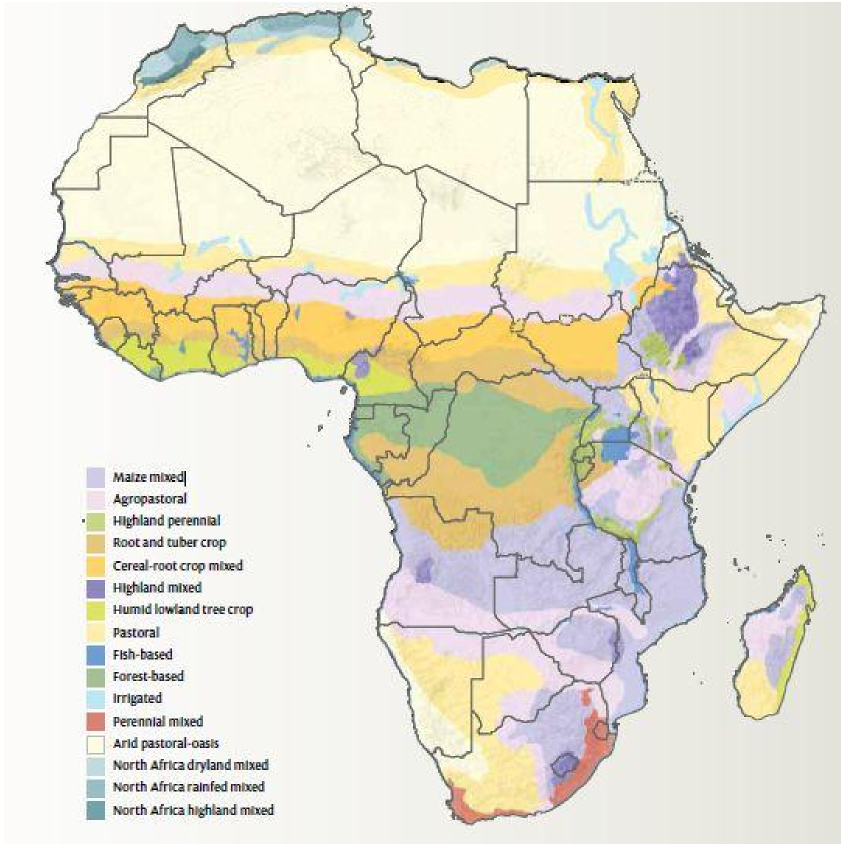

Figure 2.6: Atlas of Africa agricultural farming system
Source[2]

Ifejika (2010) and Chidumayo *et al.* (2011) found that the adverse impacts of climate change on smallholder farmers in Sub-Saharan Africa (SSA) is greatly contributing to the worsening situation of crop production and food insecurity on the continent. The impacts also increase the vulnerability portfolio of the continent's rain-fed dependent agriculture sector to climate variability and change. These studies further confirmed that the impacts of climate change will continue to increase the vulnerability of many communities and agricultural system in Sub-Sahara Africa to the extreme changes due to weather events such as flood, drought and desert encroachment. This change will affect the whole farming system (Figure 2.6) in Africa. Similarly, the warming temperatures and a shorter wet season could lead to a significant reduction in cereal production which could have an adverse impact on households

[2] http://agriculturenigeria.com/research/research-updates/atlas-of-african-agriculture

and national food security status. In several countries in Africa, the impacts of the variability and change in climate patterns will continue to be on the increase in every sector of the economy with agriculture sector being one of the most impacted by these adverse climatic events (Stern, 2007; FAO, 2013; FAO, 2017).

The situation of the increasing impacts of climate change is widespread in other regions of Africa. In East Africa, Mwebaza and Louise (2009) found that the impacts of climate change in the region will become more severe than already anticipated because of the other multiplier effects of the current stressors noting that the current food shortages observed in Kenya are testimony to the unexpected impacts of climate change in the region. The study also found that food crisis in Kenya and other countries within the region is a reflection of how minimal or no attention has been paid with regards to well-designed adaptation strategies and climate policies. The study by Omemo *et al.* (2015) that sought to assess the impacts of drought on household's food options and juvenile diet in the Lake Victoria Basin (LVB), Kenya corroborates Mwebaza and Louise (2009) report. Omemo *et al*. (2015) found that well-designed adaptation strategies to improve household's sources of food are needed in the Lake Victoria Basin of Kenya. The LVB also faces increasingly recognizable climate change threats to households' food supplies as a result of crop failure and reduced sources of livelihood. A transdisciplinary research approach could therefore be a possible way to address the identified gaps in these studies.

The study that investigated the understanding of biophysical impacts of climate change in Nigeria by Abiodun *et al*. (2011) found that projected climate change could have adverse impacts on agriculture by causing declined crop production in the entire country. The study also found that there will be an increase in the frequency of the occurrences of heat waves, extreme rainfall with short duration, and flooding in Nigeria across all ecological zones. This study further confirmed that the prevailing and anticipated adverse consequences of changing climate are manifest in the social, economic, environmental and more importantly the agriculture sector in Nigeria. These changes could possibly have devastating impacts on food security causing increase in crop failure and general decrease in crop production nationwide and especially the maize production (Figure 2.7). This should probably necessitate further location specific investigation to fully ascertain these findings.

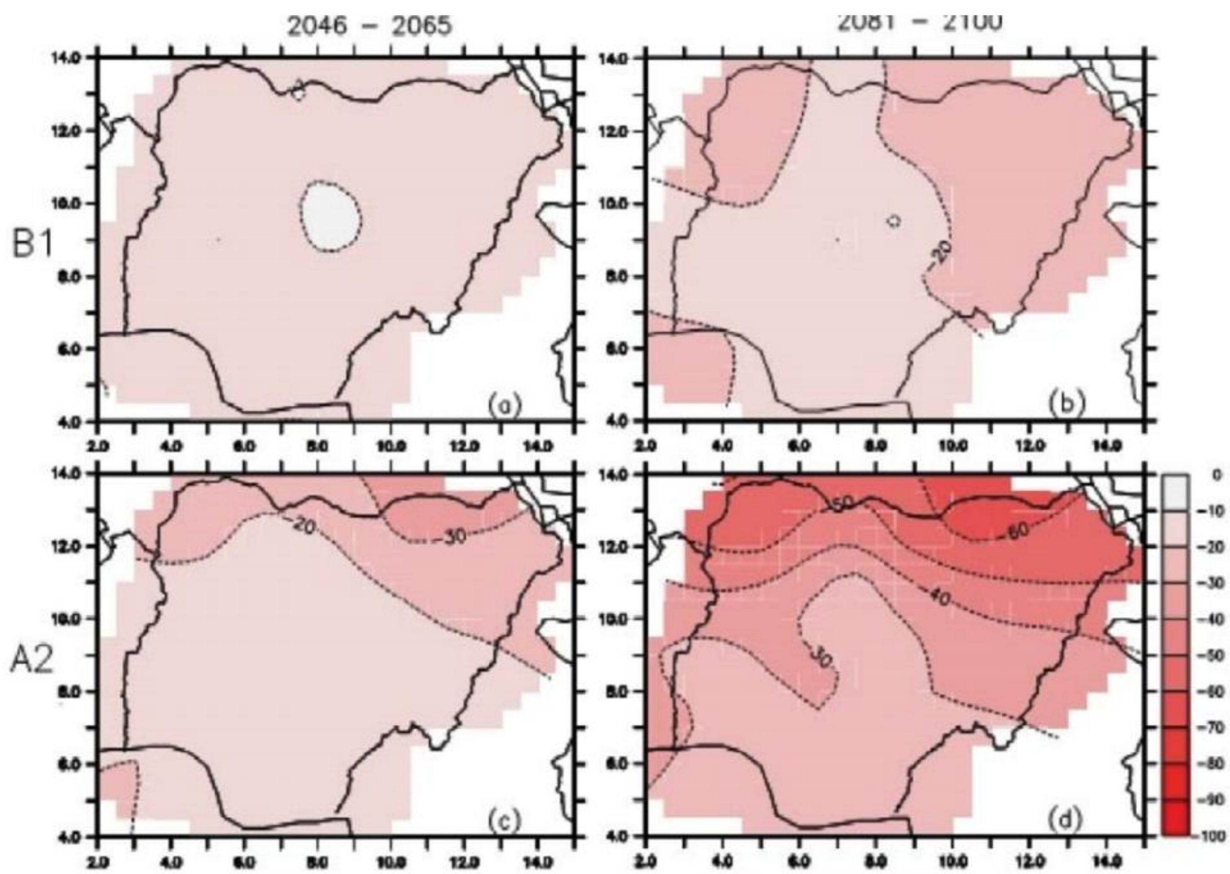

Figure 2.7: Projected negative impact of maize yield in Nigeria
Source: Abiodun *et al.* (2011)

2.1.3. Adaptation strategies and options

Gina *et al.* (2006) examined strategies at local level in the District of Vhembe in Zambia for adaptation to variability in climate and interest on communal agriculture with regard to irrigation system and making informed decision. The study found that there is an urgent need for further research that will assess how farmers are responding to the multiple challenges posed by the changing climate and what may be done to support adaptation to climate change. The study concluded that improved adaptation methods are required to address the ever increasing importance of climate-related impacts and the complexity of uncertainty and associated risks. These gaps call for urgent attention from researchers and other stakeholders involved in finding solution to the current challenge posed by climate change to embracing a new approach in the search for solutions to the problem. In Ethiopia, Aemro *et al*. (2012) investigated the strategies for adaptation of farmers in Babilie District. The study found that smallholder farmers tend to have a weak adaptive capacity to changes in the climate situation hence, policies, strategies and research that are helpful to farmers to adapt to the change are very important. Using a multinomial logic regression analysis, the study also found that sex, age and level of education attained, the size of the family, level of income, ability to access finance, proximity to market, extension services among others have significant impact on choice adaptation methods.

In a study on climate change and agriculture in different part of Africa and Nigeria, Ifejika (2010) and Ozor (2014) observed that farmers have adopted several adaptation strategies in many rural communities to cope with the vagaries of climate change especially in Southeast Nigeria though there still exist some challenges on the effectiveness with the implementation of some of those adaptation options available to the farmers.

2.1.4 Vulnerability to climate variability and change

The degree, magnitude and length of time to which a system is susceptible to, unable to cope with, failure to adapt to and recover from climatic shocks and other negative impacts of climate variability and change is referred to as vulnerability. Vulnerability can result from many factors including the characteristics, magnitude, length, and rate of climatic changes to which a system is exposed, its sensitivity and ability to adapt to the impacts of these changes (IPCC, 2013; Ogallah, 2014). Vulnerability is also the rate to which a system or community is unable to prevent, mitigate, cope with and incapable of adapting to particular hazards over a given period of time (WANEP, 2014). The vulnerability of smallholder farmers to the adverse impacts of climate change has become pronounced in recent time as their ability to adapt is gradually being eroded by little or no access to effective adaptation strategies. In order to minimize the vulnerability of these target groups to climate impacts, concerted efforts will be required by all stakeholders towards building resilience to prevailing climatic shocks.

2.1.5 Resilience to climate change impacts

Resilience is a situation where the system, individual, smallholder farmers, farming community or group is/are able to withstand climatic shocks and changes and capable of recovering from such shocks and changes when exposed to such adverse conditions (UNFCCC, 1992; Ogallah, 2014; IPCC, 2014). When such a system absorbs such disturbances be it social, economic or ecological and still retain its basic functioning roles and capacity for self-reorganization and well able to adapt to these changes, resiliency seems to have occurred (GoK, 2013). Achieving resiliency should be one of the expected objectives and aim of any climate intervention targeting agriculture sector and farmers that are already being impacted adversely by current variability and change in climate patterns.

2.1.6 Adaptive capacity to climate variability and change

This is a situation where individuals, organisms or communities are able to adjust, cope and moderate their lifestyle to the potential climatic variation and changes in their environment (Ifejika, 2010). The ability to adapt by individuals or social groups varies and also a function of their access to and control over resources such as land, credit facilities, and climate information (AMCEN, 2011). The poor particularly have limited access to some of these resources and as such are most vulnerable to environmental shocks, climate variability and change and have the least capacity to develop viable adaptive capacities and/or strategies (Ogallah, 2014). Enhancing the adaptive capacity of a community therefore calls for integrated approach of using indigenous knowledge, new and innovative ideas and strategies by community members to reduce their vulnerability to the adverse consequences of the changing climate and increasing their resilience against the observed changes. Local communities are also capable of generating good evidence that can help in resilience building and adaptive capacity to climate change as they are much closer to the impacts and their space in the adaptation spectrum compared to the other groups in the society (Atela *et al.*, 2016).

2.1.7 Climate change and the Sustainable Development Goals (SDGs)

The Sustainable Development Goals have an overarching ambitious goal of ‘ending extreme poverty in all its forms everywhere by 2030’ while ‘Leaving No One Behind’. In recognition of the impacts of climate change in the development trajectory, SDG Goal #13 expressly states "Take urgent action to combat climate change and its impacts". Learning from experience, the achievement of MDGs was severely constrained by the insufficient attention paid to climate change (NEST and Woodley, 2011a). It is therefore important that the new development framework has placed attention on climate change in setting a standalone goal for it in the SDGs.

CHAPTER THREE

STUDY AREA AND METHODS

3.1 Location and description of the study area

Nigeria has a land mass area of 909, 890 km^2 and is located between longitudes 3^0 and 14^0 E and latitude 4° and 14°N (Nwajiuba, 2008). It had a population of 182 million as at 2017 with an annual growth rate of 3.5 percent (NPC, 2006; WB, 2013; NPC, 2017). It has been projected that with this annual growth rate, the estimated number of people in Nigeria will reach about 210 million by 2021 (NPC, 2017). This increasing growth rate will have dire consequences on the country's ecosystem and its carrying capacity thereby putting enormous pressure on land and other natural resources which are dependent on climate variables. Already, climate trends and projections point to significant adverse impacts on agriculture, livelihoods, and reduced food production in Nigeria (NASPA-CCN, 2011).

This study was conducted in Nigeria's Southwest region of the State of Oyo (Figure 3.1a). The State is situated between latitudes 7^o N and 19^{o}N and longitudes 2.5^o E and 5^o E. Its capital city, Ibadan, is one of the largest cities in West Africa with a population of 5,592,000 people, a total household number of 1,248,105 and occupying a land mass of 28,254 km^2 (NPC, 2006). Oyo comprises 33 Local Government Areas (LGAs) (Figure 3.1b). Egbeda is one of the 33 LGAs in Oyo State, located in the rainforest agro-ecological zone; It lies between latitudes 7° 21´and 8° N and longitudes 4° 02´ and 4°28´E (Figure 3.2), bordered to the North by Lagelu Local Government Area, the West by Ibadan North East, to the East by Osun State and to the South by Ona-Ara LGA (Abegunde *et al*., 2015). Egbeda Local Government Area has a population of 281,573, occupies 191 km^2 and has 65,466 households (NPC, 2006).

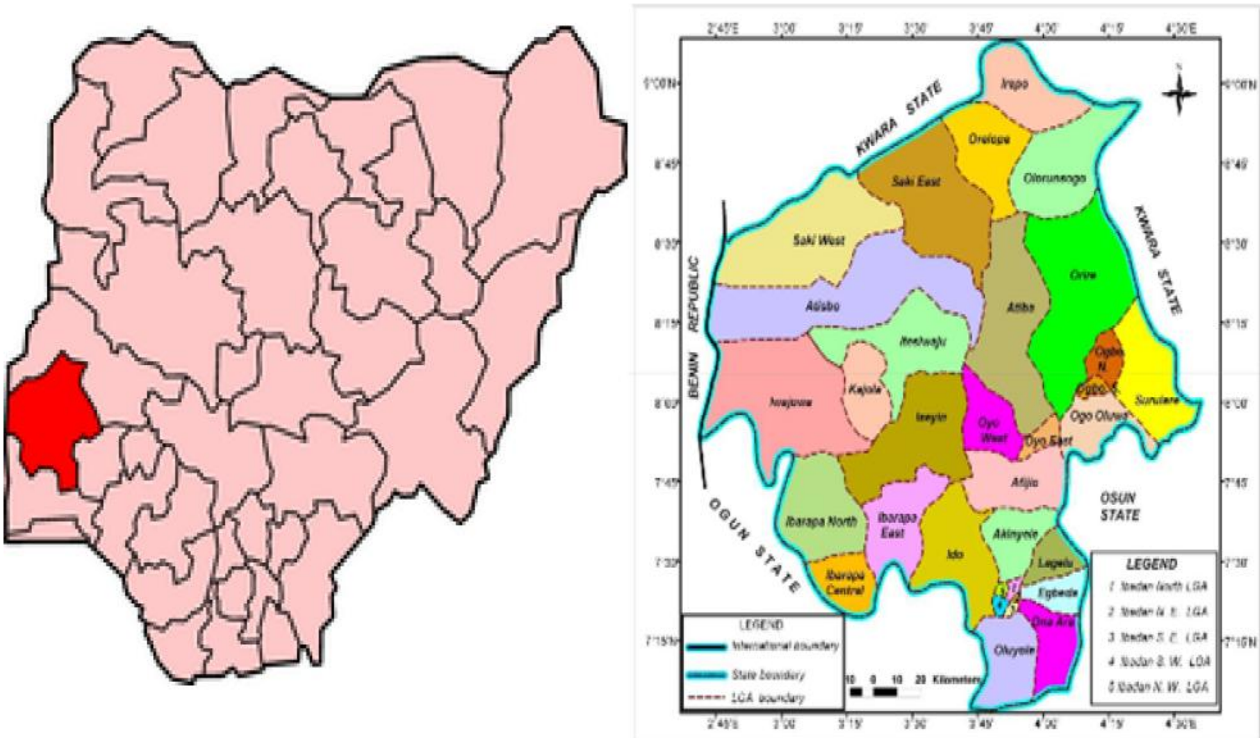

Figure 3.1: a). Map of the study area (left Nigeria showing location of Oyo state; b). right Oyo State)
Source: Google map and Abegunde *et al*. (2015).

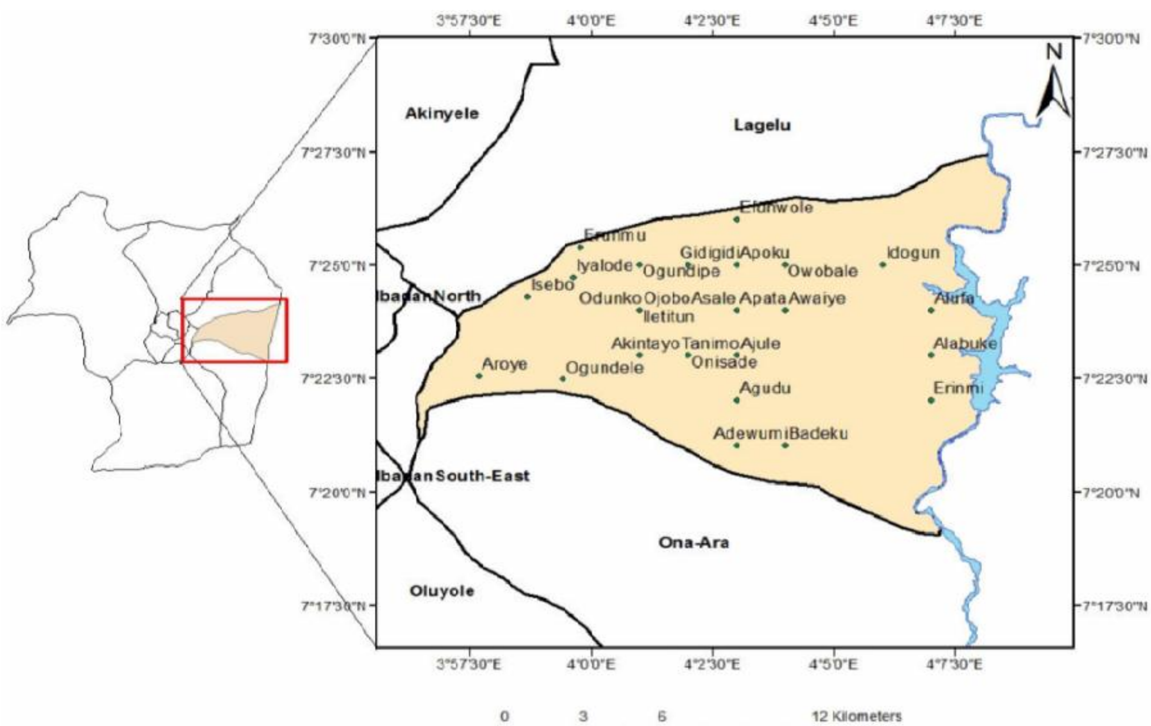

Figure 3. 2: Map of Egbeda Local Government Area
Source: Google map and Abegunde *et al*. (2015).

3.1.1 Biophysical setting

3.1.1.1 The Climate

The southern region of Nigeria has a climate that is humid with annual rainfall of over 2000 mm while the northern part is semi-arid with annual rainfall of less than 600 mm (Abiodun *et al*., 2011). The micro climate of the southwest region which is part of the southern zone is characterised by its tropical rain-forest climate and the annual rainfall ranging from 1524 mm to 2032 mm per annum (Bello *et al.*, 2012). The rain in Southwest region starts around March/April and lasts up to October/November annually. Daily mean temperatures vary from 19 degrees Celsius to 35 degrees Celsius. Maximum and minimum humidity is between 80 percent and 60 percent, respectively.

3.1.1.2 The Vegetation

There are six vegetation zones and seven agro-ecological zones in Nigeria, namely (Figure 3.3): mangrove and freshwater swamps along the coast, and moving from the south towards the north is the rain forest, Guinea Savannah, Sudan Savannah, and Sahel Savannah in the extreme north and the mountain in the northeast and northcentral (Abiodun *et al*., 2011; NASPA–CCN, 2011) figure 3.4. The type of vegetation in Oyo state is that of Guinea Savannah and with species of derived Savannah around the Oyo and Saki areas while that of Ibadan Ibarapa area is that of a Tropical rainforest (Ganiyu *et al*., 2013). Figure 3.4 provides an overview of the vegetative cover of Egbeda.

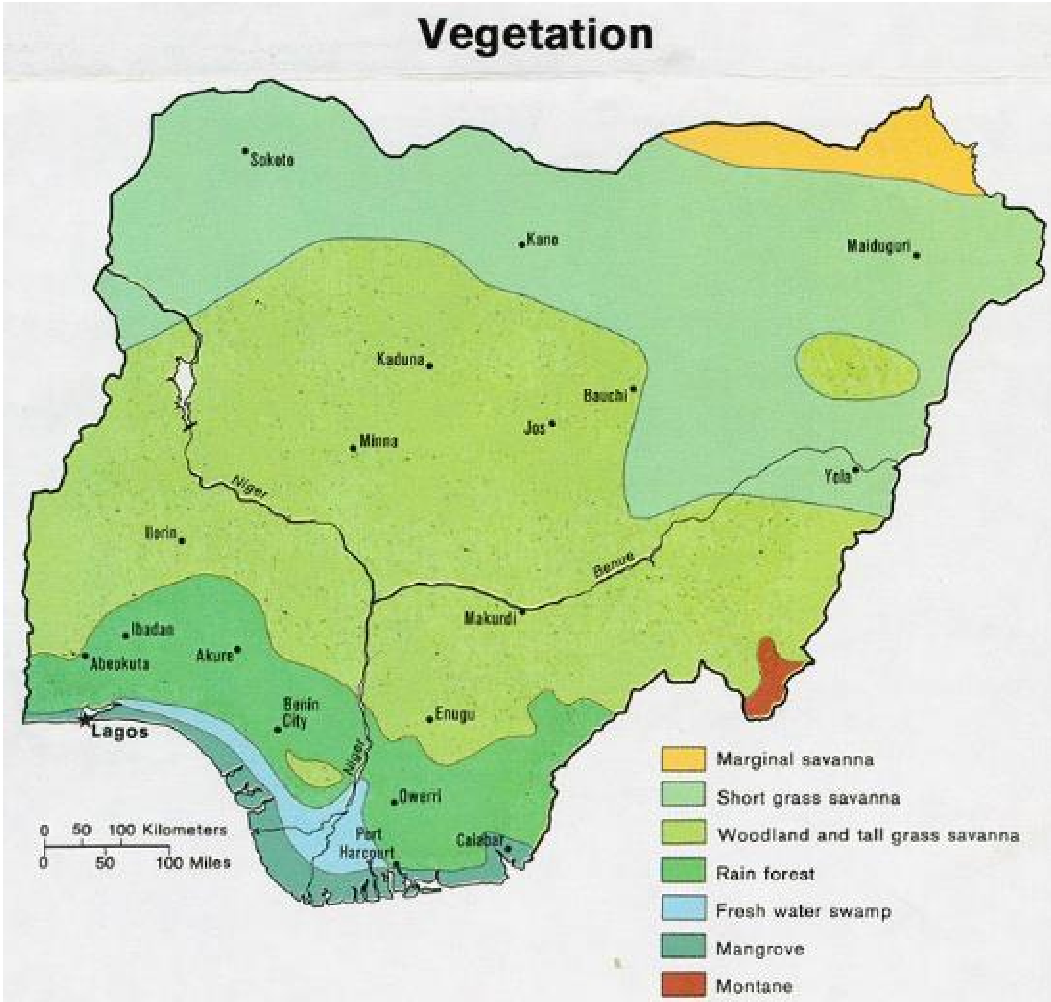

Figure 3.3: The agro-ecological zones in Nigeria
Source: NASPA-CCN, 2011

3.1.1.3 Land use, land use changes and resources

Land use in Nigeria is closely tied to land ownership. Ownership of land falls under four broad categories regardless of who the law stipulates to hold the land in trust for whom and these categories include individually-owned, family-owned, community-owned, and government-owned (NEST, 2012). The study area covers approximately 264 square kilometres. The larger portion of the area is covered by vegetation when compared to settlements and water bodies; while the water bodies covers most of the eastern part, the westward part is dominated by settlement (Abegunde *et al.*, 2015). As a result of population and economic growth among other factors, Egbeda has witnessed several changes in its land use and land cover especially in the study communities. The land use in Egbeda can be classified as follows: agricultural tree crop plantation, settlements, disturbed forest, intensive (crops) smallholder rain-fed agriculture, natural water bodies (rivers and streams) and reservoirs. Figure 3.4 depict some of the features of these classifications. Some areas of cleared land are haphazardly being used for field trials of selected crop or are cultivated (Fagbemi, *et al.*, 1995).

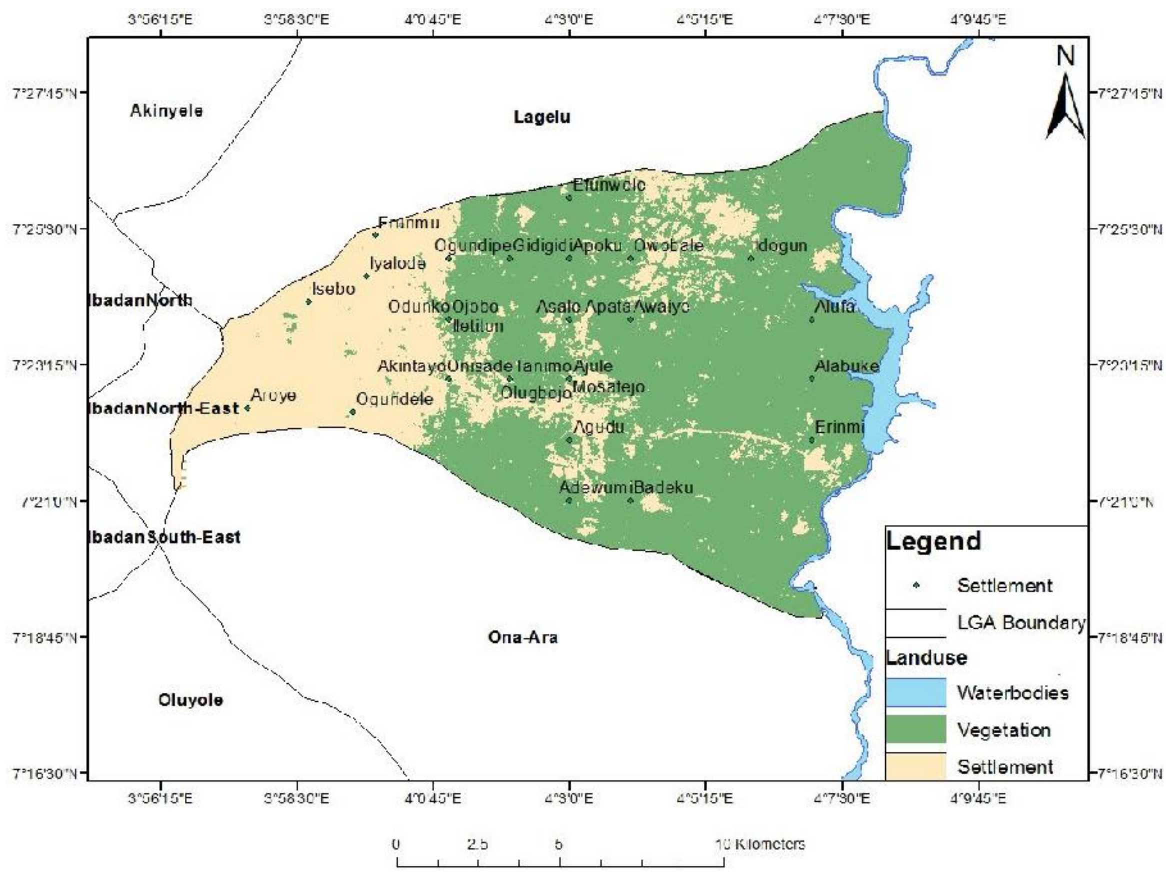

Figure 3.4: Map of Egbeda LGA showing settlement, water bodies and vegetation
Source: Abegunde *et al.* (2015).

3.1.14 Physiography and drainage

The Oyo State capital of Ibadan and Egbeda LGA are part of the Niger-Guinea coast watershed dominated by landforms which are closely related to its geology which comprises igneous rocks and metamorphic rocks of the Precambrian basement complex which forms part of the African crystalline shield (Fagbemi *et al.*, 1995). The rock composition and joints are important factors in weathering and evolution of the landscape with the weaker banded gneiss more deeply weathered; more eroded and, hence, form more subdued features than more resistant quartzite and gneiss (Fagbemi *et al.*, 1995). There are streams and other water bodies in Egbeda though no lake is found in communities so some of the farmers depend on these streams for their farming activities.

3.1.1.5 Water resource

Nigeria has a coastline of 853 km along the Atlantic Ocean in the Gulf of Guinea. Other sources of water found in the country include private and shared public dug wells, bore holes, streams, rain water harvested during rainy season, drains as the sources of water for domestic chores and irrigation, groundwater, surface water and rivers, dams and ponds among others (NEST and Tegler, 2011b; NEST, 2012). Oyo State has some rivers that provide a natural source of water to humans, animals and plants. There are some dams, streams and springs dotted all over the state (Figure 3.4). One of the water resources in Egbeda is the *Asejire* dam that was constructed in 1972. Despite these different sources of water in the community, there is hardly enough safe and clean water for drinking. The communities therefore depend on the water from the nearby stream, dug wells and harvested rain water as sources of drinking water. Those who can afford the water pump machines use the water from the stream for their irrigation farming while those who cannot afford to buy such equipment manually irrigate their farm with water from the nearby stream. Most of the farms are situated along the bank of the streams.

3.1.1.6 Biophysical vulnerabilities

The entire Nigeria is vulnerable to the negative impacts of climate change and no part of the country is immune to these impacts though the impacts varies from one agro-ecological zone to the other (NEST and Woodley, 2011a; NEST and Tegler, 2011b). Both fauna and flora are very susceptible to these impacts. The loss of biodiversity, rapid environmental degradation, crop failure and climate change induced diseases all point to the biophysical vulnerability of the country, including the South-western region of the country to the impacts of the changing climate. The variation and change of the climate also affect livestock and crop production as well as the hydrologic balance of the environment and the agriculture sector significantly

(Ayanwuyi *et al.,* 2010). The extensive Nigerian coastline of 853 km runs along the Atlantic Ocean towards the Gulf of Guinea is inhabited by the coastal urban and rural settlements, making it even more vulnerable to the impacts of climate variability and change (NEST and Tegler, 2011b).

3.2 Socio-economic setting

3.2.1 Political and administrative context

Nigeria operates a Federal system of government with three (3) arms of government and three (3) tiers of government as provided for in the country's Constitution. The three (3) arms of government are the executive, the legislative (bicameral in nature made up of the Senate and House of Representatives) and the judiciary. The three tiers of government are the Federal Government (FG), the State and the Local Government. Nigeria has thirty-six (36) States and the Federal Capital Territory (Abuja) with 774 Local Government Areas (LGAs).

Egbeda LGA is one of the Local Government Area in Oyo State. Similar to what is obtained at the Federal and State levels, Egbeda local government councils have the executive, legislative and the judiciary arm of government. There are departments and various divisions within each LGA. While the various departments and divisions implement the policies and directives of the Executive arm, the local government service commission is responsible for the employment of senior members of staff of the local government. *Baale* who is the traditional chief is also indirectly responsible for the administration of the communities under the formal administration of the local government through its elected supervisory councillors representing the communities. Other stakeholders that play critical roles in the political and administrative issues at the Federal, States, and Local levels are traditional rulers, religious leaders, the civil society organizations and the private sector.

3.2.2 National/Regional/Local Economic Setting

Nigeria's economy is highly dependent on oil and gas. The proceeds from the oil have over the years since the oil boom era of early 1970s been shared to run the economic engine of the country from the Federal to State and Local Government levels. The agriculture sector which was the main stay of the country's economy before the oil boom era continues to suffer neglect over the years though it contributes significantly to the GDP of Nigeria.

The financial allocation is shared monthly by the Revenue Mobilization Allocation and Fiscal Commission (RMAFC) from the federation account among the Federal, State and Local Government which are the three (3) tiers of government in Nigeria. This is in addition to the Internally Generated Revenues (IGR) by every State of the federation which is used to manage the economy of each State. However, this practice seems no longer sustainable in the face of declining global oil markets and attendant impacts of climate change that affects sectors that are climate sensitive and where some of the IGR are being generated from. The GDP of Nigeria will decline significantly in the face of prevailing climate change under the business as usual scenario and this will increase the debt portfolio of the country as well as its inability to feed its growing population (NEST and Tegler, 2011b). Some of the economic activities in the research communities include agriculture, trading, public service and art works.

3.2.3 Social setting

The proximity of Egbeda LGA to Ibadan, the State capital, gives it a peri-urban outlook. This characteristic enhances social capital and social cohesion and networks among various social groups in the communities of Egbeda. Though being a patriarchal society, which draws its exigencies from what is obtained from the larger society country-wide, the social relationships between men, women, and youth in Egbeda is cordial. In these areas, subsistence and semi-commercial farming constitute the main occupation of the people and this also depends on rainfall.

3.2.4 Health setting

The proximity of Egbeda LGA to Ibadan accords it the luxury of proximity to the premier and referral University College (Teaching) Hospital (UCH) that provides first class health care services not only to the people of the Southwest but Nigeria at large and West Africa. The State government of Oyo also provides primary health care services through the LGA and Ministry of Health. Private health care providers are also found in almost every corner of the State. Egbeda communities have access to all these facilities but the constraint remains their affordability. The cost of health care both in private and public health centres is exorbitant to most members of the public in Nigeria and this can force the people to resort to alternative sources of medication such as traditional medicine that may also have its side effect.

3.2.5 Regulatory framework

There are various regulatory frameworks that govern the operations of different policies and programmes related to issues of agriculture, water resources, environment, and climate change at the federal, state and local government levels in Nigeria. Some of these according to INRUAF (2010) include but are not limited to the Federal Government of Nigeria (FGN), States and LGA laws, policies, Constitution of the Federal Republic of Nigeria (Promulgation) Act of 1999; and National Agency for Food and Drug Administration and Control Act of 1992; Federal Environmental Protection Agency Act (FEPA of 1988); Agricultural Research Council of Nigeria Act No 44 of 1999; Oyo State Laws/Edicts and Regulations; State Lands CAP 119; Oyo State Agricultural Development Project CAP 98; Oyo State Environmental Protection Agency, 1999; Ministry of Environment and Water Resources Law, 2001. Some of these regulatory frameworks are aimed at ensuring food security, poverty eradication and environmental protection and sustainability.

3.2.6 Socio-economic vulnerabilities

The changing climatic condition poses a big challenge to food security and livelihoods of about 98 million Nigerians, with serious socio-economic threats for almost 70 percent of the population with agriculture as their main source of livelihood (Zabbey, 2007). The impacts of the changing climate in the country are also expected to rise, causing further losses and increasing the socio-economic vulnerability of the people in the face of the current business as usual (BAU) scenario. The impacts of climate change in the target localities among the smallholder farmers have in recent years manifested in socio-economic hardship even as social cohesion is threatened as the usual financial and other non-financial support that individuals and groups provide to each other has reduced drastically (Zabbey, 2007). This is partly so because climate variability and change have posed and have become a serious threat to agricultural production which is the main means of livelihoods of the people of Southwest Nigeria (Apata, 2011).

3.3 Conceptual Framework Model

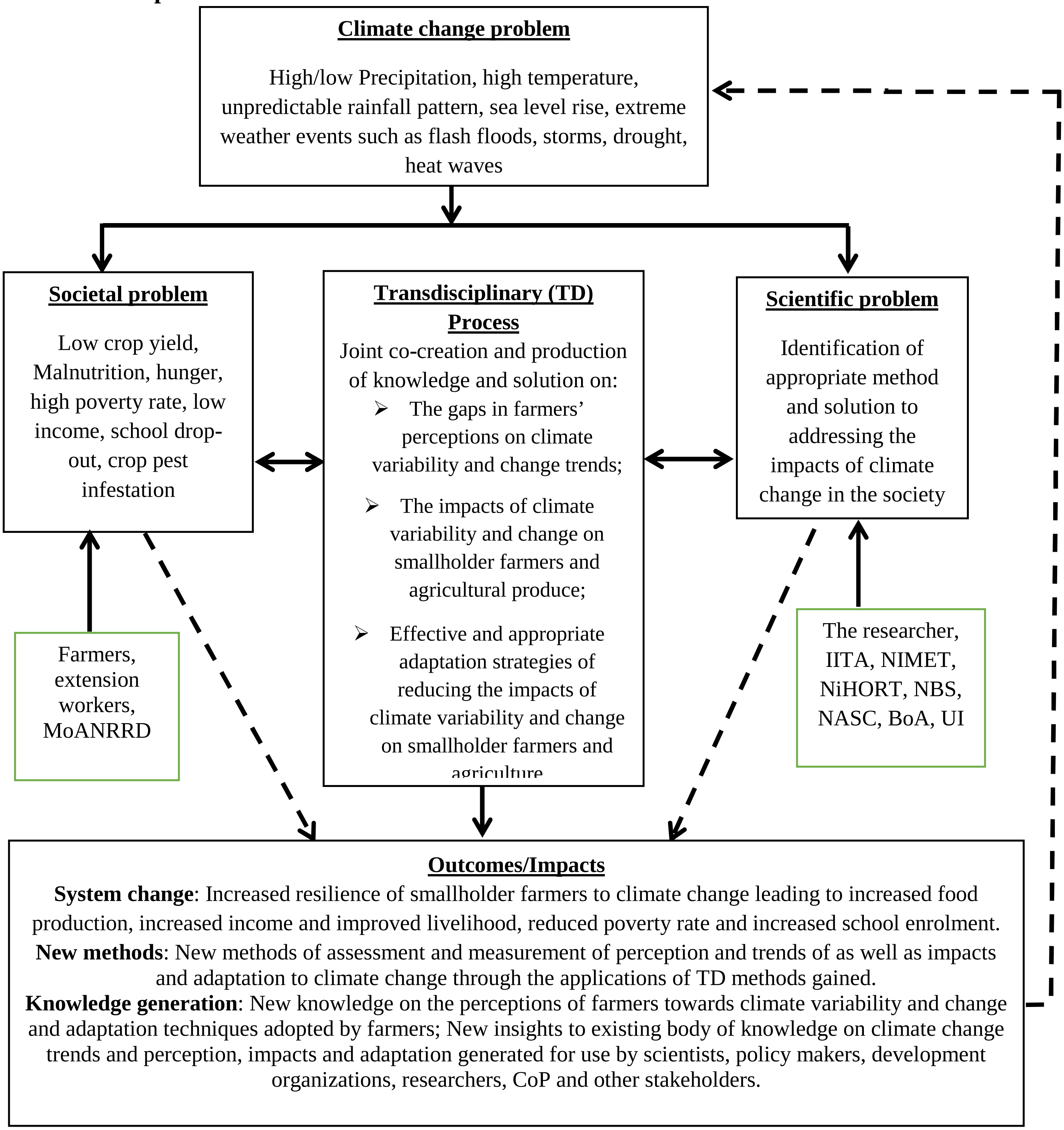

Figure 3. 5: The conceptual framework model
Source: Author's own design

In order to better understand the profile of the target group in this study, assess their perception about climate variability and change and also analyse the climate change trends in the region, a conceptual framework was designed. The framework also served as a guide as to how the impacts of climate variability and change were examined as well as the adaptation strategies adopted by the farmers with the aim of designing effective adaptation response strategies based on improved knowledge on climate variability and change with regard to smallholder farmers in Southwest Nigeria. Figure 3.5 depict the conceptual framework model for this research study.

The model illustrated an approach aimed at providing solution that is effective and sustainable in addressing the challenges of climate change using a transdisciplinary (TD) approach where science and research (scientific/research questions that need to be addressed) meet the people and society (societal problems that need to be addressed). The approach also brings together different actors and stakeholders from both sides of the divide (science and society) to jointly co-create and co-produce knowledge. This leads to effective solutions (outcomes/impacts) that lead to system change, new methods and strategies to address the problem and in the process generating new insights to the body of knowledge for the good and benefit of the people, society, the scientific and research community, community of practice and other interested stakeholders.

3.4 Methods

3.4.1 Introduction

This study adopted the Extract, Transform, Load (ETL) methods (Figure 3.6) in combination with other tools and methods for each specific objective in the collation, processing, analysis and presentations of the findings of the research. The ETL method is the process where data sourced from multiple sources are extracted (Extract) into one place, the extracted data are then converted from its previous form (transformed) and then written into the target (Load) database for analysis and interpretation (Beal, 2017).

The primary and secondary data was obtained and analysed in addition to the ETL using different methods and tools (Section 3.14; Section 3.15; Section 3.16 and appendix I, II and III). For the sampling techniques for all the specific objectives, the researcher used a purposive approach based on some criteria such as the experience of the farmer(s), ability for self-expression, good retentive memories of past and current climate events and ability to compare and contrast the various changes in their environment and farming practices among others. In selecting those households for interview, the researcher mostly used the multi-stage sampling techniques. The choice of the multi-stage sample techniques which partly hinged on the principle of cluster sampling was best suited for a study of this nature which deals with enquiries that involved a large geographical area of coverage (Kothari and Gaurav, 2014).

The research communities chosen are based on their roles and geographical advantages in agriculture in Oyo State and in the region. These included the state's vegetation and climate that supports the cultivation of arable crops and rearing of livestock with cultivable arable land of 27,107.93 km^2; good market demands for agricultural products; and the presence of agro-processing industries, enterprises and related institutions.

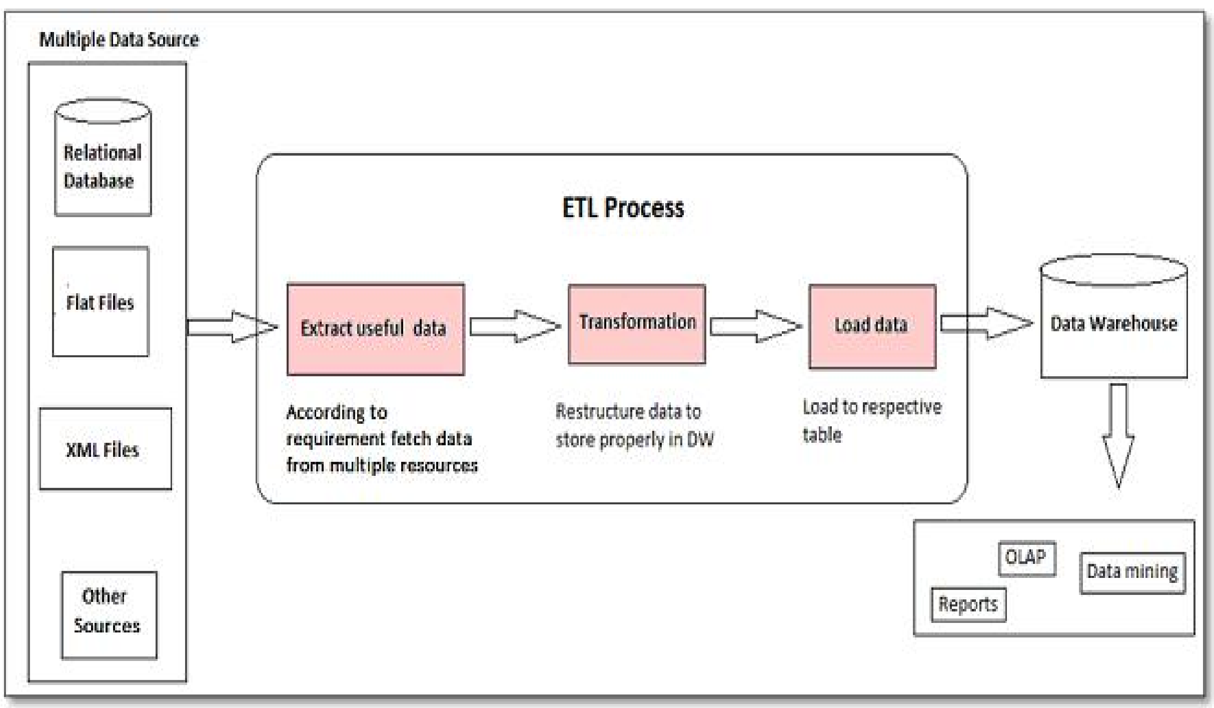

Figure 3. 6: The Extract, Transform, Load (ETL) flow-chart (Adapted from Beal, 2017)

3.4.2 Sample size determination

In determining the sample size of this study, the researcher used the Yamane (1967) and Israel (1992) formula which is used to determine the sample size of a survey population. The infinite sample size of the infinite population is first determined and then the sample size of finite population.

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

Where n - the sample size N - the population size, e - the acceptable sampling error * 95% confidence level and p = 0.5 are assumed

$$n = \frac{65466}{1+65466(.05)2} = 400$$

Accordingly, the total sample size is 400. This study used a sample size of 411 well above the recommended minimum sample size of 411 based on Yamane (1967). This value (411) is also in line with Israel (1992) which recommends the use of published tables with a given set of criteria including for example with a precision of ±10%, variability and confidence level of P=0.5 and 95% respectively in which a sample size of 400 is robust enough for a size of a population that is >100,000.

3.4.3 Determination of coefficient of variation (CV) and Standardized Anomaly Index (SAI)

Data for the climate parameters were obtained. The annual data gathered was covering 1985-2015 on temperature, rainfall, relative humidity, wind, sunshine and cloud cover from NiMET and were analysed with the use of ETL, Minitab version 16 software, Microsoft excel, linear trend model, standardized anomaly index (SAI), standard deviation, mean and coefficient of variation (which aided in the normalization of volatility of the variations and the determination of the degree of variability of the climate parameters obtained. The descriptive statistical analysis was used, thus:

CV for a population:

$$CV = \frac{\sigma}{\mu} * 100\%$$

CV for a sample:

$$CV = \frac{s}{\bar{x}} * 100\%$$

Where

Mean ($\bar{x}$) $= \frac{\sum x}{N}$

x = rainfall variable while N = number of years

And

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

σ = standard deviation

$\sum$ = sum of

x = each value in the data set

$\bar{x}$ = mean of all values in the data set

n = number of value in the data set

If the degree of variability of the parameter under study has a CV of less than 20 (CV<20) it is regarded to be low; CV>20 but <30 would be regarded as moderate and C>30 as high respectively (Hare, 2003 in Asfaw *et al.*, 2018).

The Annual Rainfall Anomaly Index (RAI)

The rainfall data was subjected to further calculation and analysed using the RAI which was also relevant for the analysis of the anomalies for temperature. The RAI was adapted by Freitas in 2005 and Araújo in 2009 though initially developed by Rooy in 1965. RAI was used to analyse the intensity and frequency of mostly rainfall and in some cases, the temperature pattern thus:

$$\text{RAI} = 3 \left[\frac{N - \bar{N}}{\bar{M} - \bar{N}}\right] \quad \text{For positive anomalies (1)}$$

$$\text{RAI} = -3 \left[\frac{N - \bar{N}}{\bar{X} - \bar{N}}\right] \quad \text{For negative anomalies (2)}$$

Where: N = current annual rainfall, when RAI is generated (mm); $\bar{N}$ = annual average rainfall of the historical series (mm); $\bar{M}$ = average of a decade highest annual rainfall of the historical series (mm); $\bar{X}$ = average of a decade lowest annual rainfall of the historical series (mm). Positive anomalies indicate values above the mean, negative anomalies show values below the mean (Juliana and Gláuber-Pontes, 2017). This study adapted the RAI method, CV to arrive at the final conclusion on the anomaly, intensity, variability and change in the climate parameters analysed for this study as well as compared with the perceptions of farmers on those changes in the observed climate.

3.4.4 Stakeholder consultative meeting and Reconnaissance survey

Prior to the choice of the target communities, the researcher undertook consultative meetings with relevant stakeholders in the region to discuss on the choice of the communities where the research will best benefit most and where target group can be located and available for the research. Some of the stakeholders consulted at this stage include the following: Nigerian Meteorological Agency (NiMET) Ibadan station; Federal Bureau of Statistics; Oyo State Ministry of Agriculture and Rural Development; Ministry of Environment; Oyo State Emergency Management Agency (OYOSEMA); National Horticultural Research Institute (NiHORT); Oyo State Agricultural Development Programme (OYSADEP); Directorate of Agriculture, Egbeda Local Government Area; National Agricultural Seed Council (NASC) Southwest regional office; University of Ibadan and Nigerian Environmental Study/Action Team (NEST). Majority of these stakeholders were unanimous on the choice of the research communities. A reconnaissance visit was then undertaken in the research communities in August 2015 to better understand the climate change situation among the smallholder farmers. The visit which was conducted through the community gate keepers and opinion leaders gave more impetus and insight into the real climate change situation faced by smallholder farmers in these communities. Those contacted during this visit included the

Chairman, Farmers Association, the leader of Young Farmers Association, the traditional chiefs (*Baale*) of the communities, religious leaders, leaders of women groups, and Director of Agriculture of Egbeda Local Government Area.

3.4.5 Transect walk and observation method

The researcher conducted another familiarization visit in the research communities in November 2015 to have first-hand information on the biophysical features of the communities. This helped the researcher to well appreciate the resources (human, material and natural) with other features and facilities available in the communities and some impacts of climate change in the communities as well as observe how the community members are coping with these impacts. The transect walk and observational method also helped in the understanding of the relationship between the communities and their environment as well as among the community members themselves in understanding the power dynamics in the communities. This exercise also was helpful during the Focus Group Discussions and data analysis stage to cross examine some of the information provided by the community members and those obtained during the transect walk in the communities.

3.4.6 Development and designing of data collection instrument

Following the reconnaissance visits, transect walk and observations conducted in the target communities and review of some literatures the researcher embarked on the development and designing of the data collection instrument. For any successful transdisciplinary research, the instrument is very important because it is considered as the heart of any survey exercise (Kothari and Gaurav, 2014). The instrument was designed such that it was able to collect data on general household information, data related to the overall objective and for each of the specific objectives of the study.

3.4.7 Training of the research assistants on the data collection instrument

A total of sixteen (16) research assistants were recruited and trained for three days in January 2016 on the data collection instrument and its content (Appendix I, II and III). This was aimed at getting the research assistants understand the basic issues of climate variability and change; have a good understanding of the data collection instruments; how information should be recorded in the instrument; how it was designed and its intent and how to document other relevant information that might be useful in the research in the cause of the exercise, among others.

3.4.8 Pre-testing and confirming the validity of the data collection instrument

The quality and credibility of any data obtained and analysed rest squarely on the validity of the data collection instrument used to elicit specific information from the target source. To avoid error of measurement using any data collection instrument, it is important to subject such instrument through a series of tests. The instrument should adequately respond to the issue(s) under investigation such as: are the content of the instrument relevant to the questions the research is trying to answer? Are there any ambiguity in the questions been asked? Do the respondent(s) understand the questions been asked? Do the research assistants understand the context and content of the questionnaire? Is the instrument adequate to elicit the required information for the research? In order to sufficiently respond to the testing of the validity of the data collection instrument, the researcher subjected the instrument to a pre-testing of it in the field with the target respondents in the research communities with the help of the research assistants.

This exercise was carried out at the early stage of the research work in January 2016. In order to avoid data that might not be useful in the final analysis because such are either incomplete partially or fully or inadequate to draw an accurate or valid result and conclusion on a particular research case (Kothari and Gaurav, 2014), this process was undertaken.

3.4.9 Refinement of the data collection instrument

The data collection instrument was subsequently refined with inputs obtained from the field following the pre-testing and confirmation of the validity of the instrument exercise. This was done February 2016. This activity greatly helped not only in obtaining valid data from the field survey during the main data collection period but also saved a lot of time and cost that would have been spent to verify the validity of the instrument during the main administration of the instrument on the field.

3.4.10 Data collection

Primary data: The primary data was obtained using the data collection instrument (the household survey questionnaires) which was designed (Appendix I, II and III) to elicit information qualitatively and quantitatively from the target respondents of four hundred and eleven (411) households in the target communities. This exercise took place from March to May 2016.

The household survey questionnaire was administered to individual household heads, key informant interviews and through FGDs with four (4) focus groups (2 women and 2 men focused groups) ensuring gender parity and using the SAS^2 tool and key informant interviews. The questionnaire covered the following sections: The profile of the farmers which included general information; social-economic and geographical characteristics; information on climate variability and change trend and the smallholder farmers' perception; the impacts of climate variability and change on the smallholder farmers; the adaption strategies and options practiced by the smallholder farmers and any other relevant information that added value to the research work.

Secondary data: Thirty-one (31) years meteorological data from 1985 to 2015 was collected from the Nigerian Meteorological Agency, Ibadan stations. The information covered climate parameters of temperature, rainfall, relative humidity, sunshine and cloud cover for the period under study. Other secondary data used were also obtained from credible publications such as peer review journals, books, government archival records and other relevant documents. Similarly, several literatures were also reviewed in addition to NiMET data.

3.4.11 Assessment of farmers' socio-economic profile, perception, climate variability and change trends

Primary data was sourced with the use of household survey questionnaires (Appendix I and Appendix III–Box IV), FGD, key informant interviews (Plate 3.3), oral history and observations. The primary data obtained was analysed using the Extract, Transform, Load (ETL) tool (Figure 3.6); Statistical Packages for Social Science (SPSS) version 20; Microsoft Excel, descriptive statistics, MCA and ADM tools (Plate 3.2, Plate 3.1). The secondary data from credible literature sources, archival records, journals and other published documents were obtained as well as meteorological data.

Plate 3.1: FGD sessions with the application of SAS2, MCA and ADM tools
Source: Fieldwork, 2016/2017

Plate 3. 2: FGD sessions with the application of SAS2, MCA and ADM tools
Source: Field survey, 2016/2017

Plate 3.3: Interviews with smallholder farmers (left & right)
Source: Field survey, 2016/2017

3.4.12 Examination of impacts of climate variability and change on smallholder farmers

In the assessment of the impacts of climate variability and change on smallholder farmers in Southwest Nigeria for this study, the researcher collected primary data from four hundred and eleven (411) households to investigate the impacts climatic changes have had on them with the use of the survey questionnaire (Appendix I). Focus group discussion, key informant and in-depth interview using SAS^2 tools (Appendix II, Plate 3.1, Plate 3.2) were also used to elicit primary quantitative and qualitative information for this investigation. With the research instrument, the researcher also adopted the use of open and closed ended structured interview to collect further qualitative and quantitative data.

Secondary data was also collected from reports which also showed climate change related impacts and this was used to triangulate the level of impacts. The combination and triangulation of these primary and secondary data obtained was used to quantify the overall impacts of climate variability and change on the smallholder farmers in the target communities. The researcher analysed the data using standardized data set and for the collected data\. To further analyse the data, the researcher employed the use of computer software - SPSS version 20 and household characteristics that was collected and analysed adopted the use of SAS^2 tool. Descriptive statistics were also used in the analysis including the presentation of the results in graphs, charts, diagrams.

Generally, in the examination of these impacts of climate variability and change on the smallholder farmers, the same methods and tools (Section 3.15) were applied with the exception of the use of the tool in Appendix III in the data collection, the use of Minitab version 16 software, liner trend model and use of CV, and the standardized anomaly index (SAI) in the analysis of meteorological data.

3.4.13 Determination of adaptation strategies adopted by smallholder farmers

In the examination of the adaptation strategies and options practiced by smallholder farmers in the research communities in the region, primary and secondary data was obtained for the analysis. The researcher took recorded data on available adaptation strategies to climate change and variability from the relevant government offices as well as other credible reports and the primary data was sourced from 411 households. The data so obtained and triangulated assisted in the determination of the adaptation options and/or strategies of the smallholder farmers to climate variability and change in the study areas. The data obtained from the field survey was analysed using SPSS version 20 for the quantitative and thematic analysis techniques were applied to the qualitative with the application of SAS^2 tool. Descriptive statistic with charts, graphs, and diagrams was also used to illustrate the outcome of the data analysed.

Specifically, the primary data was sourced (Section 3.14) with use of the designed survey instruments (Appendix I, II, and Appendix III –Box I, II, III) and administered. FGD, key informant interviews with the use of observation method was also adopted in the collation of data. The data was analysed with the use of SAS^2, Multi Criteria Analysis (MCA), Adaptation Decision Matrix (ADM) (Appendix III –Box I, II and III) and SPSS tool.

CHAPTER FOUR

TRENDS IN CLIMATE VARIABILITY AND CHANGE, PERCEPTION AND SOCIO-ECONOMIC PROFILE OF SMALLHOLDER FARMERS IN SOUTHWEST NIGERIA

4.1 Introduction

The variability and change in climate have been acknowledged as one of the major factors affecting smallholder farmers and their ability to adapt kept diminishing over the years especially in several parts of the developing countries because of their least adaptive capacity in the face of these changes in the climatic pattern (FAO, 2013; FAO, 2017).

Climate variability and change will continue to define development pathways both now and in the near future. Different parameters can be used to define climate variability and change such as temperature, rainfall pattern, relative humidity, sunshine intensity, sea level rise and extreme weather events. The heightened impacts of the changing climate especially the increase in global temperature and unpredictable rainfall patterns will continue to intensify in Nigeria and other developing countries especially in Africa, a continent dependent on climate sensitive and rain fed agriculture with a total of 97 percent of crop land, employing 60 to 65 percent of the labour force and recognised to be the most vulnerable continent to the impacts of climate variability and change (Stern, 2007; NEST and Tegler, 2011b; UNEP, 2014). the perception of smallholder farmers on the issues of climate variability and climate change also receive little or no attention in the broader climate change discourses (Progress *et al.*, 2011).

4.2 Results

4.2.1 Profile of the households in the study area

1). Age Distribution of Respondents

The age of the youngest household head was 23 years old while the oldest was 76 years old.

2). Distribution of respondents by sex

The sex distribution of the household heads is presented in the Figure 4.1, showing a largely male dominated region, where most households are headed by males.

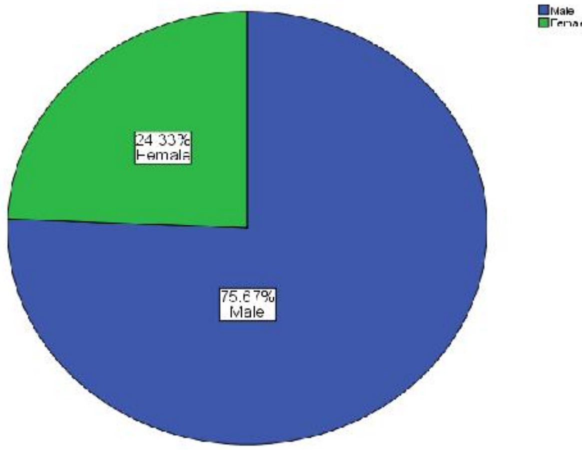

Figure 4.1: Sex of household head

Source: Fieldwork, 2016/2017

From the total number of 411 households surveyed, 76 percent were male headed household while 24 percent were female (Figure 4.1).

3). Distribution of respondents based on marital status

Figure 4.1 below shows the distribution based on marital status. From the data, it is clear that a typical household in this region is composed of people in marriage.

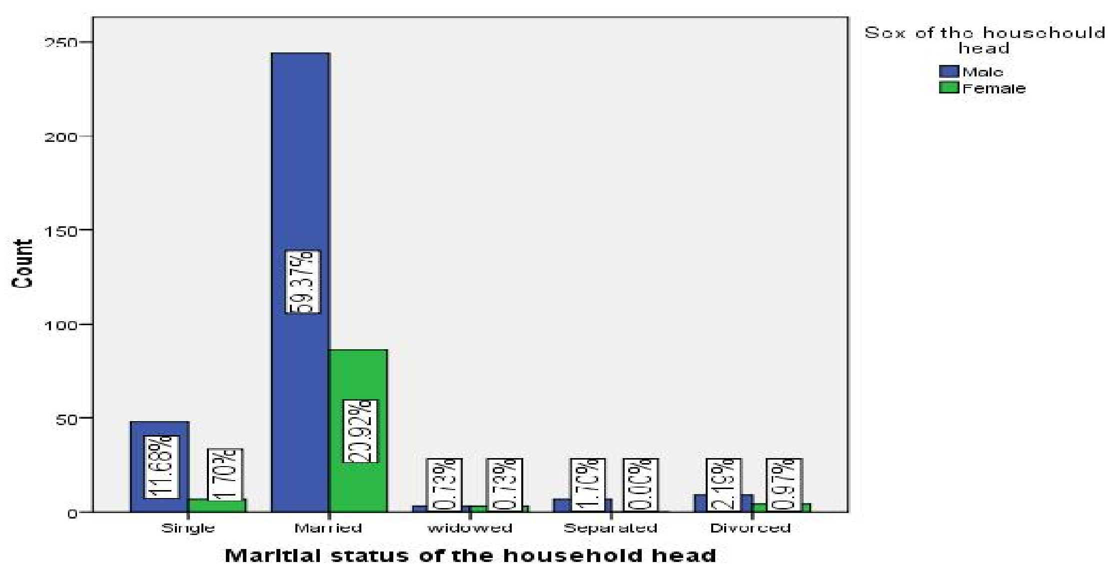

Figure 4.2: Marital status of household heads

Source: Fieldwork, 2016/2017

From the analysis of the survey, 13 percent of household heads are single (and of this subset, 87 percent are male and 13 percent are female). The household heads that are married stands at 80 percent (of this subset, 74 percent are male and 26 percent female). Widowed household heads constitute 1.46 percent (of this sub set, 50 percent are male and 50 percent female). The separated household heads made up 2 percent while those divorced totalled 3.2 percent (Figure 4.2).

4). Distribution of respondents based on educational level

The graph below (figure 4.3) shows the distribution of respondents based on educational level. Notably households are dominated by fairly literate people who completed primary, secondary and middle level colleges.

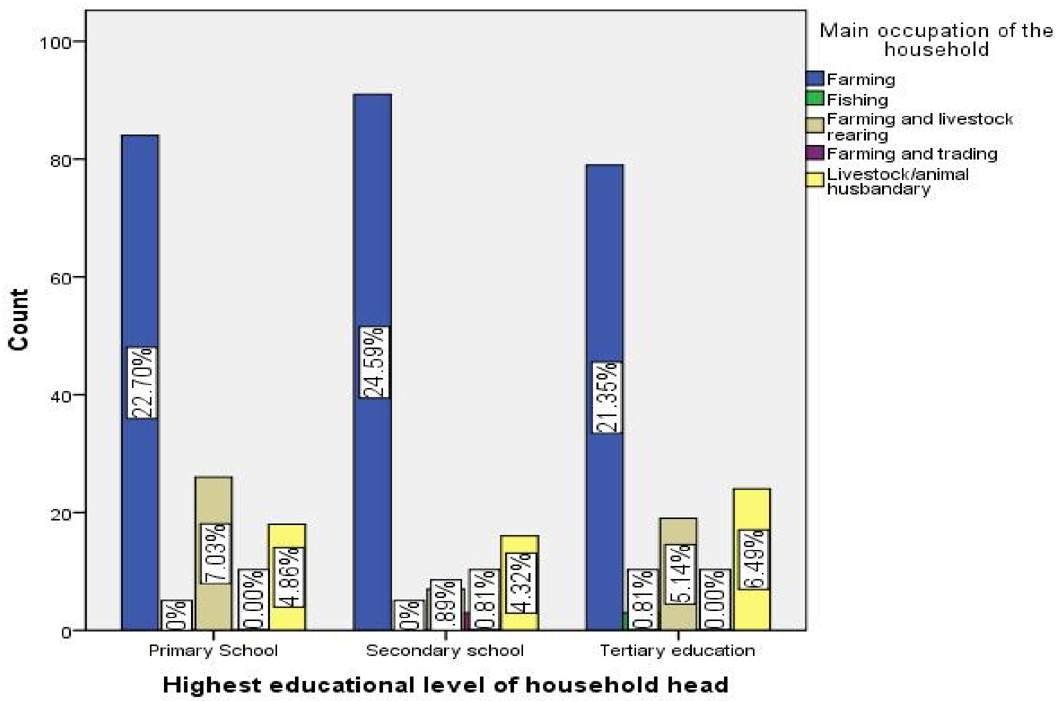

Figure 4.3: Main occupation of household heads and their level of education

Source: Fieldwork, 2016/2017

The percentage of household heads with primary school level of education was 35 percent (and of this subset, those engaged in farming stood at 66%, 0% in fishing, 20% in farming combined with livestock rearing, 0% farming combined with trading while 14% are those engaged in only livestock rearing). Those with secondary school level of education is 31 percent (and of this sub set, those engaged in farming stood at 80%, 0% in fishing, 3% in farming combined with livestock rearing, 3% farming combined with trading and 14% are those engaged in only livestock rearing). Those that acquired tertiary education constitute 34 percent (and of this sub set, those engaged in farming stood at 63%, 2% in fishing, 15% in farming combined with livestock rearing, 0% farming combined with trading and 19% are those engaged in only livestock rearing) (Figure 4.3).

5). Education level of household heads and participation in decision making at community level

The relationship between education and decision making was examined, and the data were presented in the Fig 4.4.

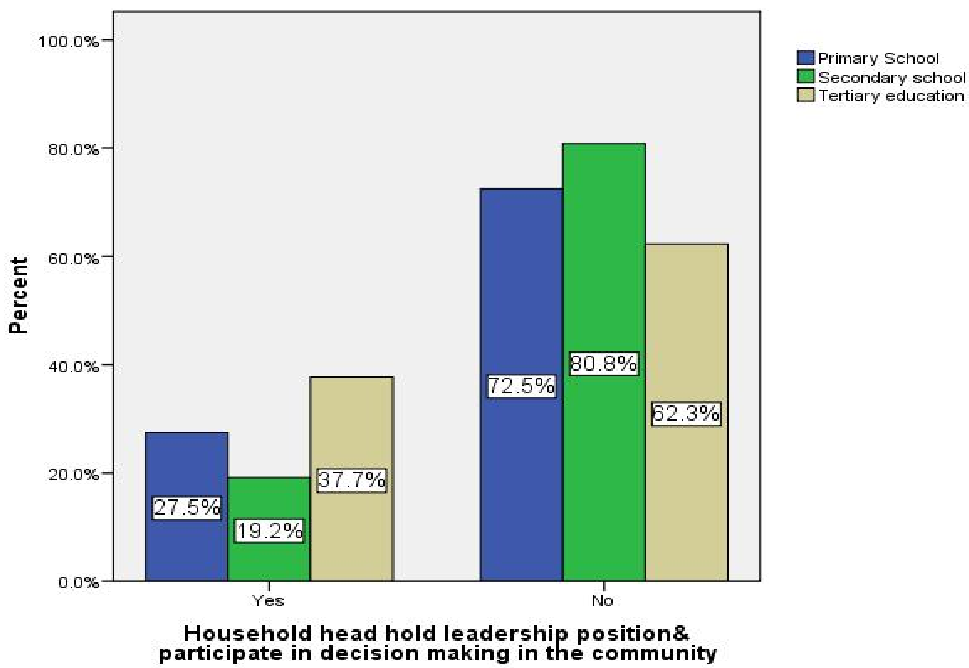

Figure 4.4: Participation in decision making by household against level of education of the smallholder farmers
Source: Fieldwork, 2016/2017

Only 28% of respondents participated in decision making at the community level (and of this sub set, 33% attained primary level of education, 23% secondary education and 45% tertiary education) while 72% did not (and of this sub set, 34% attained primary level of education, 37% secondary education and 29% tertiary education). If this fraction is pitted against education level, it is clear that those with tertiary education are the majority of those that participated in the decision making (Figure 4.4).

6). Occupation of household heads

Majority, 69 percent of the total 411 households surveyed were engaged in farming, while 1 percent were engaged in fishing, 15 percent in farming and livestock rearing, 1 percent in farming and trading combined and those involved strictly in livestock rearing only was 14 percent. From the graph, it is clear that the study targeted respondents from the farming communities (Figure 4.5).

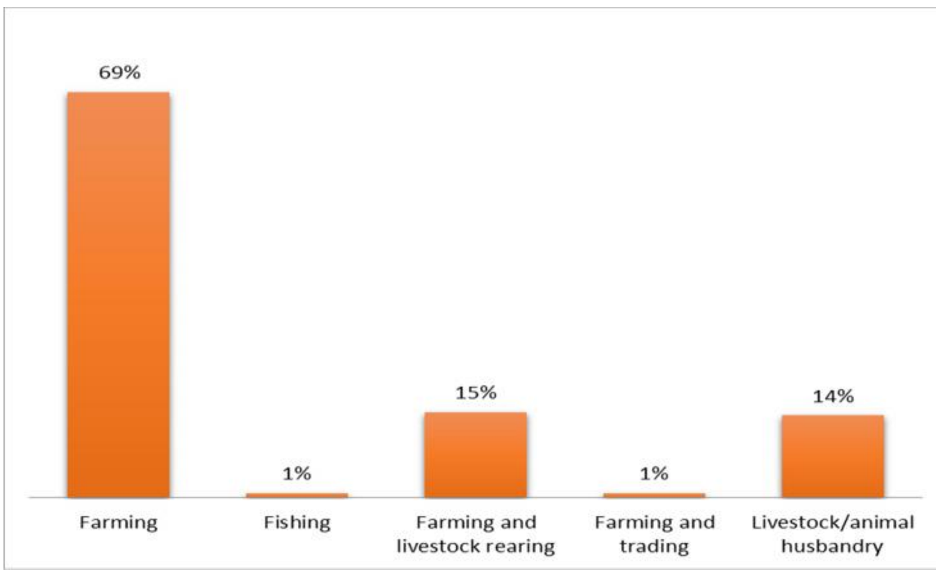

Figure 4.5: Main occupation of household head
Source: Fieldwork 2016/2017

7). Major crops/livestock kept by households

This was explored to profile households in terms of their dominant livelihoods in the era of climate change. The results show a mixed farming model dominated by farming of cereals, tubers and vegetables.

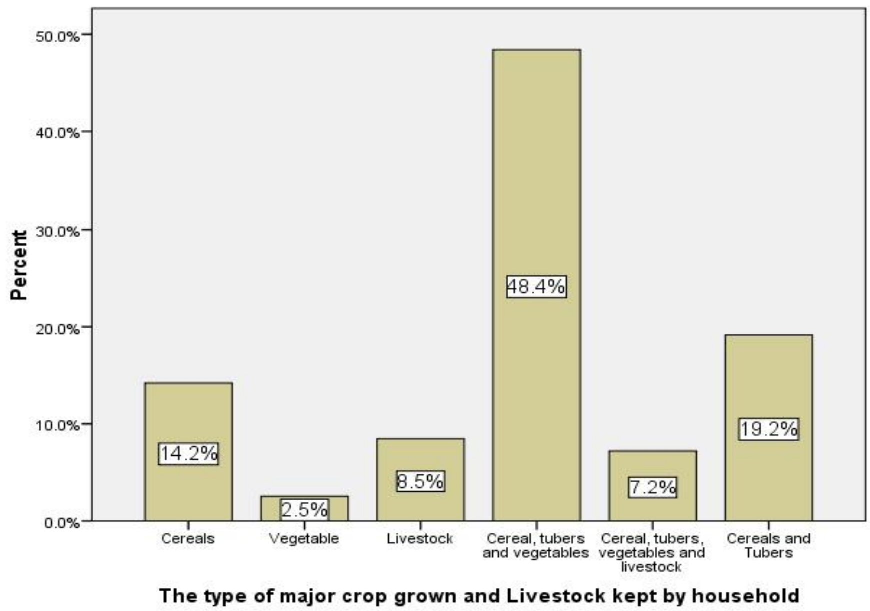

Figure 4.6: Combination of crop grown and livestock kept by household

Source: Fieldwork, 2016/2017

The following were the results obtained from household heads on the combination of crop grown and livestock kept in the study area: Cereals, tuber and vegetable (48 percent); cereals only (14 percent); cereals and tuber (19 percent); only livestock (9 percent); cereal, tuber, vegetable and livestock (7 percent) and only vegetables (3 per cent) (Figure 4.6).

8). Mode of farmland acquisition by households

This was important to shed light on the relationship between source of farmland and its utilization. Most farmland was sourced through inheritance and leasing.

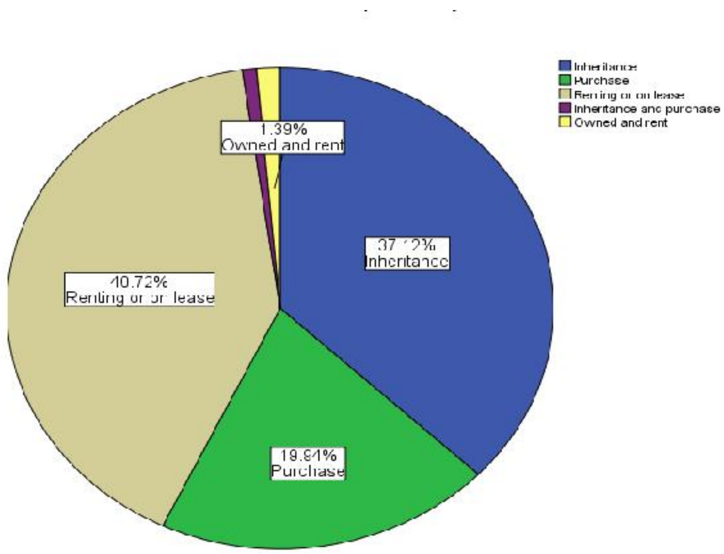

Figure 4.7: Kind of farmlands owned by households

Source: Fieldwork, 2016/2017

As shown in Figure 4.7 41 percent of households operate on rented or lease farmland; 20 percent purchased their farmland; 37 percent inherited the farmland, 1 percent owned their farmland, while 1 percent operated on both inherited and purchased farmland.

9). Access to climate information

From the results, majority, 68%, of households have access to climate information, and 29% of the respondents said they do not have access. This implies that most farming activities are influenced by the available climate information as shown by Figure 4.8 below.

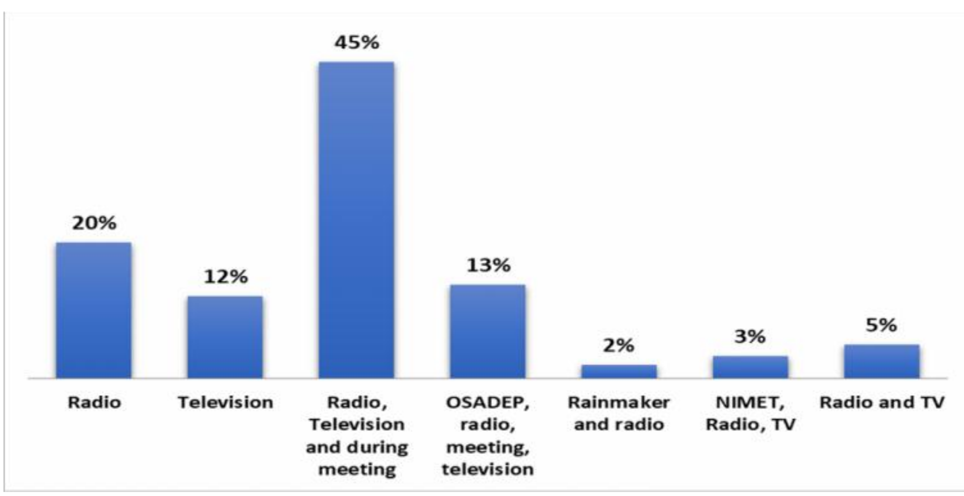

Figure 4.8: Sources of climate information received by households

Source: Fieldwork, 2016/2017

A total of 45 percent of the household heads indicated they received climate information on rainfall, temperature, sunshine; relative humidity, wind speed and cloud cover from radio, television and during farmers' association meetings. About 10 percent receive the information through radio; 13 percent through Oyo State Agricultural Development Programme (OYSADEP), radio, meeting and television; 12 percent receive the information through television only; a meagre 3 percent get the information from NiMET, radio and television combined, while the rest obtained the information through other sources including rain makers (2 per cent) as shown in Figure 4.8.

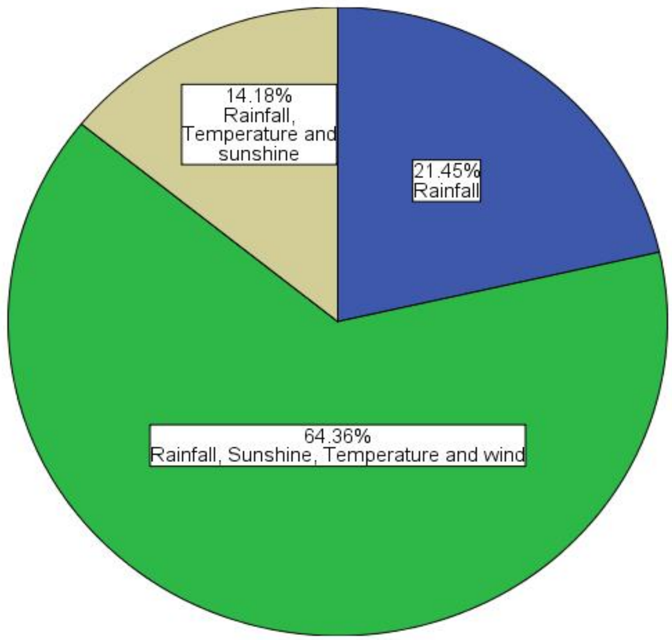

Figure 4.9: Percentage of the type of climate information received
Source: Fieldwork, 2016/2017

Majority, 64 percent of household heads received information only on rainfall, sunshine, temperature and wind. 14 percent of the household heads received information on rainfall, sunshine, and temperature without information on wind while the balance of 21 percent said they only received climate information on rainfall (Figure 4.9).

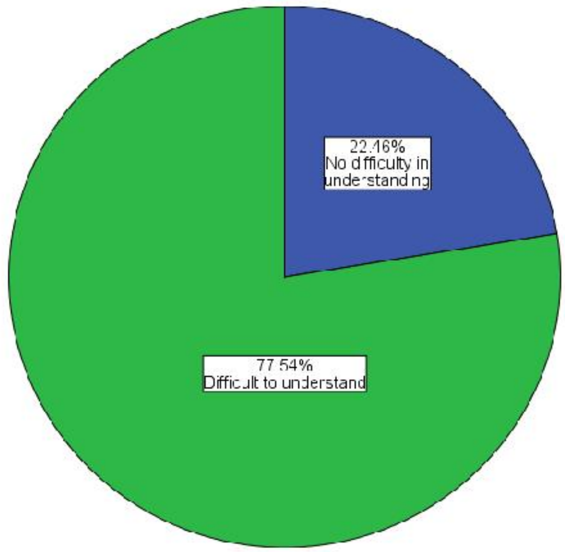

Figure 4.10: Level of understanding of climate information received by household

Source: Fieldwork, 2016/2017

As shown in Figure 4.10, only a small fraction (22.5%) had no difficulty understanding climate information received, while the rest which constitutes the majority (77.5%) had difficulty understanding the information.

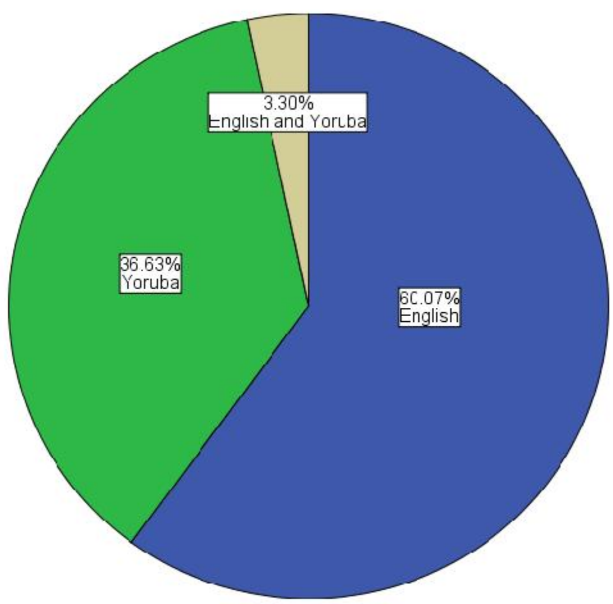

Figure 4.11: Language in which climate information is communicated

Source: Fieldwork, 2016/2017

Climate information is communicated mainly in the English language. This was according to 60% of the respondents. 37% of them received the information in Yoruba language, while the rest said they sometimes received the information in both languages (Figure 4.11).

11). The general perceptions of changes in weather and climate pattern

The general perception on the changes in weather and climate pattern over the past 31 years (1985-2015) was that there has been significant change in the weather and climate pattern.

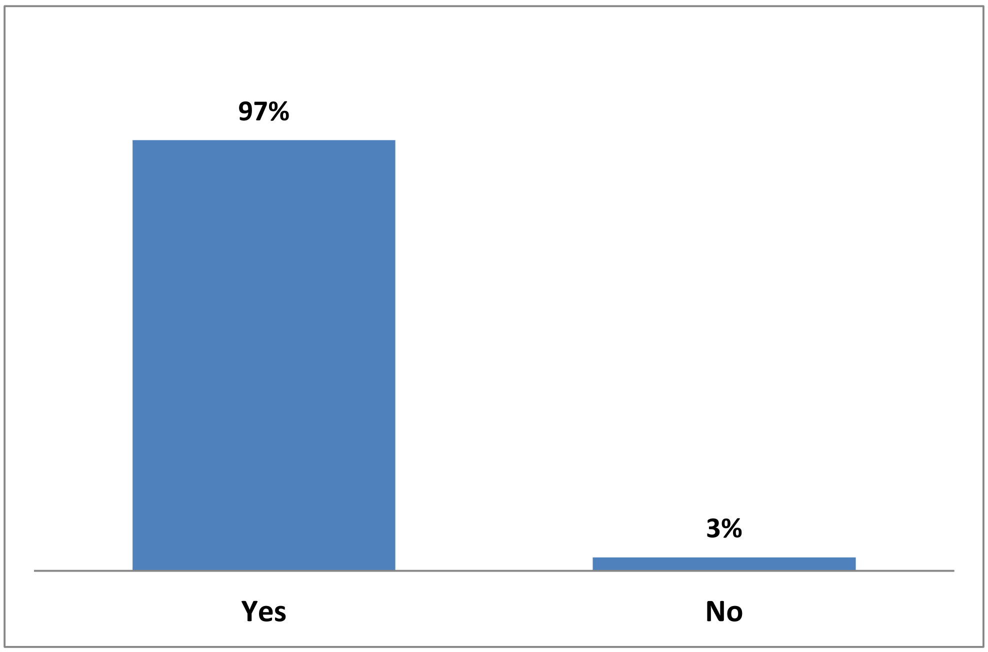

Figure 4.11: The General perception of change in weather and climate (1985-2015)
Source: Fieldwork, 2016/2017

The general perception of the household heads on the change in weather and climate pattern showed that majority (97 per cent) said they are indeed changes that have been observed while a small number (3 percent) said they did not perceive any change (Figure 4.12).

4.2.2 Rainfall

From the visualization of the occurrence of the annual rainfall trend and the anomalies (Figure 4.13), 12 years are with a positive value that depict the rainy years with higher rainfall and the remaining 18 years showed negative values which indicated years of low rainfall with varying degrees of intensity both for the positive and negative values.

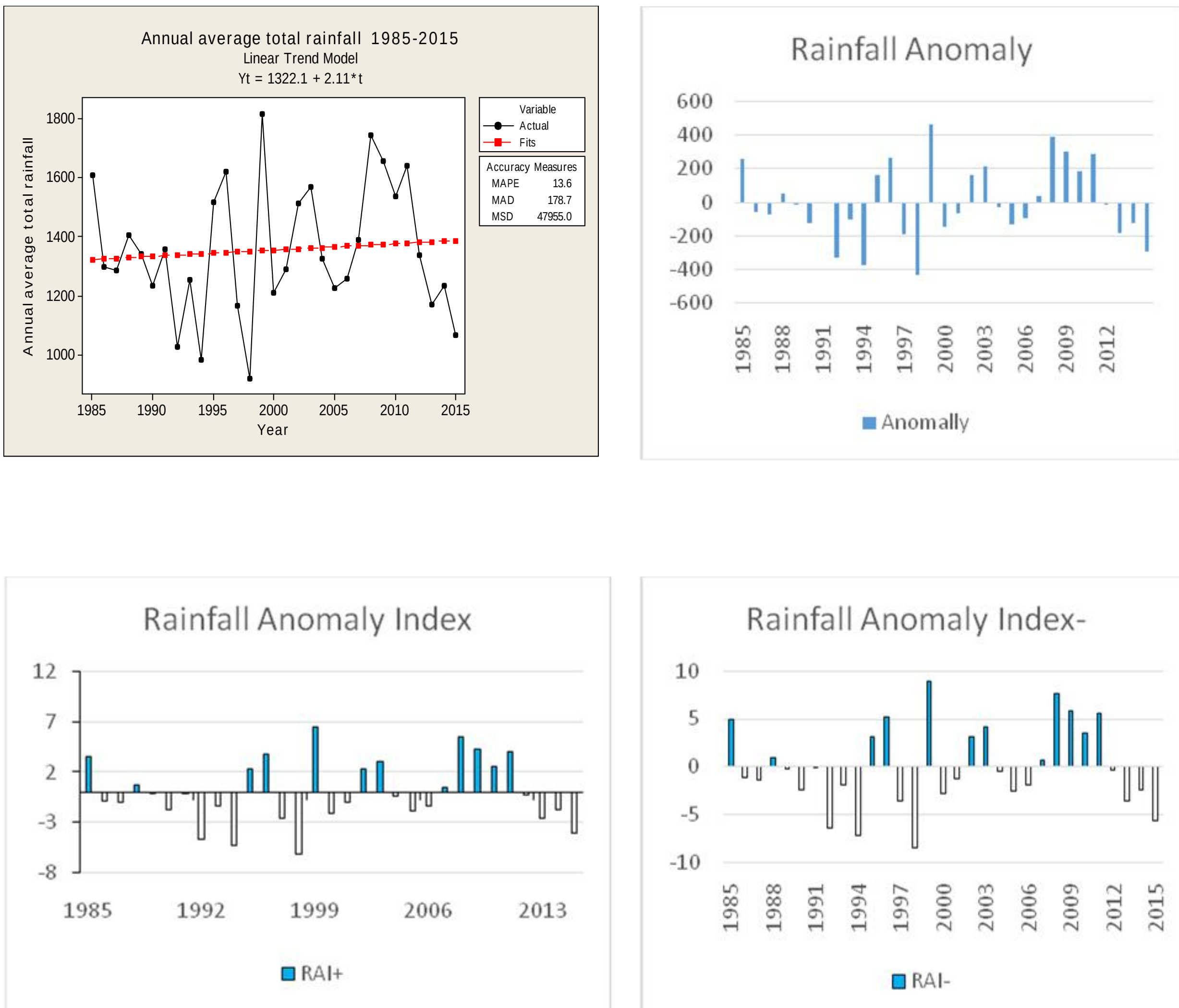

Figure 4.12:The annual average rainfall and the anomalies
Source: Authors computation NIMET data, 2016/2017.

Table 4.1 depicted for all the years under study of a CV>30. All the years are with the variances that showed a high deviation from the mean and from each other. In the past 31 years, majority, 62 percent of the total household heads indicated that rainfall had decreased between 1985 and 2015 while 38 percent maintained that rainfall had actually increased within the same period.

Table 4.1: Annual rainfall coefficient of variation

			Rainfall		
Year	Mean	Standard Deviation (SD)	Coefficient of variation (CV)	Coefficient of variation (CV) %	Variability
1985	134	103	0.7	70	High
1986	108	87	0.8	80	High
1987	107	118	1.1	110	High
1988	117	108	0.9	90	High
1989	112	86	0.7	70	High
1990	103	85	0.8	80	High
1991	113	84	0.7	70	High
1992	86	82	0.9	90	High
1993	105	81	0.7	70	High
1994	82	73	0.8	80	High
1995	127	97	0.7	70	High
1996	135	95	0.7	70	High
1997	97	74	0.7	70	High
1998	77	71	0.9	90	High
1999	151	136	0.9	90	High
2000	101	87	0.8	80	High
2001	107	103	0.9	90	High
2002	126	104	0.8	80	High
2003	131	108	0.8	80	High
2004	111	84	0.7	70	High
2005	102	83	0.8	80	High
2006	105	95	0.9	90	High
2007	116	123	1.0	100	High
2008	146	124	0.8	80	High
2009	138	99	0.7	70	High
2010	128	111	0.8	80	High
2011	137	110	0.8	80	High
2012	112	89	0.7	70	High
2013	98	71	0.7	70	High
2014	103	68	0.6	60	High
2015	89	76	0.7	70	High

Source: Authors computation from NIMET data, 2016/2017.

In Table 4.2, in the last 20 years from the base year of 1985, majority of the household heads (61%) perceived that there was a decrease in rainfall while 39 percent said rainfall had increased. In the last 10 years from the base year of 1985, majority, 90 percent of the household heads perceived that there was a decrease in rainfall while 10 percent perceived that rainfall had increased. In the year 2015 (Table 4.2), majority, 95 percent of the household heads perceived that there was decrease in rainfall and its duration while 5 percent said it had increased. As one goes back in the years, it seems that the respondents forget the duration of rainfall but remember the droughts in recent years as depicted in Table 4.2.

Table 4.2: Household's perception of change in rainfall duration (1985 – 2015)

Year (s)	Increase		Decrease		No idea		No change		Total	
Baseline 1985	No	%	No	%	No	%	No	%	No	%
30	156	38	255	62	-	-	-	-	411	100
20	160	39	251	61	-	-	-	-	411	100
10	41	10	270	90	-	-	-	-	411	100
2015	21	5	390	95	-	-	-	-	411	100

Source: Fieldwork, 2016/2017

Thirty-six percent of household heads believed that the change in rainfall pattern is due to climate change. 25 percent perceived that the change in rainfall pattern has been caused by an act of God; 22 percent perceived the cause as a result of the sin of mankind while 10 percent said it’s caused by both the sin of mankind and an act of God. The remaining 6 percent have no idea of the cause as shown in Figure 4.14. The above information was corroborated by perceptions that emerged during interviews where one participant had this to say: “*The rainy season in the past used to start in the month of March and we also start our farming activities but as you can see now, we are already in the month of May and the rain is yet to start, the pattern has really changed and we are worried*”. Mrs. Adekunle Tinuke, A female farmer in Egbeda.

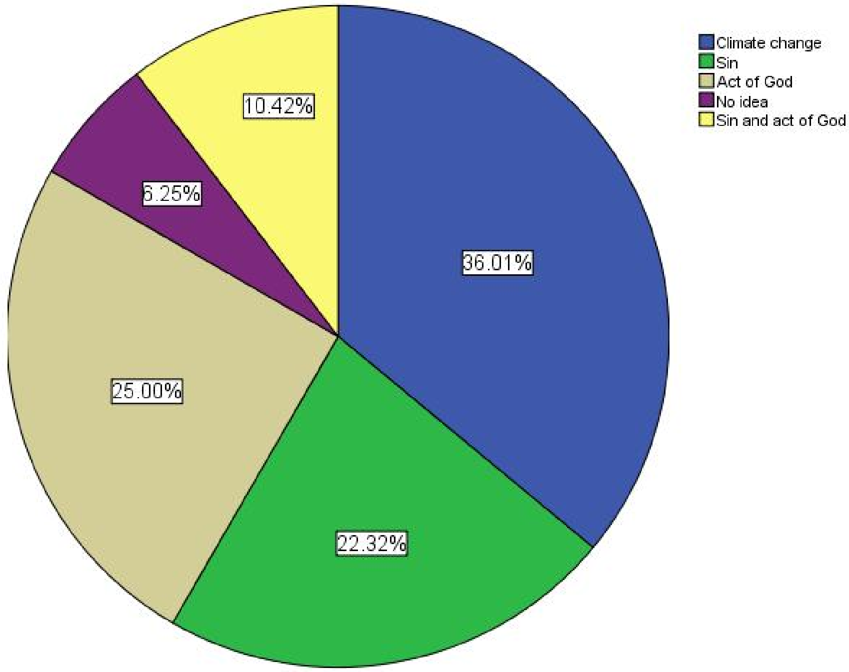

Figure 4.13: Household perceptions of the cause of climate variability and change
Source: Fieldwork, 2016/2017

When asked whether the household heads are worried or not about the changes in the rainfall pattern, an overwhelming percentage (96%) indicated they are worried while a meagre percentage (4%) are not worried by the changes (Figure 4.15).

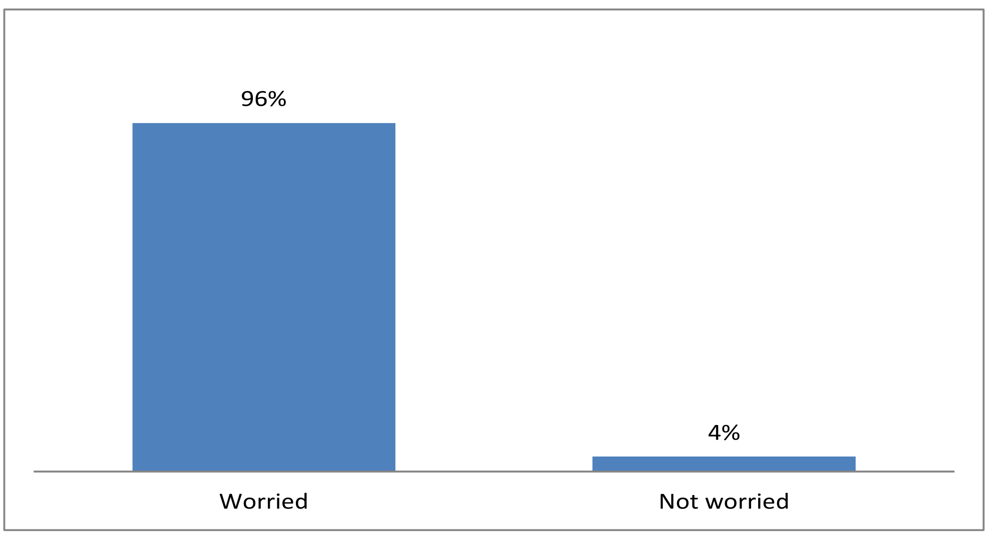

Figure 4.14: Household's worried or not in the changes in the rainfall pattern
Source: Fieldwork, 2016/2017

On who was responsible for the changes in the rainfall pattern, 40% of household heads said it was God, 31% attributed it to humans, 16% stated it was nature while 13% had no idea on who could be responsible for the changes in the rainfall pattern (Figure 4.16).

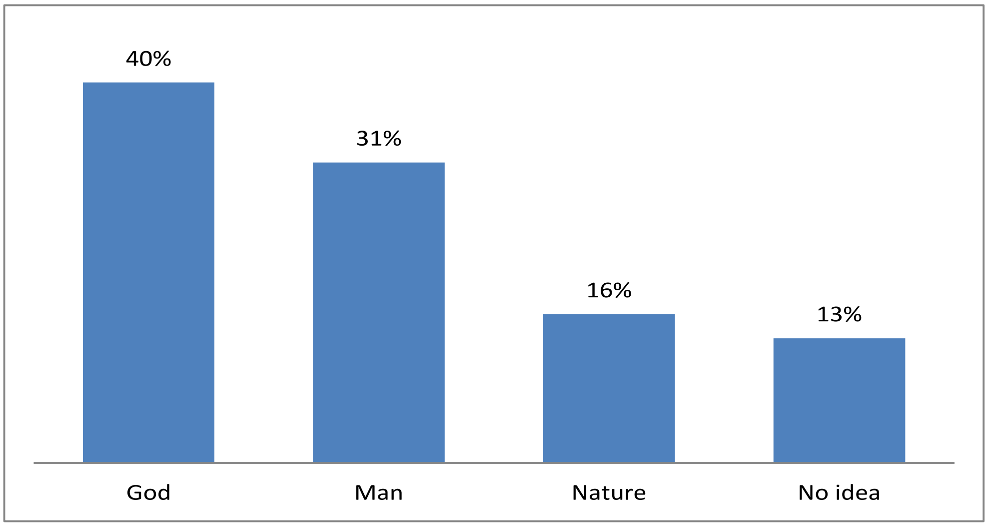

Figure 4.15: Households' perception of who is responsible for changes in the rainfall
Source: Fieldwork, 2016/2017

Figure 4.17 depicts some of the suggested actions to be taken in the changing rainfall pattern as perceived by household heads. According to them the community ought to take the following measures to reduce impacts of changing climate: prayers (72%), good policy (18%), planting trees (2%), and good policy with tree planting (3%), do nothing (4%) and pray and do nothing (1%).

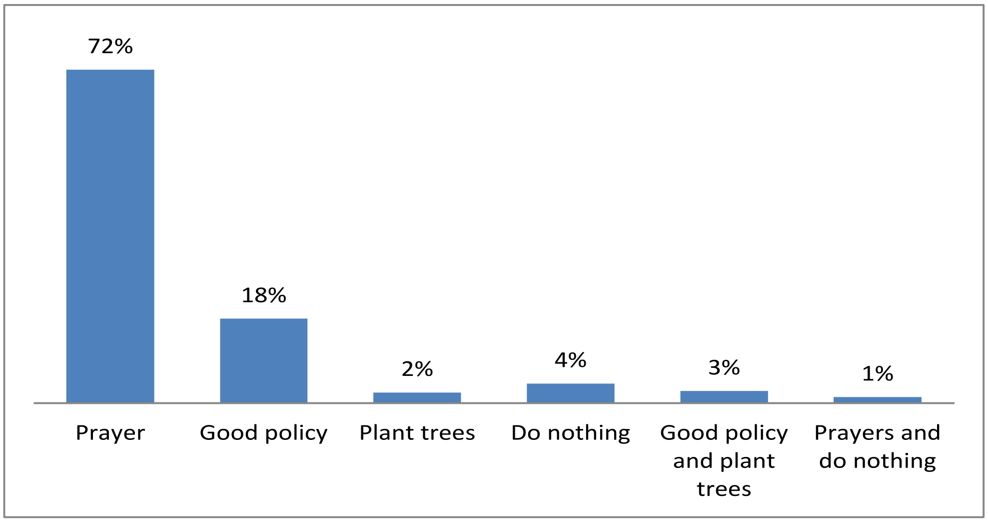

Figure 4.16: Households' perception of action to be taken in the changes in rainfall
Source: Fieldwork, 2016/2017

4.2.3 Temperature

1). The trends of maximum temperature (T_{Max})

The years, 1985, 1986, 1988, 1990, 1993, 1997, 1999, 2000, 2002, 2003, 2005, 2009, 2011 and 2012 were the years with records of below normal maximum temperature of the 31 years studied while the remaining 12 years (1987, 1991, 1994, 1995, 1996, 1998, 2001, 2004, 2006, 2007, 2008 and 2010) witnessed above normal maximum temperature with only 1992 that recorded normal temperature (Figure 4.18). The year 2003 recorded the highest maximum temperature of 35^{o}C during the period under review.

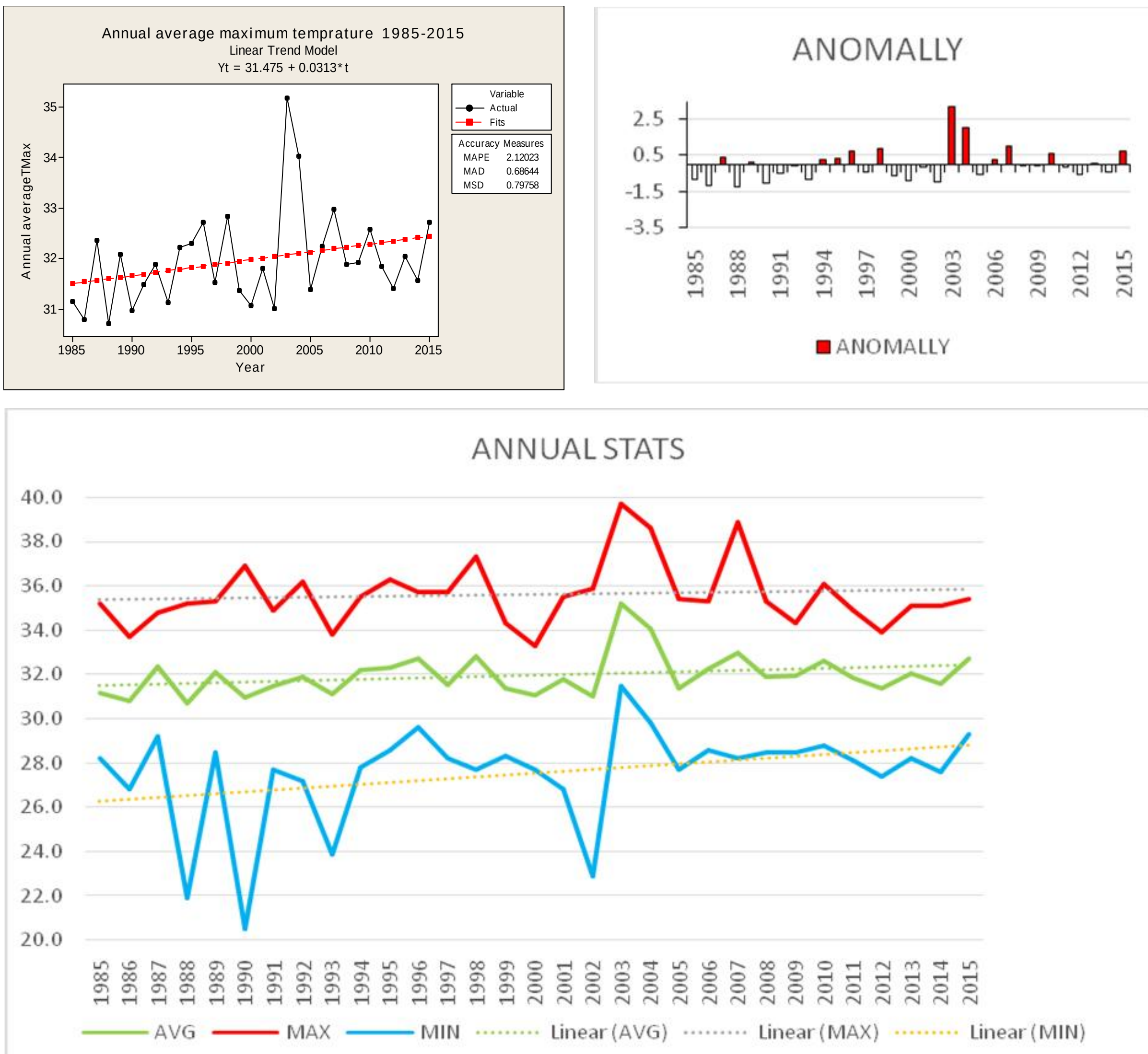

Figure 4.17 Average Maximum Temperature (TMax), anomaly and the annual statistics
Source: Authors computation from NIMET data 2017

2). The average minimum temperature (T_{Min})

The years 1987, 1998, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, and 2015 all recorded above average minimum temperature while the rest of the years witnessed below average minimum temperature with 1993 having the lowest below normal during the year under study as depicted in Figure 4.19 with varying degrees of anomalies.

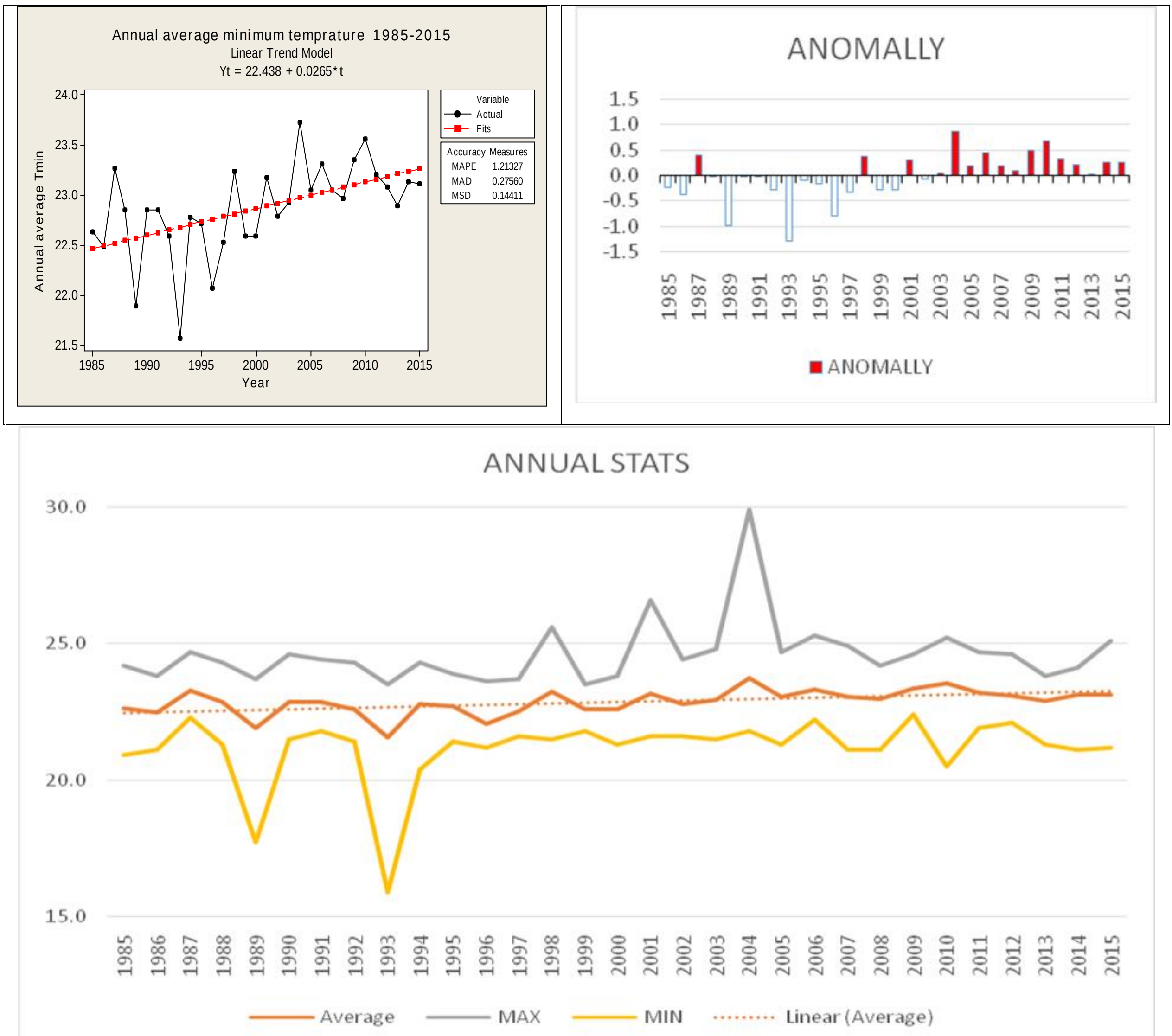

Figure 4. 18: The average minimum temperature (TMin), annual statistics and the anomaly

Source: Authors computation from NIMET data, 2017.

As shown in Table 4.3 for all the years analysed, both the maximum (T_{max}) and minimum (T_{min}) temperatures showed a coefficient of variation (CV) of <20 which were closer to the mean and which had low deviation from the mean and from each other though the anomaly tends to be on a high side.

Table 4.3: Annual temperature coefficient of variation

Temperature							
Year	Mean **(Tmax)**	**(Tmin)**	Standard Deviation (SD) T_{max}	Standard Deviation (SD) T_{min}	Coefficient of variation (CV) % T_{max}	Coefficient of variation (CV) % T_{min}	Variability
1985	31	23	2.2	0.9	6.95	4.26	Less
1986	31	22	2.3	0.9	7.39	3.96	Less
1987	32	23	1.8	0.7	5.84	3.28	Less
1988	31	21	3.5	0.9	11.59	4.34	Less
1989	32	21	2.3	1.5	7.44	6.96	Less
1990	31	23	4.1	0.8	13.46	3.93	Less
1991	31	23	2.6	0.7	8.44	3.36	Less
1992	32	23	2.7	0.9	8.69	4.01	Less
1993	31	22	2.7	2.0	8.96	9.39	Less
1994	32	23	2.5	1.1	7.96	4.64	Less
1995	32	23	2.2	0.6	6.81	2.98	Less
1996	33	22	1.8	0.7	5.68	3.40	Less
1997	32	23	2.2	0.6	7.06	2.73	Less
1998	33	23	3.0	1.3	9.17	5.61	Less
1999	31	23	2.1	0.6	6.90	2.70	Less
2000	31	23	1.9	0.7	6.26	3.34	Less
2001	32	23	2.5	1.2	8.16	5.44	Less

Table 4.3 continued

Year	Mean Tmax	Mean Tmin	Standard Deviation (SD) T_{max}	Standard Deviation (SD) T_{min}	Coefficient of variation (CV) % T_{max}	Coefficient of variation (CV) % T_{min}	
2002	31	23	3.4	0.9	10.98	4.06	Less
2003	35	23	2.8	0.9	8.19	4.32	Less
2004	34	24	2.9	2.2	8.64	9.39	Less
2005	31	23	2.6	1.1	8.52	4.98	Less
2006	32	23	2.3	0.9	7.22	4.29	Less
2007	33	23	3.5	1.2	10.75	7.05	Less
2008	32	23	2.2	0.8	7.05	3.66	Less
2009	32	23	1.8	0.7	5.73	3.18	Less
2010	33	24	2.2	1.2	6.85	5.16	Less
2011	32	23	2.2	0.8	7.11	3.49	Less
2012	31	23	2.1	0.7	6.94	3.42	Less
2013	32	23	2.3	0.9	7.33	3.97	Less
2014	32	23	2.1	0.9	6.92	3.98	Less
2015	33	23	2.1	1.2	6.69	5.59	Less

Source: Authors computation from NIMET data, 2016/2017

4.2.4 Perceptions on changes in the climatic patterns

As shown in Table 4.4, in the last 30 years from the base year of 1985, majority of respondents (51%) perceived that there was increase in temperature, with 49% indicating that they had perceived a decrease in temperature. Similarly, in the last 20 years from the base year of 1985, majority, 58 percent, of the household heads perceived that there was an increase in temperature while 42 percent said temperature had decreased. Lastly, in the last 10 years from the base year of 1985, majority, 86 percent, of the household head perceived that there was an increase in temperature while only 14 percent said temperature had actually decreased. In the year 2015 majority, 91 percent, of the household heads perceived that temperature had increased while only a meagre 9 percent perceived that temperature had decreased.

Table 4.4: Household head's perception of change in temperature for the past 31 years (1985-2015)

Year (s)	Increase		Decrease		No idea		No change		Total	
Baseline 1985	No	%	No	%	No	%	No	%	No	%
30 years	210	51	201	49	-	-	-	-	411	100
20 years	238	58	173	42	-	-	-	-	411	100
10 years	353	86	58	14	-	-	-	-	411	100
2015	374	91	37	9	-	-	-	-	411	100

Sources: Fieldwork, 2016/2017

From the focused group discussion with the farmers (Figure 4.20), a good number, 35 percent, of household heads believed that the change in temperature pattern was due to climate change. 24 percent perceived that the change in temperature pattern has been caused by an act of God; 25 percent perceived the cause as a result of the sin of mankind while 11 percent said it was caused by both the sin of mankind and an act of God. The remaining 5 percent have no idea of the cause (See Figure 4.20).

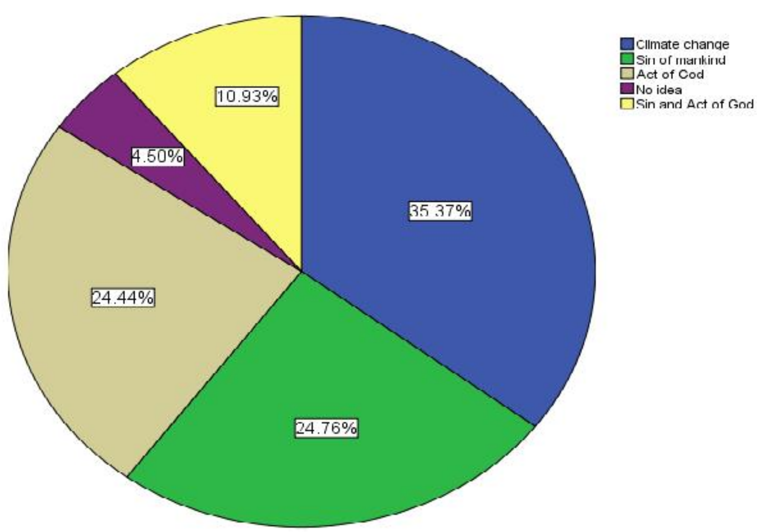

Figure 4.19: Household perception of the causes of changes in temperature

Source: Fieldwork, 2016/2017

When asked whether household heads were worried about the changes in temperature pattern, 96% of them indicated they were worried while 4% were not worried as shown in Figure 4.21.

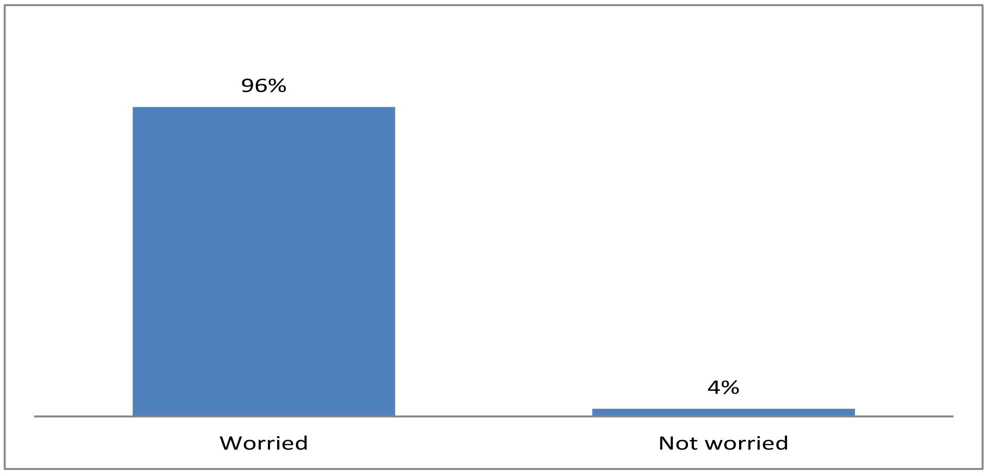

Figure 4. 20: Household's worried or not in the changes in temperature

Source: Fieldwork, 2016/2017

When the household heads were asked who they believed was responsible for the changing pattern of temperature, a majority of them (35%) believed it was caused by climate change. Others (Figure 4.22) attributed to the cause to the following: sin of mankind (25%), an act of God (24%), a combination of sin and act of God (11%) and those that did not have idea of the causes (5%).

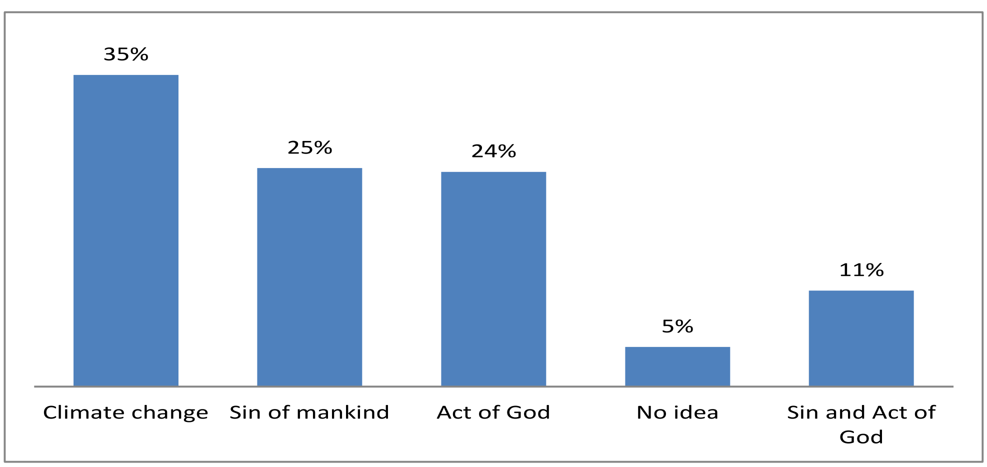

Figure 4. 21: Households' perception of the causes of changes in temperature

Source: Fieldwork, 2016/2017

Figure 4.23 shows the perception of household heads on who is responsible for the changes in temperature pattern thus: God (42%), man (32%), nature (13%) and no idea (13%).

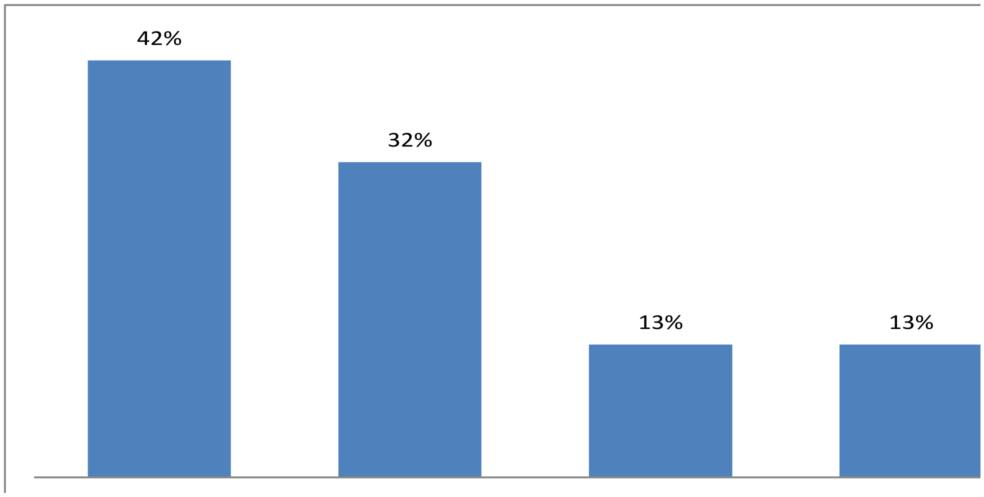

Figure 4. 22: Households' perception on who is responsible for the changes in temperature

Source: Fieldwork, 2016/2017

On what action to be taken in the face of the changing temperature pattern, the survey result (Figure 4. 24) shows various actions that members should take, which include prayer (72%), good government policy (13%), planting of trees (7%), prayer and do nothing (4%) and simply do nothing (4%).

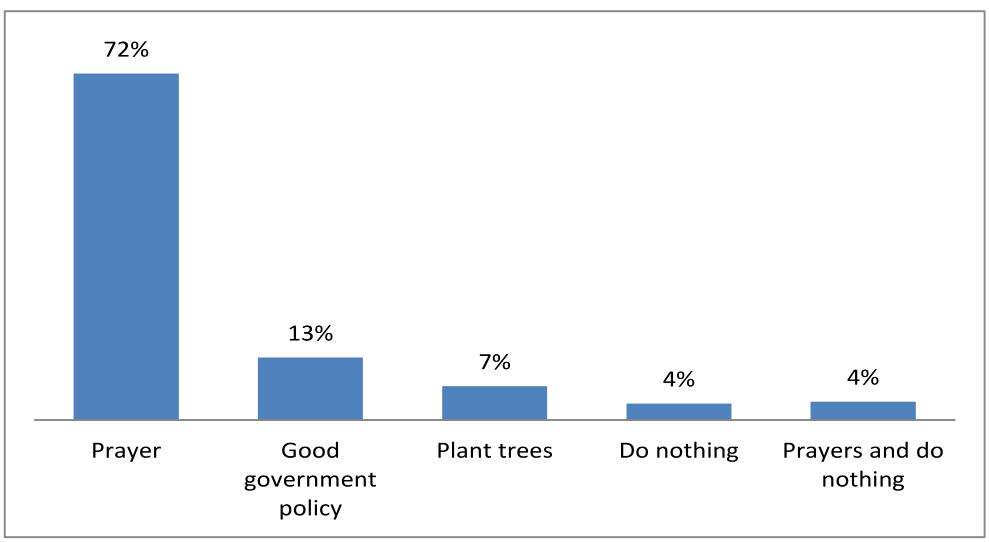

Figure 4.23: Households' perception of what action to be taken in the changes in temperature

Source: Fieldwork, 2016/2017

4.2.5 Sunshine and household perception of the causes of changes in sunshine

The trend of the average sunshine (solar irradiation) over the study region was found to be decreasing with high level of intra and inter annual variation (Figure 4. 25 and Table 4.5).

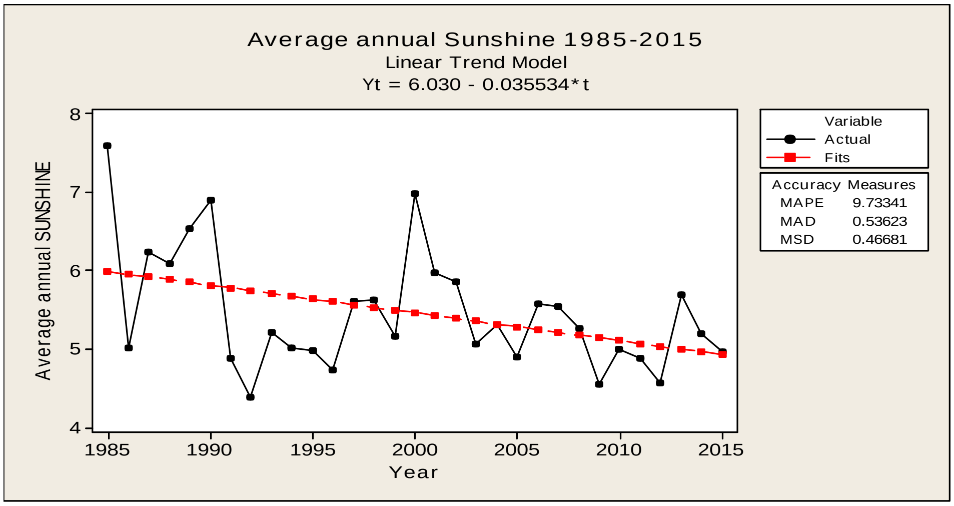

Figure 4.24: The average annual sunshine
Source: Authors computation from NIMET data, 2016/2017.

As shown in Table 4.5, unlike rainfall (Table 4.1) and temperature (Table 4.3) that showed some either CV higher or lower respectively, the CV as shown (Table 4.5) for sunshine showed all the characteristics of less, moderate and high CV<20, CV>20<30 and CV>30 for the years analysed.

Household perception of the causes of changes in sunshine

Figure 4.26 below shows the perception of household of the causes in the changes of sunshine experienced in the community over the stipulated period. The survey result showed that 31 percent of household heads believed that the change in sunshine hours is due to climate change. 24 percent perceived the change has been caused by an act of God; 27 percent perceived the cause as a result of the sin of mankind while 11 percent said it’s caused by both the sin of mankind and an act of God. The remaining 7 percent have no idea of what has caused the changes in the sunshine intensity over the past years as shown in Figure 4.26.

Table 4.5: Annual sunshine coefficient of variation

Year	Mean	Average Annual Sunshine (W/m^2) Standard Deviation (SD)	Coefficient of variation (CV)	Variability
1985	7.6000	7.6794	101.04%	High
1986	5.0083	1.6281	32.51%	High
1987	6.2417	1.5872	25.43%	Moderate
1988	6.0917	1.9771	32.46%	High
1989	6.5333	2.0426	31.26%	High
1990	6.9100	2.3607	34.16%	High
1991	4.8750	1.4007	28.73%	Moderate
1992	4.3750	1.6084	36.76%	High
1993	5.2167	1.4462	27.72%	Moderate
1994	5.0167	1.6562	33.01%	High
1995	4.9833	1.6762	33.64%	High
1996	4.7250	1.6218	34.32%	High
1997	5.6083	1.3156	23.46%	Moderate
1998	5.6333	1.5876	28.18%	Moderate
1999	5.1583	1.2114	23.48%	Moderate
2000	6.9833	1.2986	18.60%	Less
2001	5.9833	1.7492	29.23%	Moderate
2002	5.8667	1.3701	23.35%	Moderate
2003	5.0583	0.9233	18.25%	Less
2004	5.3083	1.4614	27.53%	Moderate
2005	4.9000	1.5487	31.61%	High
2006	5.5833	1.5726	28.17%	Moderate
2007	5.5417	3.2877	59.33%	High
2008	5.2583	1.8590	35.35%	High
2009	4.5500	1.4818	32.57%	High
2010	5.0000	1.3172	26.34%	Moderate
2011	4.8750	1.5006	30.78%	High
2012	4.5667	1.4528	31.81%	High
2013	5.7000	1.4855	26.06%	Moderate
2014	5.2000	1.6583	31.89%	High
2015	4.9667	1.3579	27.34%	Moderate

Source: Authors computation from NIMET data, 2016/2017.

More than half, 53 percent of the total household heads indicated that the sunshine have decreased between 1985 and 2015 while 47 percent maintained that sunshine had actually increased within the same time frame as shown in Table 4.6.

Table 4.6: Household's perception of change in sunshine (1985-2015)

Year (s)	Increase		Decrease		No idea		No change		Total	
Baseline 1985	No	%	No	%	No	%	No	%	No	%
30	193	47	218	53	-	-	-	-	411	100
20	234	57	177	43	-	-	-	-	411	100
10	366	89	45	11	-	-	-	-	411	100
2015	374	91	37	9	-	-	-	-	411	100

Source: Fieldwork, 2016/2017

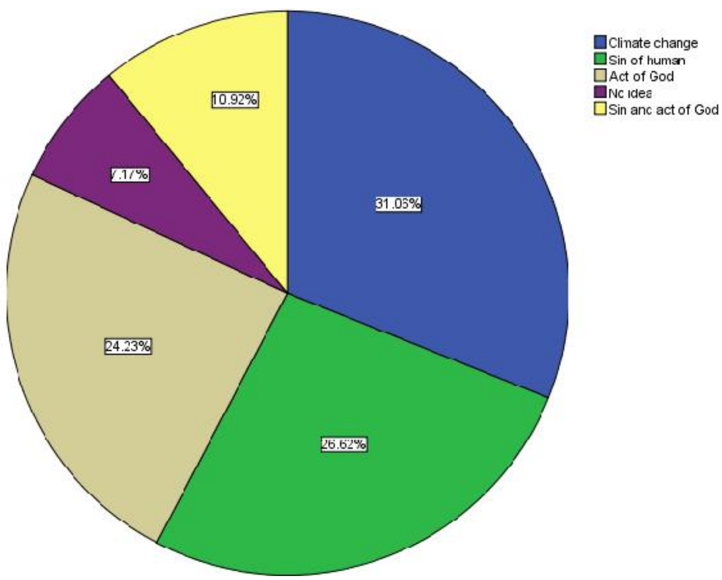

Figure 4.25: Household perception of the causes of changes in sunshine hours
Source: Fieldwork, 2016/2017

On whether the household heads were worried about the changes in the sunshine as shown in Figure 4.27, a total of 93% said they were worried while 7% were not married.

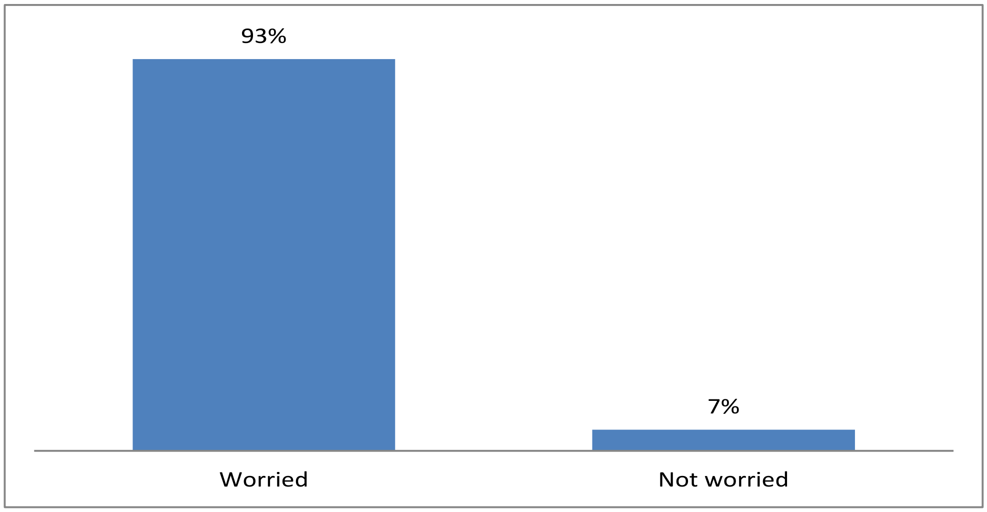

Figure 4. 26: Households worried or not in the changes in sunshine

Source: Fieldwork, 2016/2017

On what action to be taken in the changing sunshine hours, the following (Figure 4.28) was the perceptions of the farmers: 77% prayer, 15% good government policy, 3% planting of trees, 3% do nothing and 2% do nothing but pray.

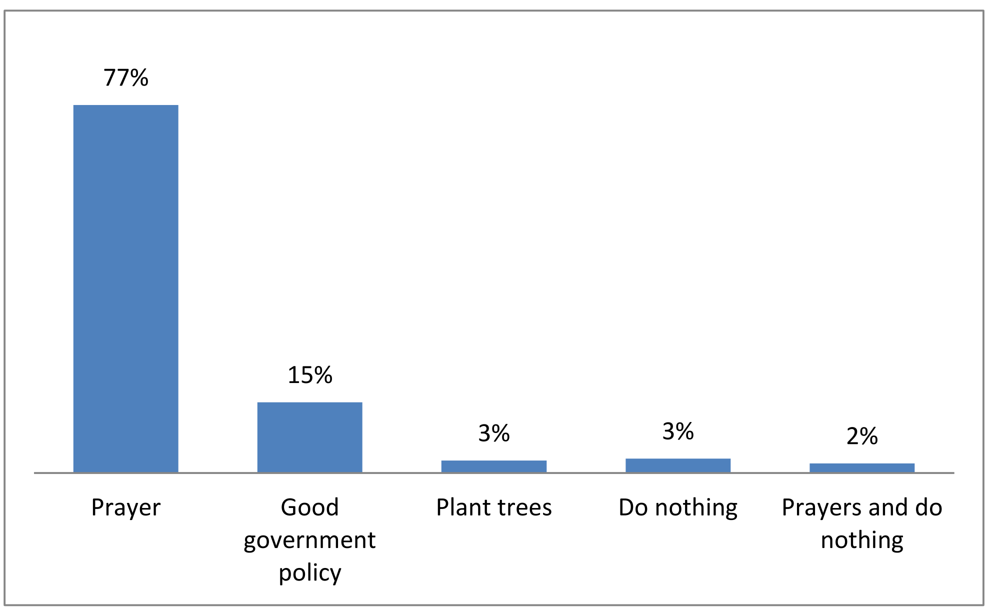

Figure 4.27: Households' perception of what actions to be taken in the changes in sunshine intensity

Source: Fieldwork, 2016/2017

4.2.6 Wind speed

The 31 years' meteorological data analysed (Figure 4.29) for the average wind speed shows an increased trend with different degree of variation in the wind speed pattern (Table 4.7) during the period under review. Though the variation shows a decrease in wind speed of 23 mph in 1991 below the mean, the year 1998 and 2007 recorded the highest wind speed compared to the other years within 1985 to 2015.

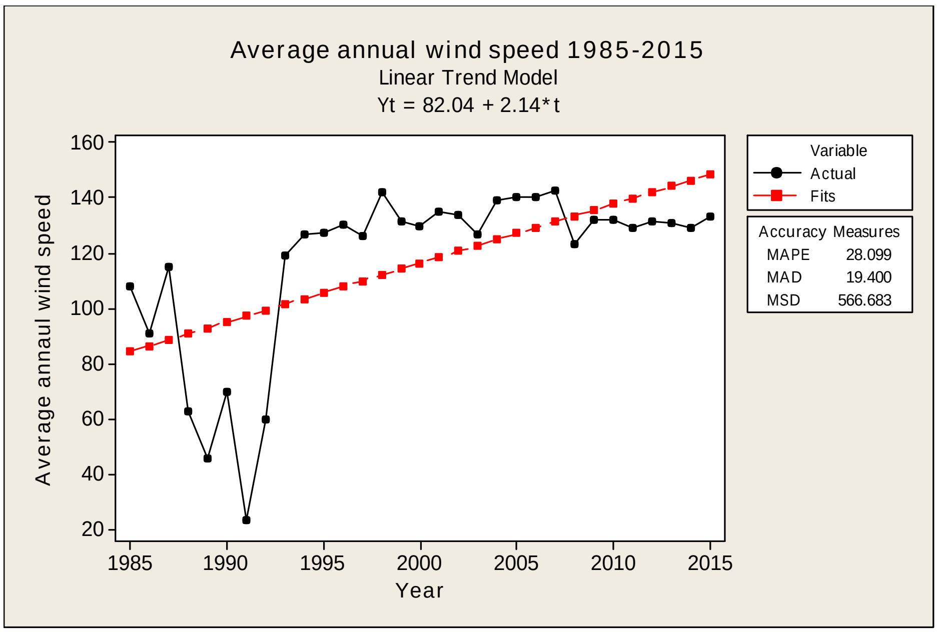

Figure 4.28: The average wind speed and the anomaly

Source: Authors computation from NIMET data, 2016/2017.

Similar to the result of the CV for the sunshine hours (Table 4.5), the CV as shown (Table 4.7) for wind speed portrayed same trend for the years analysed in which the result showed different degree of variability with the CV<20; CV>20<30 and CV>30.

Table 4.7: Annual wind speed coefficient of variation

Year	Average Annual wind speed		Coefficient of variation (CV)	Variability
	Mean	Standard Deviation (SD)		
1985	108.0183	22.7448	21.06%	Moderate
1986	90.7317	25.9034	28.55%	Moderate
1987	114.7125	49.0129	42.73%	High
1988	62.7283	36.7750	58.63%	High
1989	45.7275	22.6596	49.55%	High
1990	69.4525	39.4170	56.75%	High
1991	23.1833	14.8087	63.88%	High
1992	59.9450	32.9238	54.92%	High
1993	118.9683	25.6542	21.56%	Moderate
1994	126.8733	29.5303	23.28%	Moderate
1995	126.9692	24.2516	19.10%	Less
1996	130.2975	18.0210	13.83%	Less
1997	126.1067	26.2351	20.80%	Moderate
1998	141.9283	31.1267	21.93%	Moderate
1999	131.1717	19.8372	15.12%	Less
2000	129.9025	16.2914	12.54%	Less
2001	134.9492	22.7188	16.84%	Less
2002	133.9975	26.8413	20.03%	Less
2003	126.7333	22.8021	17.99%	Less
2004	139.1358	23.8140	17.12%	Less
2005	140.3025	26.2128	18.68%	Less
2006	140.4525	26.9326	19.18%	Less
2007	142.7858	30.2310	21.17%	Moderate
2008	122.9267	36.1224	29.39%	Moderate
2009	131.6792	16.9340	12.86%	Less
2010	131.7125	25.9123	19.67%	Less
2011	129.2708	22.3653	17.30%	Less
2012	131.3850	24.3534	18.54%	Less
2013	130.8342	19.9014	15.21%	Less
2014	128.7292	25.7034	19.97%	Less
2015	133.4108	27.4888	20.60%	Moderate

Source: Authors computation from NIMET data, 2016/2017.

Over the past thirty-one-year period (Table 4.8), majority, 58 percent of the total household heads indicated that wind speed has increased between 1985 and 2015 while 39 percent maintained that wind speed had actually decreased. Over the last 20 years from the base year of 1985, majority, 61 percent, of the household heads perceived that there was increase in wind speed while 36 percent said wind speed had decreased and 3 percent did not perceive any change in the wind speed. Over the last 10 years from the base year of 1985, majority, 74 percent of the household heads perceived that there was increase in wind speed while only 23 percent said wind speed had actually decreased and 3 percent did not perceive any change in the wind speed pattern; while in the year 2015, majority, 79 percent of the household heads perceived that wind speed had increased while a small fraction (19 percent) perceived that it had decreased and 2 percent did not perceive any change in the wind speed pattern.

Table 4.8: Household's perception of change in wind speed (1985-2015)

Year (s)	Increase		Decrease		No idea		No change		Total	
Baseline 1985	No	%	No	%	No	%	No	%	No	%
30	238	58	160	39	-	-	12	3	411	100
20	251	61	148	36	-	-	12	3	411	100
10	304	74	95	23	-	-	12	3	411	100
2015	325	79	78	19	-	-	8	2	411	100

Source: Fieldwork, 2016/2017

A total of 29 percent of household heads believed that the change in wind speed pattern was due to climate change. 25 percent perceived the change in wind speed pattern has been caused by an act of God; 26 percent perceived the cause as a result of the sin of mankind while 12 percent said it’s caused by both the sin of mankind and an act of God. The remaining 7 percent have no idea of what has caused the changes in the wind speed pattern over the past years as shown in Figure 4.30.

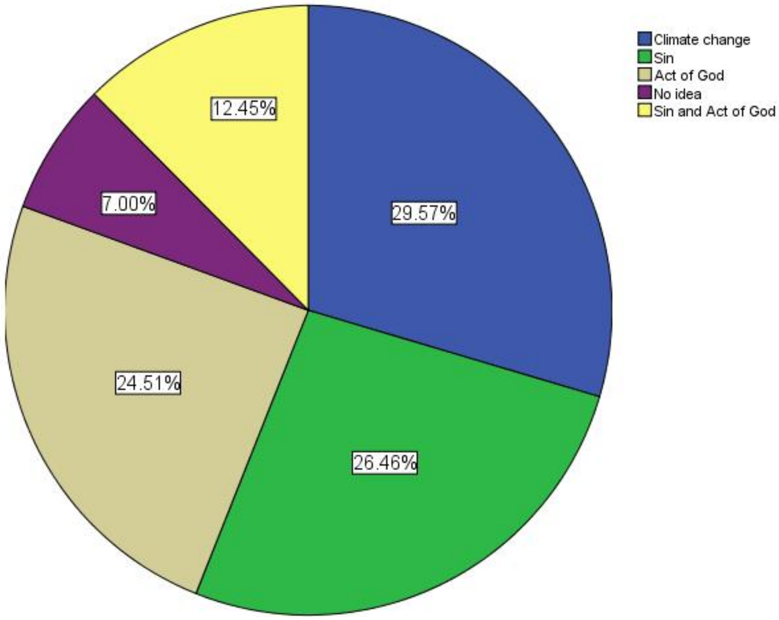

Figure 4. 29: Household perception of the causes of change in wind speed
Source: Fieldwork, 2016/2017

Majority (66%) of household heads said they were worried while 35% said they were not worried about the change in wind pattern in the region as shown in Figure 4.31.

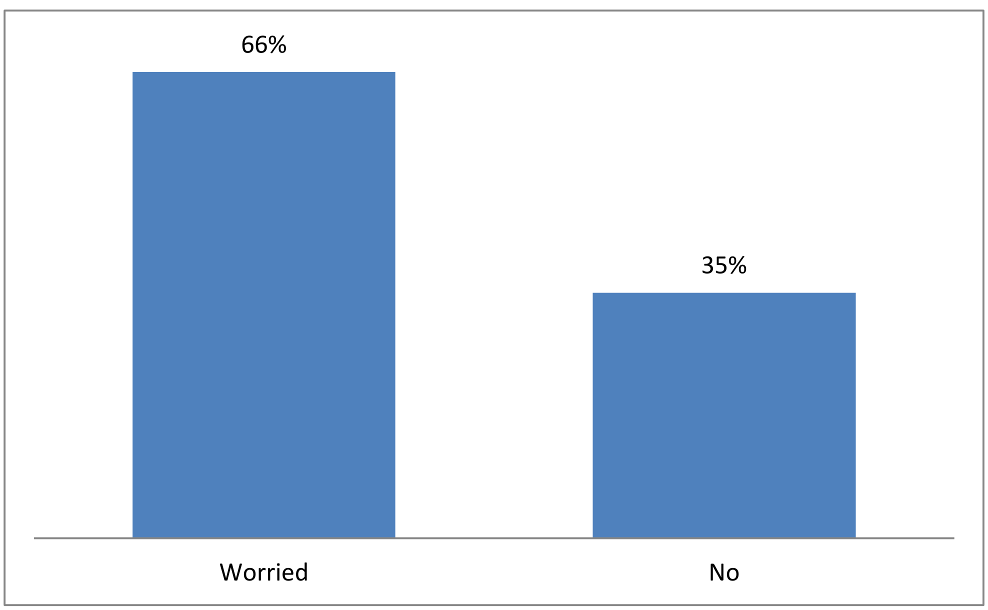

Figure 4. 30: Household's worried or not about change wind speed pattern
Sources: Fieldwork, 2016/2017

On who is responsible for the change in wind pattern, household heads responded as follows (Figure 4.32): God (40%), man (27%), nature (14%), and no idea (19%).

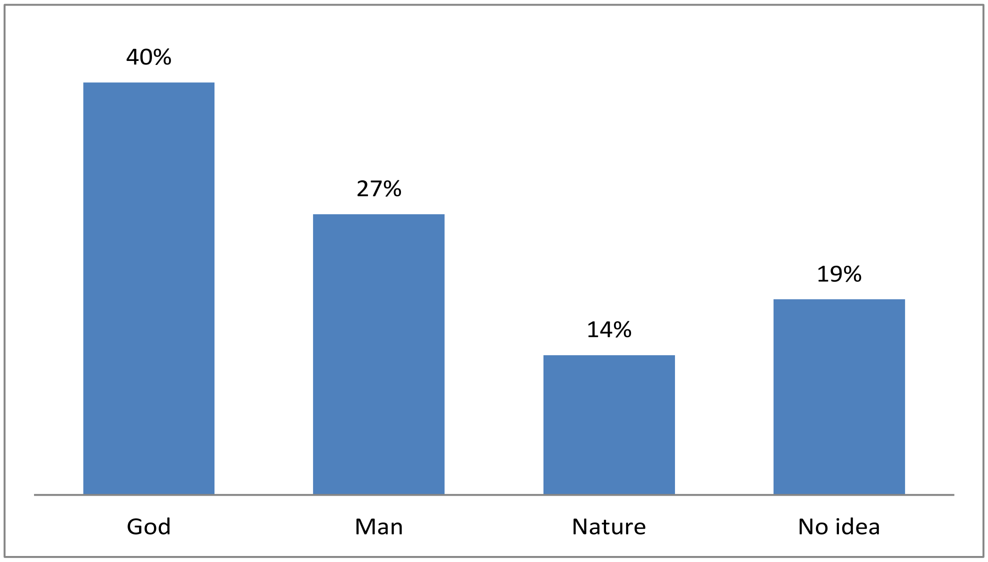

Figure 4.31: Household's perception on who is responsible for change wind speed pattern
Source: Fieldwork, 2016/2017

Majority (75%) of household heads believed the action to be taken in the face of changing wind pattern was prayer. 14% said it should be good government policy, 3% indicated planting of trees and 4% each agreed that doing nothing and pray is the only action to take as indicated in figure 4.33.

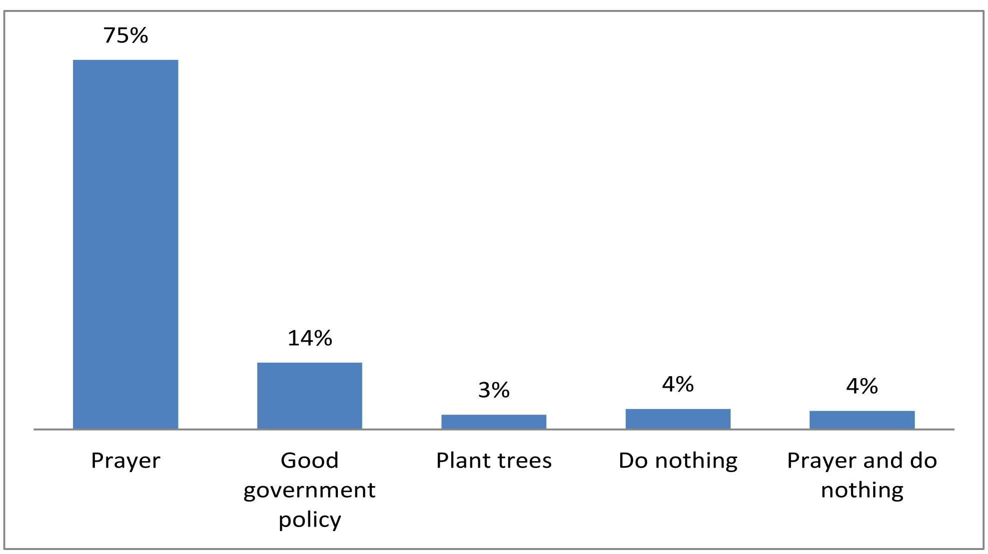

Figure 4.32: Household's perception of what action to be taken about the changes in wind speed pattern
Source: Fieldwork, 2016/2017

4.2.7 Relative humidity

The year 1993 recorded (Figure 4.34) the lowest relative humidity (74.09%) while highest was recorded in 1996 at 82.41%. On the average for the 31 years (1985-2015), the months of January and July recorded the lowest and highest rate of relative humidity of 66.45% and 87.03% respectively.

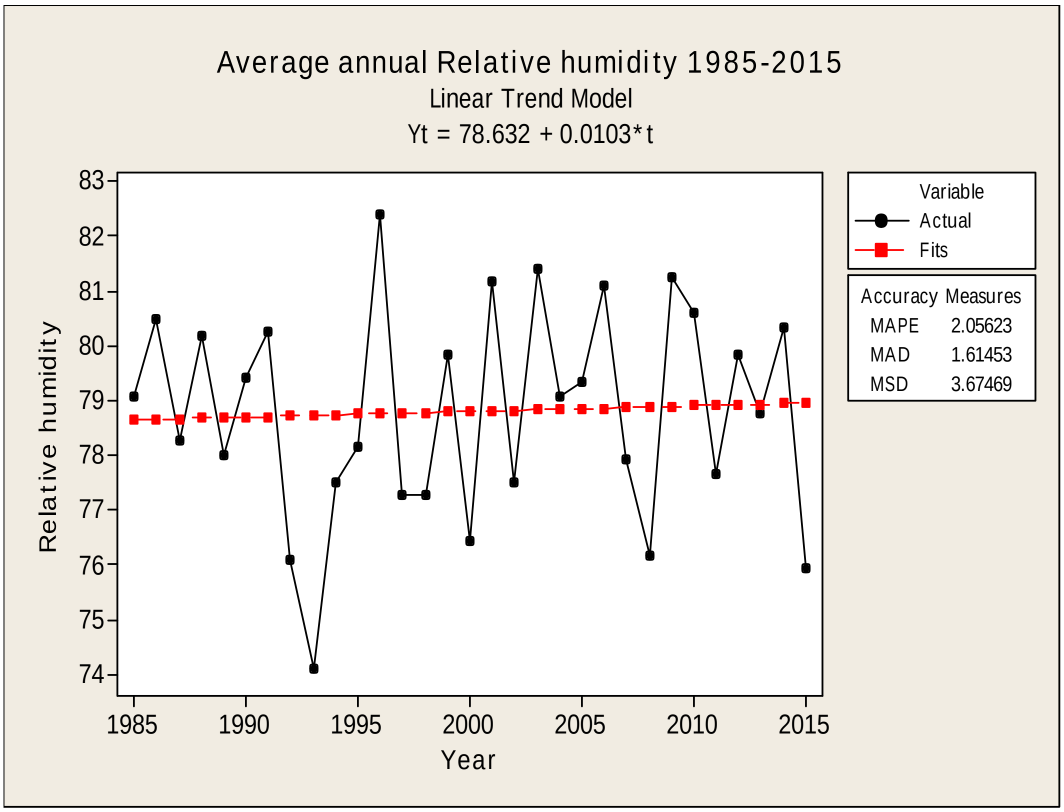

Figure 4.33: The average relative humidity

Source: Authors computation from NIMET data, 2016/2017.

As shown in Table 4.9 for all the years analysed, the relative humidity showed a coefficient of variation which was CV<20 and was closer to the mean but not very far apart or spread out from the mean and from one another.

Table 4.9: Annual relative humidity coefficient of variation

Year	Average Annual relative humidity (%) Mean (%)	Standard Deviation (SD)	Coefficient of variation (CV)	Variability
1985	79.0833	9.0780	11.48%	Less
1986	80.5000	7.0887	8.81%	Less
1987	78.2500	5.8754	7.51%	Less
1988	80.1667	7.2553	9.05%	Less
1989	78.0000	9.4340	12.09%	Less
1990	79.4167	7.2395	9.12%	Less
1991	80.2500	5.7753	7.20%	Less
1992	76.0833	10.2669	13.49%	Less
1993	74.0909	11.8126	15.94%	Less
1994	77.5000	8.8459	11.41%	Less
1995	78.1667	10.1064	12.93%	Less
1996	82.4167	3.6846	4.47%	Less
1997	77.2500	10.8407	14.03%	Less
1998	77.2500	10.5761	13.69%	Less
1999	79.8333	5.6691	7.10%	Less
2000	76.4167	11.2358	14.70%	Less
2001	81.1667	7.8298	9.65%	Less
2002	77.5000	10.0208	12.93%	Less
2003	81.4167	4.5727	5.62%	Less
2004	79.0833	6.1976	7.84%	Less
2005	79.3333	9.4985	11.97%	Less
2006	81.0833	6.7880	8.37%	Less
2007	77.9167	11.2210	14.40%	Less
2008	76.1667	13.1835	17.31%	Less
2009	81.2500	5.8184	7.16%	Less
2010	80.5833	4.3293	5.37%	Less
2011	77.6667	8.9100	11.47%	Less
2012	79.8333	6.5680	8.23%	Less
2013	78.7500	7.0843	9.00%	Less
2014	80.3333	5.7349	7.14%	Less
2015	75.9167	13.6898	18.03%	Less

Source: Authors computation from NIMET data, 2016/2017.

Over the past 31 years, majority, 67 percent of the total household heads indicated that relative humidity had increased between 1985 and 2015 while 33 percent maintained that it had actually decreased. Over the past 20 years from the base year of 1985, majority, 64 percent of the household heads perceived that there was increase in relative humidity while 36 percent perceived that the relative humidity had decreased. Over the past 10 years from the base year of 1985, majority, 73 percent of the household head perceived that there was increase in relative humidity while only 27 percent said relative humidity had actually decreased. In the year 2015, majority, 77 percent of the household head perceived that relative humidity had increased while a meagre 23 percent perceived that it had decreased.

Table 4.10: Household's perception of change in relative humidity (1985-2015)

Year (s)	Increase		Decrease		No idea		No change		Total	
Baseline 1985	No	%	No	%	No	%	No	%	No	%
30	275	67	136	33	-	-	-	-	411	100
20	263	64	148	36	-	-	-	-	411	100
10	300	73	111	27	-	-	-	-	411	100
2015	316	77	95	23	-	-	-	-	411	100

Source: Fieldwork, 2016/2017

According to 28 percent of household heads, they believed that the change in relative humidity was due to climate change. 20 percent perceived the change was an act of God; 32 percent perceived the cause as a result of the sin of mankind while 11 percent said it was caused by both the sin of mankind and an act of God. The remaining 8 percent had no idea of what had caused the changes in relative humidity over the past years as shown in Figure 4.35.

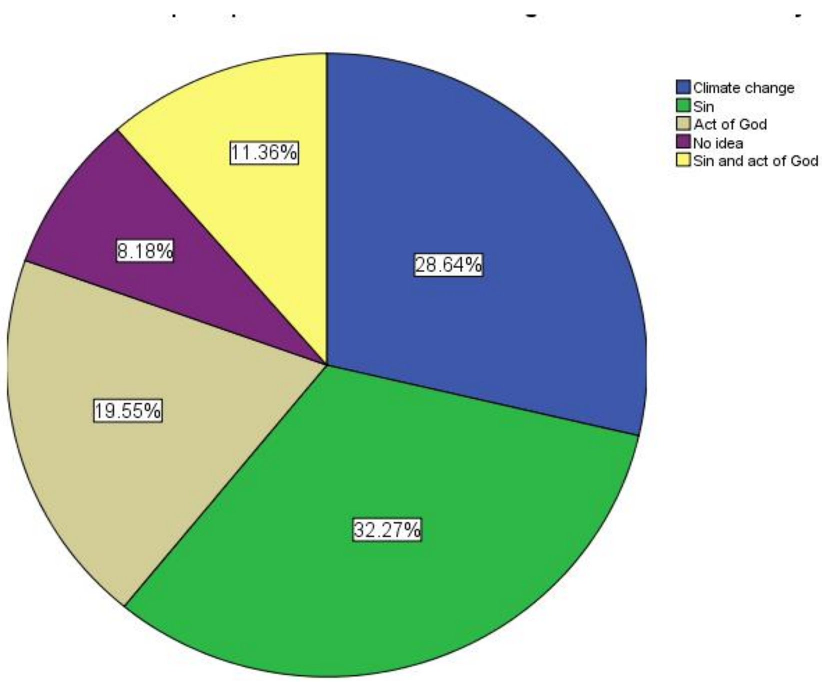

Figure 4. 34: Household perception of the causes of change in relative humidity

Source: Fieldwork, 2016/2017

Households held different perceptions on who is responsible for the changes in the relative humidity observed in the community. As presented in Figure 4.36, a total of 40% of the household heads perceived God was responsible, 32% agreed it was human being while 10% of them perceived nature was responsible and 18% had no idea on who was responsible.

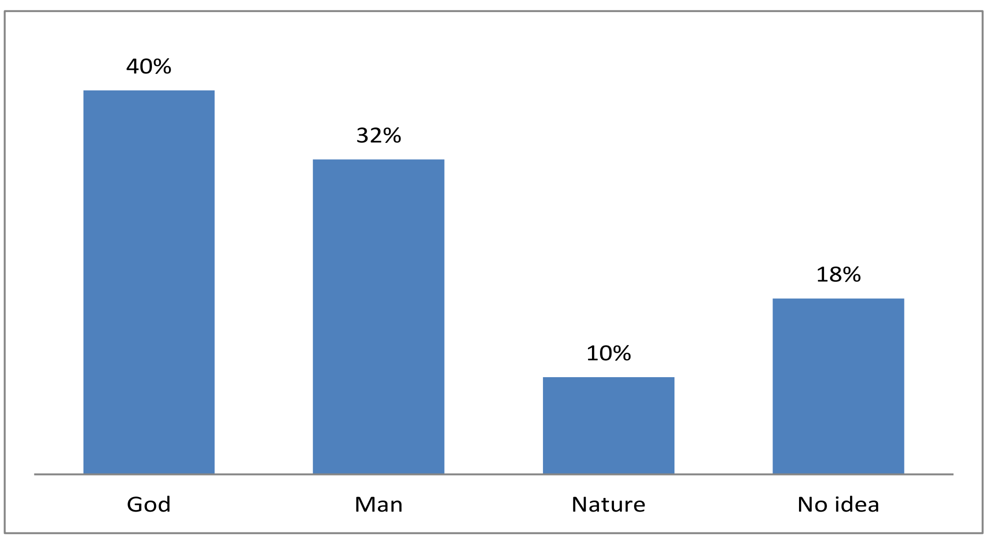

Figure 4.35: Household's Perception of who is responsible for change in relative humidity

Source: Fieldwork, 2016/2017

Majority of the household heads (77%) are of the opinion that the action to be taken in the face of changes experienced in the relative humidity was prayer while 14% indicated that good government policies could be a way to address the changes. The percentage of household heads that perceived the action to be taken was planting of trees, or do nothing while praying stood at 3%, respectively, as shown in Figure 4.37.

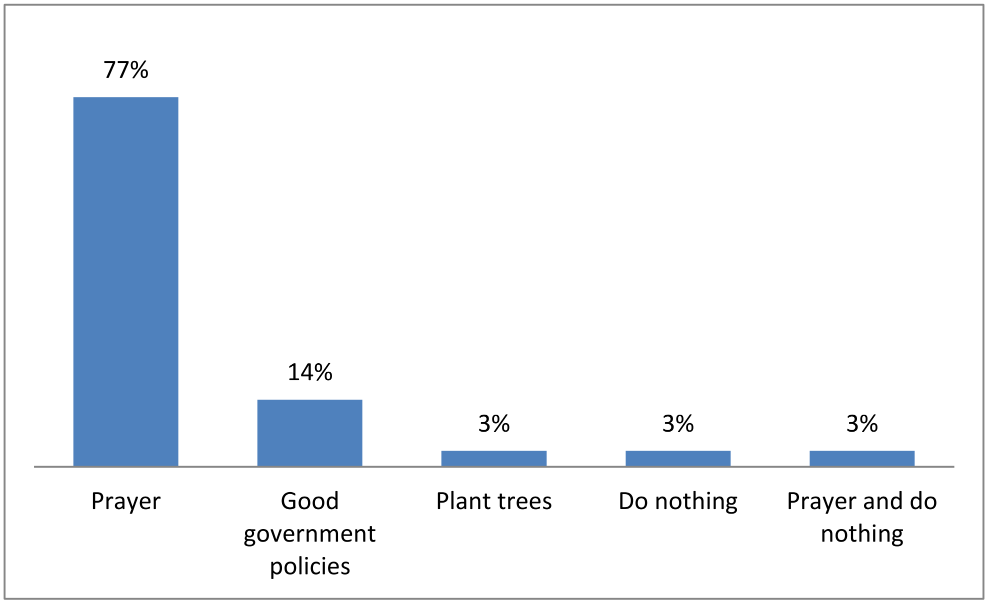

Figure 4.36: Household's perception on what action to be taken in the changing relative humidity
Source: Fieldwork, 2016/2017

4.3 Discussion

4.3.1 The gender profile of the smallholder farmers

Male and female are all involved in smallholder farming in the research communities. The implication of and insight from the result from the marital status of household heads (Figure 4.2) would mean targeting more married smallholder farmers who constitute the majority (critical mass) in the climate change initiatives in the community. The representation of women (13%) compared to men (87%) would also require deliberate efforts to increase the proportion of women in agriculture in this community and probably removing any identifiable barriers to their participation in this sector. Relating this closely with the gender dimension however shows that the level of involvement of both sexes in the farming sector varied significantly.

While men may have access to and control over land, financial resources–access to credit and other climatic information among other factors of production- this is limited for the women folk and because climate variability and change affects everyone, the impacts on women and children is much higher than men. Women are most often involved in activities such as planting, harvesting, processing and marketing while the male folk are dominantly engaged in land preparation, weeding, spraying and their dominance in leadership is also visible in processing and marketing in some instances.

Gender equality means that there are equal opportunities available to both men and women, boys and girls for them to be able to realise their full potential and contribute to the growth and development of the society and derive the benefits equally thereof (FAO, 2013; Ogallah, 2014). In Nigeria, the differentiated impacts of climate change on both male and female are further strengthened by the historical, cultural, religious and social norms. These differences are manifested in the unequal household division of labour among men and women, and 'feminization' of poverty due to gender inequalities (NEST, 2011c).

The result from this study also brings to the fore (Figure 4.2), that there could be lack of interest in farming among the singles (who are mostly the youth). Making agriculture a business in the form of agri-business, climate smart/resilient agriculture and provision of additional incentives could attract this group into agriculture which could lead to increased productivity, food security and reduced unemployment that is prevalent among this group.

4.3.2 Participation in decision making

The result from the finding on the participation in decision making in the community showed that 66% of households engaged in farming attained only primary education (Figure 4.3) but the majority that participated in decision making are those that attained the tertiary level of education (Figure 4.3). This then could mean that this is the group of farmers who did not have tertiary education and which constitutes the majority is disenfranchised from any major decision that could be made and could have an impact on their farming system. This creates a gap such that deliberate efforts need to be made that would bring this group of farmers with primary level of education to any farming and climate decision making table that would have direct implications on their farming system as well as designing of adaptation strategies that can be sustainable in the long run. A situation where decisions are made on their behalf may be counterproductive and should be seen as what I would call '*not for them without them*'.

4.3.3 Social network

Other social networks that exist in the communities include the youth cooperatives, farmers' women, young farmers' and traders' associations and the "*Baale*" which comprises the community chief with his executive council. Different people from different ethnic backgrounds in Nigeria are found in Oyo state, although the Yoruba ethnic group is the majority in the State. This social network, which constitutes the social capital, was seen as a valuable part of coping strategies in the face of climate change impacts as some of the community members testified during the FGDs (Plate 3.2).

4.3.4 Occupation of household heads

From the analysis of the result in Figure 4.5, majority (69%) of the smallholder farmers in the region were actively engaged in only farming while closely related to this group were those engaged in farming and livestock (15%). Those engaged only in animal husbandry were 14% of the total. This confirmed the finding of Apata (2011) that indicated that majority of smallholder farmers in Southwest Nigeria was involved in farming. The implication of this therefore is that climate change intervention priority in the region should be targeted more on smallholder farmers and if resources allow, then followed by those combining farming with livestock as livestock rearing could provide alternative livelihood options, source of organic manure and an adaptation strategy to some of the farmers with such practices (Table 6.1).

4.3.5 Crops grown and livestock kept by household

The analysis result from the combination of crop grown and livestock kept by household (Figure 4.6) depicted that many (48%) of the smallholder farmers in the region cultivate cereals, tubers, vegetables and kept livestock. The reason for this could be spreading their risks in the face of climate change in such a way that if one fails, the other options become the fall back and as an adaptation strategy (Table 6.1). This would then mean that any climate change intervention for this group of farmers should be designed towards the enhancement of productivity of these commodities which they are used to rather than introducing a new type that may not be well accepted or adapted in the region either by the farmers or the compatibility of such with the environment and the soil leading to waste of resources. Farmers are known to be hesitant to adopt new practices that they are not used to. The adoption of new practices is informed by their indigenous knowledge. A combination of climate resilient varieties of cereals, tubers, indigenous vegetables and livestock could work well in addressing climate variability and change impacts in the region as opposed to other crops like fruits, fibres, spices, sugarcane, cotton etc.

4.3.6 Acquisition of farmlands

The kind of farmland owned by the households showed many farmers (41%) said they operated on leased land for their farming activities compared to 37% that inherited the portion of their farming lands and the 19% that actually bought such farming land (Figure 4.7). This therefore would mean that in the adverse climatic events in the region, the impacts could be more on those that operated on leased land in terms of difficulty in the repayments of loans or debts and faster recovery from such climatic shock (more vulnerable). A weather index-based insurance could target more of this group of those who leased land for their farming activities in the region as part of climate risk insurance strategies to reduce their vulnerability and build their adaptive capacity. This does not mean that the other group should be left out of such a scheme but the finding of this study could provide a guide on the level of priority that should be considered when prioritizing such intervention such as the risk insurance, and of course, if resources allows, all farmers deserved to be insured under such scheme.

4.3.7 Access to and understanding of climate information received by farmers

Despite this high percentage of the smallholder farmers that indicated they have access to climate information, the challenge as indicated in Figure 4.10 is how the information is being processed by them and whether or not they understand the information received to help their farming activities. With regard to understanding of the climate information received by the farmers, as shown in Figure 4.10, only a small fraction had no difficulty understanding climate information received, while the majority (77.5%) had difficulty understanding the information. The implications of this gap in understanding (77.5%) the climate information by the farmers could range from weak adaptive capacity, increase vulnerability, decrease in crop yield, maladaptation, among others. This requires that the manner, channel and languages (Figure 4.11) climate information are provided to the farmers who are the end users and mostly with low level of education (Figure 4.3) in this case need to be improved to enable the farmers make informed farming decisions that affect their livelihoods and farming activities. This finding confirms the UNECA (2011) which found that many farmers found it difficult to understand climate information they received. Communicating climate information in the local languages where these farmers resides and demystifying the scientific content of such information could help the farmers' level of understanding.

4.3.8 Changes in weather and climate patterns

The result of this study showed that majority of the farmers (97%) agreed that there were changes in the weather and climate pattern during the period under review (Figure 4.12). This general perception held by the farmers corroborate the analysed results from the meteorological data obtained from NiMET on temperature, rainfall, sunshine, relative humidity and cloud cover which showed the general trend in the changes in weather and climatic condition of the region.

4.3.9 Rainfall

The average annual rainfall for the past 31 years (1985-2015) was 1,356 mm. The result of the annual rainfall obtained from the meteorological data from 1985 to 2015 (Figure 4.13) showed some degree of variability in the rainfall pattern. It also showed a continuous decreasing trend in the duration between 2011 and 2015. The year 1999 recorded the highest (1816 mm) rainfall while the year 1998 recorded the lowest rainfall (921 mm). The findings also showed that there was an increase in rainfall by 2 mm per annum and this can provide a clue to the recent flood events recorded in the study areas in recent time and the accompanied shorter duration of rainfall as the smallholder farmers testified during the field survey and FGDs. There was a higher level of variability and intensity in the rainfall pattern (CV>30) in the region as the study revealed in Table 4.1 and Figure 4.13 indicated higher inter annual rainfall variability and high level of intensity respectively. All these changes and variability come at a huge cost to smallholder farmers who rely on rainfall for their farming activities and other means of livelihoods. The month of January on the average during the period under review recorded the lowest (148 mm) amount of rainfall. This agrees with the findings of Ayanlande *et al*. (2016) which confirmed that more than half of the years' data analysed recorded below normal rainfall and with higher level of variability (Figure 4.13 and Table 4.1). This will however increase the cost of adaptation for smallholder farmers especially if irrigation measures are adopted. This finding (Figure 4.13 and Table 4.1) also corroborate Olaniran (2007); NASPA-CCN (2011); Uduak *et al*. (2012); Chibuike *et al.* (2014) that showed that early cessation of rainfall was recorded for Southwest Nigeria in the past four decades and it has continued to spread to other part of the country.

4.3.10 Perception of household on changes in rainfall pattern

The perceptions held by household heads were triangulated with the meteorological and other secondary data obtained on the various climate parameters. The perception of household with regards to change in rainfall pattern (Table 4.2) corroborate that of Garfoth (2014) and Asfaw *et al.* (2018) in which majority of respondents interviewed agreed that rainfall had actually decreased in a study that looked at adaptation to climate change in farming systems and international policy, and the study on the variability and time series trend analysis of rainfall and temperature in north and central Ethiopia, respectively.

4.3.11 Perception of household on temperature changes

The linear trend analysis for the meteorological data from 1985 to 2015 (Figure 4.18) showed that there was a constant increasing trend in maximum temperature (T_{Max}) by 0.03 degree Celsius per annum with high intensity and less variability in the temperature pattern (Table 4.3 and Figure 4.18). The minimum temperature during the year under review also increased by 0.03 degree Celsius per annum from the meteorological data analysed (Figure 4.19) with high intensity and less variability (Figure 4.19 and Table 4.3). Both the increasing trend in T_{max} and T_{min} with their attendant varying degrees of intensity and variabilities (Figure 4.18, Figure 4.19 and Table 4.3) in the temperature patterns comes at a cost to smallholder farmers. The increase in both the T_{max} and T_{min} with the increasing level of intensity and different degree of variability from this study goes to confirm the findings of NEST and Woodley

(2011a), NEST and Tegler (2011b), NEST (2011d), NASPA-CCN (2011), Abiodun, *et al*. (2011), Apata (2011), UNEP, (2014), IPCC (2014) and Ujah *et al.* (2014). The findings also agree with Anuforom (2013) who reported that for 5 decades since 1951, the surface air temperature over Nigeria continued to rise with high intensity and varying degree of variability. These changes in temperature pattern (Ozor 2014) is attributable to climate change.

4.3.12 Perception of households on temperature changes

The finding from this study (Table 4.4) on the farmers' perception with regards to increase in temperature corroborate that of Ayanlande *et al.* (2016) that compared the smallholder's perception of climatic change with the meteorological data and showed that majority of the farmers that participated in the study perceived variation in the weather and climatic pattern in Southwest Nigeria in agreement with historical meteorological data. With regard to the farmers' perception on the causes of changes in temperature, the result (Figure 4.4) Progress *et al.* (2011) who found that some farmers perceived supernatural forces to be responsible for the changing climatic situation, hence the attribution of the causes of climate variability and change in this study to an act of God which is supernatural.

4.3.13 Sunshine (solar irradiation)

The sunshine analysis (Figure 4.25) showed that there was a decreasing trend in the average sunshine with high degree of variability (Table 4.5). This scenario comes with costs for adaptation to climate change for the smallholder farmers. The finding (Table 4.20) on the average showed that the perception of the majority of the farmers contradicted the resulted of the analysis from the meteorological data that pointed to the fact that sunshine has reduced during the period under review (Figure 4.25). While majority of the farmers perceived an increase, the meteorological data indicated a decreasing trend. This requires r further investigation and climate education for smallholder farmers in the region to create awareness. With the average solar radiation which showed a reduction of -0.035 W/m^2 per annum during the period under study from the meteorological data analysed will have adverse implications for plant photosynthesis which can lead to reduced crop yield Abiodun *et al*. (2011).

4.3.14 Wind speed

The finding from the study (Figure 4.29 and Table 4.7) on the average wind speed showed a continuous increasing trend with high degree of variability in the wind speed pattern during the period under review for the study communities in the region. It means that the smallholder farmers have to grapple with the fluctuations in the wind speed pattern which in most cases resulted in some extreme windstorm in the region as corroborated in the focus group discussion with the smallholder farmers.

4.3.15 Relative humidity

The relative humidity from 1985 to 2015 showed no significant increase but some fluctuations in the trend and with less variability (Figure 4.34 and Table 4.9). This finding (Figure 4.35) confirmed that of NEST (2011d) and Abiodun *et al*. (2011) that indicated that most parts of Nigeria within that period of time under study recorded above 60% of relative humidity level showing fluctuations of between 90% and 100% in some of the years. On the average for the 31 years (1985-2015), the months of January and July recorded the lowest and highest amount of relative humidity of 66.45% and 87.03% respectively. The significant variation pattern has implications for smallholder farmers, plants and animals. For example, an increase in relative humidity can as well signify an apparent increase in temperature and this can in turn be a hindrance to evaporation of perspiration and evapo-transpiration as well as increasing the incidence of other pests and diseases (NEST and Tegler, 2011b).

4.4 Conclusion

The finding from this study on climate variability and change trends as well as the smallholders' perceptions on these changes showed that the rainfall pattern, temperature, sunshine, wind speed and relative humidity in the region had changed in the past 31 years between 1985 and 2015 with varying degrees of variability and intensity. The awareness which the farmers also held from their perception on all these climate parameters, with the exception of sunshine hours, corroborates the meteorological and other secondary data obtained for the study areas. Both the scientific (meteorological) data and the smallholder farmers' perceptions on the changes in the climatic pattern during the period under study agreed to the fact that climate variability and climate change has been observed and experienced with its negative consequences and with varying perceptions on the causes, who is responsible and what actions to be taken to address the impacts.

Rainfall has become highly unpredictable and erratic characterised by high coefficient of variation and decreased duration of rainfall pattern coupled with high level of variability. This was observable by smallholder farmers in the late onset of rainfall (from the usual March/April to now May/June and sometimes July) and early cessation of the rain occasioned by flash floods. Both the maximum (T_{max}) and minimum (T_{Min}) temperature had actually increased by 0.031 degree Celsius and 0.026 degree Celsius per annum, respectively, during the period under review with high level of and less variability. Finding from this study showed an increase of 2.1 mph per annum in the wind speed pattern between 1985 and 2015 as relative humidity also increased by 0.01% per annum during the same period under study. At this rate and in the business as usual scenario, the relative humidity of the region is expected to increase by 0.3% by 2030 and the consequences of this could be hindrances to evaporation of perspiration and evapotranspiration for plants as well as increasing the incidences of pest and diseases. It can also lead to high risk of malaria fever for humans.

Gap still exists though as to how best to bridge the perception and understanding of farmers on climate variability and climate change with the modern technology and scientific findings. This calls for further research and urgent action to be taken in finding appropriate means of communicating climate information tailor-made towards meeting the need of smallholder farmers for a well-informed action against climate change and its impacts. Demystification of the scientific findings and involving smallholder farmers in the co-production, packaging and dissemination of such information could offer a way forward. This is because even in a situation where the farmers received such climate information as found out in this study, they had difficulties in understanding such climate information.

This study further showed the information gap in the provision of climate information services (CIS) that is required by the farmers. Good knowledge of the micro climate and perceptions held in an area like this study investigated will help researchers, policy makers, planners and farmers to also plan adequately for adaptation strategies to adopt. Lack of or inadequate and appropriate climate information services can lead to mal-adaptation which can further increase the vulnerability of farmers to climate change with its impacts. Though this study showed that majority of the farmers are worried about the changes in all the climate parameters analysed in this study, majority of them ranked prayer '*very high*' on their list of the actions to be taken; this option alone is not good enough and will certainly not be adequate to address the impacts of climate change in the region.

CHAPTER FIVE

THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON SMALLHOLDER FARMERS IN SOUTH WEST NIGERIA

5.1 Introduction

Despite the fact that some studies have been undertaken on climate change, the impacts of climate variability and change which are very visible in many communities and among different groups of people in the society still require an in-depth study as the available studies on these impacts are still in short supply (Apata, 2011). The increase in the build-up of Greenhouse Gases in the atmosphere have resulted in the current global warming observed through the increase in temperature, unpredictable rainfall patterns and flash floods among other climate variables in recent time (John, 2009; FAO, 2013; Ogallah *et al.*, 2017a; Ogallah *et al.*, 2017b).

Although the whole world experiences these changes in different regions, the impacts are differentiated among continents, sectors, people and ecosystems. While some regions of the world may have the ability to adjust to the pounding impacts of climate change, the African continent remains vulnerable to these devastating impacts (Stern, 2007; NEST and Tegler, 2011b; IPCC, 2014; Steger, 2017). One of the major sectors in Africa that is most susceptible to these impacts is the agriculture sector which also employs the largest labour force in the continent, providing food and creating jobs for millions of its people (Stern, 2007; UNEP, 2014). The incidences of erratic rainfall and increasing temperature have further complicated the already bad situation of poor crop yields experienced by many smallholder farmers (Ogallah *et al.,* 2017a) who depend on this climate sensitive production sector for their livelihood (Ifejika, 2010; Bello *et al.,* 2012). This has led to farmers trying out different strategies to adapt to the adverse impacts of climate change especially in many developing countries including Africa (NEST and Woodley, 2011a, NEST and Tegler, 2011b, NEST, 2011d; Ogallah *et al.*, 2017c). Other studies (Ifejika, 2010; Chidumayo *et al.,* 2011) also found that smallholder farmers in Sub Sahara Africa bears the brunt of the impacts of climate variability and change yet have the least capacity to adapt.

Some of the impacts from the finding of this study in Southwest Nigeria points to the fact that smallholder farmers are still grappling with such climate variability and change challenges which are manifested not only in the agriculture sector such as decline in their crop and livestock produce but also in the deteriorating health status, decrease in income level and experiences of recession in other socio-economic livelihood of the people (Ogallah *et al.*, 2017d).

5.2 Results

5.2.1: Actual versus expected maize yields from smallholder farmers' practices

The study sought to understand the expected versus actual yields from farming, farming and livestock rearing and farming and trading carried out among the three groups of smallholder farmers as shown in Figure 5.1. The result obtained from the analysis showed averages for 2014 and 2015 for both the expected and actual maize yield per hectare of land for the three group of farmers thus: Farming only (expected yield 500 kg and actual yield 400 kg); farming combined with livestock (expected yield 2100 kg and actual yield 2200 kg) while farming combined with trading (Expected yield 350 kg and actual yield 85 kg).

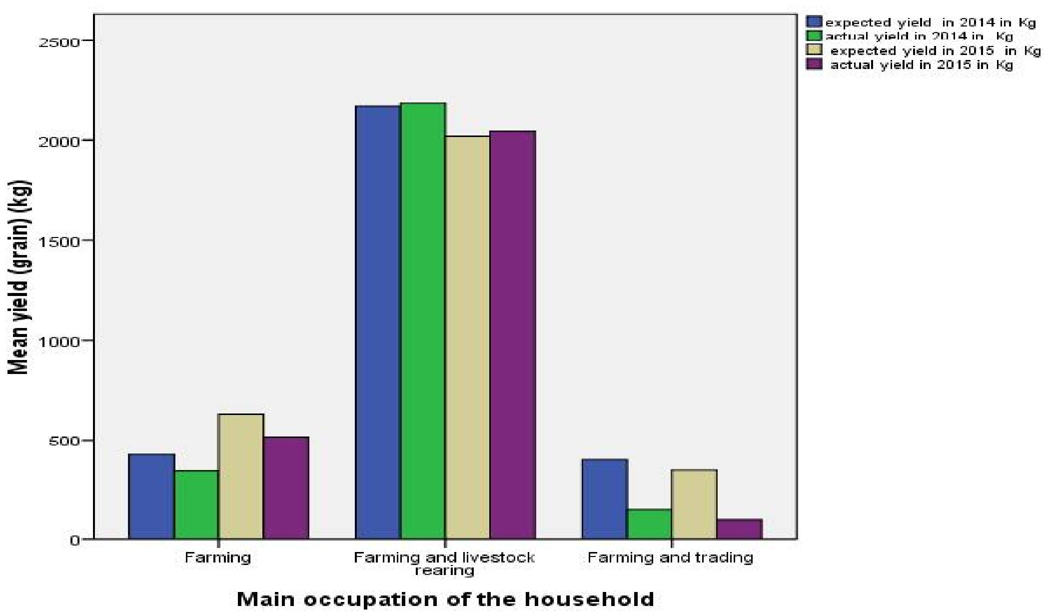

Figure 5.1: Household's actual versus anticipated maize (yield) harvest
Source: Fieldwork, 2016/2017

Plate 5.1: Application of SAS2 by the researcher with community members on the impacts of climate change on their crops and livestock, income level and adaptation strategies from the FGDs.

Source: Fieldwork, 2016/2017

5.22: Reasons for variation in the maize yield as perceived by households

On the reasons that led to the variations in the quantities of harvested maize (Figure 5.2), majority of the farmers (58%) attributed it to erratic rainfall, 23% said it was a combination of erratic rainfall, increase in temperature and sunshine hours. Others (11%) attributed the variation in yield to erratic rainfall and increase in temperature and pest infestation, while 1% stated it was due to increase in sunshine hours and 6% said it was due to application of fertilizer with irrigation practices.

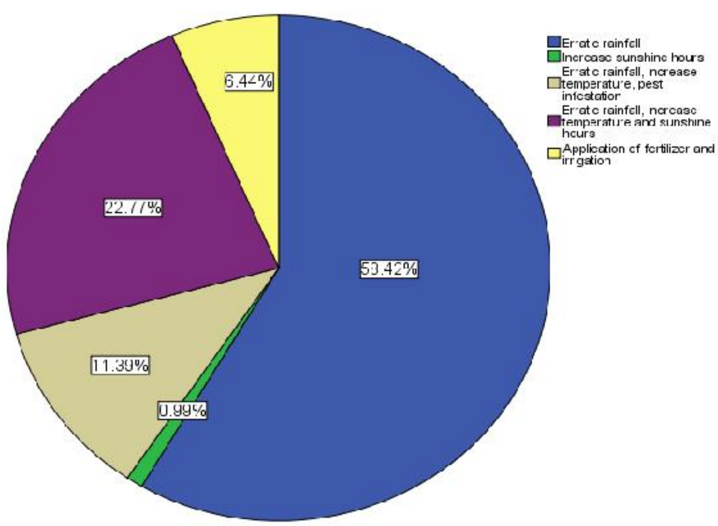

Figure 5.2: Household’s perceived reason for variation in maize yield (harvest)

Source: Fieldwork, 2016/2017

5.2.3: Actual versus anticipated cassava harvests

The result obtained from the analysis as computed (Figure 5.3) showed the averages for 2014 and 2015 both for the expected and actual cassava harvest per hectare of land for the three group of farmers thus: Farming only (expected harvest 21,763 kg and actual harvest 17,381 kg); farming combined with livestock (expected harvest 7,687 kg and actual harvest 6,020 kg) while farming combined with trading (expected harvest 14,000 kg and actual harvest 10,000 kg).

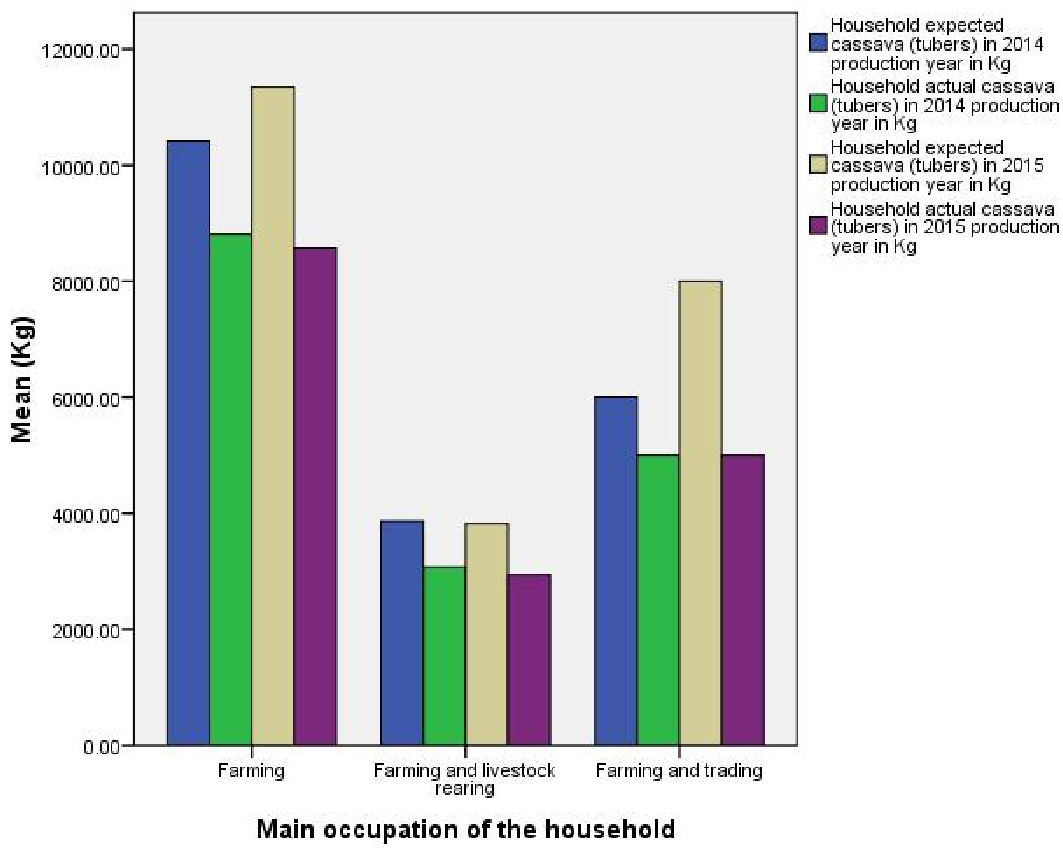

Figure 5.3: Household's actual versus anticipated cassava harvest (mean in kg)

Source: Fieldwork, 2016/2017

5.2.4: Reasons for variation in cassava harvest as perceived by households

On the reasons that led to the variations in the quantities of harvested cassava (Figure 5.4), majority of the farmers (43%) attributed it to erratic rainfall, 30% said it was a combination of erratic rainfall, increase in temperature and sunshine. Others 14% attributed the variation in yield to erratic rainfall and increase in temperature and pest infestation, while 2% stated it was due to crop pest infestation and 10% said it was due to application of fertilizer.

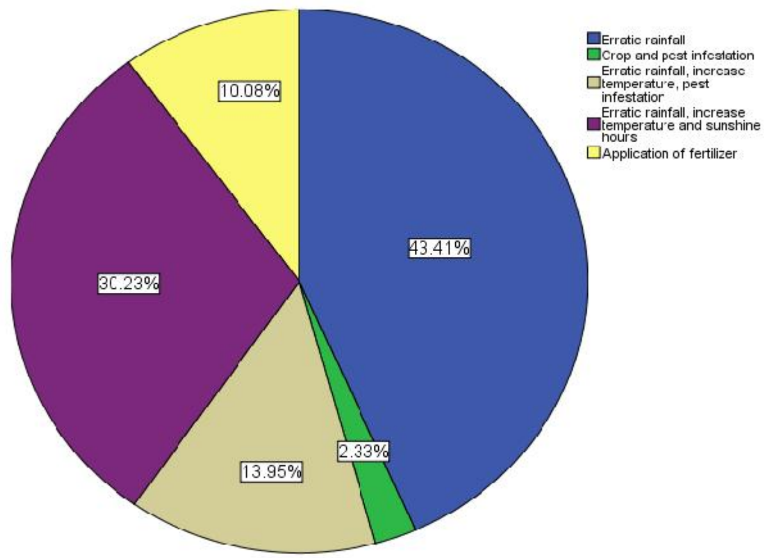

Figure 5.4: Household's perceived reasons for variation in cassava harvest

Source: Fieldwork, 2016/2017

5.2.5: Actual versus expected vegetable yields from the households

The result obtained from the analysis as computed (Figure 5.5) showed average for 2014 and 2015 both for the expected and actual harvest of vegetable per hectare of land for the two groups of farmers thus: Farming only (expected harvest 8,174 kg and actual harvest 6,361 kg); farming combined with livestock (expected harvest 2,550 kg and actual harvest 1,750 kg).

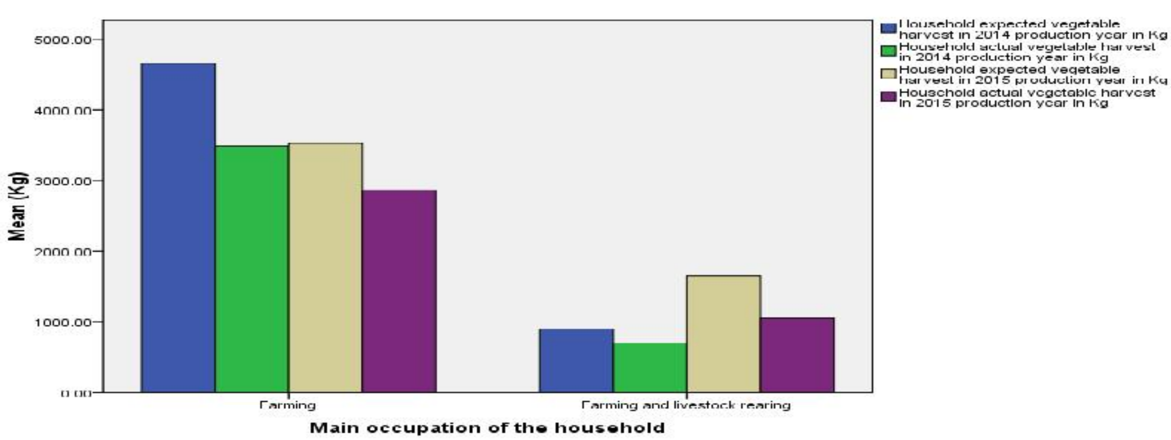

Figure 5.5: Household’s actual versus anticipated vegetable harvest (mean in kg)

Sources: Fieldwork, 2016/2017

5.2.6: Reasons for variation in the vegetable harvest as perceived by households

More than half (53%) of the farmers believed the reason for the variation in the quantities of harvested vegetable in 2014 and 2015 (Figure 5.6) was as a result of erratic rainfall while the remaining 47% attributed it to a combination of factors such as erratic rainfall with increase in temperature and sunshine.

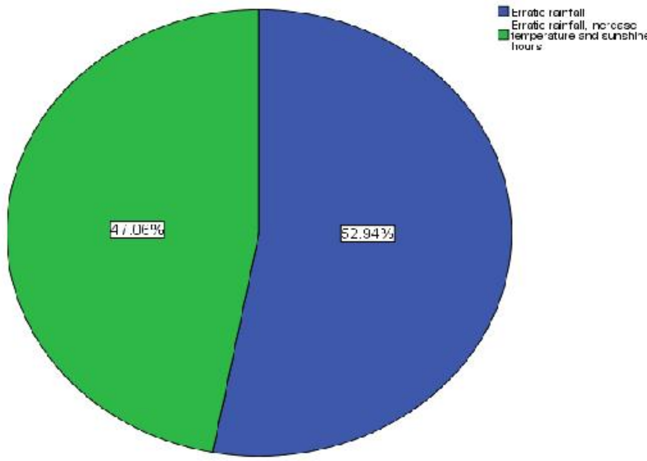

Figure 5.6: Household's perceived reason for variation in vegetable harvest

Sources: Fieldwork, 2016/2017

5.2.7: Actual and expected livestock production in 2015/2016

The result obtained from the analysis as computed (Figure 5.7) showed the average for 2014 and 2015 both for the expected and actual livestock (goat/sheep) production for the two groups of farmers thus: Farming only (expected number of livestock 3 and actual number of livestock produced 2); farming combined with livestock (expected number of livestock produced 10 and actual number of livestock produced 9).

"*Look at all I could harvest this year (pointing at the few bags of maize in his store), it is half of what I used to harvest in the past. The harvests are decreasing by the years and I believe lack of good rain and the high heat is the cause of this problem. The high heat is also causing different sickness for us*" Mr. Adeniyi Adewumi, A smallholder farmer in Awaye, Egbeda

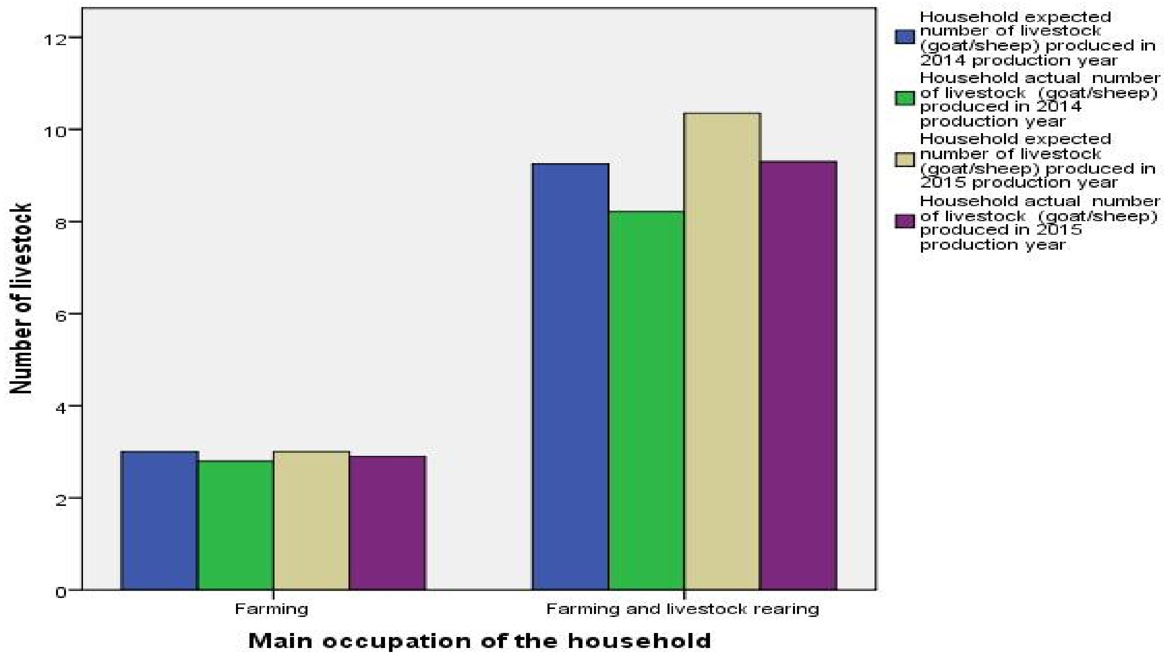

Figure 5.7: Household's actual versus anticipated livestock production in 2014/2015

Sources: Fieldwork, 2016/2017

5.2.8: Average household agricultural production change due to climate parameters

Average household agricultural production change due to erratic rainfall, increase in temperature and pest infestation in 2014 and 2015 production years was at 73%. Figure 5.8 depicts the spread as indicated by different farmers.

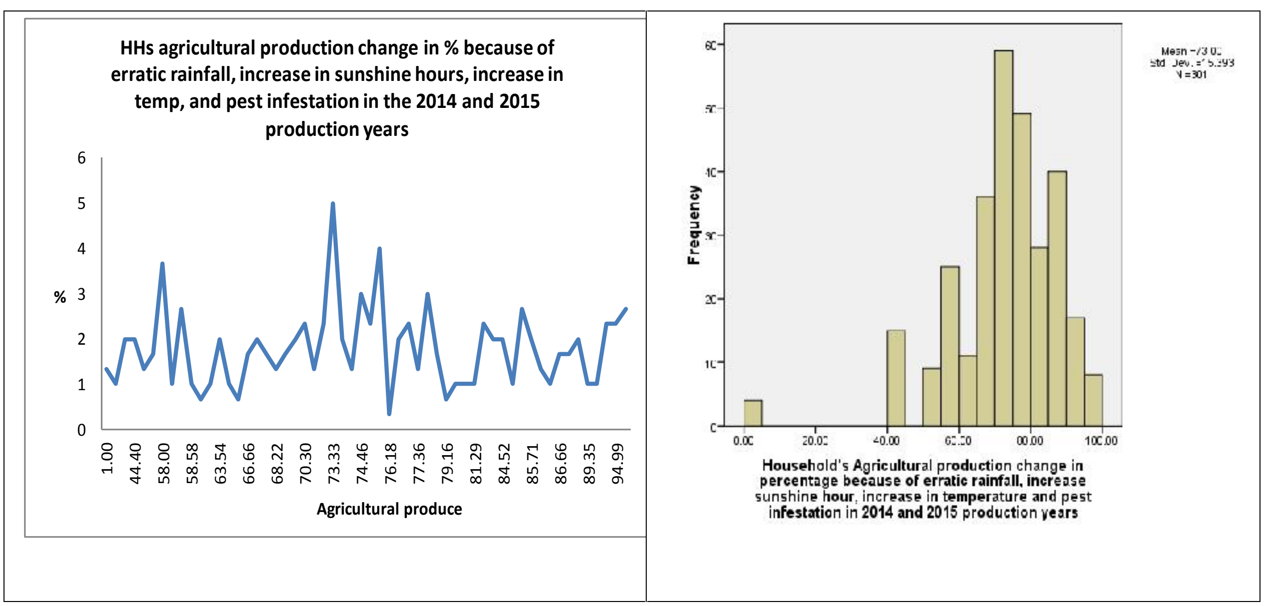

Figure 5.8: Average household agricultural production change
Source: Fieldwork, 2016/2017

5.2.9: Impact of climate variability/climate change on health

More than half (64%) of the household heads indicated that climate change affected their health while 35% of them indicated climate change had no impacts on their health as shown in Figure 5.9.

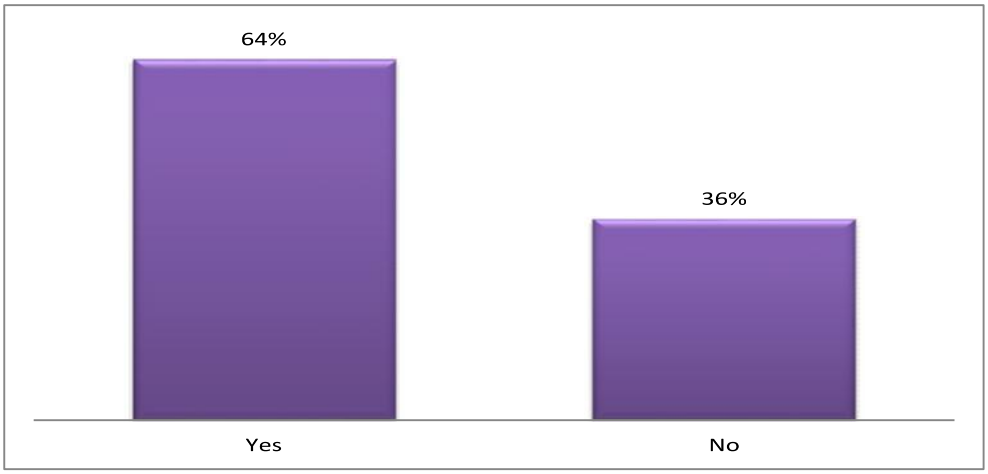

Figure 5.9: Changes in climate pattern affects household's health or not
Source: Fieldwork, 2016/2017

Majority (73%) of the household heads (Figure 5.10) indicated that the change in climatic pattern in the past years had caused different types of disease especially malaria and other types of diseases they suffered from while 27% specifically attributed the heat rashes experienced in the communities to the impacts of changing climate.

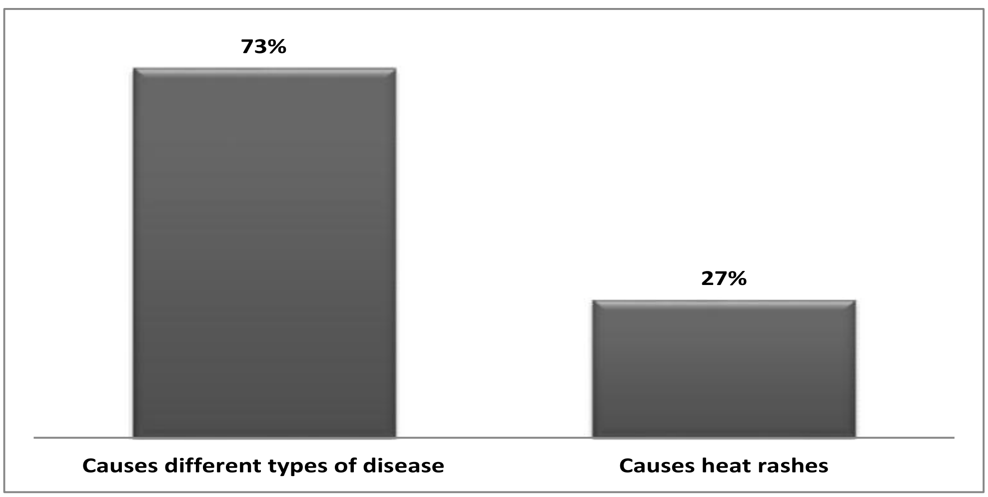

Figure 5.10: How changes in climate pattern affects household's health
Source: Fieldwork, 2016/2017

5.2.10: Impact of climate variability/climate change on income

When asked whether climate change had affected the household income negatively Figure 5.11, a significant number (82%) of household heads agreed that climate change had affected their level of income while 18% disagreed.

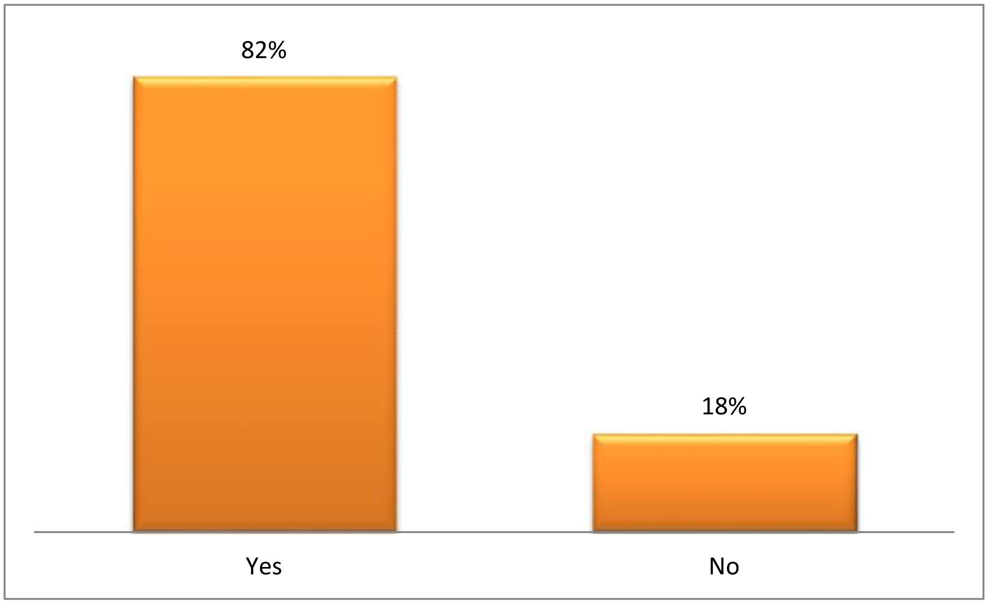

Figure 5.11: Changes in climate pattern affects household's income or not

Source: Fieldwork, 2016/2017

Plate 5.2: Left-Right: A community member narrated his ordeal on the effects of climate change on his health showing one of the impacts on his right leg and this happens whenever there was increase in temperature.
Source: Fieldwork, 2016/2017

5.2.11: How climate change pattern affects household income

From the result in Table 5.12, a further analysis on how the income of the household heads are negatively impacted by climate change showed and manifested through (Table 5.12) the following outcomes: poor harvest created lower income (74%), increase in the rate of expenditure (19%), increase debt rate (4%), high rate of school drop outs (1%), lower income earning, increase expenditure and increase debt (2%).

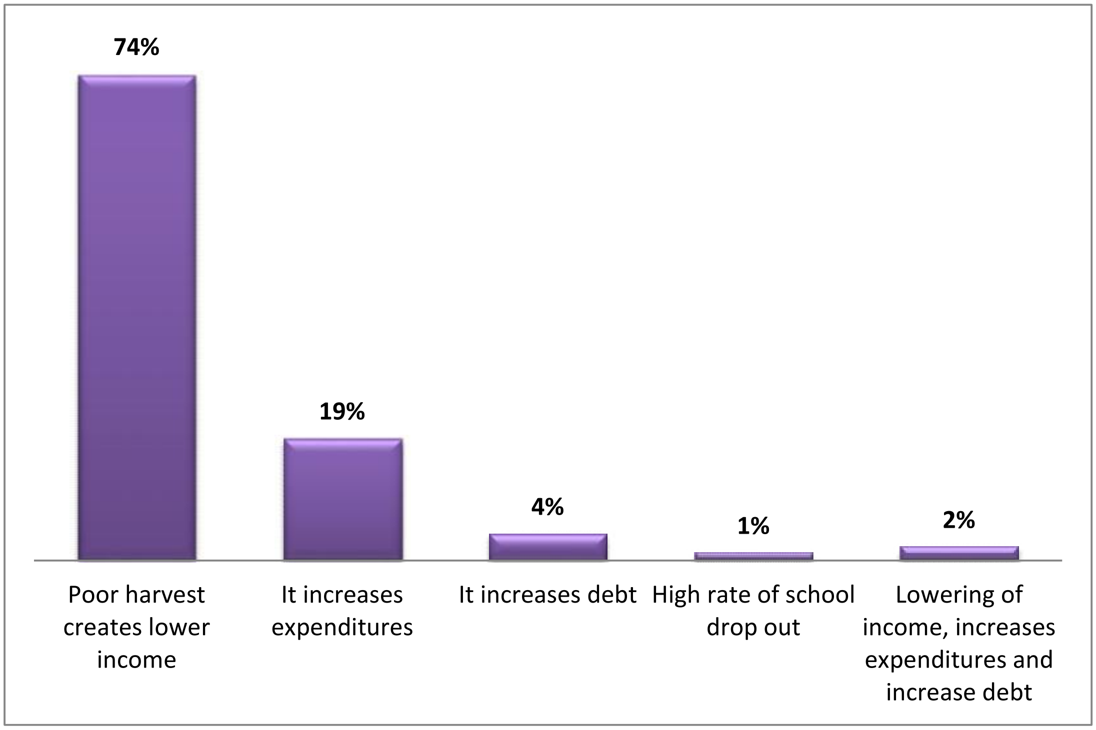

Figure 5.12: How changes in climate pattern affect household's income

Source: Fieldwork, 2016/2017

5.3 Discussion

5.3.1 Yields: Maize

The difference on the average in the actual maize yield versus the expected yield (Figure 5.1) in 2014 and 2015 indicate that the actual harvested maize fell by 69% short of the total expected harvest during the period. It also showed that the difference for those who combined farming and livestock rearing in which their actual harvest was slightly above their expected harvest (by 100 Kg) using a combination of other strategies such as addition of organic manure from the animal dung or able to access other agricultural inputs (Table 6.1

and Figure 6.1) from the sales of their livestock for their farming activities as well as serving as alternative livelihood option.

With the exception of farmers that combined both farming and livestock rearing whose actual harvested maize crop was slightly above the expected harvest during the period in review, the other two categories (only farming and those combining farming with trading) experienced a decline in their maize harvest as the actual harvested was lower than what they expected to harvest during the same period. The reason for the variation in the harvest maize ranged from incidences of erratic rainfall pattern, increase in temperature and sunshine, pest infestation, to application of inorganic fertilizer and practice of irrigation. It was confirmed that farmers who used irrigation realized more maize yields compared with those who entirely depend on rain-fed agriculture within the same period. The finding from this study in part agreed with that of Abiodun *et al.* (2011) that found maize production will be adversely impacted by the changing climatic patterns in Nigeria where other factors remained constant. Without a change in adaptation strategy, the impacts of climate change would probably lead to reduce yields.

5.3.2 Cassava

The difference in the actual cassava harvested versus the expected yield (Figure 5.3) in 2014 and 2015 mean that the percentage of the actual harvested cassava fell by 76% short of the total expected harvest during the period. There was consistency in the actual harvested cassava which fell short of expected harvested in 2014 and 2015 for all the three categories of the farmers surveyed.

5.3.3 Vegetables

A good number of smallholder farmers in the study area engaged in vegetable farming. In the year 2014 and 2015, on the average, the expected harvest from vegetable fell far short from the actual harvest as shown in Figure 5.5. In both years and for the two groups of farmers, the actual vegetable harvested by the farmers compared to what they expected to harvest on average fell by 74% of the expected yield. This compares with the findings from Abiodun, et al (2011).

5.3.4 Livestock

Similar to the experience of crop farmers regarding expected harvest and the actual harvest which showed a great decline (Figure 5.1; Figure 5.3 and Figure 5.5), livestock farmers also experienced a decline in livestock production as the actual livestock production for the two years fell below the expected production by 93% as shown in Figure 5.7.

5.3.5 General agricultural productivity

The study showed an average of 73 percent in household agricultural production change (Figure 5.8) due to erratic rainfall, changes in sunshine, increase in temperature and pest infestation in 2014 and 2015 production years.

5.3.6 Health status

Majority (64%) of the smallholder farmers who are also heads of households indicated that the changes in the climatic pattern over the years had negatively impacted their health status. Over 70% of these household heads indicated that these impacts of the changing climate on their health status had caused different types of diseases for them with 27% of them specific on heat rashes (Plate 5.2 and Figure 5.10). This finding corroborate the reports and study (WHO, 2009; Okoye, 2014, IPCC, 2014) that cited risk of ill-health and also showed that incidences of diseases had increased with the new challenge of cases of infectious diseases in many parts of the developing world due to changes in climate, seasonal changes and decreasing level of food production. The report (WHO, 2009) further indicated that the number of population of Africans that will be as risk of disease like malaria by 2030 will rise to 170 million and globally that of dengue will rise to 2 billion by 2080.

5.3.7 Income level

The impacts of climate change had negatively affected the income levels of the smallholder farmers as indicated by over 80% of the household heads that participated in this study (Figure 5.11). This finding corroborates the result from IPCC (2014) that listed reduced level of income and loss of livelihood as some of the risks that comes with climate change.

According to the respondents, the negative impacts of the changing climate on the level of income was manifested or experienced through drivers such as poor harvest that had created lower income for them, increase in expenditure rate, increase in family debt profile, school drop-out due to inability to pay for school fees and a combination of all these factors on their income as shown in several figures and tables, and findings from other studies reviewed in this chapter. For example, a positive income level has a positive impact on the effectiveness of any adaptation action (Atela *et al.,* 2016).

5.4 Conclusion

All the categories of farmers (those whose main occupation is farming, those combining farming with livestock rearing and those combining farming with trading) in the period under review on the average experienced a decrease in their actual harvest in maize, cassava, vegetable and livestock produce compared to what they were expected to harvest and produce in the same period. The reason, according to the farmers, was as a result of erratic rainfall pattern, increase in temperature and relative humidity, pest infestation and changes in sunshine hours, all attributable to climate change impacts. The impacts of climate change are likely to increase in the near future if effective measures are not urgently taken to address it. As found in the previous chapter, the temperature, relative humidity, wind speed has continued to increase and the rainfall pattern has been erratic in the past 31 years and the projection showed that this trend is likely to continue if urgent measures are not taken. The implication of these changes therefore is that smallholder farmers will bear the brunt of these impacts through decreased crop yield, crop failure, increased poverty level and general downward trend in agricultural productivity including the negative impacts of the changing climate on health and income l of these farmers.

Increase in temperature, erratic rainfall patterns, pest infestation which are linked to climate change and variability are the major challenges responsible for the decline in agriculture produce and other related problems such as income level in the study area. The long term impacts are more of perception than experiences as not only the farmers will suffer from the negative consequences of climate change and variability but also the government through decrease in the Gross Domestic Product for the country. It has been observed that the study area has not had so many conflicts compared to the north-eastern part of Nigeria. However, population has increased marginally in Southwest Nigeria. Additionally, the major driver of change in the region has been climate which has led to high demand for natural resources like water, arable land and forest resources which are becoming scarce by the day.

CHAPTER SIX

ADAPTATION STRATEGIES TO CLIMATE VARIABILITY AND CHANGE PRACTICED BY SMALLHOLDER FARMERS IN SOUTHWEST NIGERIA

6.1 Introduction

In many parts of the world, different communities practice different adaptation strategies to the changing climate in order to survive. Adaptation to climate change is not a second option to those adversely impacted by climate change especially in developing countries. Several studies have shown how different people adapt to different impacts of climate change over time, scope and space. Smallholder farmers through the deployment of their Indigenous Knowledge (IK) over time have not substantially and adequately learned some of the tricks of survival in the face of this wicked problem of climate change. Some of these strategies seem to be failing and are no longer sustainable because of the unprecedented and rapid changes and variability in the climatic pattern thereby leading to mal-adaptation and increasing the level of vulnerability of the smallholder farmers to the adverse impacts of climate change.

In Nigeria, in the non-oil sector, agriculture contributes a significant proportion to the real GDP of the country. Despite the contribution of this sector to the nation's GDP, the sector continued to be adversely impacted by climate variability and climate change resulting in reduce crop yield and farmers uncertain on the best adaptation strategies to adopt in the changing climate. Effective adaptation strategies will not only lead to food security and safeguarding livelihood for millions of people including farmers but also contribute significantly to the growth in the national GDP and poverty reduction efforts of the government at local and national levels. This chapter analyses the findings on the adaptation strategies and options adopted by smallholder farmers in addressing climate variability and change in Southwest Nigeria.

6.2 Results

Majority (84%) of farmers plant different crop varieties as adaptation strategies to climate change while 16% of them do not undertake such practices (Table 6.1). As part of the adaptation strategies, 78% of the farmers adopted different planting dates to adapt to the changing climatic pattern while 22% of them did not. Majority of the farmers (67%) indicated they did not change from farming to other off-farm activities as an adaptation strategy but 33% of them did diversify to other off-farm activities. Household heads that changed from crop farming to livestock rearing as adaptation strategy stood at 46% while more than half (54%) of them did not adopt such practice. Household heads that changed from livestock rearing to crop farming as an adaptation strategy stood at 42% while more than half (58%) of them did not.

Majority of the household heads (73%) practiced irrigation farming and 27% did not. As part of their adaptation strategy, 58% of household heads adopted the practice of soil conservation techniques while 42% did not practice soil conservation techniques as part of their adaptation strategies. The practice of terracing as an adaptation strategy was undertaken by 52% of household heads while 48% did not. The practice of making mulch as an adaptation strategy was adopted by majority (66%) of the household heads while 34% of them did not adopt practice.

A total of 53% of the households increased the hectares of their farmlands as part of their adaptation strategies while 47% of them did not. Majority (74%) of household heads adopted the use of short gestation or early maturing crop varieties as an adaptation strategy and 26% of them did not. For a region that is prone to floods, 54% of household heads used flood resistant crop varieties as an adaptation strategy while 46% of them did not. Only 34% of the household heads used drought resistant crop varieties as an adaptation option while majority (66%) did not.

The use of disease and pest resistant crop varieties was practiced by the majority (75%) of the farmers while 25% of them did not adopt such practice. Almost all the household heads (96%) used inorganic fertilizer in their farming practices as adaptation strategies to climate change while a meagre percentage (4%) did not. The result from the households that did not used organic fertilizer as an adaptation strategy stood at 93% which constituted the majority of the farmers while only 7% adopt the use organic fertilizer.

Table 6.1: Adaptation strategies practiced by households

S/N	Adaptation strategies practiced	Percentage (%)		
		Yes	No	Total
1	Planting different improved crop varieties	84	16	100
2	Adoption of planting on different dates	78	22	100
3	Diversified from farm to off-farm activities	33	67	100
4	Changed from crop to livestock rearing	46	54	100
5	Changed from livestock rearing to crop	42	58	100
6	Practiced irrigation farming	73	27	100
7	Practiced other soil conservation techniques	58	42	100
8	Practiced terracing	52	48	100
9	Practiced mulching	66	34	100
10	Increased hectare of farmland	53	47	100
11	Plant early maturing crops	74	26	100
12	Plant flood tolerant crop varieties	46	54	100
13	Plant drought tolerant crop varieties	34	66	100
14	Plant pest resistant crop varieties	75	25	100
15	Use of inorganic fertilizer	96	4	100
16	Use of organic fertilizer	7	93	100

Source: Fieldwork, 2016/2017

From the analysis obtained in Table 6.2, a total of 50% of households planted different crop varieties with high level of practice followed by 42% medium level and 8% with low level of the practice. On the level of practice of land fragmentation by households, the following result was obtained 9% high, 51% medium and 40% low; level of practice of tillage practices as adaptation measures to climate change: 32% high, 46% medium and 22% low.

The level of practice of multiple planting dates showed 37% high, 49% medium and 14% low. Irrigation farming as an adaptation measure to climate change stood at 48% high, 32% medium and 20% low; crop diversification as an adaptation measure to climate change: 19% high, 40% medium and 41% low. The level of practice of households that engaged in off farm activities as adaptation measures to climate change were 9% high, 24% medium and 67% low. The level of practice of those that adopted mulching as an adaptation measure to climate change was 20% high, 34% medium and 46% low.

Table 6.2: The rate of adoption of the adaptation practices by farmers

S/N	Adaptation practices	Percentage (%)			
		High	Medium	Low	Total
1	Plant different improved crop varieties	50	42	8	100
2	Land fragmentation	9	51	40	100
3	Minimal tillage practices	32	46	22	100
4	Adopted different planting dates	37	49	14	100
5	Practiced irrigation farming	48	32	20	100
6	Practiced crop diversification	19	40	41	100
7	Engaged in off-farm activities	9	24	67	100
8	Practiced mulching	20	34	46	100

Source: Field survey result, 2016/2017

The most effective climate change adaptation strategies practised by household

With regard to the effectiveness of the adaptation strategies practiced by the farmers (Figure 6.1), the combined use of farm inputs such as inorganic fertilizer, irrigation facilities, early maturing crops and pest tolerant varieties was top on the list at 32% followed by use of disease and pest resistant varieties at 30%. The following depicts the order of effectiveness in addition to the first two already mentioned: use of irrigation 19%, use of flood resistant varieties 5%, adopting different planting dates 4%, planting of early maturing varieties 3%, changing from livestock to crop farming 3%, planting different varieties of crops 2% and increasing hectare of farmland 2%.

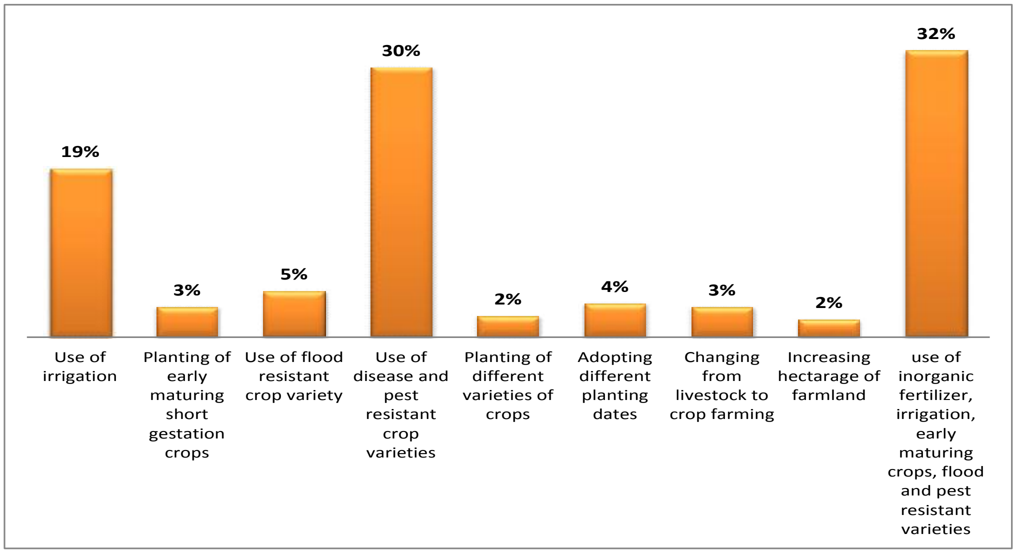

Figure 6.1: Effectiveness of households' adaptation practices ranked by smallholder farmers
Source: Fieldwork, 2016/2017

A total of 39 percent of household indicated that access to agricultural inputs like inorganic fertilizers was important for adaptation strategy, 32 percent said it was very important and 29 percent indicated not important. A combination of those that stated it was important and very important therefore stood at 71 percent compared to the 29 percent that said it was not important (Figure 6.2).

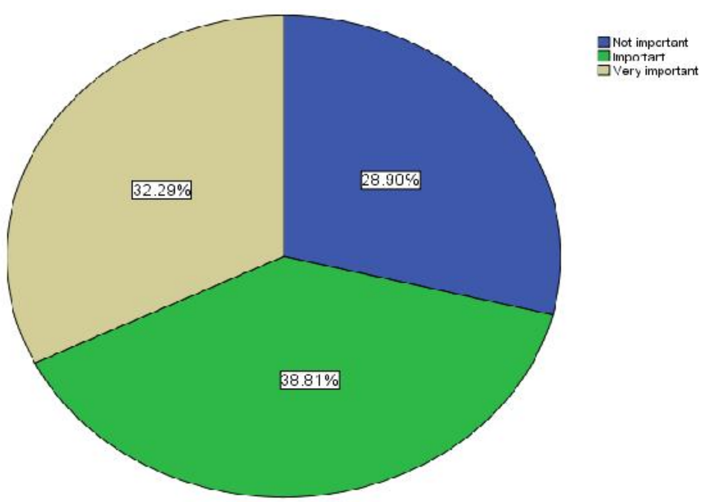

Figure 6.2: Level of importance of agriculture inputs to household adaptation strategy to climate impacts

Source: Fieldwork, 2016/2017

6.3 Discussion

The result from this study on the most effective adaptation strategies from the entire list of the strategies practiced by the farmers had many of the farmers ranking no single practice as the most effective but the combination of practices (32 percent of the farmer) such as the use of inorganic fertilizer, practice of irrigation farming, use of early maturing crop varieties and use of flood and pest tolerant varieties as the most effective of all the practices depending on the variety and type of crops farming practised (Figure 6.1 and Table 6.1).

The study showed that agricultural inputs (such as agro-chemicals and inorganic fertilizers etc) were very effective compared to other strategies practiced by the farmers. A further analysis into the importance of these agricultural inputs which was rated as the most effective compared to others showed an overwhelming 71 percent of the smallholder farmers affirming that it was very important and the remaining 29 percent indicated it as not all that important (Figure 6.2). The reason for this ranking of the agricultural inputs requires a further location specific research. It would also be important to investigate how the socio-economic profiles and purchasing power of the farmers affect access to and availability of such agricultural inputs in adaptation to climate change in the region.

The results from this study confirm some of the findings from other studies (Ozor, 2014; NEST and Woodley, 2011a, NEST and Tegler, 2011b; NEST, 2011c; NASPA CCN, 2011; Onyeneke *et al.*, 2010) which showed that the farmers in Nigeria are adopting and practicing different adaptation strategies. Some of these strategies recorded little success while some did not due to various reasons which the majority of respondents attributed to the unpredictable climatic conditions beyond the coping capacity of the farmers (Bello *et al.*, 2012; Ademola *et al.*, 2012; Olajide, 2014; Abiodun *et al.*, 2011; NASPA CCN, 2011).

6.4 Conclusion

This chapter looked into what the farmers were doing to adapt to the impacts of the changing climate pattern. From the preceding chapters, the finding from this study has established that both the smallholder farmers and scientific community agreed that climate has changed in the past few decades and the impacts of these changes on smallholder farmers in developing countries and especially in the study area have negative consequences for crop and livestock production, health status and level of income. The adaptation strategies practiced by the farmers as found from the study include the following: a). Planting different varieties; b) adopting different planting dates; c) diversification from farm to off- farm activities; d) changing from crop farming to livestock rearing; e) changing from livestock to crop farming; f) practice of irrigation farming; g) practice of conservation agriculture; h) terracing; i) mounding and ridges; j) increase the hectare of cultivated land; k) planting of early maturing crop varieties; l) use of flood tolerant crop varieties; m) use of drought tolerant crop varieties; n) use of pest/disease resistant varieties and o) application of organic and inorganic fertilizer.

The level of intensity of practice of the above adaptation strategies among the smallholder farmers varied as some of the farmers either rated their level of intensity of practice as either high, medium or low. The ranking of the level of intensity of practice of these adaptation measures also depends on several factors as can be deduced from the findings of this study in the general profile information section of the farmers. These included but were not limited to access to resources (climate information, land, finance/capital etc), educational level of the farmers, age, sex, health status among other factors. This also calls for further research to establish the exact actual and casual factors responsible for these different levels of intensity of practice by the farmers.

There is no doubt therefore that smallholder farmers have over the years adopted different adaptation strategies as found in this study and other findings of previous and current studies. The focused group discussion with the farmers showed that these adaptation strategies were sustainable in the long run and were appropriate to help them to better adapt to the impacts of climate variability and change, although some of the associated cost of such adaptation strategies are way beyond the reach of the smallholder farmers given their level of economic status, adaptive capacity, vulnerability and exposure to the ever increasing climate shocks and hazards.

CHAPTER SEVEN
SYNTHESIS AND DISCUSSION

The results from the study with regard to the variability and change in the climatic pattern vis-à-vis the smallholders' characteristics, the impacts of the changing climate and the strategies for adaptation that the farmers adopted showed the importance of designing localized effective adaptation response strategies based on the improved knowledge on the climate issue for smallholder farmers in Southwest Nigeria with the use of a transdisciplinary (TD) approach is what this study presented in the various chapters of this work. The transdisciplinary approach used in this study created the platform where the science and research on the issues of climate variability interfaced with the societal problem of climate change experienced by smallholder farmers in Southwest Nigeria. This helped to jointly co-create and co-produce the adaptation response strategies outlined in this study which has contributed to the generation of new insights to the body of knowledge on the issue of climate variability and change, provided new approaches to addressing the problem and as well system change (Figure 3.5).

The TD approach used in this research confirmed Chevalier *et al*. (2008) of the effectiveness of the use of social analysis system for participatory research and for collaborative inquiry, action and learning and social engagements with different stakeholders to find solution to a complex problem through Knowledge Sharing (KS). It also agreed with the "Knowledge Democracy" approach of the Community-Based Participatory Action Research (CBPAR) advocated by Openjuru *et al*. (2015) which defined CBPAR as a collaborative effort between academic researcher and non-academy based community members using multiple knowledge sources and research methods to generate social actions and create positive societal change. Below are the highlights of some of the major findings from this research study.

The findings from the various sections in this study with regard to smallholder farmers' profile and characteristic showed that though all the smallholder farmers indicated that they received climate information through different channels, 78% of them had difficulty in understanding the information received to help them in their farming practices in the face of changing climatic pattern. This finding confirm other study reports (UNECA, 2011; NEST, 2011c; FAO, 2013; Madukwe *et al.,* 2014; UNFCCC, 2015) which showed the gap in climate information services and call for education, training and awareness creation on climate change at local and global levels. Some of these reports further showed that in Africa, there was still a gap in the knowledge sharing on climate change and how farmers understood such climate information to help their farming activities and emphasized the critical role with regard to farmers' education.

With regard to the scientific data and the perception of smallholder farmers on the trends in changes in the climatic pattern using five variables of rainfall, temperature, relative humidity, wind speed and sunshine, the study found on an average, an increased trend with high level of variability for most of the variables examined. The findings showed that the rainfall pattern has become unpredictable; average maximum temperature (T_{Max}) and minimum temperature (T_{Min}) increased by 0.04 degree Celsius and 0.03 degree Celsius per annum respectively; relative humidity increased by 0.01% per annum and wind speed also increased by 2.14 mph per annum while a decrease of -0.035W/m^2 per annum was recorded for sunshine. The perceptions of the smallholder farmers on the average on all these variables corroborate the results analysed from the available meteorological data obtained as well as other studies (Progress *et al.,* 2011; NASPA-CCN, 2011; ATPS, 2011; Abiodun *et al,* 2011; Garforth, 2014; Ogallah *et al.*, 2017b). This finding confirmed farmers' perceptions on the causes of the changes, and who was responsible and what kind of action taken to address these problems varied greatly among the farmers.

Given the above results, it is possible to project the following scenario in the business as usual situation in the region that by 2030, the rainfall amount could increase by 63mm with shorter duration, but higher intensity. The maximum temperature (T_{Max}) and minimum temperature (T_{Min}) could increase by 0.9 degree Celsius and 0.7 degree Celsius, respectively. Both T_{Max} and T_{Min} on the average would likely increase by 1 degree Celsius by 2030, which corroborate other findings (Stern 2007; UNEP 2011; Abiodun *et al*. 2011; Anuforom 2013; IPCC 2014); relative humidity could hit 0.3%; wind speed could increase by 64 mph and solar irradiation reduced by -1.07 W/m^2.

Having established the various findings in the preceding chapters 1 to 4, the variability and climate change trends using the TD methods and perception of the smallholder farmers on these changes with a conclusion that the climate had changed during the period under review, chapter five of this study build on what the impacts of the changing climate had on the smallholder farmers, their agricultural practices, health status and income level. The finding showed that the changes in the climatic pattern experienced through increase in temperature, erratic rainfall pattern, increase in the wind speed and relative humidity with decrease in sunshine had impacted negatively on the smallholder farmers. These impacts that resulted from the changes had led to decreased agricultural produce of up to 73 percent on the average; increased the incidences of different types of diseases experienced by many households that reported they suffered from heat rashes. The impact had also led to decreased level of household income as reported by over 80% of households from the findings of the study. The result of this study agreed with other studies (WHO, 2009; Okoye, 2014, IPCC, 2014; NEST and Tegler, 2011b; NEST, 2011d; Stern, 2007; UNEP, 2014; Ifejika, 2010; Chidumayo *et al.,* 2011) that found the different impacts on different sectors resulting from climate change including agriculture, health, income and at different levels of the society from global to local level.

While the changes in the climatic pattern had led to different impacts on smallholder farmers as found in chapter four and five of this study, the sixth chapter evaluated the various adaptation strategies that farmers used to adapt to the impacts of climate variability and climate change. The result found that smallholder farmers had practiced various adaptation strategies such as planting of different crop varieties, land fragmentation, tillage practice, multiple planting dates, irrigation practice, crop diversification, off-farm activities, mulching, cover cropping, use of inorganic fertilizer, and change in farmland. The amount of the practices of these adaptation strategies also vary greatly among the farmers as high, medium or low. The effectiveness of these practices from the study showed the combination in the use of agricultural inputs such as inorganic fertilizer, improved crop varieties, irrigation facilities, and use of flood and pest resistance crops was the most effective compared to adopting a single strategy such as off-farm activities, changing from crop to livestock and changing of planting dates practiced by the farmers. The findings of this study corroborate other studies

(Ifejika, 2010; NASPA-CCN, 2011; NEST and Woodley, 2011a; NEST, 2011d; Ozor et al., 2014; Atela *et al.*, 2016; FAO, 2017) on the adaptation options and strategies that farmers had adopted in their effort to adapt to the impacts of climate change.

CHAPTER EIGHT

GENERAL CONCLUSIONS AND RECOMMENDATIONS

8.1 General Conclusion

This study confirmed that the temperature, relative humidity and wind speed has continued to increase and the rainfall pattern erratic while the sunshine has reduced in the past 31 years (1985-2015) with different degrees of variabilities and intensities during the period under review and the projections showed that this trend would likely continue if urgent actions are not taken now. The study further showed that the farmers' perceptions of increased trend in temperature, unpredictable rainfall pattern, increased wind speed, increased relative humidity and changes in sunshine were also in line with science and the analysed results from meteorological and other secondary data that was obtained. Smallholder farmers from the study were found to have different perception levels on the causes of these changes in climate pattern during the period under review.

The implication of this therefore is that smallholder farmers will suffer from these impacts which has already resulted in decreased crop yield, crop failure, increase poverty level and general downward trend in agricultural productivity. Increased temperature, erratic rainfall, increased relative humidity and wind speed and reduced sunshine which are linked to climate variability and change are responsible for the decline in agriculture produce in the study areas.

Conclusively, this study proposes the adoption of "*Integrated Community-Based Planned Adaptation Strategy (ICPAS)*" (Appendix IV) as an effective adaptation response to the impacts of climate variability and change as found in this study.

8.2 Recommendations

Government and policy makers

Mirroring strategies such as National Adaptation Plan (NAP) at local level through the establishment of Local Adaptation Plan of Action (LAPA) as well as initiative such as establishment of Community Adaptation Fund (CAF) could stimulate local level actions on climate change by different stakeholders at national and local levels.

Subsidizing agro-inputs for farmers and removal of tariff on new modern farming technologies including renewable energy technologies in the agriculture sector by government could help farmers to better adapt to the impacts of climate change. The government should reduce the current interest rate on agricultural loan to a single digit to encourage more smallholder farmers to access such loans.

The Federal and state governments in Nigeria can pursue effort towards establishing a National and/or State Agricultural Insurance Programme to take care of the insurance need of farmers across Nigeria and at the local levels as part of their climate change and agriculture programme. The role of agriculture extension workers in the whole equation of climate change adaptation can never be over-emphasized but this group have been inactive in the last decade. Government at Federal and State level in Nigeria should revisit this matter and make this group functional again through conscious support and funding provision with concrete oversight monitoring and supervision plan to ensure their effectiveness.

Since most meteorological and extension agencies are institutions of the government, provision of early warning system on climate related hazards and events as well as relevant weather information should be prioritized by the government using these established institutions. Public Private Partnership (PPP) with mobile telecommunication service providers to get the information and weather application tools to smallholder farmers should also be vigorously be pursued so that farmers are well informed and able to take necessary actions and precautions in their farming activities. Implementation of Comprehensive Africa Agricultural Development Programme (CAADP) could be another vehicle through which the government could promote its climate change strategies.

Research institutions and other scientists

There is still need for further research to be able to concretely establish more location specific impacts, varying perceptions, and economic cost of climate change to agriculture and also on the smallholder farmers for effective adaptation strategy tailored toward meeting the need of this target group.

The media

This sector, whether mainstream or social media sometimes is overlooked despite the crucial role it plays in knowledge brokerage and management. This study showed that most of the farmers get their climate information through the media outlets. Given the important role of the media, media houses and journalists can help in getting climate change information to the farmers and also from farmers on the ground to the scientists serving as go-between farmers and the scientists, research institutions and meteorological agencies. Media houses can dedicate a segment of their weekly programme to climate change issues. This would contribute to effective adaptation to climate change not only at the local level but also at the national level. The information should also be communicated in such a language, form and channel that are easily accessible and understandable to smallholder farmers.

Non-Governmental Organizations:

Over the years, NGOs has continued to play a very important role not only in raising awareness about climate change but have become an active player in designing and implementation of adaptation initiatives with local communities and smallholder farmers aimed at building their adaptive capacity to the impacts of climate change. This role needs to be further strengthened through crowd resource sourcing by NGOs for implementation of local adaptation actions with local communities and smallholder farmers in the face of increasing impacts of climate change. Religious institutions and the clergies also play an important role in adaptation to climate change, hence the need for such institutions to use their platforms to promote discourses around climate change and how to adapt to its impacts.

Smallholder farmers

Behaviour and attitude are great assets and resources in adapting to the adverse impacts of climate change. There is a need to embrace new technologies and practices that work better than existing ones in the face of changing climate. Agri-business, sustainable intensification, agro-ecology practices and adoption of climate resilient agriculture with Good Agricultural Practice (GAP) would help in resilience building towards the impacts of climate variability and change. Smallholder farmers should embrace some of these GAPs in order to adapt to the changing climate and its adverse impacts.

All aforementioned initiatives as recommended will be helpful in building the resilience of farmers to the impacts of climate change also securing livelihood and food security and sovereignty based on some well-informed appropriate adaptation strategies at local, national and regional level.

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APPENDICES

APPENDIX I: FIELD SURVEY INSTRUMENT

My name is Samson, Samuel Ogallah. I am a PhD candidate in the Institute for Climate Change and Adaptation, University of Nairobi (UoN). Currently I am conducting a PhD research field work entitled *"Impacts of Climate Variability and Change and Adaptation Strategies on Smallholder Farmers in Southwest Nigeria"*
The study has the permission of the University of Nairobi. Your kind response to the questions in this questionnaire will be greatly appreciated.

I. General information

State…………………….
Village/community: ……………………………
Local Government Area……………….
Code ------------------
Name of Enumerator: ……………………..........
Date of Interview: ………………………...........

SECTION B: SOCIO-ECONOMIC AND GEOGRAPHICAL CHARACTERISTICS

1. Name of household head (optional)/Code....................................
2. What is your age (specify in year)?..................
3. What is your sex? (a). Male …………… (b). Female………………
4. What is your marital status?
   a. Single ( ) b. Married ( ) c. Widowed ( ) d. Separated ( ) e. Divorced ( )
7. What are the environmental problems that affect your life most?
   ……………………………………………………………………………………
   ……………………………………………………………………………………
8. State the types of crop produced and income obtained. Use table 1 below

Table 1. Crop production and income from the sector

Types of crops	Production year 2015	The price and production years of the 2015			
	Total area cultivated in /hectare	Total production in (kg) /bags/trucks	Value in Naira	Total consumed (kg)/bags	Amount Sold (N)
Maize					
Cowpea/Beans					
Cucumber					
Garden egg					
Cassava					
Vegetable					
Yam					
Others (specify)					

9. State the types of livestock produced and income obtained. Do you own livestock? If yes, indicate the number of livestock you have and the income earned last year. Use table 2 below

Table 2. Livestock size and income from the sector

Type of livestock	Number owned (At the time of interview)	Number sold in 2015	Total income obtained (Naira)
Cow			
Goat			
Sheep			
Donkey			
Chicken			
Others (specify)			

10. What is your educational level? (Indicate highest class completed) ……………
11. Indicate the type of building occupied by your household

a. Mud wall with thatch roof ( ) b. Mud wall with zinc roof ( ) c. Brick wall with zinc ( )

12. Please provide information on household structure in the table 3 below:

Table 3. Characteristics of Household Members

No. of household member (optional)	Sex	Relationship with household head (child, nephew, etc.)	Age	Highest educational level	Employed? Yes/No	Is the employment permanent? Yes/No

13. **Leadership profile and empowerment**

Kindly provide information on your participation in decision making in your community in Table 4 below.

Table 4. Leadership & Empowerment Characteristics

Social Group	Member of group?		Ever held position?		Position held	Ever participate in taking decision in the group?	
	YES	NO	YES	NO		YES	NO
Community as a whole							
Community Committee							
Cooperative							
Others (specify)							

14. What is the main occupation you depend on for a living?

(a.) Farming ( ) (b). Fishing ( ) (c). Others (specify)………………………….

15. State how you acquired the plots, their sizes and the crops grown in table 5 below:

Table 5. Farm plots and crops grown

Name or locations of Plots	Mode of Acquisition	Size (hectare)	Type of Crops grown

Objective 1: To assess climate variability and change trends and smallholder farmers' perception.

Climate information sources

16. Have you ever received any climate information (e.g. on rainfall, temperature, etc.)?

(a). Yes (b). No

17. If "yes", where do you get information from?

(i.) --

(ii)--

(iii)--

Availability of climate information

18. Do you know of any person/institution that gives information on weather?

(a). Yes (b). No

19. If "yes" to question 17, name these persons or institutions (include formal and informal institutions e.g. rain maker). If "No" to question 17, go to question 23.

(i)...(ii)..

(iii)... (iv)..

20. What is the distance (in kilometers) to the nearest source of information Centre from you?..

21. How many minutes does it take you to get to the person/center?......................

22. What type of climate information do you receive and its availability (e.g. information on rainfall ( ), sunshine ( ), windstorm ( ), wind ( ), cloud ( ), temperature ( ), sea level ( ), etc.)? (Tick and also indicate in table 6 below).

Table 6. Climate information Sources, type of information, Frequency of supply & Availability

Source of Information	Type of information	Frequency /how often (daily, weekly, monthly, yearly)	Availability (RA=Readily available); (OA=Often Avail.); (NA=Not available)
Radio only			
TV only			
Internet			
Radio & TV			
Extension workers			
Radio & meetings			
Meetings			
NiMET			
Rainmaker			
Others (please specify)			

Accessibility to the source of climate information

23. How accessible are the climate information sources to you? How far is the source and how easy to understand are the information supplied? (Indicate in Table 7)

Table 7. Understanding of Information provided

Types of information	Its sources	What language is the information provided? (English language, mother tongue, etc.)	Did you face difficult to understands? 0=No; 1=Yes	Sources of difficulty for understanding **0**. Language **1**.Technical term **2**. Complexity of channels used to announce

24. Do you readily access weather information? Provide your view on accessibility of climate information to you in the table 8 below (List them in order of how readily they make information available).

Table 8. Accessibility of Climate Information

Origin of information	Type of information	Easily accessible	Rarely accessible	No accessibility
	Rainfall			
	Flooding			
	Temperature			

Perception of climate information

25. Have you heard about climate variability/ change before? (a). Yes ……… (b). No

If Yes, how do you understand it?...

....

26. From what source(s) did you hear it from? (Tick below as appropriate)

(i) Weather station ( ) (ii) Extension workers ( ) (iii) Radio ( ) (iv) Television ( )

(v) Other sources (specify): ----------------------------------

27. Do you consider climate information you get adequate? (a). Yes (b). No

28. Indicate the regularity of the climate information you receive is in Table 9 below.

Table 9. How regular is the Climate Information received

Information on:	Source of information	Did you get it daily? **0**=No **1**.YES	Did you get monthly? **0**=No; **1**=Yes	Did you get annually? **0**=No; **1**=Yes
Temperature				
Rainfall				
Sunshine				
Flood				
Others (Specify)				

29. Timeliness the weather information you receive from your various sources? (Indicate in Table 10 below)

Table 10. Indicate how timely, correct and adequate information provided is

Source of information	Information type	How correct is information provided? **1**=Always correct, **2**=Sometimes correct **3**=Never correct)	Is the information provided on time? (Yes/No)	Is the information provided good enoughfor your farming purpose? (Yes/No)	Is information provided adequate? "**1**=Adequate" or "**2**=Not adequate"

30. Do you observed any change in weather pattern in your community? a. Yes ( ) b. No ( )

31. If "yes" in question 30, indicate in which of the following climate parameters you observed these variations/changes (use table 11)

Table 11. Variations in weather/climate noticed

Weather/climate element	Changes observed 30 years ago **0**. Decrease **1**.Increase	Changes observed 20 years ago **0**. Decrease **1**.increase	Changes observed10 years ago **0**. Decrease **1**.Increase	Changes observed in this year **0**. Decrease **1**.increase
Rainfall				
Temperature				
Relative humidity				
Sunshine hours				
Wind speed				
Heat waves				
Drought				
Others(specify)				

32. Please provide answers to the following statements in Table 12 on your awareness of climate variability

Table 12. Awareness level relating to climate variability

Statements	Agree	Disagree	Not aware
There is change in rainy period recent days			
The dry season is now longer recent days			
The wind has become stronger recent days			
Temperature has increase in recent days			
There is now occurrence of flood			

33. How will you describe the present weather conditions in this community compared to about 30 years back? (Use table 13 below)

Table 23. Changes in weather conditions (variability)

	Change observed			
Rainfall				
Characteristic	Increase	Decrease	No Change	When was this noticed? Year? or month? Specify
Amount				
Intensity				
Pattern				
Duration				
Early Onset of rain				
Late cessation of rain				
Temperature				
Characteristic	Increase	Decrease	No change	When was this noticed? Year? Or month? Specify
Duration				
Intensity				
Wind				
Characteristics	Increase	Decrease	No change	When was this noticed year? or month? Specify
Speed				
Pattern				
Relative Humidity				
Characteristic	Increase	Decrease	No change	When was this noticed year? or month? Specify
Percentage				
Sunshine				
Characteristic	Increase	Decrease	No change	When was this noticed year? or month? Specify
Duration				
Intensity				
Cloud Cover/Harmattan period				
Characteristic	Increase	Decrease	No change	When was this noticed
Duration				

34. What is your perception of the change in climate in your community (Use table 14 below)

Table 14. Perception of climate variability/change impacts

Climate variables	What do you think caused the situation?	**Who** do you think is responsible?	**What** do you think caused the problem?	What actions do think should be taken?	How often does this worrying conditions happen?	What is your need in this situation
Did you worry with Increase temperature? **0**=No, **1**=Yes if yes answer the above column						
Did you worry with Erratic rainfall **0**=No **1**=Yes if yes answer the above column						
Did you worry with Flood **0**=No, **1**=Yes if yes answer the above column						
Did you worry with Pest infestation **0**=No, **1**=Yes if yes answer the above column						
Did you worry with Heat waves						
Did you worry with Drought						
Others (specify)						

35. How would you describe the conditions of land, forest and water source of this community compared to the condition30 years ago? (Use table 15 below)

Table 15. Condition of natural resources

Resource	Improved	Degraded	No change
Land			
Forest			
Water resources			
Soil erosion			
Others (specify)			

36. What are the weather related problems that occur in this community and which of them affect your agricultural production most –rank in order of their effect from high to low (e.g. **1**. **C**hange in temperature, **2**. Pest infestation, **3**. Flood, **4**. Drought, **5**. Soil fertility, **6**. Erratic rainfall, **7**. Heat waves **8**. Others (Specify)?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………

Knowledge Level of Climate variability

37. From your understanding, climate variability is characterized by? (Indicate in table 16)

Table 16. Characteristics of Climate variability

#	Statements on climate trends for the past 30 years and above	**0**=No, **1**=Yes
1	There is change in the onset of rain	
2	There is change in rainfall duration	
3	There is change in rainfall pattern	
4	There is change in sea-level	
5	There is change in temperature	
6	There is change in sunshine hours	
7	There is change in sunshine intensity	
8	There is change in season	
9	There is new species of plants, trees appearing	
10	Some species of plants, trees & fishes are disappearing	
11	The level of occurrences of flooding has increased	
12	Streams are drying up	
13	Forest fire	
14	Deforestation	
15	Changes in wind speed	

Objective 2: To examine the impacts of climate variability and change on smallholder farmers

38. Provide an estimation of what you think is the impacts of climate variability and change on your agricultural outputs in this community (Use table 17) below.

Table 17. Rating of impact of climate variability and change on agricultural output

Type of crops	Expected harvest potential (bags/kg in 2014	Actual harvested 2014 (bags/kg)	Expected harvest potential (bags/kg in 2015	Actual harvested in 2015 (bags/kg)	Reasons for variances
Maize					
Cassava					
Garden egg					
Others (specify)					

39. Indicate the level of importance of the factors below in exposing your agriculture and adaptation strategies to the impact climate variability and change. Rate on a scale of **0** to **2** (**0** =Not important; **1** = Important; **2** = Very important) (Use table 18).

Table 18. Rating of impact of climate variability

#	FACTOR	RATING		
		Not Important (**0**)	Important (**1**)	Very Important (**2**)
1	Availability of irrigation			
2	Availability of water for livestock			
3	Rainfall			
4	Drought			
5	Low agricultural output			
6	Lack of farm labor.			
7	Availability of nearby market			
8	Availability of facilities for storing harvest			
9	Availability of processing facilities			

10	Availability of transportation and distribution system			
11	Increase population			
12	Level of income			
13	Conflict			
14	Others (specify)			

40. Do the change in climate pattern have any effect on your health and or that of your households? If “Yes” how?

…………………………………………………………………………………………………

41. Do the change in climate pattern have any effect on your level of income and that of your households? If “Yes” how?

…………………………………………………………………………………………………

42. Please give information on land management by your household (Use table 19).

Table 19. Land Resource Management

Total farmland owned (ha)	Total Cropped area (ha)	Total fallow area (ha)	How often do you access to irrigation facilities? (Indicate “daily”, “weekly”, “fortnightly”, “monthly”, etc.)

43. What is the likelihood of occurrence of climate hazards in this community? (Use Table 20)

Table 20. Occurrence of climate hazards in the past 30 years

Events/hazards	Yearly	For many months in a year	In 5 years interval	In 10 year interval	Others Specify
Flooding					
Rising sea-level					
Streams drying up					
Drought					
Livestock diseases					
Crops pest/disease					
Outbreak of human disease					
Windstorm					
Heatwave					
Landslide					

44. How many times have the climate events/hazards listed in Table 21 occurred in your community in your lifetime?

Table 21. Occurrence of Climate hazards

Hazard Events	No of times event occurred 30 years ago		No. of times event occurred 20 years ago		No of times event occurred 10 years ago	
	No. of times occurred **1**.yearly **2**.monthly **3**. three months interval 4. 5 years interval	**Damage caused** **1**.farmland destroyed, **2**.people killed**3**.houses destroyed, others----	**No of times occurred** **1**.yearly **2**.monthly **3**. three interval 4. 5 years interval	Damage caused **1**.farmland destroyed **2**.people killed **3**. houses destroyed, etc.	**Damage caused No of1**.farmland destroyed, **2**.people killed**3**..houses destroyed, others----	Damage caused **1**.farmland destroyed, **2**.people killed**3**.houses destroyed, others----
Flooding						
Sea level rising						
Drying up of streams						
Drought						
Wind havoc						
Heat wave						
Others						

45. Who were affected by the hazard? (kindly tick) 1. Men....., (2) women....., (3) both......... (4) Children.........

46. Who were the most adversely affected during these hazards?

Women ( ) Men ( )

47. How are the men affected? ---

----

48. how are the women most affected? --

----

49. How severe are the impacts in 44 above on the following? (Rate as follow: **H**=high, **M**=Medium, **L**=Low)

(a) Food production ------- (b) livelihood base ------------ (c) Health ---------- (d) Rivers/streams-------

50. Please provide information on your household's income and expenditure in the table 22 below.

Table 22. Household income and expenditure

Income Naira/Month	Debt owed	Loan given out by household	Savings made	Remittance received
Primary occupation				
Other Sources				

51. Which of these assets is owned by your household? (Use table 23).

Table 33. Household asset ownership

Asset	Number	Year of Purchase
Building		
Motorcycle		
Motor vehicle		
Bicycle		
Boat		
Radio		
Television		

52. From the climate events that happen in this community, indicate an estimated loss that your household may have incurred in agricultural production

(i)Farmland (in hectare) …………………………….

(ii)Yield decrease (quantity or monetary value) ………………………………….

(iii)Cost of land augmentation (monetary value) ……………………………….

(iv) Additional cost of production (monetary value) ………………………………

(v) Reduction in cultivable land (in hectares) ………………………………….

(vi) Livestock destroyed ---

53. Was there loss of human lives during occurrences of climate related hazards?

a. Yes b. No

54. If yes, how many deaths and injuries was recorded?

No. of deaths ----------------No. of those injured-----------------------------------

55. Please provide an estimated area of farmland land that was affected------------------------

56. If buildings, other assets were destroyed, provide an estimated cost of such in the table 24 below:

Table 24. Destruction from climate variability in -----years? 1, 5, 10, 30?

Destroyed item	Number/ Year	Estimated Cost Naira
Building		
Household property		
Other assets		
Farmlands		
Others –specify		

57. Which of the following diseases are frequently happening in your family –tick as many that are applicable?

Asthma ( ); Dengue ( ); Fever ( ); Vomiting and dysentery ( ); Cholera ( );

Heat rashes ( ); skin disease ( ); Water borne diseases ( ); Malaria ( ); others (please specify) ……………….

Objective 3: To evaluate smallholder farmers' adaptation strategies and options to climate variability and change

58. Which of the following strategies does your household use to adapt to the problems of climate variation and change? Tick as appropriate (For Crop / Livestock Farmers Only)

(i) Plant different types of crops	a). Yes	b.) No
(ii) Adopt different planting dates	a.) Yes	b.) No
(iii) Practicing other non-farm activities	a.) Yes	b.) No
(iv) Changing from cropping to livestock	a.) Yes	b.) No
(v) Changing from livestock to cropping	a.) Yes	b.) No
(vi) Use of irrigation/ watering	a.) Yes	b.) No
(vii) practice of soil conservation technique	a.) Yes	b.) No
(viii) Terracing	a.) Yes	b.) No
(ix) Drainage	a.) Yes	b.) No
(x) Planting on mounds/ridges	a.) Yes	b.) No
(xi) Increasing hectares of land cultivated	a.) Yes	b.) No
(xii) Use of short gestation crops	a.) Yes	b.) No
(xiii) Use of flood tolerant varieties	a.) Yes	b.) No
(xiv) Use of drought resistance crops	a.) Yes	b.) No
(xv) Use of disease/pest resistant varieties	a.) Yes	b.) No

59. Which of these measures in #58 above is and/or are the most effective in adapting to climate variability in this community? (List them in order of their effectiveness) -----------

----

60. What immediate (coping) actions do you taken before when climate hazards happened (Use in Table 25)

Table 25. Climate event &coping measures taken

Climate Event	Coping measures	What amount did you spend taking the action(naira)	Did your action took care of the problem? **0**=No **1**=Yes

61. State the level of intensity of the practice used by ticking the appropriate box in table 26 below.

Table 26. Intensity of Agricultural practices

S/No	Practices	High	Medium	Low
1.	Multiple crop types/varieties			
2.	Land fragmentation			
3.	Use of alternative fallow/tillage practices			
4.	Multiple planting dates			
5.	Irrigation practice			
6.	Crop diversification			
7.	Off-farm employment			
8.	Mulching			
9.	Cover cropping			
10.	Fertilizer application			
11.	Organic manure application			
12.	Planting trees			
13.	Shading/sheltering			
14.	Change in food crop farmland size			

62. What are the measures people living in this community use to respond to the following? See table 27 below.

Table 27. Actions to respond to climate hazards

Hazard	Actions taken
Soil Erosion	
Flooding	
Early rainfall	
Late rainfall	
Long dry season	
Short dry season	
High-wind-speed	
Excessive heat	
Others(specify)	

63. How many times have you been trained by extension workers on improved agricultural techniques? …………………………….

64. Provide the name of the improved agricultural techniques you currently use?

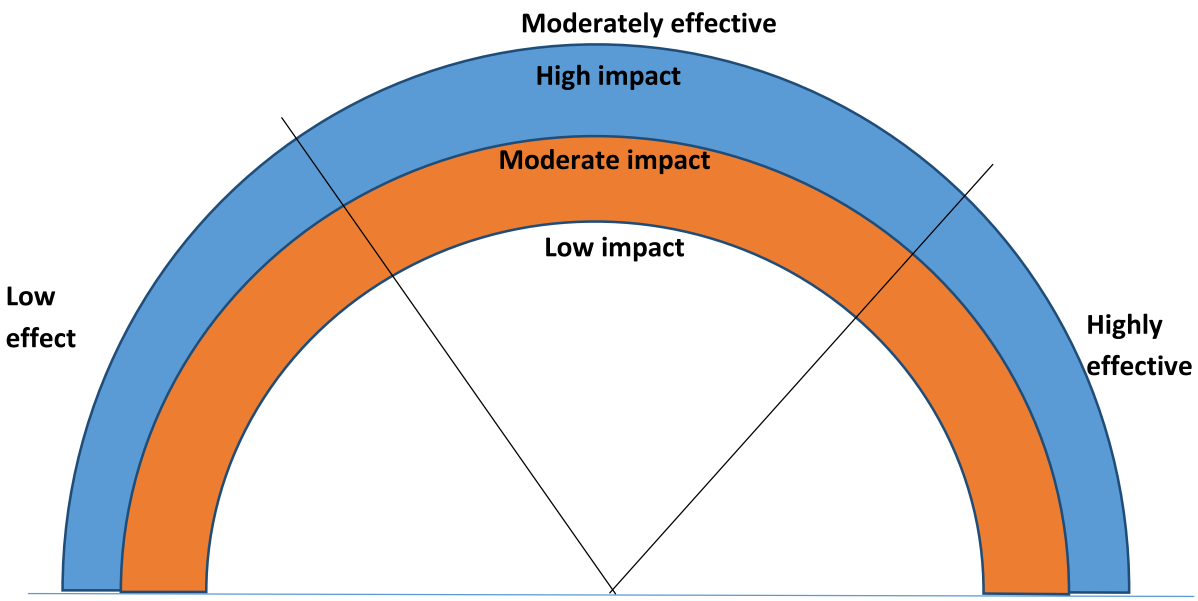
(i)..

(ii) ....

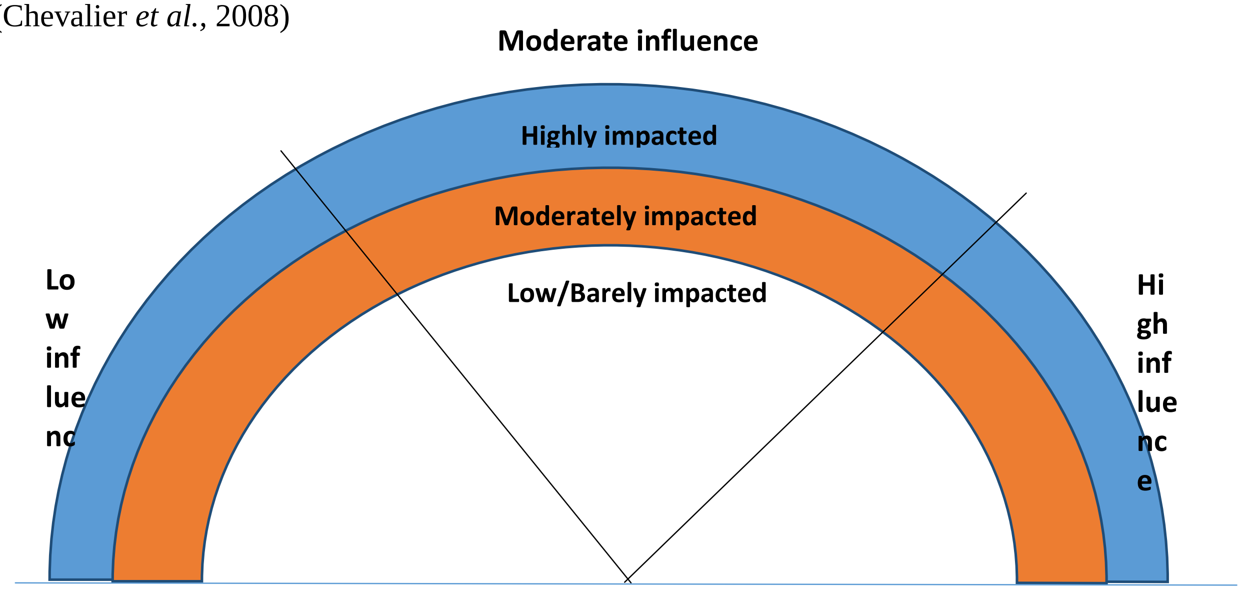
(iii) ....

APPENDICE II: ASSESSMENT OF IMPACTS AND RESPONSES (FGD & KII)

Effectiveness of adaptation strategies. Adapted from SAS[2] (Chevalier *et al.*, 2008)



Level of impacts and influence of the those affected by climate change. Adapted from SAS[2] (Chevalier *et al.*, 2008)



APPENDICE III*:* ASSESSMENT OF ADAPTATION OPTIONS

Box I: MULTICRITERIA ANALYSIS (MCA) (Adapted from UNFCCC, 2005)	
Description	This tool/methodology is a structured method used to determine overall preferences among alternative options, where the options achieve several objectives. In MCA, desirable objectives are specified and corresponding characteristics or indicators are identified. The indicators for measurement may not always be based in monetary terms, but also on quantitative assessment (using scoring, ranking and weighting) of varieties of qualitative impact categories and criteria. other environmental and social indicators as may be needed can be developed alongside the economic costs and benefits. Explicit recognition is given to the fact that a variety of both monetary and non-monetary objectives may influence policy and adaptation decisions. MCA provides techniques for comparing and prioritizing different options, even though a variety of indictors can be adopted as fit-for-purpose. MCA includes a range of related techniques including SAS[2], some of which follow this entry.
Appropriate Use	Multi-criteria analysis or multi-objective decision making is a type of decision analysis tool that is particularly applicable to cases where a single-criterion approach (such as cost-benefit analysis) falls short, especially where significant environmental and social impacts cannot be assigned monetary values. MCA allows practitioners to include socio-economic, environmental, technical as well as financial criteria.
Scope	Locations: ……………… Sectors: ………………. Target group: …………….
Key Output	A single most preferred option is……………… Ranked options as follows: High, Medium, Low Short list of options further as: Acceptable/feasible/high-medium impact options are: Unacceptable/not feasible/low impact options are:

Key Input	Criteria of evaluation as well as relevant metrics for those criteria. #1. Ease of implementation #2. Cost effectiveness/affordability/accessibility #3. Possibility of yield increase #4. Replicability #5. Level of impacts of cc on the respondent/group #6. Environmental impacts #7. Ease of application of the technology/inputs #8. Gender consideration
Computer Requirements	Personal computer.
Applications	Research study on the impacts of climate variability and change and adaptation strategies adopted by smallholder farmers in Southwest Nigeria
Cost	Dependent on research budget, time, scope and availability of the target group of smallholder farmers, but in general is inexpensive.

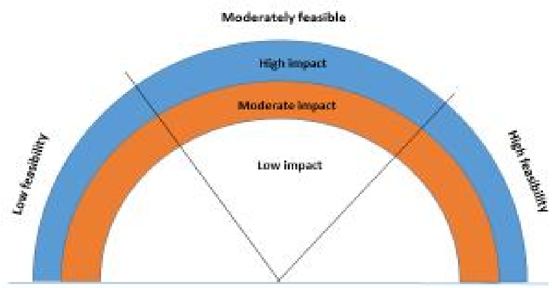
Box II: Adaptation Decision Matrix (ADM)	
Description	The ADM uses multi-criteria assessment approach to evaluate the relative cost effectiveness of adaptation choices and options available. The stakeholders are asked to agree onclear criteria to be used in evaluating options and its weighting. Available climate data, modelling and scenarios were possible can be integrated in the application and use of ADM. Participants/stakeholders are requested to give a score for example from 0 to 7 on how well each of the criterion is met under a particular scenario for each chosen option. The scoring was based on the researcher/expert judgment. Scores were multiplied by weights and summed up to estimate which

	options best meet the criteria. The scores were compared to relative costs to assess cost-effectiveness.
Effective Use	This technique is useful with many important value additions especially in finding effective adaptation option as well as in making well-informed adaptation policy objectives which may not be easily monetized or expressed in a common metric. However, good research, analysis, combination with any other tool and expert judgement would be needed to provide a basis for the evaluation to guide against biasness in the result.
Scope	Location: ……………… Sectors: ………………. Target group: …………….
Outputs	Relative cost-effectiveness of alternative adaptation options. #1. Very expensive #2. Expensive #3. Not expensive
Inputs	A ranking of how well adaptation objectives are met using alternative strategies; estimated costs of adaptation measures. …………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………
Computer Requirements	Personal computer with Excel spreadsheet software.

Applications	Research study on the impacts of climate variability and change and adaptation strategies adopted by smallholder farmers in Southwest Nigeria
Cost	Dependent on research budget, time, scope and availability of

	the target group of smallholder farmers, but in general it was inexpensive.

Box III: Screening of Adaptation Options using Social Analysis System (SAS^2)



Adapted from SAS^2 (Chevalier, *et al.*, 2008)

Box IV: Timeline and force-field (Researcher's own design)

Timeline and force field

Dateline	Event /Impacts	Response measures		
		Coping	Adaptation	Mitigation
1985-1990				
1990-1995				
1995-2000				
2000-2005				
2005-2010				
2010-2015				

Appendix IV: The ICPAS model