ADOPTION OF TECHNOLOGIES FOR ADAPTATION TO CLIMATE CHANGE BY MAIZE FARMERS IN NORTH-WEST AGRO-ECOLOGICAL ZONE OF NIGERIA

Ph.D. (Agricultural Extension and Rural Sociology)

BY

Emmanuel Yusuf DODO (B.Sc. ABU, M.Sc. ABU)
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FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY
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NIGERIA.

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TITLE PAGE

DECLARATION

I declare that this thesis titled "**Adoption of Technologies for Adaptation to Climate Change by Maize Farmers in North-West Agro-Ecological Zone of Nigeria"** has been written by me and it is a record of my research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All borrowed information has been duly acknowledged in the text and a list of references provided.

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_____	_____
Professor T.K. Atala	**Date**
Chairman, Supervisory Committee	
_____	_____
Professor D.F. Omokore	**Date**
Member, Supervisory Committee	
_____	_____
Professor M.G. Maiangwa	**Date**
Member, Supervisory Committee	
_____	_____
Professor Z. Abdul-Salam	**Date**
Head of Department,	
Agricultural Economics and Rural Sociology,	
Ahmadu Bello University, Zaria	
_____	_____
Professor K. Bala	**Date**
Dean, Post Graduate School	

DEDICATION

This thesis is dedicated to my late wife Deborah who saw it with her eyes but could not partake in the fruits therein. May her gentle soul rest in perfect peace.

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TABLE OF CONTENTS

TITLE PAGE i

DECLARATION ii

CERTIFICATION iii

DEDICATION iv

ACKNOWLEDGEMENTS v

TABLE OF CONTENTS viii

LIST OF TABLES xi

LIST OF FIGURES xii

LIST OF ABBREVIATIONS xiii

ABSTRACT xv

CHAPTER ONE 1

1.0 INTRODUCTION 1

1.1 Background to the Study 1

1.2 Statement of the Problem 3

1.3 Objectives of the Study 5

1.4 Research Hypotheses 6

1.5 Justification of the Study 6

CHAPTER TWO 8

2.0 LITERATURE REVIEW 8

2.1 Concept of Climate Change 8

2.1.1 Causes of climate change 9

2.1.2 Effects of climate change on agriculture 12

2.1.3 Climate change adaptation and mitigation in developing countries 23

2.1.4 Coping strategies against climate change in Nigeria 26

2.2 Economic Importance of Maize 35

2.3 Background to Adoption Studies 39

2.3.1 The diffusion process 41

2.3.2 The adoption or innovation-decision process 41

2.3.3 Importance of adoption studies 44

2.3.4 Review of empirical studies on adoption 44

2.4 Constraints to Adoption of Climate Change Adaptation Strategies 48

CHAPTER THREE 50
3.0 THEORETICAL FRAMEWORK 50
3.1 Adoption of Innovation Theory 50
3.1.2 Application of the adoption theory 57
3.2 Conceptual Framework 57
3.2.1 Concept of Perception 57
3.2.2 Concept of Effects 59
3.2.3 Level of Living 61
3.3 Conceptual Model 63
CHAPTER FOUR 66
4.0 METHODOLOGY 66
4.1 Description of the Study Area 66
4.2 Sampling Procedure and Sample Size 70
4.3 Method of Data Collection 70
4.4 Analytical Techniques 73
4.4.1 Descriptive Statistics 73
4.4.2 Linear regression model 73
4.4.3 Z-test statistic 75
4.5 Definitions and Operational Measurements of Dependent and Independent Variables 76
4.5.1 Dependent variable 76
4.5.2 Independent variables 79
4.5.3 Effects of adoption 85
CHAPTER FIVE 88
5.0 RESULTS AND DISCUSSION 88
5.1 Farmers' perception on the effects of climate change on maize production 88
5.2 Local climate change coping strategies used by maize farmers 92
5.3 Awareness and adoption of promoted technologies for coping with climate change 96
5.3.1 Awareness 96
5.3.2 Adoption 97
5.4 Sources of information on the promoted technologies 100
5.5 Extent of relationship between respondents' socio-economic, institutional and technology-specific factors and adoption of promoted technologies 101
5.5.1 Socio-economic factors 102
5.5.2 Institutional factors 102
5.5.3 Technology-specific factors 103

5.6 Effects of adoption of the technologies for adaptation to climate change on maize famers' outputs, income and level of living 105
5.7 Constraints to adoption of technologies for adaptation to climate change by maize farmers 106

CHAPTER SIX 110

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 110
6.1 Summary 110
6.2 Conclusions 112
6.3 Recommendations 113
6.4 Contributions of this study to knowledge 114
6.5 Areas for further study 116

REFERENCES 117

APPENDIX I 132
Adopters' Questionnaire 132

APPENDIX II 149
Questionnaire for Non-Adopters 149

APPENDIX III 161
Lirkert scale of respondents perceptions of effects of climate change on maize production (n -159) 161

LIST OF TABLES

Table 3: Adopters' perceptions of effects of climate change on maize production (n =159) 92

Table 4: Distribution of respondents according to local strategies used for coping with climate change 96

Table 5: Distribution of respondents according to awareness of promoted technologies for coping with climate change (n =159) 97

Table 6: Distribution of respondents according to adoption of promoted technologies for coping with climate change (n =159) 99

Table 7: Summary of respondents' levels of awareness and adoption of promoted technologies and their rankings (n = 159) 100

Table 8: Distribution of respondents according to sources of information by technology (n=159) 101

Table 9: Linear regression analysis on the extent of relationship between socio-economic, institutional and technology-specific factors affecting adoption of promoted maize production technologies 105

Table 10: Z-test for differences in output, income and level of living between adopters and non-adopters of promoted technologies for adaptation to climate change (n =159) 106

Table 11: Distribution of respondents according to constraints in adoption of the promoted technologies 109

LIST OF FIGURES

Figure 1: Model showing factors affecting adoption of promoted technologies for adaptation to climate change and their effects on farmers' outputs, income and level of living. 65

Figure 2: Map of Nigeria showing the North-West Agro-Ecological Zone 69

LIST OF ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
ARCN	Agricultural Research Council of Nigeria
BNRCC	Building Nigeria's Response to Climate Change
CCCFR	Centre for Climate Change and Fresh Water Resources
CEEPA	Centre for Environmental Economics and Policy for Africa
CFCs	Chlorofluorocarbons
CTA	Technical Centre for Rural Cooperation
CO_2	Carbon dioxide
DTM	Drought-Tolerant Maize
ENSO	El Niño Southern Oscillation
EU	European Union
FAO	Food and Agricultural Organization
FEPA	Federal Environmental Protection Agency
GDP	Gross Domestic Product
ILO	International Livestock Organization
IISD	International Institute for Sustainable Development
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
IPCC	Inter-governmental Panel on Climate Change
KADP	Kaduna State Agricultural Development Project
NAERLS	National Agricultural Extension and Research Liaison Services
NARIs	National Agricultural Research Institutes
NARSP	National Agricultural Research Strategy Plan
NEST	Nigerian Environmental Study Action Team

NMetS	Nigerian Meteorological Society
NPC	National Population Commission
SSA	Sub-Saharan Africa
SADC	Swiss Agency for Development and Cooperation

ABSTRACT

In Nigeria, concerted efforts have been made by governments, non-governmental agencies and researchers to combat the menace of climate change on agricultural production. In pursuance of this noble objective, some technologies have been promoted by government and non-governmental agencies for adoption by farmers. This study examined the adoption of some of these technologies among maize producers in North-West agro-ecological zone of Nigeria. Data for the study were collected through questionnaire that was administered on 159 purposively-selected maize farmers using a multi-stage sampling procedure. The data were analyzed using frequencies, percentages, Z-test and linear regression. The findings revealed that the perceived most severe effects of climate change of maize production were severe drought (89.4%), too much rain/flood (71.8%) and increased weed incidence (66.6%). The most common local strategies employed by farmers against climate change were the use of organic waste (22.6%), crop diversification (19.8%) and leaving crop residues in the field (19.2%). The results also showed that the promoted technologies against climate change that farmers were most aware of were mixed cropping (100%), mixed farming (94%), optimum use of organic waste (94%) and crop rotation (93%), and those they were least aware of were mulching (29.6%), minimum tillage (16.4%) and water harvesting (9.4%).The most adopted of the technologies against climate change were mixed farming (96%), mixed cropping (95%) and the optimum use of organic waste (90%), and the least adopted were minimum tillage (13.2%), afforestation (11.3%) and water harvesting (5.7%).The most important sources of information on the promoted technologies were radio (53%), friends and relatives (23%), and extension agents (19%) and the least important sources were newspapers (1.7%), agro-dealers (1.5%), television (1.4%), field days (1.3%), demonstrations (0.4%) and agricultural extension bulletins (0.2%). The factors that significantly influenced adoption of the promoted technologies were household size (0.060), labour availability (0.427), membership of association (0.064) information sources (0.414), compatibility (0.056), complexity (-0.047), relative advantage (0.046) and cost of technology (-0.205). The Z-test results revealed that there was a significant positive effect of adoption of the promoted technologies on adopters' output, income and level of living. The most important constraints to adoption of the promoted technologies against climate change were (i) high cost of the technologies (34.2%); (ii) problem of pests and diseases (22.1%); and (iii) complex nature of the technologies (19.0%). Some of the recommendations made were that policy makers and other stakeholders in the agricultural sector should promote the use of demonstrations, field days and extension bulletins in the dissemination of the promoted technologies. Given that high cost of some of the technologies was a constraint to their adoption, there is the need to encourage farmers to form cooperative societies to enable them have easier access to credit facilities and other inputs needed for effective adoption of the promoted technologies.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Agriculture plays an important role in the economies of developing countries in terms of food supply, employment, income generation, and source of raw materials for industries (NAERLS, 2009). About 90% of Nigeria's population, particularly those living in rural areas, depend on agriculture for their livelihood (NAERLS, 2009).

However, agriculture in Nigeria is highly sensitive to environmental variability and weather extremes such as droughts, floods and severe storms (Mortimore and Adams, 2001., Nigerian Meteorological Society (NMetS), 2010., Butt *et al*., 2005). Climate change is perhaps the most serious environmental threat to the efforts of alleviating hunger, malnutrition, disease and poverty in Africa, mainly through its impact on agricultural productivity (Butt *et al*., 2005).

The forces that shape the climate are critical to farm productivity because agricultural practices are mostly weather-dependent (Lobell *et al*., 2008). In Africa in general, climate change exerts direct effects on the environment where crops are produced. These affects soil temperature and moisture levels and also determine the vitality of both beneficial organisms and the pests involved in crop production (Mortimore and Adams, 2001). Enormous uncertainties surround global climate change. Estimates of cropland reductions due to climate change vary widely from 10 to 50 percent and this exposes farmers to high risks and uncertainties (Molua, 2000).

The two most influential factors to be considered in the environment in relation to climate change are temperature and rainfall. According to the Inter-governmental Panel on Climate Change (IPCC, 2007), temperature and rainfall are considered essential

factors because plants can grow only within certain limits of temperature and rainfall. For each crop variety, there are not only optimal temperature and rainfall limits, but also optimal temperatures and rainfall for different growth stages and functions, as well as lower and upper lethal limits (IPCC, 2007). For instance, an increase in average temperature can lengthen the growing season in regions with a relatively cool temperature, adversely affect crops in regions where summer heat already limits production, increase soil evaporation rates, and increase the chances of severe droughts. Change in rainfall amount and patterns can affect soil erosion rates and soil moisture (IPCC, 2007).

Maize is becoming increasingly important as a food security crop (NAERLS, 2009). Nigeria is the largest maize producer in West Africa (FAO, 2007). This crop is most widely grown in the northern guinea savanna where, with sorghum, are two of the main cereal crops on 30 to 40% of the cultivated land area (Smith *et al*., 1997). The demand for maize for food, animal and industrial use is increasing rapidly as population expands across the region. The Food and Agricultural Organization (FAO) (2007) reported that more than 50% of all Sub-Saharan African (SSA) countries assign over 50% of their cereal area to maize. According to Bamire (2007), increasing the productivity of maize-based cropping systems has strategic importance for food security and socio-economic stability of African countries and the sub-region. However, recurring droughts, floods, storms and other extreme weather events, due to change in the climate, provide a continuous challenge to maize production (Bamire, 2007). The level of production of maize is being threatened by climatic changes and this much change in the climate is likely to alter production of maize and major food staple crops for millions of people in Africa (NAERLS, 2009). Adoption of adaptation technologies to climate change by

maize farmers will help reduce the risks of the adverse effects of climate change on maize production in the north-west agro-ecological zone of Nigeria.

1.2 Statement of the Problem

The North-West zone of Nigeria is the leading producer of cereals (sorghum, millet, maize), legumes (cowpea, groundnut) and vegetables (tomato, onion, pepper) (NARSP, 1997). However, despite the immense agricultural production potentials of this zone, many production constraints still exist. The zone is characterized by rainfall variability, especially late onset and early cessation of rains, often resulting in shorter growing season. This, in turn, leads to death of seedlings, low yields or even crop failure (Ogungbile *et al*., 1999). The torrential nature of tropical rain during the short humid season also makes the zone susceptible to flooding and erosion. The reduced quantity of rainfall increases the desertification process, leading to, among other things, lower crop yields and grazing problems for livestock. High annual temperatures, ranging between 30-40 ^{o}C, coupled with high solar radiation causes potential crop water use (potential evapo-transpiration) to exceed rainfall much of the time (Jayne *et al*., 1989). Poor soil water infiltration and soil water-holding capacity exacerbates the bad crop-water situation (Jayne *et al*., 1989).

The North-west zone is, therefore, susceptible to the adverse effects of climate change. Addressing climate change and the damages it causes is, therefore, necessary. Policy makers increasingly recognize that policies will have to be developed and adopted both to mitigate and to adapt to the effects of climate change. The Federal Environmental Protection Agency (FEPA), Centre for Climate Change and Fresh Water Resources (CCCFR) and the Agricultural Research Council of Nigeria (ARCN) have organized national training workshops on disaster management and early warning systems and have also generated and promoted the adoption of climate-smart agricultural production

technologies in the efforts to achieve reliable disaster risk reduction in Nigeria. However, little is known about how these technologies reach farmers or about farmers' response to them. Not much is also known for certain which farmers in the zone adopt these technologies and which do not. Also, little is known about the channels of information through which farmers hear of the promoted technologies. The few studies conducted have found a wide gap between awareness and adoption of improved agricultural technologies among farmers (Atala, 1980).

Most studies in extension and rural sociology have also tended to concentrate attention on adoption behaviour of farmers, while overlooking the impact of recommended technologies on farmers' livelihood (Atala, 1986). There is paucity of data on the effect of climate change on maize production as well as on the adoption and impact of promoted technologies for adaptation to climate change in the study area. Since changes in agricultural communities come about partly by the use of recommended agricultural technologies, it becomes necessary to study the adoption of these technologies and its impact on maize farmers' output, income and level of living and to also identify the various sources of information on these technologies. This study therefore intends to provide answers to the following research questions:

i. What is the farmers' perception on the effect of climate change on maize production in the study area?

ii. What are the local climate change coping strategies used by maize farmers?

iii. What are the levels of farmers' awareness and adoption of adaptation technologies for coping with the effect of climate change?

iv. What are the sources of information on the adaptation technologies for coping with effect of climate change?

v. What are the socio-economic, institutional and technology-specific factors influencing the adoption of technologies for adaptation to climate change?

vi. What are the effects of adoption of the adaptation technologies on maize farmers' outputs, income and level of living?

vii. What are the constraints associated with adoption of the promoted technologies for adaptation to climate change?

1.3 Objectives of the Study

The broad objective of the study was to assess the adoption of the promoted climate change technologies for maize production and its effects on the farmers' livelihood in the North-West agro-ecological zone of Nigeria. The specific objectives were to:

i. examine farmers' perception on the effect of climate change on maize production in the study area;

ii. identify the local climate change coping strategies used by maize farmers;

iii. determine the levels of farmers' awareness and adoption of adaptation technologies for coping with the effect of climate change;

iv. identify the sources of information on the adaptation technologies for coping with the effect of climate change;

v. determine the socio-economic, institutional and technology-specific factors influencing the adoption of technologies for adaptation to climate change;

vi. determine the effects of adoption of the adaptation technologies on maize farmers' outputs, income and level of living, and

vii. identify the constraints associated with adoption of technologies for adaptation to climate change.

1.4 Research Hypotheses

Ho_1: There is no significant relationship between farmers' socio-economic, institutional and technology-specific factors and the adoption of the promoted technologies for adaptation to climate change.

Ho_2: There is no significant difference in output, income and level of living between the adopters and non-adopters of the promoted technologies for adaptation to climate change.

1.5 Justification of the Study

Addressing climate change and the damages it causes is an urgent priority for developing countries. The purpose of this study is to allow for proper understanding of the effects of climate change and for improving the adoption of response measures against climate change by maize famers. This study also stresses the need for studies beyond adoption and diffusion. By generating a better understanding of how technologies influence the welfare of farmers, impact evaluation of technologies can provide a basis for modification and improvement of the technologies by stakeholders in combating the adverse effects of climate change and to ensure an appropriate level of both public and private support. Also, if farmers' preference for sources of information is known, these sources could be used more effectively by the promoters of the technologies for adaptation to climate change.

This study therefore is expected to provide relevant information to policy makers, scientists, extension agents and farmers on farmers' perception of the effects of climate change on maize production, on the local coping strategies used by farmers and the adoption of promoted technologies against climate change.

Identification of the factors affecting the adoption of promoted technologies for adaptation to climate change in maize production is important for policy makers, researchers and organizations involved in combating the menace of climate change on the environment, specifically on agriculture, as it will indicate the factors to which attention should be paid. Information from this study on the local coping strategies used by farmers and constraints to the adoption of the promoted technologies for climate change adaptation by maize farmers will be useful to Non-Governmental Organizations, the Centre for Climate Change and other research agencies so that appropriate recommendations that reflect farmers' agro-ecological and socio-economic conditions can be made. Agricultural research and extension systems stand to gain from the findings of the study in terms of which local coping strategies and promoted technologies need to be mastered by them so they can be more widely adapted to farmers' circumstances.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of Climate Change

The Inter-governmental Panel on Climate Change (IPCC) (2007) described climate change as a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. According to the Panel, the most general definition of climate change is a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause. The Panel further explained that, it may be a change in average weather conditions, or in the distribution of weather around the average conditions (more or fewer extreme weather events).

In the context of environmental policy, the term climate change has become synonymous with anthropogenic global warming. Within scientific journals, global warming refers to surface temperature increases while climate change includes global warming and everything else that increasing greenhouse gas levels will affect (IPCC, 2007).

The Nigerian Environmental Study Action Team (NEST) (2004) indicated that, climate change is a marked change in the long-term average of a regions weather conditions. According to Bello (2010), the climatic system is an open system and is in a steady state over a given period of time. According to him, if this steady state is disturbed as a result of changes in one or more components making up the system or there are changes in the amount of solar radiation powering the system, the climate will move over a to a new state of equilibrium to produce a new climatic state. He, therefore, defined climate change as the long-term persistence of either positive or negative anomalies of a given

or combination of climatic events above or below the norm that characterizes climate change. He identified the indices of climate change to include a change in any or combinations of the following:

(i) surface albedo, (ii) annual mean temperature, (iii) mean temperature during the growing season, (iv) day/night temperature range, (v) extreme seasonal temperatures, (vi) rainfall seasonality and replicability of the mean rainfall regime, (vii) duration of the growing season and annual precipitation rates, and (ix) shifts in rainfall belts. The manifestation of any or combinations of these changes in different ecosystems could alter significantly the composition and characteristics of the components of the ecosystems (Bello, 2010).

2.1.1 Causes of climate change

Climate change is caused by factors such as biotic processes, variations in solar radiation received by the earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as "global warming" (IPCC, 2007).

Most climate scientists agree that the main cause of the current global warming trend is human expansion of the "greenhouse effect" which is the warming that results when the atmosphere traps heat radiating from the earth toward space (IPCC, 2003, 2007, Oreskes, 2004., USGRP, 2009).

According to IPCC (2007), the rate at which energy is received from the sun and the rate at which it is lost to space determines the equilibrium temperature and climate of the earth. This energy is distributed around the globe by winds, ocean currents, and other mechanisms to affect the climate of different regions of the world (IPCC, 2007).

In its third assessment report, the IPCC (2007) argued that certain gases in the atmosphere block heat from escaping thereby contributing to the greenhouse effects. According to the report, gases that contribute to the greenhouse effect include:

i. Water vapour: Water vapour increases as the earth's atmosphere warms, but so does the possibility of clouds and precipitation, making these some of the most important feedback mechanisms to the greenhouse effect.

ii. Carbon dioxide (CO_2): Carbon dioxide is released through natural processes such as respiration and volcanic eruptions and through human activities such as deforestation, land use changes, and burning of fossil fuels. The report says that, humans have increased atmospheric CO_2 concentration by a third since the Industrial Revolution began.

iii. Methane: It is a hydrocarbon gas produced both through natural sources and human activities, including the decomposition of wastes in landfills, agriculture especially rice cultivation, as well as ruminant digestion and manure management associated with domestic livestock.

iv. Nitrous oxide: This is a powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

v. Chlorofluorocarbons (CFCs): These are synthetic compounds of industrial origin used in a number of applications, but now largely regulated in production and released to the atmosphere by international agreement for their ability to contribute to destruction of the ozone layer.

In this regard, IPCC (2007) reported that the consequences of changing the natural atmospheric greenhouse gases that are likely to be of effect on the environment indicates that earth will become warmer and some regions may welcome warmer temperatures, but others may not. Warmer conditions will probably lead to more evaporation and precipitation even though individual regions will vary, some becoming wetter and others dryer. The report also shows that, a stronger greenhouse effect will warm the oceans and partially melt glaciers and other ice thereby, increasing sea level. The ocean water will also expand if it warms, contributing further to sea level rise. Furthermore, some crops and other plants may respond favourably to increased atmospheric CO_2, growing more vigorously and using water more efficiently. At the same time, higher temperatures and shifting climate patterns may change the areas where crops grow best and affect the make-up of natural plant communities (IPCC, 2007).

Theoretically, Bello (2010) showed that, the causes of climate change could be grouped into the following:

(A) Astronomical causes

i. Changes in the precession of the equinoxes.

ii. Change in the eccentricity of the earths' orbit about the sun.

iii. Change in the obliquity of the plane of ecliptic.

(B) Terrestrial causes

i. Changes in the earths' topography as a result of lithosphere motions including sea-floor spreading and continental drift, continental uplift, and mountain building.

ii. Changes in atmospheric chemistry which could arise due to extrusive volcanic activities that could produce gaseous particulate emissions and thereby leading to the formation of layers of persistent stratospheric aerosols.

iii. Changes in snow and ice cover of the earth surface.

iv. Changes in distribution of lands and water surfaces.

(C) Extra-terrestrial causes

i. Variation in the amount of incident solar radiation (solar output).

ii. Variation in the absorption of solar radiation outside the earths' atmosphere.

(D) Causes due to human activities

i. Industrial and agricultural practices, including animal husbandry.

ii. Forest and grassland clearing and burning

iii. Lumbering, fuel wood and charcoal extraction

iv. Oil extraction, burning of fossil fuel, production of cement and all forms of quarrying and mining. Bello (2010) indicates that human activities contribute significantly to the current trend of global warming attributed to concentration of carbon dioxide and other anthropogenic greenhouse gases in the atmosphere.

2.1.2 Effects of climate change on agriculture

Considerable research work has been carried out on the effects of climate change on agricultural production. In its report, IPCC (2007) showed that global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and the interaction of these elements (IPCC,2007). These conditions determine the carrying capacity of the

biosphere to produce enough food for the human population and domesticated animals. IPCC (2007) argued that the overall effect of climate change on agriculture will depend on the balance of the effects.

2.1.2.1 Positive effects

Increase in temperature and carbon dioxide (CO_2) can be beneficial for some crops in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Rising CO_2 concentration in the atmosphere can have both positive and negative consequences. Increased CO_2 is expected to have positive physiological effects by increasing the rate of photosynthesis. Currently, the amount of carbon dioxide in the atmosphere is 380 parts per million (ppm) (IPCC, 2007). In comparison, the amount of oxygen is 210,000 ppm. This means that plants may be starved of carbon dioxide as the enzyme that fixes CO_2 also fixes oxygen in the process of photorespiration. The effects of an increase in carbon dioxide would be higher on C3 crops (such as wheat) than on C4 crops (such as maize), because the former are more susceptible to carbon dioxide shortage. The report also showed that increased CO_2 leads to fewer stomata developing on plants which leads to reduced water usage (IPCC, 2007).

Rises in temperature, for example, helps to grow crops in high altitude areas and towards the poles. In these areas, increase in temperature extend the length of the potential growing season, allowing earlier planting, early harvesting and opening the possibility of completing two crop cycles in the same season (Khannal, 2009). The warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms.

2.1.2.2 Negative effects

The Scientific Consensus on Climate Change suggests that, due to climate change, "the southern part of Africa could lose more than 30% of its main crops, especially maize, by 2030 (Oreskes, 2004). In South Asia, losses of many regional staples, such as rice, millet and maize could top 10%. The IPCC's third assessment report (2003) concluded that the poorest countries would be hardest hit with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidences. Also, in Africa and Latin America, many rain-fed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply for even small climate changes. Falls in agricultural productivity of up to 30% over the 21st century are projected (Oreskes, 2004). Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization. Marine life and the fishing industry will also be severely affected in some places (IPCC, 2003; Oreskes, 2004: IPCC, 2007).

IPCC (2003) also reported that climate change could affect agriculture in following ways:

i. productivity, in terms of quantity and quality of crops;

ii. agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers;

iii. environmental effects, in particular in relation to frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity;

iv. rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities; and

v. organisms may become more or less competitive, as well as humans may develop urgency to more competitive practices, such as flood resistant, salt-resistant varieties or drought-tolerant varieties.

As part of the IPCC's Fourth Assessment Report, Schneider *et al.* (2007) projected the potential future effects of climate change on agriculture. With low to medium confidence, they concluded that for about a 1 to 3 °C global mean temperature increase (by 2100, relative to the 1990–2000 average level) there would be productivity decreases for some cereals in low latitudes, and productivity increases in high latitudes. In the IPCC Fourth Assessment Report, "low confidence" means that a particular finding has about a 2 out of 10 chances of being correct, based on expert judgment and "medium confidence" has about a 5 out of 10 chances of being correct.

A study by Jatto (2013) suggests that climate change could cause farm outputs in sub-Saharan Africa to decrease by 12 percent by 2080 - although in some African countries, the decrease could be as much as 60 percent, with agricultural exports declining by up to one fifth in others. It was concluded that, adapting to climate change could cost the agriculture sector about $14 billion per year globally.

IPCC (2007) reported that low-lying areas such as Bangladesh, India and Vietnam will experience major losses of rice crop if sea levels rise as expected by the end of the century. Vietnam, for example, relies heavily on its southern tip, where the Mekong Delta lies, for rice planting. It was stated that, any rise in sea level of not more than a metre will drown several km^2 of rice paddies, rendering Vietnam incapable of producing its main staple and export of rice (IPCC, 2007).

The IPCC (2007) reported that weeds would undergo the same acceleration of cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most

weeds are C3 plants, they are likely to compete even more than now against C4 crops such as maize.

The process of nitrogen fixation, associated with greater root development is also predicted to increase in warmer conditions and with higher CO_2, if soil moisture is not limiting (FAO, 2007). The increased CO_2 levels lead to a positive growth response for a number of staples under controlled conditions also known as the carbon fertilizations effect (Mark et al. 2008). But when temperatures exceed the optimal level for biological process, crops often respond negatively with a steep drop in net growth and yield. Khannal (2009) stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop.

Global warming would cause an increase in rainfall in some areas, which would lead to an increased atmospheric humidity and the duration of the wet seasons (IPCC, 2007). Combined with higher temperatures, these could favour the development of fungal diseases. Similarly, because of higher temperatures and humidity, there could be an increased pressure from insects and disease vectors (IPCC, 2007).

In Africa, IPCC (2007) projected that climate variability and change would severely compromise agricultural production and access to food. This projection was assigned “high confidence”. It was reported that Africa's geography makes it particularly vulnerable to climate change, and seventy per cent of the population rely on rain-fed agriculture for their livelihoods (IPCC, 2007). For instance, Tanzania's official report on climate change suggests that the areas that usually get two rainfalls in the year will probably get more, and those that get only one rainy season will get far less. The net result is expected to be that there would be 33% less maize, the country's staple crop will be grown (IPCC, 2007).

Uncertainties in the onset of the farming season, due to changes in rainfall characteristics (early rains may not be sustained, and crops planted at their instance may become smothered by heat waves) can lead to an unusual sequence of crop planting and replanting which may result in food shortages due to harvest failure. Extreme weather events such as thunderstorms, heavy winds, and floods, devastate farmlands and can lead to crop failure (BNRCC, 2008).

In Northern Italy, a record yield drop of 36% was observed, while in France maize yield was reduced by 30% as result of climate change in the year 2002 (Easterling *et al.*, 2007). According to Easterling *et al.* (2007) weeds, like crops, show positive response to elevated carbon dioxide ($CO_{2)}$. Moreover, weeds show a larger range of responses, including larger growth, to elevated CO_2 because of their greater genetic diversity as affected by climate change. Several important crop weeds in the United States have expanded since the 1970s, which is consistent with climate trends (Easterling *et al.*, 2007). However, future weed distribution and the accompanying changes in weed–crop competition remain highly uncertain. Pests and crop diseases migrate in response to climate changes and variations (the tsetse fly has extended its range northward) and will potentially pose a threat to livestock in the drier northern areas. (BNRCC, 2008).

According to Easterling *et al.* (2007) and Gitay *et al.* (2001), climate change would impact on grain and forage quality of crops. For instance, in rice, the amylose content of the grain, a major determinant of cooking quality, is increased under elevated CO_2 (Easterling *et al.*, 2007). However, concentrations of iron and zinc, which are important for human nutrition, would be lower (Easterling *et al.*, 2007). Moreover, the protein content of the grain decreases under combined increases of temperature and CO_2 (Easterling *et al.*, 2007).

Studies (Easterling *et al.,* 2007;Oseni and Masarirambi ,2011) have shown that higher CO_2 levels lead to reduced plant uptake of nitrogen (and a smaller number showing the same for trace elements such as zinc), resulting in crops with lower nutritional value. This would primarily impact on populations in poorer countries less able to compensate by eating more food, more varied diets, or possibly taking supplements.

El Nino Southern Oscillation (ENSO) will affect monsoon patterns more intensely in the future as climate change warms up the ocean's water. Crops that lie on the equatorial belt or under the tropical Walker circulation, such as rice, will be affected by varying monsoon patterns and more unpredictable weather. Scheduled planting and harvesting based on weather patterns will become less effective (Oreskes, 2004).

Areas such as Indonesia where the main crop consists of rice will be more vulnerable to the increased intensity of ENSO effects in the future. A University of Washington professor, David Battisti, studied the effects of future ENSO patterns on the Indonesian rice agriculture using IPCC (2007) annual report and 20 different logistical models, mapping out climate factors such as wind pressure, sea-level, and humidity, and found that rice harvest will experience a decrease in yield. Bali and Java, which hold 55% of the rice yields in Indonesia, will likely experience 9–10% delayed monsoon patterns, which prolongs the hungry season. Normal planting of rice crop begins in October and harvest by January. However, as climate change affects ENSO and consequently delays planting, harvesting will be late and in drier conditions, resulting in less potential yields.

Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers. Meanwhile, warmer water temperatures are likely to cause the habitat ranges of many fish and shellfish species to shift, which could disrupt ecosystems. Climate change could make it more difficult to grow crops, raise animals,

and catch fish in the same ways and same places as usually done in the past (IPCC,2007).

In his study on the influence of climate change on maize production in Kenya, Bancy (2000) reported that the adverse effects of climate necessitated farmers to adopt the use of early-maturing cultivars and the practice of early planting of maize as a means to cope with hunger and poverty. A study by Oseni and Masarirambi (2011) on effect of climate change on maize production and food security in Swaziland revealed that 50% of the population of the country who planted maize experienced severe drought which resulted in crop losses of 2%. In the same study, rainfall cessation at critical stages of crops growth in the country led to about 21% drop in yield of crops, especially maize in Swaziland.

IPCC (2007) noted that pests and diseases can also depress crop and livestock production; and high temperatures with the current warming trend may hinder livestock production and reproduction by reducing animal weight gain, dairy production and feed conversion efficiency. Livestock are also usually subjected to long treks to find water and grass in the more southerly areas of the country during the dry seasons. In the years of drought in the Sahelian zone in the 1970s and1980s crop harvest failure was remarkable throughout the region (BNRCC, 2008). The situation led to the intensification of crop irrigation as a response mechanism. Flood hazards in both the north and south of the country consistently posed a danger to farmlands and hence, to food security.

According to IPCC (2007), climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production (IPCC, 2007). That is, socioeconomic factors, international competitions, technological

development as well as policy choices will determine the pattern and effect that agro-climatic changes will have on agriculture (Brussel, 2009). Khannal (2009) classified the patterns of effects of climate change on agriculture into biophysical and socio-economic effects. The biophysical effects include physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic effects include decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest (Khannal, 2009).

The developing world already contends with chronic poverty and food crisis. The estimate for Africa is that 25-42% of species habitat could be lost, affecting both food and non-food crops (Khannal, 2009). Habitat change is already underway in some areas, leading to species range shifts and changes in plant biodiversity which include indigenous foods and plant-based medicines. FAO (2007) reported that up to 11% of arable land could be highly affected by climatic change in the developing world. There will be a reduction of cereal production in 65 countries and retardation of about 16% of agricultural gross domestic product (GDP). A decrease of up to 30% in world food production due to effects of climate change on agriculture is generally predicted (IPCC 2007).

In Africa, climate change in some parts has altered the dynamics of drought, rainfall and heat waves, and triggered secondary stresses such as the spread of pests, increased competition for resources, the collapse of financial institutions, and attendant

biodiversity losses. In many parts of Africa it seems that warmer climates and changes in precipitation will destabilize agricultural production. This is expected to undermine the systems that provide food security (Gregory *et al.,* 2005). Whilst farmers in some regions may benefit from longer growing seasons and higher yields, the general consequences for Africa are particularly adverse for the poor and the marginalized that do not have the means to withstand shocks and changes.

Evidence from the IPCC suggests that areas of the Sahara are likely to emerge as the most vulnerable to climate change by 2100 with likely agricultural losses of between 2 and 7% of affected countries's GDP. Western and Central Africa are expected to have losses ranging from 2 to 4% and Northern and Southern Africa are expected to have losses of 0.4 to 1.3% (Mendelsohn *et al.,* 2000).

According to Bello and Isiguzo (1999), there has been persistent positive temperature anomaly at locations in the rainforest of Nigeria since 1990. Their report indicates that temperature increases at about 0.2-0.3^{0}C per decade in various locations of Nigeria. Also, Bello (1998) documented evidence of climate change based on rainfall records in Nigeria. He derived the indices of rainfall seasonality from 1930-1993 which show that there has been a decline in the rainfall regime in all the ecological regions of Nigeria. He reported that during this period, production of the major cereals and legumes fell drastically. In northern Nigeria, peanut harvest fell from 764,000 tonnes in 1968-69 to 25,000 tons in 1972-73 (Bello, 1988).

The negative effects of climate change on agricultural yields will be exacerbated by more frequent weather events. For example, Brussel (2009) stated that rising atmospheric CO_2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the

volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place. Climatic variations will have consequences for the availability of water resources, pests and diseases and soils leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, according to Brussel (2009), the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question.

According to Khannal (2009), the patterns of the effects of climatic change are, however, dependent on latitude, altitude, type of crop grown and livestock reared. Mark *et al.* (2008) highlighted some of the direct effects of climate change on the agricultural system as: (a) seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations; (b) alteration in evapo-transpiration (c) alteration in land suitability for agricultural production. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. However, when looking critically on plant production, the pattern of climate change has both positive and negative impacts.

Scenarios are used in order to estimate climate changes effects on crop development and yield. Each scenario is defined as a set of meteorological variables, based on generally accepted projections. For example, many models are running simulations based on doubled carbon dioxide projections, temperatures rise ranging from 1 °C up to 5 °C, and with rainfall levels an increase or decrease of 20%. Other parameters may include humidity, wind, and solar activity. Scenarios of crop models are testing farm-level adaptation, such as sowing date shift, climate adapted species (vernalisation need, heat

and cold resistance), irrigation and fertilizer adaptation, resistance to disease. Most developed models are about wheat, maize, rice and soybean.

2.1.3 Climate change adaptation and mitigation in developing countries

Climate change adaptation

Adaptation to climate change is a policy response to climate change that seeks to reduce the vulnerability of social and biological systems to climate change effects (Schneider *et al*., 2007). Thus, the capacity and potential for humans to adapt (called adaptive capacity) is unevenly distributed across different regions and populations (Schneider *et al*., 2007). Adaptation means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage it can cause, or taking advantage of opportunities that may arise. Adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts (Schneider *et al*., 2007).

The IPCC (2001) indicated that adaptation is the means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The panel argued that adaptation is the strengthening of coping capacities which usually builds resilience to withstand the effects of natural and human-induced hazards (IPCC, 2001). Examples of adaptation measures include: using scarce water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defences and raising the levels of dykes; developing drought-tolerant crops; choosing tree species and forestry practices less vulnerable to storms and fires; and setting aside land corridors to help species migrate (IPCC, 2007).

It has been argued that adapting to climate change would be a more effective means of dealing with global warming than reducing emissions of greenhouse gases. Adaptation is a necessary strategy because of the current and projected climate disruption precipitated by high levels of greenhouse gas emissions by the industrialized nations (Verbruggen, 2007). Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts because it is not certain that all climate change can be mitigated (Verbruggen, 2007). And indeed the odds are quite high that in the long run more warming is inevitable, given the high level of GHGs in the atmosphere, and the (several decade) delay between emissions and impact.

According to Klein *et al*. (2007), even the most effective reductions in emissions, however, would not prevent further climate change impacts, making the need for adaptation unavoidable (Klein *et al*., 2007). In a literature assessment, Klein *et al*. (2007) showed that, even if emissions are stabilized relatively soon, climate change and its effects will last many years, and adaptation will be necessary. Therefore, climate change adaptation is especially important in developing countries since those countries are predicted to bear the brunt of the effects of climate change (Klein e*t al*., 2007).

The Intergovernmental Panel on Climate Change (IPCC) (2007) has reported that agriculture is responsible for over a quarter of total global greenhouse gas emissions. Given that agriculture's share in global gross domestic product (GDP) is about 4 percent these figures suggest that agriculture is highly Green House Gas-intensive. Innovative agricultural practices and technologies can play a role in climate mitigation and adaptation. This adaptation and mitigation potential is nowhere more pronounced than in developing countries where agricultural productivity remains low; poverty, vulnerability and food insecurity remain high; and the direct effects of climate change

are expected to be especially harsh. Creating the necessary agricultural technologies and harnessing them to enable developing countries to adapt their agricultural systems to changing climate will require innovations in policy and institutions as well.

Lybbert and Sumner (2012) suggest some policy principles in relation to adaptation to climate change: (1) institutional responses to enhance information flow, incentive and flexibility; (2) policies and institutions that promote economic development and reduce poverty will often improve agricultural adaptation and may also pave the way for more effective climate change mitigation through agriculture; (3) business as usual among the world's poor is not adequate; (4) existing technology options must be made more available and accessible without overlooking complementary capacity and investments; (5) adaptation and mitigation in agriculture will require local responses, but effective policy responses must also reflect global impacts and inter-linkages, and (6) trade will play a critical role in both mitigation and adaptation, but will itself be shaped importantly by climate change (Lybbert and Sumner, 2012).

Climate change mitigation

Another policy response to climate change, known as climate change mitigation is to reduce greenhouse gas (GHG) emissions and/or enhance the removal of these gases from the atmosphere (through carbon sinks)(Verbruggen, 2007). Climate change mitigation are actions to limit the magnitude and/or rate of long-term climate change (Verbruggen, 2007). Climate change mitigation generally involves reductions in human (anthropogenic) emissions of greenhouse gases (GHGs) (Verbruggen, 2007).Examples of mitigation include switching to low-carbon energy sources, such as renewable and nuclear energy, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere.

2.1.4 Coping strategies against climate change in Nigeria

Coping strategy is an adjustment made to a human, ecological or physical system in response to a perceived vulnerability (IPCC, 2001). Specifically, IPCC (2001) described coping to climate change as adaptation in natural or human systems in response to actual or expected climatic stimuli and their effects which moderates, harms or exploits beneficial opportunities. Coping (adaptation) is an important component of climatic change effects and vulnerability assessment and is one of the policy options in response to climatic change impacts (Smith and Lenhart, 1996; Fankhauser, 1996). Adaptation to climatic change is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high because ability to adapt is low (Hassan and Nhemachena, 2008).

In agriculture, adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socio-economic conditions including climatic variability, extreme weather conditions such as droughts and floods and volatile short-term changes in local and large-scale markets (Kandlinkar and Risbey, 2000). Farmers can reduce the potential damage by making tactical response to these changes. According to Brussel (2009), adaptive measures to climatic change in agriculture range from technological solutions to adjustments in farm management or structures and to political changes such as adaptation plans. Barry and Mark (2002) categorized agricultural adaptation options into technological development, government programmes and insurance; farm production practices, and farm financial management. The first two categories are principally the responsibility of public agencies and agri-business and adaptation here could be thought of as system-wide or macro scale. The last two categories mainly involve farm level decision making by farmers.

The process of organic agriculture, being a holistic approach in climatic change adaptation, can be classified as two major kinds of modification in the production systems: (a) increased diversification and (b) protecting sensitive growth stages by managing the crops to ensure that these critical stages do not coincide with very harsh climatic conditions such as mid-season droughts (Hassan and Nkemechena, 2008). Under these two modification techniques, according to the authors, the adaptation strategies farmers perceive as appropriate include crop diversification using different crop varieties, varying the planting dates, harvesting dates, increasing the use of irrigation, increasing the use of water and soil conservation techniques, shading and shelter, shortening the length of the growing season and diversifying from farming to non-farming activities. Some strategies that serve as an important form of insurance against rainfall variability are: increasing diversification by planting crops that are drought- tolerant and/or resistant to temperature stresses, taking full advantage of the available water and making efficient use of it, and growing a variety of crops on the same plot or on different plots, thus reducing the risk of complete crop failure since different crops are affected differently by climate changes (Benhin, 2006). Such farm-level adaptations aim at increasing productivity and dealing with existing climatic conditions and draw on farmers' knowledge and farming experience.

Farmers developed and practised many adaptation strategies in the tropics peculiar to the impact of climate change in their localities. Jagtab (1995) identified adaptation options in relation to agricultural sector. These include crop diversification, mixed cropping, using different crop varieties, changing planting and harvesting dates and mixing less productive, drought varieties and high-yield water-sensitive crops.

Adesina *et al*. (2009) gave some indigenous adaptation strategies to climate variability by farmers. These include fall back on previous harvest, rainwater harvesting, diversification of livelihood and use of forecasts to prevent responding to a false start of the rains. Other measures adopted by farmers include; planting drought resistant crop varieties, social networking, migration to wetter region and to pray for rain.

In a study of impact of climate change and local adaptation strategies of various socio-economic groups in Isabella Northern Philippines among 10 farmers, Eileen (2009) reported that local climate change adaptation strategies of farmer respondents in Isabella among others were, planting other crops in-between cropping (3%) and use of organic fertilizer (4%). Organic fertilizers are cheaper than inorganic fertilizer, hence more affordable. Adjusting crop calendar was also a good option reported by farmers (3%). For example, farmers indicated that they usually plant the first crop in May and the second one in October. In recent years, however, typhoons hit the province in October and November every year. Other strategies such as no fertilizer input in order to lessen the amount of money at risk (2%), optimizing rice productivity, optimum use of fertilizer and other inputs (3%), planting of drought-resistant varieties of crops were also identified to be used by farmers in the region (1%). These adaptation strategies however, were used in complementary way.

In a study of climate change impact and adaptation in agricultural sector: the case of smallholder farmers in Zimbabwe, Mutekwa (2009) observed that the most popular adaptation strategies in Murowa ward included planting short season varieties, crop diversification and varying planting dates. The main thrust of these strategies is increased diversification and escaping sensitive growth stages through crop management practices that ensure that critical growth stages do not coincide with hash

climatic condition in the season, such as midseason droughts. Crop diversification improves household food security since different crops are affected differently by the same climatic condition. Also, given the high frequency of mid-season dry spells and shortening of the rainy season, farmers used short-season and drought-resistant crop varieties, for example, instead of planting local varieties of maize, farmers have opted for hybrid maize that takes a short period to mature and yields more than traditional varieties in good years.

Onyekale and Madukwe (2010) explored the adaptation measures used by crop farmers in the southeast rainforest zone of Nigeria to climate change and revealed that portfolio diversification was the most commonly used method as reported by 20% of the farmers. This strategy involves the use of improved crop varieties, intercropping and using different crop varieties that survive in adverse conditions. Other strategies used by the farmers included the use of soil conservation techniques (15%), changing planting dates (11.7%) and planting of trees (10%).

In a study of farmers' adaptation strategies and perception to climate change in Ondo State, Nigeria, Oyerinde and Osanyande (2010) reported that majority (68%) of the farmers interviewed changed planting and harvesting dates as an adaptation strategy against changes in the climate. Twenty- four percent (24%) reported that they used different crop varieties and two percent (2%) each reported changing from farming to non-farming and planting of trees, respectively. They further observed that farmers were using crop management practices that include the use of water and soil conservation techniques and varying planting and harvesting dates to ensure that critical and sensitive growth stages do not coincide with very harsh conditions in the season. It is important to

note that these adaptation strategies should not be taken as independent strategies but should be used in complementary way.

Deressa (2010) explored perception and adaptation to climate change in the Nile Basin of Ethiopia and reported that 58% of the farmers interviewed adapted in one way or the other to climate change. He further observed that the strategies used by the farmers include the use of irrigation (4%), planting of trees (21%), and early and late planting (21%). Other strategies included the use of different crop varieties (13%) the use of soil conservation techniques such as mulching, zero tillage and organic fertilizer application (15%). The use of different crop varieties as adaptation strategy could be associated with the less expensive and ease of access by farmers to new crop varieties that can withstand the new climatic events. However, the limited use of irrigation could be attributed to the needs for more capital and the low potential for irrigation in the region.

Adebayo *et al*. (2012) examined farmers' awareness, vulnerability and adaptation to climate change in Adamawa State, Nigeria. The results showed that about 30% of the respondents use seed-tolerant variety, while about 26% altered their planting schedule. Also, about 21% of the respondents' plant early maturing seed, about 12% used different tillage systems and about 11% diversify their crops. This study has revealed that farmers adapt different adaptive measures to minimize the effect of climate change in the area. Information from focused group discussion revealed that some farmers have switched over from guinea corn to sweet potatoes due to crop failure arising from early cessation.

Idrisa *et al*. (2012) studied the awareness and adaptation strategies to climate change among farmers in the Sahel Savanna zone of Borno State, Nigeria. Results on adaptation strategies practised by respondents revealed that farmers used irrigation to

augment shortfall of rains (5.33%), mulching/cover cropping (80.0%), planting deeper than usual (37.78%), planting ahead of rains (97.78%), intensive manure application (66.67%) and planting crop varieties tolerant to climate change (73.33%).

Anyola *et al*. (2013) examined socio-economic factors influencing climate change adaptation among crop farmers in Umuahia South Area of Abia State, Nigeria and observed that farmers practised tree planting (13.3%), cultivation of early-maturing crop (73.3%), mixed farming (76.7%) and use of improved crop varieties (21.7%). Other adaptation strategies practised include increased use of family labour (11.7%), diversification of livelihood (1.7%), cover cropping (90%), change in planting and harvesting dates (45%), irrigation practice (2.5%), crop rotation (15.8%) and river side/bank cultivation (7.5%).

In a study in Imo and Enugu States in Southeastern Nigeria, Hassan and Nkemechena (2008) found that one of the appropriate adaptation strategies by farmers is shading and shelter, which can only be provided through agro-forestry and afforestation. Agro-forestry and afforestation may have become particularly needed because of the prevailing predominance of dry periods, accompanied with heat waves, erratic rainfall, thunderstorms and floods/erosion.

At farm level, the practice of organic agriculture is one of the most important measures for adaptation to climate change by farmers. Organic agriculture, according to IFOAM (2007), is a holistic production management system which enhances agro-ecosystem health, utilizing both traditional and scientific knowledge. It prevents nutrient and water loss through high organic matter content and soil covers, thus making soils more resilient to floods, drought and land degradation processes. In organic agriculture, soil fertility is maintained mainly through farm internal inputs (organic manures,

legume production, wide crop rotation), rejection of energy-demanding synthetic fertilizers and plant protection agents with less or no use of fossil fuel (FAO, 2008).

Kurukulasurya and Rosental (2003) noted that the short-term adaptation measures for climate change by farmers include crop insurance for risk coverage, crop/livestock diversification to increase productivity and protection against diseases, adjusting the timing of farm operations to reduce risks of crop damage, change crop intensity and adjust livestock management to new climatic conditions, food reserves and storage as temporary relief, changing cropping mix, permanent migration to diversify income opportunities, defining land use and tenure-rights for investments. On a long term note, the authors stated the following as best adaptation options for climate change: development of crop and livestock technology adapted to climate change stress, develop market efficiency, irrigation and water storage expansion, efficient water use, promoting international trade, improving forecasting mechanisms, institutional strengthening and decision-making structures.

Brussel (2009) highlighted the possible short- to medium-term adaptation practices to changes in climate by farmers to include:

i. adjusting the timing of farm operations such as planting or sowing dates and treatments;

ii. technical solutions such as protecting overheads from frost damage or improving ventilation and cooling systems in animal shelters;

iii. choosing crops and varieties better adapted to the expected length of the growing season and water availability and more resistant to new conditions of temperature and humidity;

iv. adapting crops with the help of existing genetic diversity and new possibilities offered by biotechnology;

v. improving the effectiveness of pest and disease control through, for instance, better monitoring, diversified crop rotations, or integrated pest management methods;

vi. using water more efficiently by reducing water losses, improving irrigation practices and recycling or storing water;

vii. improving soil management by increasing water retention to conserve soil moisture and landscape management such as maintaining landscape features, providing shelter to livestock;

viii. introducing more heat-tolerant livestock breeds and adapting diet patterns of animals under heat stress conditions. Individually or the combination of these adaptation practices by farmers have substantial potential to counterbalance adverse climatic changes and to take advantage of positive ones.

The recurring droughts in the northern part of Nigeria provide a continuous challenge to agricultural production and particularly maize production which has necessitated the adoption of some drought-tolerant maize varieties cultivated in the areas. Studies by Bamire (2007) on community assessment for the drought-tolerant maize for Africa project in the dry savanna of Nigeria showed that 80% of the farmers in Kano and Katsina States Nigeria have adopted the use of improved open-pollinated varieties (OPVs) as a measure to cope with drought in the area.

In their studies on coping strategies of small arable farmers to climate change in Ogun state, Nigeria, Agbonlahor and Ashaolu (2011) revealed that arable crop farmers

adopted the practices of late planting, reduction in the length of the cropping cycle, involvement in off-farm activities and change in cropping mixtures as measures to cope with the adverse effects of climate change on arable crop production. Other measures highlighted in their study included intensification of dry season farming using *fadama* (low-lying flood plains) resources and the adoption of delayed planting as a means of reducing the negative effects of climate change on crop production.

Concerted efforts have been made worldwide, particularly in Nigeria, by both governments and researchers to combat the menace of climate change. Efforts worth mentioning include: provision of funds for sustainable climate policies and development of sustainable technologies by the Swiss Agency for Development and Cooperation (SADC) and the European Union (EU) launched in 2008 and disseminated by the Food and Agriculture Organization (FAO), International Institute for Sustainable Development (IISD) and promoted by the United Nations Communication Group (UNGC) task force on climate change.

In Nigeria, the Farmer Field School System and the Songhai Farms offer additional channels for promoting knowledge transfer and adoption of the technologies known as "Climate-smart Agricultural Technologies". The Climate-smart technologies or practices available in smallholder agricultural production are crop management, livestock management, soil and water management, agro-forestry, integrated food energy systems (intercropping with legumes, crop rotations, drought-resistant varieties, improved storage and processing techniques), greater crop diversity, improved feeding strategies, rotational grazing, fodder crops, grassland restoration and conservation, manure treatment, improved livestock health, animal husbandry improvements, minimum tillage, contour planting, terraces and bunds, planting pits, water storage,

alternate wetting and drying (rice), dams, pits, ridges, improved irrigation, for example, drip, boundary trees and hedgerows, nitrogen-fixing trees on farm, multipurpose trees, improved fallow with fertilizer shrubs (NEST, 2004; FAO, 2011).

This study intends to focus on the technologies promoted by the Agricultural Research Council of Nigeria (ARCN) and the Centre for Climate Change and Fresh Water Resources, Federal University of Technology, Minna. The technologies include the use of afforestation, use of improved crop varieties, conservation tillage, optimum use of organic matter, mixed farming, crop rotation and water harvesting as a means of checking the menace of climate change in Nigeria.

2.2 Economic Importance of Maize

Maize is one of the main cereal crops of West Africa, and the most important cereal food crop in Nigeria (NARSP, 1997). Maize is becoming the miracle seed for Nigeria's agricultural and economic development. It has established itself as a very significant component of the farming system and determines the cropping pattern of the predominantly peasant farmers, especially in the Northern States (Ahmed, 1996). Maize has been of great importance in providing food for man, feed for livestock and raw materials for some agro-based industries. It is a basic staple for large population groups, particularly in developing countries (FAO and ILO,1997).

Maize or corn is a cereal crop that is grown widely throughout the world in a range of agro-ecological environments. More maize is produced annually than any other grain. About 50 species exist and consist of different colours, textures and grain shapes and sizes. White, yellow and red are the most common types. Maize was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops (FAO and ILO, 1997).

Worldwide, production of maize is 785 million tones, with the largest producer, the United States, producing 42%. Africa produces 6.5% and the largest African producer is Nigeria with nearly 8 million tons (FAO, 2007). Africa imports 28% of the required maize from countries outside the continent. Most maize production in Africa is rain fed. Irregular rainfall can trigger famines during occasional droughts. According to FAO (2007) estimates, about 158 million hectares of maize are harvested worldwide. Africa harvests 29 million hectares, with Nigeria as the largest producer in Sub-Saharan Africa (SSA), followed by Tanzania (FAO, 2007).

Maize is hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn syrup, a sweetener and in some cases, fermented and distilled to produce grain alcohol which is traditionally the source of bourbon whisky (Doebley, 1994). Sweet corn is a genetic variation that is high in sugars and low in starch that is served like a vegetable. Another common food made from maize is cornflakes. Maize is used as meal pap in Africa. Corn bread is also made from maize. Doebley (1994) reported that maize can be boiled or roasted on the cob, the grains can be cooked fresh or dry and the dry grain can be made into pop-corn *(guguru*) and eaten with roasted groundnuts. About 80% is consumed by man and animals, while 20% is utilized in a variety of industrial processes for production of starch, oil, fructose, corn sweetener and ethanol. Maize consists of 71% starch, 9% protein and 4% oil on a dry weight basis (Doebley, 1994).

Most recently, studies (Ogunsumi *et al*., 2005.; Oni *et al*., 2011) show that maize is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in SSA and Latin America. All parts of the crop can be used for food and non-food products. In industrialized countries, maize is largely used

as livestock feed and as a raw material for industrial products. Maize accounts for 30−50% of low-income household expenditures in Eastern and Southern Africa. Like many other regions, it is consumed as a vegetable, although it is a grain crop. The grains are rich in vitamins A, C and E, carbohydrates, and essential minerals, and contain 9% protein. They are also rich in dietary fiber and calories which are a good source of energy.

As one of the most important cereal crops in SSA and in Nigeria, it plays a vital role in the Nigerian economy. According to Oni *et al*.(2011).The maize production sector provides employment for about 70 million people in the country. The industrial uses of maize base on the physical properties of the cobs when grinded to powder are used in the manufacture of plastics, glues, adhesives, rayon, resin, vinegar, artificial leather and as diluents and carrier in the formulations of pesticides (Adebayo, 2004). According to Adebayo (2004), based on the chemical properties, the processed cobs are used in the manufacture of furfurol, fermentable sugar, liquid fuel, pulp, paper, hard boards, charcoal gas and other gasses through destructive distillation. Ojo (2000) also observed that the water in which the maize grains are soaked for the manufacture of glucose is used for growing penicillin mould.

Another field where maize finds extensive use is for livestock and poultry feed. The yellow maize has a high content of carotene which is considered to be very important in the formation of yellow colour to egg yolk and yellow tinge to milk. The chaff of the grain can be used for feeding livestock and can also be mixed as an energy supplement in poultry feed (Ogunsumi *et al*., 2005).

Worldwide consumption of maize is more than 116 million tonnes, with Africa consuming 30% and SSA 21%. However, Lesotho has the largest consumption per

capita with 174 kilogram per year. Eastern and Southern Africa uses 85% of its maize production as food, while Africa as a whole uses 95%, compared to other world regions that use most of its maize as animal feed (Ogunsumi *et al*., 2005).

Ninety percent of white maize consumption is in Africa and Central America. It fetches premium prices in Southern Africa where it represents the main staple food. Yellow maize is preferred in most parts of South America and the Caribbean. It is also the preferred animal feed in many regions as it gives a yellow color to poultry, egg yolks and animal fat (Ogunsumi *et al*., 2005).

Maize is processed and prepared in various forms, depending on the country. Ground maize is prepared into porridge in Eastern and Southern Africa, while maize flour is prepared into porridge in West Africa. Ground maize is also fried or baked in many countries. In all parts of Africa, green (fresh) maize is boiled or roasted on its cob and served as a snack. Popcorn is also a popular snack.

Maize has evolved in Nigeria from a backyard crop in the 1970s to a commodity that is third in importance to sorghum and millet, in terms of output and area cultivated (Phillip, 2001). The expansion of maize production over time may reflect positive domestic supply response since the mid-1980s to selective macroeconomic policies of government, including the import ban on some cereals (Phillip *et al.* 2000). Other factors have been equally significant. First, is the development, through collaborative research, of fertilizer-responsive and early-maturing open-pollinated and hybrid varieties (IITA 1990). Second, is the enhanced adoption of maize-growing and maize-related technologies through the vigorous extension activities of the World Bank–assisted Agricultural Development Projects (ADPs). Third, maize has emerge as a major substitute industrial raw material following the on the importation of most cereal grains

in the 1980s. And the fourth factor has been the prolonged concessional pricing of fertilizers which represent the critical input in maize production (Philip *et al*. 2000). Due to the declining fertility nature of tropical soils as a result of high use of chemical fertilizers, it has become the critical input in maize production in most parts of Nigeria resulting to prolonged concessional pricing of the commodity (IITA 1990). The subsidy on fertilizer procurement, distribution, and pricing averaged over 70 percent per annum during most of the period before the mid-1990s (IITA 1990). Presently, some of the subsidy elements are still retained. And fourth is the relative ease of transporting and storing maize grains.

Several years of research have been undertaken in Nigeria on maize by IITA and NARIs toward varietal development in relation to fertilizer response, early maturity, and resistance to pests, diseases, and parasites in Nigeria (Phillip, 2001). Much of the research work has occurred in the Northern Guinea savannah areas, perhaps due to the proven high-yield potential in this agro-ecology (Phillip, 2001). The adoption of research programmes on maize have diffused slowly through the years and over many smallholders and consumers hence the problems of fluctuating output and yield per hectare of maize in Nigeria.

2.3 Background to Adoption Studies

Majority of early research on the diffusion and adoption of agricultural innovations was done in the United States, particularly in the Midwestern land-grant universities (Arokoyo, 1981). Prior to 1960, research in this area in the developing countries was insignificant. Arokoyo (1981) observed that out of the 405 empirical studies completed before 1965 only 9.3 percent was done in the third world countries. Atala (1980) and Arokoyo (1981) revealed that the frequency of research on adoption and diffusion of technologies increased until about 1986 and has since taken a downward trend.

Although the early diffusion adoption research studies covered such diverse fields as communication and marketing, rural sociology, anthropology, education, industry, and the medical sciences, the major bulk of the studies have come from the rural sociology discipline (Atala, 1980; Arokoyo, 1981). It should be pointed out, however, that the rural sociology work on the diffusion and adoption of innovations is traceable to two significant antecedents namely: the felt need of the newly established United States cooperative extension service in 1914, to evaluate its activities in terms of changed behaviour of farmers as a measure of their adoption of the farm practices recommended by the extension service; and secondly, the work of anthropologists interested in investigating the spread of cultural traits between different cultural groups (Arokoyo, 1981).

There is no doubt that a voluminous body of literature exists in the area of diffusion and adoption of innovations. Rogers (1995), in his bibliography on the diffusion of innovations, listed over a thousand studies. The diffusion and adoption of an innovation is a multidisciplinary theory of planned social change which is brought about by the spread of new ideas, practices or technologies through a social system (Rogers, 1995). The classical diffusion-adoption theory is made up of two components (i) the diffusion process and (ii) the adoption or innovation-decision process (Atala, 1980). The distinction made between adoption and diffusion of innovations concepts is that adoption is a micro concept referring to the acceptance of an innovation by a single unit of a potential audience. Diffusion, on the other hand, is a macro concept referring to the spread of innovation through the whole of the potential audience, market or social system (Atala, 1980).

2.3.1 The diffusion process

According to Rogers and Shoemaker (1971), the diffusion process comprises four critical elements: (i) the innovation, which is defined as an idea, practice or technology that is perceived as new by an individual; (ii) its communication through various channels,(iii) over time, (iv) among members of a social system. Thus, the process involves the transmission of information about a technology from an originating source to the ultimate or potential users. Ray (2001) argued that adoption is a decision-making process, in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision-making is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of a new idea, and to confirmation of the decision (Ray, 2001). According to Ray (2001), the conventional adoption framework further simplifies the analysis of the adoption decision by its implicit assumption of an individual "decision-maker." Within the farm household, the ability to make decisions regarding resource use and technology varies according to age, gender, education and other socio-economic categories. Actual decisions can depend on a complex bargaining process among household members. Beyond the household, group processes and the ability to harness them can also play a crucial role in adoption decisions, particularly on conservation practices (Ray, 2001). Moreover, decisions about new technology are frequently prompted by an intervention in the form of a project (Cramb, 2003).

2.3.2 The adoption or innovation-decision process

A farmer's decision about whether to adopt or reject a recommended agricultural practice has been conceptualized and analyzed by researchers to occur over a period of time in terms of a logical sequence of stages rather than instantaneous (Atala,

1980;Arokoyo,1981). The adoption process was postulated by the North Central Rural Sociology Sub-committee in the United States of America for the study of farm practices as consisting of five stages(Atala, 1980;Arokoyo,1981):

i. Awareness stage: Whereby an individual becomes aware of the existence of an innovation but lacks information about it.

ii. Interest stage: The individual develops an interest in the innovation and actively seeks additional information about it.

iii. Evaluation stage: The individual makes a mental trial of the innovation relevant to his own present anticipated personal situations, weighs alternatives and then decides whether or not to try the innovation.

iv. Trial stage: Based on the individual's judgment of the worth of the innovation, he actually tries and applies the new idea or practice on a small scale to determine the relevance and usefulness of the innovation for a practical evaluation.

v. Adoption stage: Based on the individual's mental or practical evaluation, he makes a final decision to use on a continued basis and in full scale or reject the innovation.

The adoption-process can, therefore, be defined as the acquisition and processing of information about an innovation followed by a behavioural change. This refers to the mental process through which an individual passes from first knowledge of an innovation to a decision to adopt or reject (Rogers and Shoemaker, 1971). The five-stage adoption process model has, however, been criticized as too simplistic and that,

under certain conditions, stages may be skipped in the process because of the following deficiencies:

i. The model views the process as always ending in adoption whereas in reality rejecting may be the final decision

ii. The lockstep approach gives the impression that the steps always occur in the process simultaneously. It is agreed that evaluation actually occurs throughout the process rather than forming a stage in the model.

iii. It has been discovered that the process rarely ends with adoption, as there is always a further information seeking to confirm or reinforce a decision which may lead to a different outcome (Rogers and Shoemaker, 1971).

Rogers and Shoemaker (1971) have advanced the "innovation-decision process" which is conceptualized as consisting of four rather than five stages:

Knowledge: the individual is exposed to the innovation's existence and gains some understanding of how it functions.

Persuasion: the individual forms a favourable attitude or persuaded towards acceptance of the innovation

Decision: the individual engages in activities which lead to a choice to adopt or reject the innovation.

Confirmation: the individual seeks reinforcement for the innovation-decision he has made, but he may reverse his previous decision if exposed to conflicting messages about the innovation. For instance, a farmer may decide to discontinue a practice which he had previously adopted on acquiring more information about the practice. Rogers and

shoemaker (1971) defined "discontinuance" as a decision to cease use of an innovation after previously adopting it."

2.3.3 Importance of adoption studies

The importance of adoption studies includes quantifying the number of technologies adopted by users over time to assess impacts or determine extension requirements; to provide information for policy reform and to provide a basis for measuring impacts (Langyintuo and Mulugeta (2005). The sociological research on the diffusion of agricultural innovations originated in the United States in 1920s when the United States Department of Agriculture decided to evaluate the process of its programme of introducing improved farming practices among farmers (Langyintuo and Mulugeta, 2005). This sociological research on the diffusion of agricultural innovations grew rapidly in the 1950s and 1960s in the United States, and influenced the beginnings of similar studies in other countries. Agricultural technology adoption among development economists has attracted considerable attention as the majority of the populations of less developed countries derive their livelihood from agricultural production and a new technology apparently offers opportunities to increase production and productivity (Feder *et al.*, 1985; Gollin *et a*l., 2005). Abebe (2007) also showed that adoption and diffusion of innovation research was high during the 1960s in less developed countries (LDCs). This is because the ministries of agriculture saw the need for large numbers of farmers to use the results of scientific agriculture in order to prevent famine.

2.3.4 Review of empirical studies on adoption

A number of empirical studies on adoption of different technologies by different researchers (Arokoyo, 1981., Atala, 1980., Feder *et al*. 1982., Voh,1979., Akpoko and Yiljeb, 2002) considered explanatory variables that includes personal, socio-economic, technological and institutional. They argued that variables that are significant in some

studies are not necessarily significant in other studies. This is mainly due to the difference in personal, socio-economic and institutional affiliations, geographical location, technological attributes and socio-cultural nature of the society (Arokoyo, 1981). Also the adoption of an improved practice by a farmer may be necessarily based on his/her capacity to acquire and absorb information about new techniques and on his/her capacity to convert this knowledge to practice (Arokoyo, 1981).

In his exploratory study of factors associated with adoption of recommended farm practices among Giwa farmers, Voh (1979) found level of formal education, level of literacy, size of household, urban contact, contact with various sources of extension and advice, socio-economic status, leadership role, empathy, and additional occupation of farmers to be significantly related to adoption. Number of farm sites, age and decision-making on farm matters were however not significantly related to adoption.

Arokoyo (1981), in his study on the diffusion and adoption of recommended agricultural practices among farmers in the Northern States of Nigeria, found that extension service exposure, farmers' perception of the relevance of recommended practices, socio-economic status and profitability of products influenced adoption of the agricultural practices.

Akinwumi and Zinnah (1992), in their study of technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone found that participation in on-farm tests, contacts with extension agents, farm size, and farming experience were significant in explaining adoption decisions except age which was not significant among the socio-economic and institutional variables.

Akpoko and Yiljep (2002), in their study on the utilization and impact of treadle pump technology in the arid and semi-arid zones of Nigeria, found that, age, house-labour

capacity, education, farming, treadle pump ownership, extension contact, farm size and credit significantly influenced the adoption of treadle pump technology.

Akpoko and Yiljep (2002), in another study on literature review and socio-economic analysis of seed and fertilizer availability and utilization in hybrid maize production under the Nigerian deregulated marketing and subsidy withdrawal policy, found that, extension contact, timeliness of acquisition of fertilizer, ability to purchase desired quantities of fertilizer, attitude to cost of fertilizer, and attitude to yield of hybrid seed affected farmers' decision to adopt hybrid maize production. Availability of fertilizer, attitude to quantity of fertilizer, distance from source of fertilizer did not however exert significant influence on adoption.

Akpoko (2003), in his study on evaluation of the adoption of small plot adoption technique and its impact on agricultural production in south-east and south-west zones of Nigeria, found that age, off-farm income and farm size significantly influenced adoption of the technique. Education, years of farming experience, and family income did not.

Cramb (2003) in his study of factors affecting the successful adoption of new technologies by small-holders in Canberra found age, education, household size, farm size, tenure status of the farm, availability of cash or credit for farm investment, access to markets for farm produce to be associated with adoption.

The study of Doss *et al*. (2003) on adoption of maize and wheat technology for entrepreneurial innovation by farmers in Eastern Africa showed that awareness of the technologies' benefits, favourable attitude towards the innovation, possession of economic means to acquire the innovation and the physical availability of the innovation influenced adoption of maize and wheat technologies.

Tesfaye's (2004) study on adoption of in-organic fertilizer on maize in Amhara, Oromia, and southern regions of Ethiopia found that farm experience, access to credit, use of improved crop varieties, use of farm yard manure, family size, level of education and total farm size significantly influenced adoption of chemical fertilizer.

Mesfin (2005) studied farmers' perception of the yield superiority of triticale (hybrid cereal) of wheat and maize in Farta district of Ethiopia. The study found that distance to all-weather-road and market centres, non-farm income and investment cost influenced farmers' adoption decision of triticale significantly.

Adewumi *et al*. (2005) in their study of adoption of agricultural technologies for commercial arable crop farming in Nigeria found that government, land clearing, food processing and storage, development of grain silos, enabling economic policy, adequate funding of research and development, provision of adequate engineering infrastructures, provision of credit facilities and subsidies significantly influenced adoption of agricultural technologies among farmers in Nigeria.

The study of Ebojei *et al*. (2012) on socio-economic factors influencing adoption of hybrid maize production technologies, in Giwa Local Government Area of Kaduna State of Nigeria showed that adoption of maize production technologies were significantly influenced by the farmers' household socio-economic variables such as age, income education and extension contact.

Idrisa *et al*. (2012) in their study on analysis of awareness and adaptation to climate change among farmers in the Sahel savannah agro-ecological zone of Borno State of Nigeria found socio-economic factors like farm size, farming experience, better yields, income and availability of improved seeds had significant impact on the adoption of improved farming technologies.

Fadare *et al*. (2014) in their study on factors influencing adoption decisions by maize farmers found that farmers' education, farm size, fertilizer usage, and access to extension service exerted significant influence on adoption decisions by maize farmers in Nigeria.

2.4 Constraints to Adoption of Climate Change Adaptation Strategies

Arokoyo (1981) in his study on the diffusion and adoption of recommended agricultural practices among farmers in Northern States of Nigeria found that, the factors hindering the adoption of the recommended practices were lack of capital, lack of sufficient labour, unavailability of inputs, lack of credit, lack of awareness, lack of marketing and storage facilities, lack of government incentives, natural disasters (weather, pests and diseases) and recommended practices not superior to local.

Akpoko and Yiljep (2002), in their study on the utilization and impact of treadle pump technology in the arid and semi-arid zones of Nigeria, found the constraints to the use of the technology to include frequent breakdowns (19.3%), high energy requirement (9.6%), non-availability of treadle pump technology (9.3%), inadequate spare parts (7.1%), riskiness of treadle pump technology (5.8%), high skill requirement (2.6%), difficulty to operate treadle pump (2.6%), and difficulty to maintain treadle pump (2.6%).

Oyerinde and Osanyande (2010), in their study on farmers' adaptation strategies in Idanre forest Ondo State of Nigeria, found that barriers to adoption of adaptation options were lack of credit, lack of information concerning climate change forecasting; rationing of inputs and lack of seed resources.

In a study of farmers' perception and adaptation to climate change in the Nile basin of Ethiopia, Deressa (2010) found that lack of information pertaining climate change, lack

of money, shortage of labour and land and poor potential for irrigation were the major constraints to adoption experienced by farmers.

Onyeneke and Madukwe (2010) in a study of adaptation measures by crop farmers in the southeast rainforest zone of Nigeria to climate change found that most of the constraints to adoption of adaptation measures to climate change were associated with poverty, lack of information on adaptation to climate change, lack of money, unavailability of necessary resources and technologies which assist to adapt to climate change, as adaptation to climate change is costly, limited understanding of the nature and consequences of climate change, farm members' health status, unemployment and poor rural infrastructure.

Ozor and Cynthia (2010) analysed the constraints in adoption of adaptation strategies to climate change by farmers in Enugu State of Nigeria. The most difficult challenges faced by farmers were lack of improved agricultural technologies, low adaptive capacities and unsuitable agricultural practices.

Nzeadibe *et al.* (2011) studied farmers' perception of climate change governance and adaptation constraints in Niger Delta region of Nigeria and found inadequate information, low awareness level, poor government attention to environmental issues and lack of access to improved crop varieties as the major constraining factors to climate change adaptation in the region. Other constraints identified include ineffectiveness of indigenous methods, limited knowledge on adaptation measures, low institutional capacity and absence of government policy on climate change.

CHAPTER THREE

3.0 THEORETICAL FRAMEWORK

3.1 Adoption of Innovation Theory

This study is guided by the adoption of innovation theory. Rogers (1983) defined adoption of innovation as the mental process through which an individual passes from first hearing about an innovation to the final adoption or rejection. Rogers and Shoemaker (1971) defined adoption as a decision to make full use of new ideas as the best course of action available. The decision whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, economic and social factors. According to Dasgupta (1989), the term adoption is the continued use of a recommended idea or practice by individuals or groups over a reasonably long period. Ban and Hawkins (1996) also defined technology adoption as a decision to apply an innovation and to continue to use it.

Feder *et al.* (1985) defined adoption as the degree of use of a new technology when a farmer has full information about the technology and its potential. According to Feder *et al*. (1985), they classified adoption into individual and aggregate adoption, according to its coverage. Individual adoption refers to the farmers' decision to incorporate a new technology into the production process. Aggregate adoption, on the other hand, is the process of diffusion of a new technology within a region (community) or population.

Adoption is also viewed as a variable representing behavioural changes that farmers undergo in accepting new ideas and innovations in agriculture. The term behavioural change refers to desirable change in knowledge, understanding and ability to apply technological information, changes in feelings such as interest, attitudes, aspirations, values and the like; and changes in overt abilities and skills (Ray, 2001).

Adoption is the final stage of the adoption process which is characterized by the large-scale and continuous use of technology (Ogunbameru, 2001). This is possible because there is a perceived satisfaction with the adoption of the technology. Thus, the adoption process consists of hearing about a new technology, learning more about it, mentally applying it to one's situation, trying it on a limited scale, and making the final decision to adopt or not to adopt.

Research into adoption process, rate or level is an attempt to get feedback on the effectiveness of the extension service. Ogunbameru (2001) noted that the number of farmers adopting a recommended technology is often used as an indicator of the effectiveness of the extension service. However, it is a presumption that farmers will adopt any improved and proven agricultural technology that is communicated to them.

The adoption pattern to a technological change in agriculture is not uniform at the farm level. It is a complex process, which is governed by many socio-economic factors, the farmers' socio-psychological system and their degree of readiness and exposure to improved practices and ideas (Ogunbameru, 2001).

The decision to adopt usually takes time. People normally do not adopt a new practice or idea as soon as they hear about it (Rogers, 1995; Ogunbameru, 2001). They appear to go through a series of distinguishable stages. These are:-

i. Awareness-At the awareness stage, a person first learns about a new idea, product, or practice. He/she has only general information about it. He/she knows little or nothing about any special qualities, its potential usefulness, or how it would likely work for him/her.

ii. Interest- At this stage the farmer develops an interest in the new thing that he/she has learned about. He/she is not satisfied with mere knowledge of its existence. He/she wants more detailed information about what it is, how it is, how it will work, and what it will do. He/she is willing to listen, read, and learn more about it, and is inclined to actively seek the information desired.

iii. Evaluation- At this stage, a person weighs the information and evidence accumulated in the previous stages in order to decide whether the new idea, product, or practice is basically good, and whether it is good for him/her. In a sense, he/she reasons through the pros and cons mentally, and applies them to his /her situation. Perhaps this stage could very well be referred to as the `mental trial stage`. To be sure, evaluation is involved at all stages of the adoption process, but it is at this stage that it is most in evidence and perhaps most needed.

iv. Trial- At this stage, the individual is confronted with a distinctly different set of problems. He/she must actually put the change into practice. The usual pattern of acceptance is to try a little at first and then to make large-scale use of it if the small-scale experiment process is successful.

v. Adoption - At this stage a person decides that the new idea, product, or practice is good enough for full scale and continued use.

According to Rogers (1983; 1995), agricultural technology has its own factors as perceived by farmers, which affect its adoption by a given society. These factors are (1) relative advantage;(2) compatibility;(3) complexity;(4) trialability; and (5)observability. Byerlee *et al*. (1986), cited in Getachew (1993), argued that the adoption patterns of a particular component is a function of five characteristics, namely(1) profitability;(2)

riskiness;(3) divisibility;(4) initial capital requirements;(5) complexity; and (6) availability of the technology. The perceived attributes of a technology that influence adoption show that potential adopters judge the technology based on their perceptions with regard to five attributes of the technology (Rogers, 1995; Ogunbameru, 2001). These attributes are: trialability, observability, relative advantage, complexity, and compatibility. The adoption theory holds that a technology will experience an increased rate of diffusion if the potential adopters perceive that the technology: (i) can be tried on a limited basis before adoption; (ii) offers observable results; (iii) has an advantage relative to other innovations (or the status quo);(iv) is not overly complex; and (v) is compatible with existing practices and values. The theory of perceived attributes of a technology has been used as a theoretical basis for several studies relevant to the field of instructional technology (IT). Perceptions of compatibility, complexity, and relative advantage have been found to play a significant role in several IT-related adoption studies. Ogunbameru (2001) highlighted some characteristics of a technology that can arouse farmers' interest to adopt.

However, Rogers (1995) contended that the adoption of a particular component of a technology depends on the innovation-decision process and he classified the process into five functions. These are:-

i. Knowledge- The function in which an individual is exposed to the innovation's existence and gains some understanding of how it performs.

ii. Persuasion- The function in which an individual forms a favourable or unfavourable attitude towards the innovation.

iii. Decision - At this function, an individual engages in activities that lead to a choice to adopt or reject the innovation.

iv. Implementation- It is a function in which an individual puts the decision (adoption or rejection) into practice.

v. Confirmation - It is a function in which an individual seeks reinforcement for the innovation decision made. At this stage the individual may reverse his/her decision if conflicting ideas about the decision occurred.

According to Ogunbameru (2001), the perceived attributes of a technology can also influence its adoption. Rogers (1995) indicated that potential adopters judge the technology based on their perceptions with regard to five attributes of the technology. These characteristics include: (i) relative advantage over the existing technologies (ii) must be appropriate within the absorptive and managerial capacity of the individual ultimate users; (iii) the technology also must not depart radically from the current practices of farmers (iv) must not increase farmers' risks in terms of costs and (v) it must be adaptable to the local environment it serves. These factors are said to affect the adoption of any technology in a given society (Ogunbameru, 2001). In relation to the aforementioned, Ogunbameru (2001) argued that all innovations or (technologies) that are new do not have equal potential for farmers' acceptance. Those which are relatively simple and compatible with previous experience are adopted more quickly than more complicated or complex ones.

Jary and Jary (2000) and Wikipedia (2011) summed up the characteristics of a technology that determines farmers' adoption of it as technological determinism. Technological determinism points to technology as being the force which shapes society and a determinant factor in technology adoption. Technological determinists hold that, like the weather, technology is autonomous and it causes change. Technological determinism, as described by Jary and Jary (2000), is often taken to mean

simply causality (factors determining an action), an idea known in physics as cause-and-effect. It is the concept that events within a given paradigm are bound by causality in such a way that any state of an object or event is completely or at least to some large degree, determined by prior states (Croteau and Hoynes, 2003; Miller, 1997; Smith and Leo, 1994). This suggests that technological attributes are somewhat strong enough to influence adoption. Most interpretations of technological determinism share two general ideas as related to the innovation-diffusion theory:

i. that the development of technology itself follows a predictable, traceable path largely beyond cultural or political influence (developer-based); and

ii. that technology in turn has "effects" on societies that are inherent, rather than socially conditioned or produced because that society organizes itself to support and further develop a technology once it has been introduced (adopter-based).

In opposition to technological determinism are those who subscribe to the belief of social determinism or post-modernism (Croteau and Hoynes, 2003). Social determinists believe that social circumstances alone select which technologies are adopted, with the result that no technology can be considered "inevitable" solely on its own merits (Croteau and Hoynes, 2003). They believe that technological change can have implications on the past, present and future. As a theory of change in relation to adoption, it is seen as a cause and effect relationship. Causality might be understood to mean that all events have prior causes. This suggests that there is no event (or group of events) that causes itself. This means that there is either something that started causality as we understand it, but does not itself need to be caused (Croteau and Hoynes, 2003).

3.1.1 Criticisms of the classical diffusion-adoption theory

This examination of the diffusion-adoption theory will be incomplete without looking at some of the major criticisms of diffusion research which has been based on the classical diffusion-adoption theory itself. Among these criticisms are:

i. Because of its inclusion of the time dimension, there is a heavy dependence on recall data and this makes accuracy of data suspicious at times. The problem is further worsened by the fact that recall ability varies with different individuals, the type of innovation and the length of time of introduction. This shortcoming is of crucial importance when collecting data from a highly illiterate and uneducated clientele as was the case in this study.

ii. Although viewed as a multidisciplinary theory, too much emphasis has been placed on the type of innovation as the basis for the different research disciplines. Consequently, it has been difficult to exchange, standardize, and generalize findings across the various disciplines.

iii. The theory basically assumes "free or optional choice" among alternatives. So, most of the diffusion and adoption research studies have focused primarily on individual innovation-decisions to the exclusion of the collective or authority innovation-decisions. In most developing countries, agricultural policies and programmes are more often than not of the authority innovation-decision type, involving a series of government-determined and government-sponsored agricultural programmes and projects.

iv. There has been an overemphasis on the individual number of hectares and time involved in the adoption decision process as a unit of analysis rather than the

number of technologies involved and adopted vis-a-vis the outcome of the adoption (Arokoyo, 1981).

3.1.2 Application of the adoption theory

Adoption theory gives an insight to the understanding of the factors affecting the adoption of technologies for adaptation to climate change in maize production. The problems of climate change have been attributed to different environmental factors including population growth and urbanization, upsurge in human activities and changes in communities, among others. These changes have, in turn, been affected by technological advancement. However, the adoption of climate-change related technologies could result in socially beneficial changes to the society and the environment.

The problems of environmental and ecological degradation as caused by climate variability have reached a critical stage (IPCC, 2007). Moreover, environmental degradation and ecological imbalance will increase if no corrective measures are taken. This implies that it is imperative that as technology and human activity advance, there is the need to develop commensurate adaptation measures capable of helping farmers to cope with the negative effects the technologies may pose to the environment as they are being used. Technological development is seen to disrupt the existing arrangement of the social system and subsystems (Rogers, 1995). Therefore, new social adjustments often have to be made available even before the introduction of a technology into the social system (Rogers, 1995).

3.2 Conceptual Framework

3.2.1 Concept of Perception

Mead (1934) defined perception in social term as "the beginning of acts", saw perception as certain regularity of an individual's feelings, thoughts and pre-disposition

toward some aspects of his environment. Perception tends to influence the way people feel towards others and the environment they live, it also influence the decision a person takes about things around.

In another dimension perception has been seen as the process by which people receive information or stimuli from their environment and transform it into psychological awareness (Oladele, 1998). According to the author, people live in the same world and receive similar impression of perception; this is done through the eyes and ears and to a lesser extent through the senses of touch, taste and smell, but people interpret our experiences differently. This involves sensory mechanism and cognitive appraisal, and is influenced by prior learning experiences, emotional state, and current expectations. It has been noted that policy makers in agricultural development are expected to understand the complex psychology of human perception, appreciate why people interpret their environment differently that these different perceptions and knowledge influence individual's attitude towards the acceptance of an innovation. This signifies the acknowledgment of the individual interpretation of events which is socially and culturally influenced, thus influencing attitude which have a perceptual aspect (Oladele,1998).

In a developing economy, the government is the major initiator of projects to improve the economy and of efforts to reform or modernize the society. A negative perception by the population toward an intervention programme will obviously inhibit the success of such intervention. It is therefore, necessary to understand factors influencing perception and attitude, this provides one means of showing what the population prefers or how they are affected by external parameters towards a change from the original practices to a new practice. Perception studies are one way in which the investigator

may comment on the relative concern for such policy development. In this way, the population who would not normally get a chance to make their views known is given an opportunity to express their subjective views to the problems they perceive. Thus, future solutions might be made more responsive to the people for whom they aim at discovering for a certain segment of the population just what individuals "see" in their environment, how they feel about it, what it means to them and how they would be disposed to act towards it (Oladele, 1988). The perception of the farmers on the technologies will to a large extent determine the appropriateness of its solution beginning from awareness to the adoption of the technologies to get the expected results. The meaning people make out of their perception comes as a result of experience. Farmers' positive perception on the technologies here would influence him to either accept or reject the technologies base on his objective judgments of the attributes of the technologies.

3.2.2 Concept of Effects

The British Dictionary defined effect as the power to produce results or the force to produce an effect. The dictionary further described effect as the power to bring about, accomplish, make happen, validity, influence the making of a desired impression on outcome that is, power or ability to influence or produce a result or efficacy. In other words effect can also be said to be a consequence (s) or result which refer to something produced by an action or a cause.

According to Bekele and Freeman (2003), effect is the outcomes that intend changes in the well-being of individuals, households, and institutions are attributed to a particular project, programme or policy. An effect is that which is produced, usually more or less immediately and directly, something that is produced by a cause or agent.

Studies on effects of technology adoption are therefore an appropriate approach which would guide in determining the result of adoption of technologies for adaptation to climate change for maize production maize farmers output, income and level of living. This would provide data on the need to bring about, accomplishment validity and level of influence of the desired impression on the outcome and ability the technologies adopted by farmers was able to influence or produce as a result of efficacy to its adopters.

For instance, Abdoulaye *et al.* (2014) in a study of the effect of awareness and adoption of improved cassava varieties and processing technologies in Nigeria showed that the use of improved cassava varieties and use of grating machines had positive effects on adoption in the single equation estimation. Also membership in community organizations, membership in cooperatives organizations, awareness of the benefits associated with the adoption of the improved varieties, and the proportion of cassava grated had significant effect on adoption. Membership in community organization showed a positive effect in increasing the probability of adopting improved cassava varieties by 0.28.

Awotide *et al*. (2012) in their study on effect of adoption of improved agricultural technology on sustainable rice productivity and rural farmers' welfare in Nigeria showed that despite the higher area cultivated by the non-adopters, they seem not be better-off in terms of household income. The adopters had a significantly higher income from both the production of rice and other crops than the non-adopters; consequently the adopters were also able to spend more (N95151.92) on agricultural production than the non-adopters (N72215.08). In terms of the effect of adoption of improved rice varieties on the welfare of adopters and non-adopters, the result revealed that the

consumption expenditure of the adopters (N9877.71) was higher than that of the non-adopters (N9588.92). This implies that the adopters had a better welfare than the non-adopters.

3.2.3 Level of Living

Level of living is one of the important indicators of social status which is mostly found to be positively related with adoption (Rogers and Shoemaker, 1971). The concept of level of living (scale of living) is the way an individual lives, not the way he wants to live (Atala, 1988).

According to Atala (1988), the concept of level of living refers to the actual living conditions of a population. The level of living concept refers to material and impersonal resources with which individuals can master and command their living conditions. Essentially, level of living refers to the variety, quantity and quality of the goods used to meet the physical and psychic needs of an individual or an individual family.

The concept of level of living has been measured differently by researchers. Basically, two approaches have been employed. One approach has been to treat the question of the level of living from the point of its components and to treat these components separately from each other. The other approach has been to study the total interrelatedness effects of the different components of level of living, particularly in developing countries, rather than to study each component separately (Atala, 1980).

The number and types of components of level of living have differed from one research to the other. Cowhig (1962) in Atala (1980) used a five-item indexed formula: (1) average value of sales per farm, (2) average value of land and building per farm, (3) percentage of farms with telephones, (4) percentage of farms with home freezers, and (5) percentage of farms with automobiles. However, Cowhig mentioned that other

components of level of living which he did not include in his study include health, food and nutrition, education, condition of work, employment situation, aggregate consumption and savings, transportation, housing, clothing, recreation and entertainment and other subjective states such as security, human freedoms and happiness or well-being.

In earlier studies by Hagood (1952) as cited in Atala (1988), the items on farm-operator family level of living indexes were based were the following possessions: (1) electricity (2) telephones (3) automobiles and (4) average value of products sold or traded in the year preceding the census.

Allardt (1978) in Atala (1988) measured the objective level of living by the following five components: income, housing conditions, employment, education, and health. The subjective level of living, in other words, satisfaction-dissatisfaction with material and social conditions, was tapped by four indicators: perceptions of societal antagonisms, of existing social discrimination, of unjust privileges in one's own society, and subjective satisfaction with one's own income. Bluhm (1979) in Atala (1980) used sixteen variables to construct the level of living index. These include possession of a car, a radio, a television set, an electric refrigerator, an electric iron, glass panes in the windows, boots and shoes, painted exterior walls, a clean-and-cared-for house, brick wall construction, of house, size of house, electric lights, bath or shower, water piped .into the house, a toilet and curtains and furniture in good condition. An individual's level of living score is indicative of his economic power, material possession, exposure and access to information, all of which have been found to be predisposing to high adoption both in North America (Rogers and Shoemaker, 1971), and in Nigeria (Voh, 1979) where it has been established that there is a positive relationship between

individuals' level of living and adoption of innovations. In Atala (1980), level of living was however measured by checking the number of durable goods and livestock items possessed by an individual farmer. The durable goods items were: radio, bicycle, motor cycle, car, refrigerator and zinc roof. The livestock items were: cows, goats, sheep, fowl, ducks, donkeys, horses, bush fowls and others. For the purpose of this study, material possessions form level of living.

3.3 Conceptual Model

The adoption of a given technologies for adaptation to climate change is hypothesized to be influenced by socio-economic (age, household, education, farm size, farming experience, source of labour), institutional (membership of associations, extension contact, information sources) and technological attributes (compatibility, complexity, relative advantage, cost) factors. As noted by Degnet and Belay (2001), the reasons for adoption or non-adoption at farm level vary over space and time. They argued that the factors influencing adoption are neither exclusively economic nor purely non-economic. Both economic and non-economic reasons are essential motives for shaping the farmers' attitude towards the new technology and its final adoption (Degnet and Belay, 2001). The conceptual model for the study is as given in figure 1.

In this study, the independent variables in the model are the: i) socioeconomic (age, education, household size, farm size, farming experience and labour availability);ii) institutional factors (extension contact, membership of social organizations, information sources); and iii) technological attributes (compatibility, complexibility, relative advantage, cost). These variables are expected to influence adoption of climate change adaptation technologies. The adoption of adaptation (coping) strategies serves as the dependent variable. The adoption of adaptation technologies for climate change is

expected to result in increase in the outputs of maize, increases in farmers' real income and enhanced level of living for farmers.

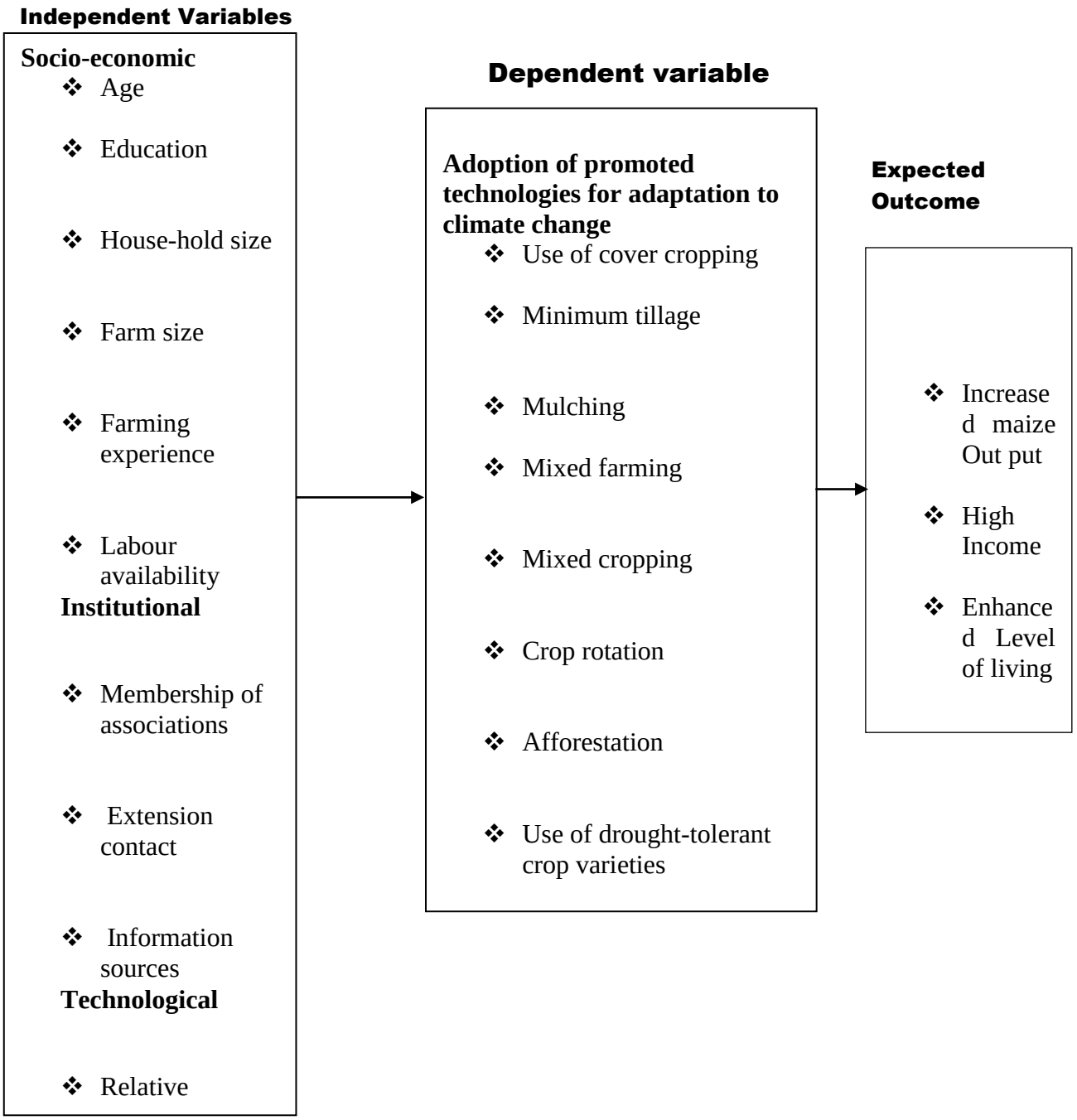


Figure 1: Model showing factors affecting adoption of technologies for adaptation to climate change and their effects on farmers' outputs, income and level of living.

CHAPTER FOUR

4.0 METHODOLOGY

4.1 Description of the Study Area

The study was conducted in the North-west agro-ecological zone of Nigeria (Figure 2). The North-west zone lies between latitudes 2^0 and 14^0 N and longitudes 07^0 and 60^0south of the Green-which meridian. The zone comprises of Kaduna, Katsina, Sokoto, Zamfara, Kano, Jigawa and Kebbi States (NARSP, 1997). The land area of the zone is 192,911square kilometres, representing 21.1% of the national land area (NARSP, 1997). According to the 2006 census, the total population of the zone was 35.7 million, with an average density of 103 persons per square kilometre. The projected population of the zone was about 41.8million representing 25.56% of the total national population in 2014, assuming an annual growth rate of 3.2% base on the CBN 2014 annual report.

Eighty percent of the population of the zone lives in rural communities. The zone has about 14 million hectares of arable land, 9.5 million of which is under cultivation. The mean annual rainfall ranges from 500mm to nearly 1200mm. The rains are unimodal and fall for 3 to 5months, the period constituting the main maize-growing season. The mean annual temperature ranges between 17^0 and 32^0C, although high temperatures of up to 42^0 occur during April/May (NARSP, 1997).

The North-west zone has undulating topography with altitudes between 350 and 680metres above sea level (NARSP, 1997). The river basins are drained by rivers Sokoto and Hadejia-Jama'are. The vegetation is typically savanna and the grass land ecology is distinguished by Sahel, Sudan and Northern Guinea Savanna. The five major soil types found in the zone are the ferruginous soils (lixisols) which make up over 50% of the zone, the weakly developed regosols, ferrasols and hydromorphic fluvisols and

gleysols (NARSP, 1997). Most of the soils in the zone are classified as having low to medium productivity (NARSP, 1996).

Arable land in the zone is classified as upland and valley bottom land (f*adama*). The f*adama* comprises less than 10% of the total land currently under cultivation. Upland areas are used for rain-fed agriculture while f*adama* areas are used for irrigation cropping during the dry season. Of the total irrigable upland area of 338,850 hectares in the zone, 72, 950 hectares are under irrigation. In addition, there are 608,400 hectares of f*adama* land which can be irrigated, indicating that the irrigation potentials of the zone are quite substantial (NARSP, 1997). Apart from arable crops such as sorghum, millet, maize, cowpea, groundnut, tomato, onion and pepper, the North-west zone is an important producer of livestock which includes cattle, goats, sheep, poultry, donkeys, rabbits, pigs, horses and camels. The zone is also characterized by appreciable forest reserves, mainly of natural savanna woodland with multipurpose trees and shrubs. The zone has about 1.88 million hectares of forest reserves, which occupy 9.74% of the total land area in the zone (NARSP, 1997).

According to NARSP (1997), about 9 million persons are engaged in agriculture, which is the major occupation of the inhabitants of the North-western zone of Nigeria. Male adults contribute about 70% of the labour supply that comes from the family. The average family holding is 3.0 hectares for upland and 0.2 hectare for f*adama* farms in the zone (NARSP, 1997). The availability of family labour and of cash to hire labour largely determines the area cultivated and types of crops grown. Farm income is supplemented by off-farm activities such as sewing, carpentry, bricklaying and blacksmithing. The constraints to agricultural production in the North-West agro-ecology are varied. The most important ones are occasional drought, decreasing rainfall

pattern, short rainy period and early cessation of rains. Annual requirement for maize has been estimated at about 14 million metric tones. The estimated annual maize production in the North-west stood at 577.51 metric tones in 2001 and increased to 622.65 metric tones in 2006 (NAERLS, 2009). The total maize land area prepared witnessed a decline in (-28.52) in the North-West as at 2006. The major field operations carried is through tractors and animal traction. Animal traction services are commonly used in the zone for ploughing, ridging and haulage operations.

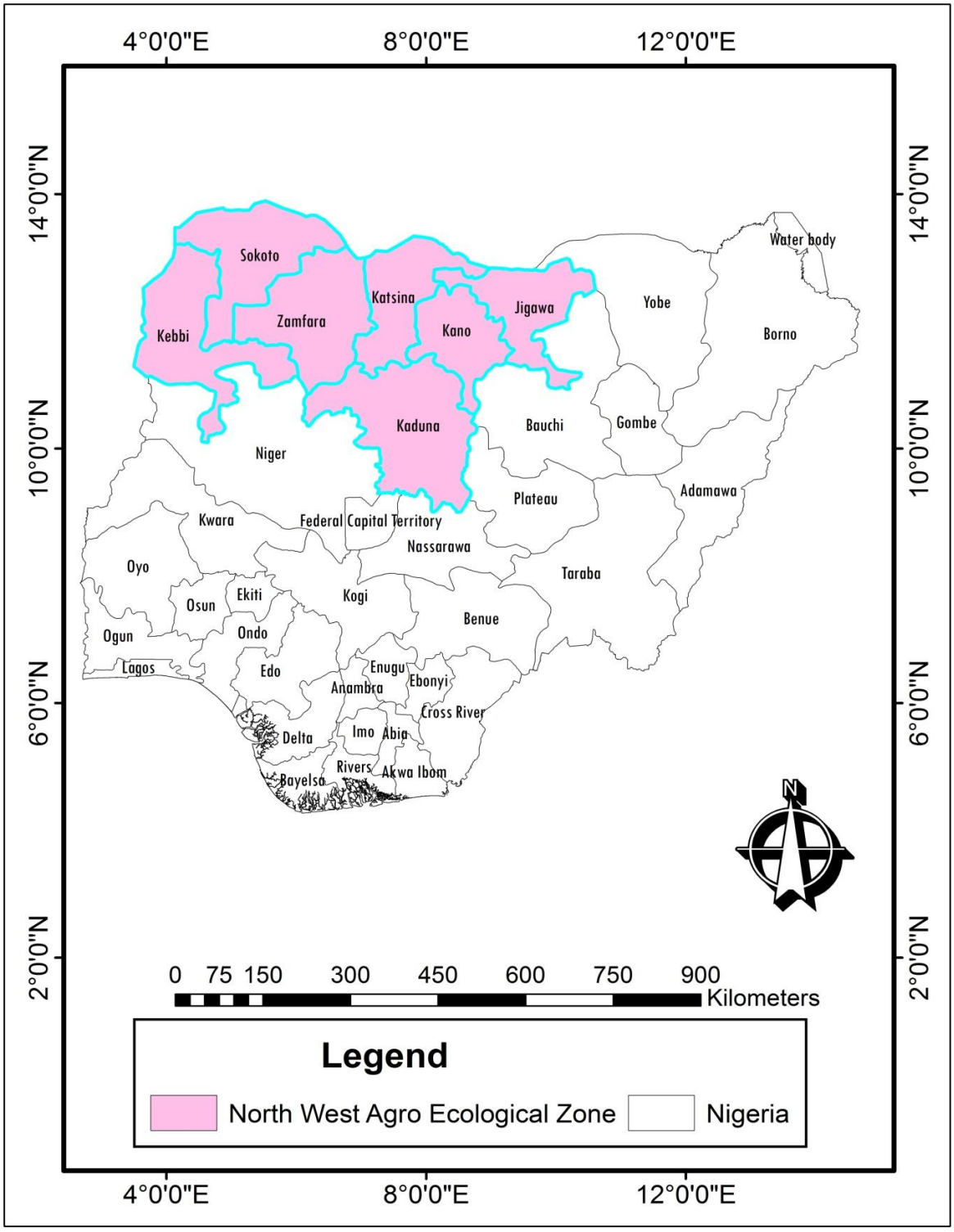


Figure 2: Map of Nigeria showing the North-West Agro-Ecological Zone

Source: NAERLS 2009 Wet Season Report

4.2 Sampling Procedure and Sample Size

The process of choosing the sample was done in multiple stages. In the first stage, four States were identified during the period of reconnaissance survey conducted in 2011 with the centre for Climate Change and Fresh Water Resources to be prone to the adverse effects of climate change in the North-Western agro-ecological zone were purposively selected. These are Katsina, Kano, Kebbi and Sokoto. In the second stage, two Local Government Areas (LGAs) in each of the four States with a high record of maize production were also purposively selected. The third stage involved a purposive selection of 50% of the farmers who produced maize on 1 hectare and above in the selected LGAs. Thus, 159 farmers served as adopters and twelve percent of the population of maize farmers in each of the selected LGAs in the four States who did not adopt the promoted technologies (also 159) formed the non-adopters for the study (Table 1).

Table: 1 Distribution of Maize Farmers in the Study Area

States	**Purposively Selected LGAs**	**Adopters**		**Non-adopters**	
		Maize farmers with 1 or more ha of maize farms *	**Selected maize farmers (50%)**	**Sample Frame**	**(12%)**
Kano	Bunkure	48	24	288	24
	Gwarzo	44	22	264	22
Katsina	Zango	42	21	252	21
	Malumfashi	51	26	306	26
Sokoto	Goronyo	30	15	179	15
	Sokoto	39	20	235	19
Kebbi	Birnin Kebbi	34	17	198	17
	Bagudo	28	14	174	15
Total		**316**	**159**	**1896**	**159**

*Based on reconnaissance survey data, 2011

4.3 Method of Data Collection

The first phase of this research work was the reconnaissance survey, which was conducted between November-December 2011, to identify the study area and to get detailed knowledge on the activities and socio-economic characteristics of the farmers

in the area. Also, this was intended to help in selecting appropriate research site in terms of the research problem. Following series of in-depth personal interviews with staff of Agricultural Development Projects (ADPs), Centre for Climate Change and Fresh Water Resources and National Emergency Management Agency (NEMA) to understand States that are more prone to the adverse effects of climate change. Based on the result of the reconnaissance survey, Kano, Katsina, Sokoto and Kebbi States were selected. The second phase involved the survey research which was used for the collection of data for analysis. Primary data were used in the study. The period of the field data collection was six months (January 2012- June 2012). The primary data were collected through use of a questionnaire instrument that was administered to the respondents by the researcher with the assistance of trained extension workers from the ADPs of the selected states. The questionnaire instrument was pretested for content validation. Use of judges was employed to validate the instrument. Experts in Agricultural Extension and Rural Sociology and Lecturers in the Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria were given the research instrument for in-depth judgment and assessment to determine the accuracy of the instrument. The use of judges was important in validating particularly the predictive ability the instrument was actually designed to measure. Each judge or expert was requested to independently give his/her expert opinion on the relevance and adequacy of the items vis-à-vis the objectives of the study, Based on the comments of the judges and experts, the research instruments were modified before being used for the data collection.

An instrument is considered reliable when it consistently produces the same result when applied to the same sample many times over. Reliability test of the instrument was determined before the final use. The test and re-test reliability is a method used to find out whether the instruments' test scores are reliable. The pretest was carried out between

22nd and 29th January, 2012. In order to achieve this, fifteen farmers representing about 10% of questionnaire sampled were administered to farmers who were not included in the study through random sampling technique and were asked the questions contained in the research instrument to determine the degree to which the questions contained therein would be clearly understood when finally used for actual data collection. Information obtained was related to the:

i. socio-economic and institutional characteristics of the respondents (age, education, farm size, household size, farming experience, extension contact, credit obtained and membership of social organizations);

ii. technological attributes such as relative advantage, compatibility, complexity, and cost of the of the technologies for climate change in maize production;

iii. respondents' perceptions of climate change and its effects on maize production;

iv. respondents' levels of awareness and adoption of the technologies for coping with the adverse effects of climate change;

v. respondents' strategies for coping with the adverse effects of climate change; and

vi. constraints to the respondents' adoption of the maize production technologies for climate change adaptation. The Kuder-Richardson reliability estimates cited in Ogbuoshi (2006) were used for analysis. The formula is given as follows:

$$KR-21\ total\ test\ formula\ = \left[-\frac{(K)(SD^2)-X(K-K)}{(SD^2)(K-1)}\right]$$

Where:

K = Number of items tested that is, total number of questions in the questionnaire

SD = Standard deviation of the scores

X = Mean of the scores

The standard deviation of the scores of 0.79 was obtained and considered as satisfactory enough to conclude that the instrument was reliable.

4.4 Analytical Techniques

The data were analyzed using frequencies, percentages, means, linear regression and Z-test statistical tools.

4.4.1 Descriptive Statistics

In this study descriptive statistics which comprise percentages, means and frequency distribution tables were used to achieve the following objectives: (i) evaluate respondents' perceptions of the effects of climate change on maize production in the North-West agro-ecological zone of Nigeria; (ii) identify and describe the traditional climate change coping strategies used by respondents'; (iii) determine the respondents' levels of awareness and adoption of maize production technologies for climate change adaptation; (iv) identify the sources of information by which farmers became aware of technologies for coping with effect of climate change; and (vii) identify constraints associated with the adoption of coping strategies against climate change in maize production.

4.4.2 Linear regression model

The linear regression model was used to determine objective v, that is, the socio-economic, institutional and technological factors (the regressors) influencing adoption of technologies for adaptation to climate change (the regressand) and to test hypothesis Ho_1 of no significant relationship between farmers' socio-economic, institutional and

technological factors and the adoption of promoted technologies for adaptation to climate change.

The implicit form of the linear regression model is specified as follows:

$Y = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8\text{----------}X_{13, u})$

Where:

Y = Number of promoted maize production technologies for adaptation to climate change adopted by a farmer.

X_1 = Age (Years)

X_2 = Household size (Number)

X_3 = Formal education (Years)

X_4 = Farm size (Hectares)

X_5 = Farming experience (Years)

X_6 = Labour availability (Number)

X_7 = Membership of social groups/associations (Years)

X_8 = Extension contact (Number)

X_9 = Information sources (Number)

X_{10} = Compatibility (Very compatible= 5, compatible =4, undecided =3, not compatible =2, not very compatible=1)

X_{11} = Complexity (Very difficult to use=1, difficult to use=2, undecided=3, easy=4, very easy= 5)

X_{12} = Relative advantage (strongly agree =5, agree =4, undecided =3, disagree =2, and strongly disagree =1)

X_{13} = Cost (strongly agree =5, agree = 4, undecided =3, disagree =2, and strongly disagree =1)

U = Error term.

4.4.3 Z-test statistic

The Z-test statistic was used to measure whether or not there is a significant difference between adopters' and non-adopters' levels of outputs, income and level of living (objective vi) and to test hypothesis Ho_2 of no significant difference in output, income and level of living between adopters and non-adopters of the promoted technologies for adaptation to climate change,

The formula for computation of Z-test adapted from Spiegel (1972) is as follows:

$$Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

Z = calculated value of Z.

$\bar{X}_1$ = mean output/ income/ level of living of adopters of promoted technologies for adaptation to climate change

$\bar{X}_2$ = mean output/ income/ level of living of non-adopters of promoted technologies for adaptation to climate change

s_1^2 = Standard deviation of output/ income/ level of living of adopters of promoted technologies for adaptation to climate change

s_2^2 = Standard deviation of output/ income/ level of living of non-adopters of promoted technologies for adaptation to climate change

n_1 = sample size of adopters of promoted technologies for adaptation to climate change

n_2 = sample size of non-adopters of promoted technologies for adaptation to climate change

4.5 Definitions and Operational Measurements of Dependent and Independent Variables

4.5.1 Dependent variable

Adoption is the use of a recommended practice on a continuous basis (NIAEM, 2007). The dependent variable used in this study was the adoption of promoted technologies for adaptation to climate change by maize farmers. This was scored by assigning a score of 1 to each of the 10 selected technologies adopted by a farmer at the time of the survey and zero to a practice not adopted. Thus, minimum score = 0, maximum = 10. These technologies were: use of cover cropping, minimum tillage, mulching, mixed cropping, mixed farming, crop rotation, afforestation, use of drought-tolerant crop varieties, water harvesting and optimum use of soil organic matter.

A cover crop is a crop planted primarily to manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem (Lu *et al*., 2000), an ecological system managed and largely shaped by humans across a range of intensities to produce food, feed, or fiber. One of the primary uses of cover crops is to increase soil fertility. Cover crops can also improve soil quality by increasing soil organic matter content. Cover crops often also reduce both the rate and quantity of water that drains off the field, which would normally pose environmental risks to

waterways and ecosystems downstream (Lu *et al*., 2000) Thick cover crop stands often compete well with weeds during the cover crop growth period, and can prevent most germinated weed seeds from completing their life cycle and reproducing. Some cover crops are used as so-called "trap crops", to attract pests away from the crop of value and toward what the pest sees as a more favourable habitat.

Minimum tillage practices conserve soil and water resources, reduce farm energy and increase crop production (Bescansa *et al*., 2006). Minimum tillage leads to positive effects in the physical, chemical and biological properties of the soil. According to Bescansa *et al*. (2006), soil physical properties that are influenced by minimum tillage are bulk density, infiltration and water retention. Improved infiltration of rainwater into the soil increases water availability to plants, reduces surface runoff and improve ground water recharge. Reduced soil cultivation reduces farm energy requirements and overall farming cost as less area has to be tilled (Bescansa *et al*., 2006).

Mulch cover reduces surface runoff and holds rainwater at the soil surface thereby, giving it more it time to infiltrate into the soil. Mulching can considerably reduce soil erosion, improve in-situ water retention, raise soil fertility and increase yield. The presence of crop residue mulch at the soil-atmosphere interface has a direct influence on infiltration of rainwater into the soil and evaporation from the soil (Erenstein, 2002). Soil biota increase under mulched soil environment, thereby improving nutrient cycling and organic matter build up over a period of several years.

Mixed cropping is system of sowing two or three crops together on the same land in the same year at the same time one being the main crop and the others are the subsidiaries. Mixed cropping permits an intensification of the farm system, which result in increase overall productivity and biodiversity in cropped fields (Vandermeer, 1989). Mixed

cropping makes more efficient use of environmental resources and provides effective coverage for the soil thereby minimizing soil erosion and exposure to solar radiation.

Mixed farming involves combining crop and livestock activities to improve soil nutrients and environmental sustainability. The waste products of one component serve as resource for the other. For instance, manure is used to enhance crop production and crop residue and by-products feed the animals. Farm animals are important links for recycling resources within the farming system in addition to the provision of transport services.

Crop rotation is the planting of crops in sequence in a four-rotational basis in which deep-rooted and shallow-rooted crops are grown systematically on the same piece of land. This is done to help crops utilize the moisture from upper to lower layers of the soil. Crop rotation provides good ground cover, help maintain or even improve soil organic matter, thereby contributing to soil fertility (Guto *et al*., 2011).

Afforestation is an agroforestry system where woody perennial plants are deliberately grown to replace the older ones on the same piece of land to obtain the benefits they bring not only to the economy and to the society but also to the ecosystem. Trees ameliorate the micro-climate, breaking the wind, moderating temperatures and raising humidity and also protect the soil against erosion by water and wind at the same time improving water infiltration. This is done either in spatial mixtures or in temporal sequence (FAO, 2007).

Drought-tolerant maize varieties are improved maize varieties that are tolerant to drought and are meant to help farmers in addressing production risks in areas severely threatened by frequent droughts and irregular rainfall.

Water harvesting is practised in highly rainfall-variable parts of Sub-Saharan Africa, particularly in semi-arid areas where dry spells are frequent. In the Sahelo-Sudanian zone in particular, moisture deficiencies pose the primary constraint on cropping, and effective water management is critical to reduce erosive and wasteful runoff and to maximize water infiltration into the soil. The system consist of rooftop catchments (collection area, conveyance system and storage facility), Zai pits technique and Atajados technique (ARCN, 2015).

Organic material is composed of organic compounds that have come from the remains of organisms such as plants and animals and their waste products in the environment (Natural Organic Matter GREEN FACTS, 2007). The organic matter in soil derives from plants and animals. In a forest, for instance, leaf litter and woody materials fall to the forest floor and when it decays to the point in which it is no longer recognizable it is called soil organic matter. When the organic matter is broken down into a stable substance that can resist further decomposition, it is called humus. Humus has the ability to withhold water and nutrients, thereby giving plants the enough capacity to survive and grow (Natural Organic Matter GREEN FACTS, 2007).

4.5.2 Independent variables

4.5.2.1 Socio-economic variables

Age (X_1)

The age of the individual, was measured as the number of years the individual has lived on earth as at the time of the investigation. It was expected that respondents' age would have negative influence on adoption of practices for adaptation to climate change. The reason is that older farmers seem to be less inclined to adopt new farm practices than younger ones (Obeta and Nwagbo, 1991).Thus, younger farmers tend to be more flexible in their decisions and adopt new ideas more readily (Obeta and Nwagbo, 1991).

Household size (X_2)

This variable was measured by adding up the number of wives, children, relatives, and other dependents actually living with a respondent in his household at the time of the investigation. The total number of people in a respondent's household was therefore the respondent's score. This variable is expected to have an inverse relationship with adoption. The reason is that larger households will attach greater importance to food security than smaller households (Njoku, 1991). Large households sizes would, therefore, have negative influence on adoption of technologies for adaptation to climate change.

Education (X_3)

Education was measured by the number of years a respondent spent in formal schooling. The respondents were asked to give the number of years spent in primary, secondary and tertiary schools. It is expected that education would be positively associated with adoption of the technologies examined. Rogers (1995) noted that education influences the acceptance and adoption of an innovation by farmers. Rogers (1995) also stressed that education is not only an important determinant of knowledge of an innovation but also an instrument for correct use of the innovation for profitability. It is expected that as the years of education of a farmer increases, his level of work-related skills and ability to acquire new skills will also increase.

Farm size(X_4)

Farm size was measured as the hectares of maize a farmer has cultivated. The expected sign of the coefficient for farm size is positive. This is because it is frequently argued that farmers with large farms are more likely to adopt improved technologies compared with those with small farms. Farmers with larger farm sizes would, therefore, have a

greater tendency to adopt maize production technologies for adaptation to climate change to avert the risks of crop failure due to the adverse effects of climate change.

Farming experience (X_5)

Farming experience was measured by the actual number of years the farmer had engaged in maize farming activities. It is expected that farming experience will have a positive influence on adoption of technologies for adaptation to climate change. Experience is the act of gaining knowledge through constant practice of a skill, which brings about specialization. More experienced farmers have greater ability to use modern practices and are more likely understand agricultural environment better in terms of when to plant, when to sale produce etc . It is expected that the longer a farmer has been into maize farming, the more knowledgeable he would be about the effects of climate change on maize production. This may motivate him/her to seek for, and adopt technologies that can help him/her to adapt his/her production to changing climatic conditions.

Labour availability (X_6)

Labour was measured based on the number of sources a farmer uses to provide labour in his maize farm. The labour variable is expected to have a positive relationship with adoption of adaptation strategies related to climate change. The adoption of adaptation technologies against climate change can be affected by the number of people available in a household to provide labour especially in peasant agriculture. Doss *et al*. (2003) reported that where labour markets do not function effectively, households must supply their own labour for farm activities, so that they may choose not to adopt a technology that requires more labour than the household can provide.

4.5.2.1 Institutional variables

Membership of social groups/associations (X_7)

Membership of social groups/associations was measured by the number of years a respondent has been a member of a social group or association as at the time the study was conducted. The expected sign of the coefficient for cooperative membership is positive. The reason is that farmers who belong to social groups are expected to have access to new ideas and practices through interpersonal and inter-farm visits and information. It is assumed that the more the number of years a respondent belongs to social organizations, the more he/she is exposed to knowledge in different subjects. Hence, the more he/she is likely to adopt the maize technologies for climate change adaptation. In this regard, it is expected that farmers who are members of cooperatives or associations are likely to share experiences and knowledge in terms of maize production issues associated with climate change. This would positively influence members' decisions to adopt strategies for addressing the menace of climate change.

Extension contacts(X_8)

Extension contact was measured as the number of times in a year an extension worker visited a respondent especially to impart knowledge on the coping strategies related to climate change. In this study, extension contact refers to the number of times an extension worker visited a farmer to impart knowledge on strategies related to effects of climate change on maize production within the year under study. A positive relationship is hypothesized between extension contact and adoption of these strategies. According to Adeoti *et al*. (1999), the efficiency of the extension system plays key role in facilitating the adoption of technologies in rural areas.

Usage of sources of information(X_9)

This was measured as the number of available credible sources of information to which a farmer has access to as at the time of study. This variable is expected to relate positively with adoption of adaptation measures related to climate change. Thus, it is expected that farmers using more information sources will have higher adoption scores than those who use less. Adoption research has found that the acceptance of new ideas is associated with the use of large number of credible information sources such as extension agents. radio, demonstration plots, television, extension bulletins, newsletters, newspapers, field days, friends and relations (Atala, 1980).

4.5.2.3 Technology-specific attributes

Technology attributes refer to the technological factors that could influence the adoption of the climate change coping technologies in the study area. This was measured using a five-point Likert type scale as follows: strongly agree =5, agree =4, undecided =3, disagree =2, and strongly disagree =1. This scale was applied in the measurement of compatibility, complexity, relative advantage and costs of the technologies respectively. In this study a 5-point scale with a cut of point 3 was used to measure the respondents' perception on compatibility, complexity, relative advantage and cost of the technologies and to draw inference on the of respondents' perception of the technologies. According to Rogers (1983), characteristics of agricultural technologies have its own factors which affect its adoption by a given society. These factors are relative advantage, compatibility, complexity, triability and observability. Byerlee *et al*. (1986), cited in Getachew (1993), argued that the adoption patterns of a particular component is a function of the characteristic of the technology.

Compatibility (X_{10})

This is the degree to which the farmer perceives an innovation to be consistent with his present needs, practices, values, management objectives and the stage of farm development (Ogunbameru, 2001). In this study, compatibility was measured based on the Likert scale of: Very compatible= 5, compatible =4, undecided =3, not compatible =2, not very compatible=1. It is assumed that compatibility will have a positive sign, because technologies that are compatible with the existing practices would be more adopted than those that are less compatible.

Complexity (X_{11})

Complexity of the technology was measured as the degree to which the adaptation technologies are perceived to be difficult to understand or put to use by a farmer in trying to cope with the effects of climate change on maize production. It is assumed that the coefficients for complex technologies will have negative signs because complex technologies will not be as readily adopted as simple ones. This was measured with the Likert scale as follows: very difficult to use=1, difficult to use=2, undecided=3, easy=4, very easy= 5.

Relative advantage (X_{12})

The degree to which farmers perceive an innovation as superior to existing practices is referred to relative advantage. Ogunbameru (2001) noted that relative advantage of an innovation is usually expressed in terms of economic gain. The probability of adoption of a new technology will depend on the difference in profitability between the new and old technologies, and the ability of the farmer to perceive the advantages and efficiently utilize the new technology (Schultz, 1995). It was measured as follows: (strongly agree =5, agree =4, undecided =3, disagree =2, and strongly disagree =1). The expected sign of the coefficient for relative advantage is positive.

Cost (X_{13})

In this study cost of the climate change adaptation technologies was measured based on likert scale of: strongly agree =5, agree =4, undecided =3, disagree =2, and strongly disagree =1. The variable is expected to have a negative coefficient. It is expected that less expensive and affordable technologies will be more readily adopted by farmers than expensive and less-affordable ones. Technologies that are capital-intensive are only affordable to wealthier farmers but those that cost little are adopted more easily by even resource-poor farmers. Farmers decisions to adopt is an investment decision, hence adoption can be expected to be dependent on cost of the technology.

4.5.3 Effects of adoption

The effects of adoption in the model was the increased output (tonnes) of maize harvested by a farmer per hectare (ha), increased income (₦) realized from the sales of maize obtained and improved level of living (value of goods possessed by a farmer). The way these variables were measured is described below.

Farm output

Output was the quantity of maize harvested by farmers on an area of land. It was measured in tonnes per hectare. The expected effect of adoption of technologies for adaptation to climate change is increase in the farmers' maize output.

Farm income

Farm income was the estimated total amount of money obtained by a farmer from maize sold after harvest during the year. The expected effect of adoption of technologies for adaptation to climate change is an increase in the farmer's income. Adoption researchers (Ekong, 2010) have found a positive relationship between farm income and the acceptance of new ideas. Past studies (Ekong, 2010) have also used income as a measure of status. Gross farm income is an indication of the size of farm operation, the

assets of a farm family or level of living, and is an important factors in determining the position one occupies in a social system. There seems to be a positive relationship between farm income and adoption of innovations.

Level of living

Level of living is generally used to describe the quantity of goods and services actually consumed by an individual and his family (Ekong, 2010).For the purpose of this study, level of living was measured by checking how many of each of the durable assets listed were possessed by an individual farmer. The durable items were: (a) car, (b) bicycle, (c) motorcycle, (d) radio, (e) television, (f) mobile phone, (g) water pump, (h)oxen, (i)animal traction, (j) tractor, and (k) generator set. Each item was given monetary value based on its current market value in 2012 as determined by the investigator. The monetary value of each item was multiplied by the total number of the same items possessed by an individual farmer. The products for all the items possessed were summed up to obtain the score for the farmer's level of living. The expected effect of adoption maize production technologies against climate change is an increase in maize farmers' level of living.

A summary of the independent variables generally described above, their measurements and apriori expectations are as shown in Table 2.

Table 2: Measurements and operationalization of variables

Variables	Measurement	Apriori Expectation
Age	Number of Years	Negative
Household size	Number of people in a household	Negative
Education	Number of years	Positive
Farm size	Number of hectares	Positive
Farming experience	Number of years	Positive
Labour sources	Number of sources	Positive
Membership of association	Number of years	Positive
Extension contact	Number of visits	Positive
Information sources	Number of sources	Positive
Relative advantage	strongly agree =5, agree =4, undecided =3, disagree =2, and strongly disagree =1	Positive
Complexity	very difficult to use=5, difficult to use=4, undecided=3, easy=2, very easy= 1	Negative
Compatibility	Very much compatible= 5, much compatible =4, undecided =3, not much compatible =2, not compatible=1	Positive
Cost	strongly agree =5, agree =4, undecided =3, disagree =2, and strongly disagree =1	Positive/ Nagetive
Output	Kilogramme/hectare	Positive
Income	Amount of money obtained from maize sold	Positive
Level of living	Asset possession (monetary value)	Positive

CHAPTER FIVE

5.0 RESULTS AND DISCUSSION

Results of the study are presented and discussed in this chapter. The results are presented in relation to the following objectives of the study that attempted to:

i. evaluate respondents' perception of climate change effect on maize production in the study area;

ii. identify and describe the local climate change coping strategies used by maize farmers;

iii. determine the levels of farmers' awareness and adoption of promoted technologies for adaptation to climate change;

iv. identify the sources of information on the promoted technologies for adaptation to climate change;

v. determine the socio-economic, institutional and technology-specific factors influencing the adoption of technologies for adaptation to climate change;

vi. determine the effects of adoption of the promoted technologies on maize farmers' outputs, income and level of living, and

vii. identify and describe constraints associated with adoption of promoted technologies for adaptation to climate change.

5.1 Farmers' perception on the effects of climate change on maize production

The first objective of the study was to examine respondents' perceptions of the effect of climate change on their maize production. The respondents' perception that climate change resulted in severe drought on maize production had a score of 4.47. This score is above the mid-point of 3 in the perception scale which clearly reveals that climate change had adverse effect on maize production. Frequent drought not only reduces water supplies but also increases the amount of water needed for plant transpiration. The occurrence of water stress during flowering, pollination, grain-filling is harmful to most crops and particularly so to maize. Increased evaporation from the soil and accelerated transpiration in the plants themselves will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought-tolerance (Rosenzweigh and

Hillel, 1993). Butzen (1996) has similarly reported that drought induced by climate change destroyed portions of the major field crops in Midwest Malawi, particularly cornfields, and that the severity of drought led to increase in the farm prices of corn and other field crops which, in turn, led to price increases in inputs in the food supply chain such as animal feed.

Respondents' perception that climate change resulted in heavy rains and floods which had deleterious effects on maize production had a score of 3.59. Flooding stresses the maize plant by cutting off the supply of oxygen to the root system (Butzen, 1996). Younger maize plants die if submerged in water for more than five days, especially in warmer weather conditions. If air temperatures are high, death may occur in only a few days, as plant metabolic processes are speeded up and the need for supply of oxygen to the roots is high. In cooler weather, submerged plants may live for up to a week. After the eight-leaf stage, plants can tolerate being submerged in water for more than eight days but may be more susceptible to disease and may experience limited root development while under water. Maize yield loss due to flooding is most pronounced in maize submerged immediately before, and during, tasselling and silking. However maize in the vegetative growth stages of 10-16 leaves and/or during the grain filling period display little yield response to flooding (Butzen, 1996).

The respondents' perception score that there was increased weed incidence in maize production as a result of climate change was 3.33. Climate change makes weeds to grow faster than field crops. This would have a negative impact on crop yields, and would in all likelihood require greater application of herbicides, a high-cost input. Rosenzweig and Liverman (2000) earlier reported that increase in atmospheric CO_2 would increase the growth rate of weed species. Maize yield reduction would be experienced because of

increased competition from C3 weeds. In developing countries where herbicides are not available or are prohibitively expensive, increase in input necessary for CO_2 benefit may not be cost-effective (Rosenzweig and Liverman, 2000).

Farmers who perceived that climate change had resulted in excessive use of chemical fertilizers had a mean score of 3.22. Excessive use of fertilizer contributes to nitrate leaching eutrophication of calcium uptake by plants, and greenhouse gas emissions (Bumb and Baanante, 1996). The excessive use of chemical fertilizers could also be expensive and it increases the cost of production. This corroborates Rosenzweig and Liverman (2000) and George and Konyar (2013); who observed that rises in prices of fertilizer and pesticides limits the adoption of farm technologies and has adverse impacts on crop yields and production levels.

Respondents' perception that climate change resulted in increase in pest and disease incidences had a mean score of 3.13. Pests and diseases reduced both quality and quantity of crops. It means that an increase in control of pests and diseases will be the consequence of increased incidences of pests and diseases. By implication, farmers would suffer losses in maize production if they fail to adopt the maize production technologies for adaptation to climate change in maize production.

The respondents' perception mean score of 3.11 indicates that climate change caused decreased yields (low harvests) from their maize fields. This is an indication that climate change has affected maize production negatively. Wolfe (2000) reported that temperature increase of 0.5 degrees could reduce photosynthesis and shorten growing period, both of which tend to reduce crop yield.

Respondents' perception that climate change resulted in limited irrigation water during the dry season had a mean score of 2.74. The demand for irrigation is projected to rise

Irrigation is an important buffer against climate change variability. According to Mohammed *et al*. (2014), farmers practice irrigation to augment shortages of rains in the Sahel Savanna zone of Borno Nigeria. Low rainfall pattern results in shortages of water and heavy reliance on irrigation. The demand for water for irrigation is projected to rise in a warmer climate, bringing increased competition between agriculture already the largest consumer of water resources in semi-arid regions and urban as well as industrial users. Falling water tables and the resulting increase in the energy needed to pump water will make the practice of irrigation more expensive particularly when with drier conditions more water will required per hectare (Rosenzweigh and Hillel, 1993).

Respondents perception mean score 2.33 showed that climate change resulted in insufficient rainfall supply for meeting the water needs of their maize crops. This is further confirmed by Alaje *et al*. (2010) who reported that the northern part of Nigeria is already experiencing reduced precipitation that is making the area drier and reduced precipitation is capable of reducing soil moisture availability.

The respondents' perception that climate change caused a reduction in the hectarage of cultivable maize land for maize production had a mean score of 2.23. IPCC (2007) reported that regionally, warmer and wetter climate predictions contributed to the increase in cultivable land observed in Russia, north-western China and the northern United States of America (USA). Conversely, a reduction in humidity was reported to be the main driver of decreases in cultivable land seen in tropical and sub-tropical areas.

The respondents' general perception that there was adverse effect of climate change on maize production had a score of 3.09. This figure is above the mid-point of 3 in the perception scale which clearly reveals that climate change has affected maize production negatively. These findings agree with those of Amos and Adeleke (2010)

who, in their study on the effect of climate change in cocoa production in Ondo State of Nigeria, found that farmers' visible effects of climate change on cocoa production included increased pest and disease attack (32%), reduction in weight of cocoa (26.2%), late ripening of cocoa pods (17.5%), and contamination of cocoa beans (20%), while the general effects included excess rainfall (7.6%), less rainfall (11.4%), high temperature (16.5%), drought (9.6%) and fluctuations in rainfall pattern (5.7%).

Table 3: Adopters' perceptions of effects of climate change on maize production (n =159)

Nature of effects	SA (5)	AG (4)	UND (3)	DA (2)	SD (1)	Weighted score	Percent weighted score	Mean score	Perception Score
1.Severe drought	122	10	12	11	4	712	89.4	4.47	3.09
2.Too much rain /flood on maize farms	66	33	18	14	28	572	71.8	3.59	
3.Increased weed incidence	68	39	2	27	23	530	66.6	3.33	
4.Excess use of fertilizer	48	42	3	30	36	513	64.4	3.22	
5.Pest/disease infestation	12	48	64	9	19	498	62.6	3.13	
6.Decreased yield	18	20	32	60	9	495	62.2	3.11	
7.Limited irrigation water	24	19	9	57	50	437	54.8	2.74	
8.Death or total loss of crops	3	14	52	39	51	356	44.6	2.23	
9.Insufficient rainfall	11	18	21	72	37	371	46.6	2.33	
10.Reduced cultivable maize land	15	18	2	79	45	356	44.6	2.23	

Key:
SA = strongly agreed
AG = agreed
UND = undecided
DA = disagreed,
SDA = strongly disagreed
P.S = Perception score

5.2 Local climate change coping strategies used by maize farmers

The second objective was to evaluate the local coping strategies against climate change adopted by the respondents. The results in Table 4 revealed that about 22.6 percent of the respondents used organic waste application as coping strategy to prevent excessive soil moisture loss, increase soil fertility and increase water-holding capacity of soils.

According to Hassan and Nkemechena (2008), the use of organic materials increases soil organic matter content and hence soil fertility level.

The results also showed that 19.8 percent of the respondents used crop diversification as coping strategy. The general advantages of crop diversification include comparatively high net returns from crops, higher net returns per unit of labour, optimization of resource use, higher land utilization efficiency and increased job opportunities (Guto *et al*., 2011). Hassan and Nkemechena (2008) had reported that increased crop diversification is a strong climate change coping strategy against crop failure.

The results further revealed that leaving crop residue on the farm after harvest was another coping strategy against climate change adopted by 19.2 percent of the respondents. The advantage of crop residue is to protect the soil against raindrop impact, impede the flow of runoff, reduce nutrient losses, soil detachment and dispersion and maintain high soil infiltration rate (Quansah *et al*., 1989).

Another 17.6 percent of the respondents used integrated crop and livestock management as a practice against climate change. Integrated crop and livestock management contribute directly or indirectly to food production and income generation. Meat and other animal products are taken as food while manure and traction play a vital role in sustaining the ecosystem on which future production depends (Singh, 1989). The use of these practices against climate change is in agreement with Benhin's (2006) position to the effect that growing variety of crops and keeping animals on the same plot is an appropriate adaptation measure for farmers because it helps to complement animal and crop failure; as crop residues may be used by animals while animal dung could be used to fertilize crops.

About 8 percent of the respondents used adjustment of planting dates as a coping strategy against climate change. The Iowa State university maize planting guide (2013) pointed out that late maize planting can result in yield decrease. Earlier plantings have been shown to offset heat and moisture stress and could be used to adapt to warmer and drier summer (Kane *et al.*, 1991). Oyerinde and Osanyande (2010) have reported that majority (68%) of the farmers they studied had changed planting and harvesting dates as an adaptation strategy against changes in the climate.

Six percent of the respondents indicated switching to other sources of income as a coping strategy against climate change. Switching to other sources of income such as selling of livestock, engaging in politics, and other non-farm activities are some of the methods used in adapting to the effects of climate change (Amos and Adeleke, 2010; Agbolahor and Ashaolu,2011).

Minimum tillage was also practised by about 1.8 percent of respondents. Minimum tillage is the least amount of tillage required to create suitable soil condition for seed germination, crop growth, and weed control (Singh, 1989). Minimum tillage has been reported to be highly effective in reducing soil losses, increase water infiltration and retention and reduce labour input per unit of output (Cleaver and Schreiber, 1992).

Use of drought-tolerant crops was indicated by about 1.6 percent of the respondents. Choosing crop varieties better suited to changing climatic conditions reduces the negative effects of climate change considerably (Kane *et al*., 1991). According to UNDP (2006), as climate change intensifies drought condition in Africa and generate fears of a new cycle of crippling food shortages, widespread adoption of drought-tolerant varieties of maize could boost harvests in African countries by 10 to 34 percent and generate up to US$1.5 billion in benefits for producers. In the same report, UNDP

(2006), further observed that with high rates of adoption of drought-tolerant maize (DTMA), more than four million producers would see their poverty level drop significantly by 2016.

Flood-tolerant crops were used by only 1.4 percent of the respondents. Planting crops that are flood-tolerant is a good strategy that serves as important insurance against rainfall variability, especially in flood-prone areas. The use of flood-tolerant crops is an effective coping strategy against climate change as reported by Hassan and Nkemechena (2007).

The use of disease-tolerant crops was indicated by only 1.4 percent of the respondents. Disease-tolerant plants exhibit little disease damage despite substantial pathogen levels. It is estimated that diseases typically reduce plant yields by 10% every year in more developed nations or agricultural systems, and often exceeds 20% in less developed settings. The advantage of planting of such crops is to protect them from pathogens by preformed mechanisms and infection-induced responses of the plant immune system (Guto *et al*., 2011).

Crop rotation was used by a very low proportion (1.1 percent) of the respondents. Crop rotation provides good ground cover and helps maintain or even improve soil organic matter, thereby contributing to soil fertility (Guto *et al*., 2011). However, the choice of a rotation for a particular area depends on the degree of adaptability of the crops to the particular environmental conditions such as soil, climate, pests, and diseases as well as social and economic considerations. These could have been the reason for the low usage (Lombin, 1981)

These results seem to be consistent with the position of IPCC (2007) that farmers use some indigenous practices to cope with adverse effects of climate change. Hassan and

Nkemachena (2008) noted that coping strategies help farmers achieve their food, income and livelihood security objectives in the face of extreme and changing climatic (drought, flood, high temperature) and socio-economic conditions.

The results that farmers use some local strategies to cope the menace of climate change for maize production also agree with those of Agbonlahor and Ashaolu (2011) in their study on coping strategies of small-scale arable crop farmers to climate change in Ogun State of Nigeria. They found that farmers used late planting (62%), reduction in the length of the cropping cycle (57%), involvement in off-farm activities (44%) and change of crop mix (12%) as coping strategies against climate change.

Table 4: Distribution of respondents according to local strategies used for coping with climate change

Coping strategies	Frequency of responses*	Percentage	Ranking
Use of organic waste	139	22.6	1st
Crop diversification	122	19.8	2nd
Leaving crop residues in the field	118	19.2	3rd
Integrated crop/livestock management	108	17.6	4th
Adjustment in planting dates	51	8.3	5th
Switching to other income sources	31	5.0	6th
Minimum tillage	11	1.8	7th
Use of drought-tolerant crops	10	1.6	8th
Use of flood-tolerant crops	9	1.4	9th
Use of disease-tolerant crops	9	1.4	9th
Crop rotation	7	1.1	10th

*Responses more than sample size due to multiple responses

5.3 Awareness and adoption of promoted technologies for coping with climate change

5.3.1 Awareness

Table 5 shows the distribution of respondents by level of awareness of the promoted maize production technologies against climate change in the study area. The results show that the promoted technologies the farmers were most aware of were mixed

cropping (100%), mixed farming (94%), optimum use of soil organic waste (94%) and crop rotation (93%). The promoted technologies they were least aware of were mulching (29.6%), minimum tillage (16.4%) and water harvesting (9.4%). The theory of diffusion of innovations model demonstrates that awareness of a technology is a necessary first step in the adoption-decision process.

Table 5: Distribution of respondents according to awareness of promoted technologies for coping with climate change (n =159)

Promoted technologies	Frequency of responses*	Percentage	Ranking
Mixed cropping	159	100	1st
Mixed farming	154	96.9	2nd
Use of organic matter	149	93.7	3rd
Crop rotation	147	92.5	4th
Cover cropping	130	81.8	5th
Use of drought tolerant crops	125	78.6	6th
Afforestation	57	35.8	7th
Mulching	47	29.6	8th
Minimum tillage	26	16. 4	9th
Rain water harvesting	15	9.4	10th

*Responses more than sample size due to multiple responses

5.3.2 Adoption

Table 6 shows the distribution of farmers by level of adoption of promoted maize production technologies for coping with climate change. The most adopted of these technologies were mixed farming (96%), mixed cropping (95%) and the optimum use of organic waste (90%) of the respondents and the least adopted ones were minimum tillage (13.2%), afforestation (11.3%) and water harvesting (5.7%). The higher adoption rates for mixed farming, mixed cropping, and use of organic manure in maize production could be because these technologies are age-long traditional agricultural production technologies of the farmers. For example, the potential benefits of crop-livestock integration have long been recognized in the semi-arid tropics of West Africa (Newman *et al*., 1979). Studies in Northern Nigeria have also indicated the overall

dominance of mixed cropping over sole crops (Norman and Pryor, 1979; Abalu, 1976; Olukosi *et al*., 1991). The yield increasing effect of organic waste is also well established on the soils of the Guinea and Sudan savanna zones of West Africa (Ofori, 1999).

The high rate of adoption of mixed farming may be attributed to the fact that it can lead to more efficient use of land unsuitable for crop production, provide a use for crop residue and by-products, provide manure, and be a source of income, savings and investment (Newman *et al*., 1979).

The high rate of adoption of mixed cropping may be attributed to the fact that it results in more efficient utilization of environmental resources, reduction in diseases and pests, helps suppress weeds, provide insurance against crop failure, provides effective soil coverage, and helps spread labour costs more evenly throughout the cropping season (Olukosi *et al*., 1991).

The reason for the high adoption rate of organic waste may be due to it being readily available to farmers at little or no cost and also its positive effects on the improvement of soil organic matter, soil structure and the biological life of the soil, all of which ultimately translate into increased output of crop (Ofori, 1999).

The low adoption rate for minimum tillage may be as a result of low level of awareness of the technology. The reason for the low adoption of minimum tillage may also be due to the disadvantages associated with the technology. For instance it was reported by Toner and Brown (2006) that it is not suited to poorly-drained land, and it requires high initial investment in equipment, and increased weed management and herbicide use.

The low rate of adoption of afforestation may be due to the fact that trees may compete with the companion crops, scattered trees in arable fields interfere with cultivation (for example, ploughing) and lead to uneven stands of the crop and tree harvesting laws and regulations could be significant barriers in many cases. In several countries, farmers are reluctant to plant trees because they fear possible expropriation of the land or future inability to harvest trees without permits (Brown, 2006; Cleaver and Schreiber, 1992).

The low adoption rate for water harvesting may be as a result of low level of awareness of the technology. Water harvesting may have also been least adopted because it is a labour-intensive technology (Cleaver and Schreiber, 1992).

This adoption pattern follows closely the respondents' awareness scores (Table 5). This could be the reason why Shaukariah (1967) stated that awareness of farm agricultural innovations tend to be related to adoption of the innovations.

Table 6: Distribution of respondents according to adoption of promoted technologies for adaptation to climate change (n =159)

Promoted technologies	Frequency of responses*	Percentage	Ranking
Mixed farming	153	96.2	1st
Mixed cropping	151	95.0	2nd
Optimum use of organic matter	143	89.9	3rd
Crop rotation	125	78.6	4th
Cover cropping	118	74.2	5th
Use of drought tolerant crops	109	68.6	6th
Mulching	24	15.1	7th
Minimum tillage	21	13.2	8th
Afforestation	18	11.3	9th
Rain water harvesting	9	5.7	10th

*Responses more than sample size due to multiple responses

A summary of the respondents' levels of awareness and adoption of the promoted technologies and their rankings are as shown in Table 7.

Table 7: Summary of respondents' levels of awareness and adoption of promoted technologies and their rankings (n = 159)

Technologies	Awareness			Adoption		
	Frequency	%	Ranking	Frequency	%	Ranking
Cover cropping	130	81.8	5th	118	74.2	5th
Minimum tillage	26	16.4	9th	21	13.2	8th
Mulching	47	29.6	8th	24	15.1	7th
Mixed farming	154	96.9	2nd	153	96.2	1st
Mixed cropping	159	100	1st	151	95.0	2nd
Crop rotation	147	92.5	4th	125	78.6	4th
Optimum used of Organic waste	149	93.7	3rd	143	89.9	3rd
Afforestation	57	35.8	7th	18	11.3	9th
Use of drought tolerant maize	125	78.6	6th	109	68.6	6th
Water harvesting	15	9.4	10th	9	5.7	10th

5.4 Sources of information on the promoted technologies

Farmers' sources of information on promoted technologies for coping with climate change in maize production were identified and the results are as presented in Table 8. The most important source was radio (53%), followed by friends and relatives (23%), and extension agents (19%). The least important sources mentioned by the respondents were newspapers (1.7%), agro-dealers (1.5%), television (1.4%), field days (1.3%), demonstrations (0.4%) and agricultural extension bulletins (0.2%). Radio has a long history as a communication tool in agriculture. Its low cost and wide reach makes it a relatively simple and effective technology for development, particularly with illiterate audiences. Another advantage of the radio is that farm broadcasts can be presented in local languages which the farmers understand (Saito and Weidemann, 1991; Agbamu, 2006).The finding that radio was the most frequently identified source of information on the promoted technologies is contrary with Voh's (1979) and Obeta and Nwagbo's (1991) findings. In Voh's (1979) study, the extension worker was identified as the most important source of information (36.3), followed by radio (33.8 percent) and friends (15 percent) and other sources (10.6%) in that order. In the case of Obeta and Nwagbo

(1991), extension (92%) was the most important source of information, followed by fellow farmers and neighbours (42%), radio (32%) and television (12%).

Table 8: Distribution of respondents according to sources of information on promoted technologies **(n=159)**

Sources of Information	Type of Recommended technologies										
	Cover crops	Min tillage	Mulching	Mixed farming	Mixed cropping	Crop rotation	Organic matter	Afforestation	DTM	Water harvest	Total
	%	%	%	%	%	%	%	%	%	%	
Radio	48	19	25	87.5	25.8	59.7	52.4	53.8	69.0	87.0	52.7
Friends/relatives	34	27	50	4.5	5.7	17.2	42.0	22.5	26.2	9.0	23.1
Ext agents	28	52	8.7	3.2	63.4	12.5	2.6	16.2	2.6	3.2	19.2
Agro-dealers	_	_	_	_	3.9	_	3.6	1.8	2.2	0.8	1.2
Television	_	_	2.5	4.8	1.2	2.4	_	3.2	_	_	1.4
Field day	_	_	9.8	_	_	1.6	_	2.5	_	_	1.3
Newspaper	_	_	_	_	_	4.7	_	_	_	_	0.5
Demos	_	_	4.0	_	_	_	_	_	_	_	0.4
Extension Bulletins	_	2.0	_	_	_	_	_	_	_	_	0.2
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	

Note: Total percentage of respondents for each technology is 159

5.5 Extent of relationship between respondents' socio-economic, institutional and technology-specific factors and adoption of promoted technologies

The fifth objective of this study was to determine the socio-economic, institutional and technology-specific factors affecting adoption of the promoted maize production technologies for coping with climate change. The results of the linear regression analysis used in achieving this objective are presented in Table 9. The linear regression model estimation gave an R^2 of 0.57, implying that the independent variables included in the model influenced respondents' decisions to adopt the technologies for adaptation to climate change by 57 percent. The regression results also showed that out of the thirteen variables included in the model, household size, labour availability, membership of association, information sources, compatibility, complexity, relative advantage, cost had a significant influence on adoption of the promoted technologies while age, education, farm size, farming experience and extension contact had no significant influence on adoption of the promoted technologies. The results are discussed in the sections below

5.5.1 Socio-economic factors

The results in Table 9 showed that the coefficients for household size (0.060) and labour availability (0.427) were the only socio-economic variables that had a highly significant influence on adoption of the promoted technologies at 1 percent level of probability.

House-hold size positively (0.060) and significantly influenced the adoption of technologies for coping with climate change. This is contrary to the a priori expectation of a negative coefficient. The reason may be that the larger the household size, the more likely the availability of household labour for the adoption of technologies.

Labour availability was positive (0.427) and significantly influenced the adoption of the promoted technologies at 1 percent probability level. The implication is that farmers with access to more labour sources would adopt more technologies for adaptation to climate change by maize farmers more than those with lesser access to labour sources. This is supported by the finding of Lee (2005) that higher labour supply is associated with higher rates of adoption of labour-intensive technologies especially those of soil conservation.

5.5.2 Institutional factors

The institutional factors that significantly influenced the adoption of the promoted technologies against climate change were membership of associations (0.064) and sources of information (0.414); both at the 1 percent level of probability.

Membership of associations enhances access to new ideas and practices in farming through interpersonal and inter–farm visits and interaction with other members of the associations. Participation in voluntary social organizations facilitates exposure to new information on farm practices, access to credit facilities and inputs and learning experiences, both of which will positively influence farmers' adoption behaviour.

Cooperative membership enhances access to information on improved technologies, material inputs of the technologies such as fertilizers and chemicals, and credit for the purchase of inputs and payment of hired labour (Njoku, 1991).

The coefficient for sources of information on technologies for coping with climate change in maize production was positive (0.414) and significantly influenced respondents' adoption at 1 percent level of probability. Sources of information create awareness by diffusing among potential adopters useful and practical information on innovations against climate change and encourages their application(Obeta and Nwagbo, 1991). This implies that credible sources of information reduce the uncertainty about a technology's performance, hence may change individuals' assessment of the technology from purely subjective to objective over time (Caswell *et al*, 2001). Literature reveals that acquisition of information about a new technology demystifies farmers' perception of the technology and makes it more acceptable to farmers.

5.5.3 Technology-specific factors

The coefficient of compatibility of the technologies was found to be positive (0.056) and significant at 1 percent probability level. The adoption of technologies for adaptation to climate change becomes easier when the technologies are compatible with the agro-ecological and socio-economic circumstances of the target farmers. For example the introduction of mould board plough was found to be physically incompatible by many west Bengal farmers because, their bullocks were not strong enough to pull the ploughs which dug deep into the soil, hence the low rate of adoption of the mould-board plough (NIAEM, 2007).

The coefficient for complexity was negative (-0.047) and significant at 1% level of probability. Rogers (1995) noted that complex technologies are not as readily adopted

by intending adopters as less complex technologies, supporting the apriori expectation of a negative relationship between the complexity of a technology and its adoption

The coefficient for relative advantage was positive (0.096) and significant at 1 percent level of probability. This means that the more the benefits to be derived from a new technology over a traditional practice, the more its adoption. A farmer perceiving an innovation to be more advantageous than his existing practice will no doubt be more inclined to adopt it and thus more favourably disposed towards accepting the innovation. These findings are consistent with that of Abara and Singh (1993) who observed that without a significant difference in outcomes between two options, as in the returns from alternative and conventional practices, it is less likely that farmers, most especially small-scale farmers would adopt the new practice.

The coefficient of cost of the promoted technologies was negative (-0.205) but significant at 1 percent level of probability. This implies that technologies that are more expensive are not readily adopted by farmers than less expensive ones. This agrees with Feder *et al.* (1985) and Abara and Singh's (1993) arguments that, technologies with high fixed costs and substantial amount of initial set-up costs are a constraint to adoption of technologies, and that only large-scale farmers will adopt these kinds of innovations. Abara and Singh (1993) also argued that technologies that are capital-intensive are only affordable by wealthier farmers hence the adoption of such technologies is limited to larger farmers who can afford them.

Thus, the hypothesis that farmers' socio-economic, institutional and technology-specific factors have no significant influence on the adoption of the promoted technologies for adaptation to climate change was, therefore, rejected and the alternate hypothesis accepted.

Table 9: Linear regression results of the extent of relationship between socio-economic, institutional and technology-specific factors of respondents and adoption of promoted maize production technologies

Variable	Coefficient	Std.error	t-value
Constant	9.390	1.468	6.395
Age	0.012	0.010	1.200
Household size	0.060	0.024	2.439***
Education	0.125	0.078	1.602
Farm size	0.006	0.023	0.608
Farming experience	0.014	0.040	0.357
Labour availability	0.427	0.157	2.719***
Membership of association	0.064	0.235	2.723***
Extension contact	0.097	0.075	1.293
Information sources	0.414	0.169	2.449***
Compatibility	0.056	0.017	3.294***
Complexity	-0.047	-0.011	-4.273***
Relative advantage	0.096	0.038	2.526***
Cost of technology	-0.205	-0.053	-3.867***

R^2 =57% *** =1%, ** = 5%,

5.6 Effect of adoption of the technologies for adaptation to climate change on maize famers' output, income and level of living

The output, income and level of living of the two groups of respondents, that is, those who adopted the promoted technologies for adaptation to climate change and those who did not were statistically compared (Table 10). The mean differences in outputs, income and level of living of these two groups of respondents were subjected to Z-test analysis. The result for output revealed that the calculated Z- value (2.55) was larger than the tabulated Z-value (1.96) at 10 percent level of probability. Indicating that, there was significant difference in output between adopters and non-adopters of the promoted technologies for adaptation to climate change. Thus, the hypothesis that there is no significant difference in the output of adopters and non-adopters of technologies for adaptation to climate change is rejected and the alternative hypothesis accepted.

The result for income revealed that the calculated Z-value (2.33) was larger than the tabulated Z-value (1.96) at 10 percent level of probability. Indicating that, there was significant difference in income between adopters and non-adopters of the promoted

technologies for adaptation to climate change. Thus, the hypothesis that there is no significant difference in the income of adopters and non-adopters of the technologies for adaptation to climate change is rejected and the alternative hypothesis accepted.

The result for level of living revealed that the calculated Z-value (12.17) was similarly larger than the tabulated Z-value (1.96) at 10 percent level of probability. Indicating that, there was significant difference in level of living between adopters and non-adopters of the promoted technologies for adaptation to climate change. Thus, the hypothesis that there is no significant difference in the level of living of adopters and non-adopters of the technologies for adaptation to climate change is rejected and the alternate was therefore accepted. It may, therefore, be generalized that the adoption of technologies for adaptation to climate change had positive and significant effect on the outputs, income and level of living of adopters of the promoted technologies.

Table 10: Z-test for difference in outputs, income and level of living of adopters and non-adopters of technologies for adaptation to climate change (n =159)

Variable	Mean	Mean difference	Z. Cal	Z-table
A. Output				
Adopters (n = 159)	2787.515			
Non-adopters (n = 159)	1643.490	1104.025	255.278	1.96
B. Income				
Adopters income (n = 159)	674227.044			
Non-adopters income (n = 159)	380433.962	293793.08	2230.173	
B. Level of living				
Adopters level of living (n = 159)	2039216.352			
Non-adopters level living (n = 159)	226864.150	18123522	12178.85	

5.7 Constraints associated with adoption of the promoted technologies for adaptation to climate change by maize farmers

Farmers' constraints with adoption of the promoted technologies for coping with climate change are as presented in Table 11. Thirty four percent of the respondents

indicated that high initial cost of the technologies hindered the adoption of the technologies. This constraint was found to have limited the adoption of mixed farming, cover cropping and minimum tillage technologies. Cattle acquisition and maintenance involves considerable capital expenditure and is, therefore, likely to be feasible only for relatively better–endowed households. Cover cropping may require special equipment and increased draught power to incorporate the cover crop biomass into the soil (Ofori, 1999). Minimum tillage involves increased dependence on herbicides. Thus, high costs of agro-chemicals limit the adoption of minimum tillage. Cost is a particularly major constraint to adoption of innovations, especially for the small-scale low-income farmers. This is supported by Khannal (2001) who argued that technologies that are capital-intensive are only affordable and limited to wealthier and large-scale farmers.

The constraint of pests and diseases, indicated by 22 percent of the respondents, was associated with the use of water harvesting, organic manure, cover cropping and mulching. Rain water systems are prone to rodents, mosquitos, algae growth, insects and lizards. Mulching annuals that are low to the ground exposes plant to insects and molds (Cleaver and Schreiber, 1992). Cover crops may also increase populations of rodents and insect pests (Ofori, 1999).

The complex nature of the technologies was reported by about 19 percent of the respondents. This constraint was associated with adoption of mulching, agro-forestry and mixed cropping. The use of mulching in soil fertility improvement is dependent on farmers' level of education farmers often either discard or burn the residue when they prepare the land for the next cropping season (Ofori, 1999). The use of agro-forestry requires a longer period for a better understanding and appreciation of interaction of various factors (Ehui, 1988). Mixed cropping is tedious to execute and evaluate as a

result of the complexity of interactions among components of the mixtures. Similarly, determining quantities and mode of application of inputs such as fertilizers and pesticides can pose problems (Olukosi *et al*., 1991).

Inadequate spacing was indicated by 9 percent of the respondents as a constraint in the use of mixed cropping and mixed farming. Mixed cropping and mixed farming are practices that result in competition for space, time and nutrients (Sosovel, 2000). Difficulties during crop harvesting and fertilizer application are some of the problems associated with mixed cropping technologies. It is also often argued that mechanization of planting, harvesting, and various operations are more difficult if not impossible in mixed cropping than sole cropping (Olukosi *et al*., 1991). In mixed farming, the diminishing availability of land is also resulting in problems concerning alternative use of land, conflicts between herders and farmers, conflicts concerning other resources such as labour and capital being devoted to crop or animal production (Newman *et al*., 1979).

The constraint of bulkiness of the technologies was indicated by about 4 percent of the respondents. This problem was associated with the use of organic waste. Bulkiness is a key constraint in the transport of organic materials. As a result, there is a strong incentive to produce organic inputs in situ (Place *et al.*, 2003).

The constraint of high labour requirement indicated by 3.9 percent of the respondents was associated with the practices of use of organic waste, mulching, agro-forestry and water harvesting. Managing manure is labour-intensive and requires transport and tools (Place *et al.*, 2003). There has also not been widespread adoption of agro-forestry due to high labour requirement for prunning (Ofori, 1999). Water harvesting requires little capital but it is labour-intensive (Cleaver and Schreiber, 1992). Labour has been identified as one of the major constraints to agricultural production. Agriculture in the

Nigerian Savanna is organized around families which are becoming increasingly nucleated. Family labour can no longer cope with labour demand on the farm due to absence of young males in the villages and farms. Hired labour has to be used but it is very difficult to find and is, therefore, expensive (Olukosi *et al*., 1991).

The constraint of bulkiness of the technologies was indicated by about 7.3 percent of the respondents. This problem was associated with the use of organic waste. Bulkiness is a key constraint in the transport of organic materials. As a result, there is a strong incentive to produce organic inputs in situ (Place *et al.*, 2003).

Table 11: Distribution of respondents according to constraints in adoption of the promoted technologies

Constraints	Frequency*	Percentage	Ranking
Costly nature of technologies	156	34.2	1st
Pests and diseases	101	22.1	2nd
Complex nature of technologies	87	19.0	3rd
Lack of adequate spacing	43	9.4	4th
High labour requirement of technologies	18	4.0	5th
Bulkiness of technologies	16	9.9	6th

***** Frequency more than sample size due to multiple responses

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The main objective of this study was to evaluate the adoption of technologies for coping with climate change by maize farmers in the North-west agro-ecological zone of Nigeria. The specific objectives were to:

i. evaluate farmers' perception of the effects of climate change on maize production in the study area;

ii. identify and describe the local climate change coping strategies used by maize farmers;

iii. identify the sources of information through which farmers became aware of technologies for coping with the effect of climate change?

iv. determine farmers' levels of awareness and adoption of the promoted technologies for coping with climate change in maize production;

v. determine the socio-economic, institutional and technology-specific factors affecting the adoption of maize production technologies for coping with climate change;

vi. determine the effects of adoption of the technologies for coping with climate change on maize farmers' outputs, income and level of living; and

vii. identify and describe constraints associated with adoption of maize production technologies for coping with climate change.

The study covered four (Katsina, Kano, Kebbi and Sokoto) out of the seven states of the North-west of Nigeria. Data were collected using a questionnaire that was administered to 159 purposively selected maize farmers with the help of trained village extension agents (VEAs) and HND II students of Agricultural Extension and Management from College of Agriculture Zuru, Kebbi State. The collected data were analyzed using descriptive statistics, Z-test and multiple linear regression model.

The results of the study showed that the perceived most severe effects of climate change on maize production included severe drought (89.4%) too much rain/flood (71.8%) increased weed incidence (68.6%), excessive use of fertilizers (64.2%), increased pest and disease infestation(62.2%) and reduced yields (62.%).

The most common local strategies employed by the respondents to cope with the adverse effect of climate change were the use of organic wastes (22.6%), crop diversification (19.8), leaving crop residue on the farm (19.2%) and crop/livestock integration (17.6%).

The promoted adaptation strategies for coping with climate change the respondents were most aware of were mixed cropping (100%), crop livestock integration (96.9), use of organize wastes (93.7%) crop rotation (92.5), cover cropping (81.8%) and use of drought tolerant crops (78.6%). There was least awareness for use of minimum tillage (16.4%) and water-harvesting (7.4%).

The most adopted of the promoted technologies were mixed farming (96.2%), mixed cropping (95%), use of organic wastes (89.9%), crop rotation (78.6%), cover cropping (74.2%) and use of drought-tolerant crops (68.6%). The least adopted were afforestation (11.3%) and water harvesting (5.7%).

The most important sources of information on the promoted technologies were radio (36.6%), friends and relatives (26.2%) and extension agents (16.1%). The least important sources were demonstrations (1.1%) and bulletins (0.2%).

The results of the linear regression analysis of the relationship between selected socio-economic, institutional and technological factors and adoption of the promoted technologies showed that out of the thirteen variables included in the model, eight had significant influence on adoption of the technologies. These eight variables were household size, labour source, membership of association, information sources, relative advantage, compatibility, complexity, and cost.

The effects of adoption of the promoted technologies for coping with climate change on respondents' output, income and level of living revealed that there was a significant difference in the output, income and level of living between adopters and non-adopters.

The major constraints against the adoption of the promoted technologies were: (i) cost of the technologies (34.2%); (ii) problems of pests and diseases (22.1%); (iii) complex nature of the technologies (19.0%).-

6.2 Conclusions

Previous adoption studies have generally indicated that farmers' socio-economic, institutional and technological factors have been helpful in explaining adoption of innovative farm practices. This study also found these variables useful in explaining the adoption of the promoted technologies for adaptation to climate change. The study also found the promoted technologies to have a positive effect on farmers' outputs, income and level of living. In general, however, high cost of the promoted technologies, pests and diseases and complex nature of the technologies were the major constraints that limited the adoption of the technologies.

6.3 Recommendations

i. Given some of the perceived adverse effects of climate change on maize production such as severe drought, too much rain and increased pest and disease attack, crop improvement research should not only aim at increasing yields, but also at improving resistance to diseases and pests, tolerance to environmental stress (drought, high temperature etcetera). Modifications in management practices such as choosing crop varieties better suited to changed climatic conditions and adjustment in the timing of farming operations, for example, earlier plantings to offset heat and moisture stresses could also be useful.

ii. The radio, friends/relatives and extension agents were found to be the major sources of information on the promoted technologies for coping with climate change. It is therefore recommended that these sources should be made more effective. Radio programmes on the recommended technologies should be made more frequent and understandable. Providing effective professional training for extension staff on the dissemination of the promoted technologies would also be helpful.

iii. It was found that use of demonstrations, field days, and extension bulletins were low in the creation of awareness on the technologies for coping with climate change. Policy makers and other stakeholders in the agricultural sector should therefore promote the use of these mass media methods of communication in the dissemination of promoted technologies. Demonstrations are particularly useful with non-literate farmers and give farmers the opportunity to observe the differences between recommended practices and traditional practices. Field days are useful in bringing farmers together in an informal situation to discuss common problems and gain useful experience from one another.

iv. It was found that factors such as farmers' socio-economic, institutional and technology-specific factors significantly influenced the adoption of technologies against climate change. This implies, therefore, that change agents in the study area should continue to pay attention to these variables.

v. Cost of some of the technologies was a major constraint to adoption. Considering the low-resource position of most peasant farmers, there is need to encourage farmers to form cooperative societies to enable them have access to credit facilities and other inputs needed for the adoption of high-cost technologies.

vi. It was found that pests and diseases were constraints to adoption of some of the promoted technologies for coping with climate change. This could be addressed through educating farmers on adoption of an integrated pest management approach which combines different pest control techniques and integrates them into the overall farming system. These include use of resistant crop varieties, use of disease-free plating materials, use of pathogens or microbial pesticides and selective use of chemical control.

6.4 Contributions of this study to knowledge

i. The study identified maize farmers' most perceived adverse effects of climate change on maize production to be severe drought (89.4%), too much rain/flood (71.8%), and increased weed incidence (66.6%) of the respondents. The least were insufficient rainfall (46.6%) and death of crops and reduced cultivable land (44.6% each) of the respondents.

ii. The study identified maize farmers' most important indigenous or traditional coping strategies against climate change to be use of organic waste (22.6%),

crop diversification (19.8%) and leaving crop residue in the field (19.2%) of the respondents. The least important were use of disease-tolerant crop (1.4%) and crop rotation (1.1) of the respondents.

iii. The study showed that the promoted technologies that farmers were most aware of were mixed cropping (100%), mixed farming (96.9%) and use of organic waste (93.7%) and those they were least of were minimum tillage (16.4%) and water-harvesting (7.4%). However, the ones most adopted by farmers were mixed farming (92.6%), mixed cropping (95.0%) and optimum use of organic waste (89.9%) of the respondents and the least adopted were water harvesting (5.7%) and afforestation (11.3%) of the respondents.

iv. The study found the most important source of information on the promoted technologies to be radio (36.6%) and the least important to be bulletins (0.2%) of the respondents.

v. The study found some socio-economic, institutional, and technological factors to be statistically significant at influencing farmers' adoption of the promoted technologies against climate change at the 1percent level of probability, these were household size, labour availability, membership of associations, sources of information, relative advantage, compatibility, complexity, and cost.

vi. The study found that the major constraints to adoption of the promoted technologies against climate change in maize production were cost of the technology (34.2%), pest and diseases (22.1%), and complex nature of technologies (19.0%).

6.5 Areas for further study

The sample used for this study only focused on maize farmers who produced maize on 1 hectare and above. This population constituted less than half of the population of maize farmers. There is the need to replicate this survey with larger samples comprising all categories of maize farmers in all the agro- ecological zones in Nigeria so that results can be compared more meaningfully.

In order to fully understand farmers adoption behaviour, research must be designed and carried out from a multi-disciplinary point of view covering not only a section of maize farmers and or the socio-economic and institutional variables of respondents but also the attributes of the technologies, psychological factors, government's role as a factor, relevance and perception of the technologies to farmers' and environmental variables that could influence adoption.

Although this study tended to focus largely on adaptation strategies for coping with climate change, the mitigation strategies should also be given equal attention. This is because it has been established that climate change can best be solved by integrating adaptation and mitigation response measures into the broader agenda of sustainable development strategies.

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APPENDIX I

Adopters' Questionnaire

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY, ZARIA

Title: **Adoption of Technologies against Climate Change for Maize Production in North-West Agro-Ecological Zone Nigeria**

Tick the box (√) or complete the spaces where necessary.

Section A: Socio-Economic Characteristics

1. Name of farmer_____
2. Local Government Area: _____
3. Age of Farmer_____
4. Household size (Number)_____
5. Highest level of Education (years):

   (a) No formal education ( )

   (b) Adult education ( )

   (c) Primary ( )

   (d) Secondary) ( )

   (e) Tertiary education ( )

   Total No. of years in school_____
6. Major occupation: _____
7. Secondary occupations:_____

   _____
8. Years of farming experience :_____
9. How long have you been into maize farming?(No. of years) _____
10. Size of farm put into maize production in 2011_____ (ha)

11. How many bags (100kgs) of maize did you realized from your maize harvest in the following cropping seasons?

    (i) 2009_____kgs
    (ii) 2010_____kgs
    (iii) 2011_____kgs

12. How many bags (100kgs) did you sell in:

    (i) 2009_____kgs
    (ii) 2010_____kgs
    (iii) 2011_____kgs

13. Income realized from the sales of maize in the last three years:

    (i) 2009_____(₦)
    (ii) 2010_____(₦)
    (iii) 2011_____(₦)

14. Major source of income? _____

15. Secondary sources of income?_____

16. Sources of labour for your farm operations?
    (i)Hired labour ( )
    (ii)Relations ( )
    (iii)Friends ( )
    (iv)Cooperatives ( )
    (v)Community ( )
17. Land tenure status:

    (i) Purchase ( )
    (ii) Inheritance ( )
    (iii) Gift ( )
    (iv) Lease ( )

Institutional Affiliation of Respondent
Social Organizations/ Farmers Associations

18. Do you belong to any social organization/farmers association (s)? (Yes) (No)
    If yes

19. Name the organization(s) you belong to
    a)_____
    b)_____
    c)_____
20. How many years have you been a member to each of these associations?
    a)_____
    b)_____
    c)_____

21. Main activity of the group(s)

(a) Production

(b) Processing

(c) Social

(d) Savings

(e) Kinship

(f) Others (specify)_____

22. Number of meetings attended for each in the last one year?
a) _____
b) _____
c) _____

23. List the most important benefit (s) derived from membership of association
_____
_____
_____
_____

24. Assessment of benefits from association (tick)
(a) Very beneficial ( )

(b) Beneficial ( )

(c) Fairly beneficial ( )

(d) Not beneficial ( )

Extension Delivery System

25. What are your frequent sources of extension messages?

(i). Agric extension agent ( )
(ii) Extension bulletins ( )
(iii) Newspaper ( )
(iv). Radio ( )
(v) Television ( )
(vi) Demonstration ( )
(vii) Field day ( )
(viii) Friends ( )
(ix) Relatives ( )
(x) Ago-dealers ( )

26. Were you visited by any extension worker during the 2011 season? Yes ( ) No ( )
If yes

27. How many times were you visited?

(0) None at all ( )

(a) Once in a year ( )

(b) On quarterly ( )

(c) Monthly ( )

(d) Fortnightly ( )

(e) Weekly ( )

Credit Facilities

28. Did you receive any cash and/or input (formal and informal credit in the year 2011 cropping season for crop or livestock production? Yes ( ) No ( )

29. If no please say why

(0) = N/A ( )

(i) no source of credit in vicinity ( )

(ii) Did not look for credit ( )

(iii) No collateral to guaranteed credit ( )

(iv) High interest rate ( )

(v) others (specify)_____

If yes

30. What was your major source of fund/credit for farming during the last farming season?

(a) Bank ( )
(b) cooperative ( )
(c) friends/relations ( )
(d) self ( )
(e) Government agencies ( )
(f) Money lender ( )
(g) others (specify) _____

Section B. Perception oo Effect of Climate Change on Maize Production

31. Has your Farm been affected by serious climate related problems in the last ten years?

Yes ( ) No ( )

32.If yes indicate as follows:

Nature of effects	SA	AG	UND	DA	SD
Severe drought and increase temperature					
Too much rain /flood on maize farms					
Hail storm					
Pest/disease infestation					
Low harvest					
Dangerous weeds					
Death or total loss of crops					
Decrease yield					
Short season length					
Decrease water supply to maize					
Excess use of fertilizer					
Reduce cultivable maize land					

Please indicate the following as it relates to your maize production

Specific problems	**Year it occurred in the last 10years**	**Has this risk/problem affected maize directly? (1=Yes, 2=No)**
Drought		
Too much rain or flood		
Frost or hailstorm		
Plant pests and diseases		
Livestock diseases		
Dangerous weeds		
Death or loss of livestock		

33. Do you agree that the rainfall pattern in Nigeria has change of recent? Yes ( )

No ( )

34. If Yes., To what extent do you agree that the rainfall pattern in Nigeria has changed over the last few years?

(i) Very much ( )

(ii) Much ( )

(iii) Little ( )

(iv) Very little ( )

(v) Not at all ( )

35.Specifically, to what extent have the characteristics of rainfall pattern in Nigeria changed?

Characteristics of rainfall pattern	Very much	Much	Little	Very little	Not at all
To what extent has drought change?					
To what extent has too much rain or flood change?					
To what extent has early rain change?					
To what extent has late rainfall change?					
To what extent has early cessation of rainfall change?					
To what extent has late cessation of rainfall change?					
To what extent has short duration of rainfall change?					

36. Do you agree that the temperature in Nigeria has changed Yes ( ) No ( )

37. If yes., what form of changes has taken place in respect of air temperature in Nigeria in the last few years?

(i) hotter ( )
(ii) cooler ( )
(iii) No change ( )
(iv) moderate ( )
(v) I don't know ( )

38. How often do you experience extreme weather events of recent? compared with 10years ago?

(i)Very often ( )

(ii) Often ( )

(iii) Rarely ( )

(iv) Never ( )

39. How prone are we to drought, especially considering weather pattern in recent times?

(i)Very prone ( )

(ii) prone ( )

(iii) Less prone ( )

(iv) Not prone ( )

40. What can you say about the characteristics of weather events in recent times?

(i)Same ( )

(ii) Changing ( )

(iii) I don't know ( )

41. Recent weather trends have serious undesirable effects on you maize production?

i)Strongly agreed ( )

(ii) Agreed ( )

(iii) Disagreed ( )

(iv) Strongly disagreed ( )

(v) Don't know ( )

42. Indicate how climate change exerts undesirable effects on your maize production practice

Undesirable effects	Strongly agreed	Agreed	Disagreed	Strongly disagreed	Not At all
Decreased yield					
Short season length					
Decreased water supply					
Excess use of fertilizer					
Pest and Disease infestation					
Flooding of land					
Reduce grazing land					

Section C. Crop Production Risk Coping Strategies

43. Indicate your crop production risk coping strategies?

Coping strategy	**Tick if applicable**	**Effects on your**	**Maize**	**Output**
Adjustment of planting dates		High	Moderate	Low
Agro-forestry				
Afforestation				
Reforestation				
Use of Ramia chop wood				
Rain water harvesting				
Mixed cropping				
Minimum tillage				
Composting of Organic waste				
Irrigation				
Intercropping				
Crop rotation				
Integrated crop/livestock Management				
Drought tolerant crops				
Flood Tolerant crops				
Animal traction				
Crop diversification				
Disease tolerant crops				
Leaving crop residue in the field				

44. List three most serious threats for livelihoods of your household? (e.g. droughts, food insecurity, etc.)

(i)_____

(ii)_____

(iii)_____

45. List three most serious constraints for improving the livelihoods of your household? (e.g. production, output marketing, input markets, health, soil condition, transportation; etc.)

(a)_____

(b)_____

(c)_____

46. Indicate the most important strategies you use to reduce or eliminate production failure risk?

i) Increase more crop/ animal production ( )

ii). Involve in Non-agric. activities ( )

iii. Buying and storing more agric produce ( )

(iv). Participate in politics ( )

(v) Involve in buying and selling animals ( )

47. What are the most important coping mechanisms against food shortage in your household?

i	Reduced frequency of food intake	vi.	Withdrawing children from school
ii	Reducing other expenditure	vii.	Selling small animals
iii	Selling Cattle	viii.	Selling farm equipment
iv	Selling other assets	ix.	Working more off-farm
v	Working at food-for-work	x.	Receiving food acid

Section D. Level of Awareness and Adoption of Improved Maize Production Technologies

48. Which of the following types of improved maize production technologies have you heard of?

(a)Use of cover cropping ( )
(b)Minimum tillage ( )
(c)Mulching ( )
(d)Mixed farming ( )
(e)Mixed cropping ( )
(f)Crop rotation ( )
(g)Optimum use of soil organic matter ( )
(h)A forestation ( )
(i)Use of drought tolerant crop varieties ( )
(j)Water Harvesting ( )

49. Tick any of the under listed sources through which you first obtained information on improved maize production technologies.

Friend/Relations ( )
Television ( )
Radio ( )
Extension Agents ( )
Social groups (e.g. town meetings ( )
Newspapers ( )
Agricultural show ( )
Agro dealers ( )

Sources of awareness	Type of Recommended technologies									
	Cover crops	Min tillage	Mulch	Mixed farming	Mixed cropping	Crop rotation	Organic matter	Afforestation	DTM	Water harvest
Radio										
Friends/relative										
Ext agents										
Agro-dealers										
Television										
Field day										
Newspaper										
Demos										
Extension Bulletins										

50. Indicate the source which you first heard of the specific improved technologies

51. Did you use any of these improved technologies in maize production in the last three years? Yes ( ), No ( ).

52. If yes, which of them have you used in your maize production? (tick where applicable)

(a)Use of cover cropping	( )	(f) Afforestation	( )
(b) Minimum tillage	( )	(g) Use of DTMV	( )
(c) Mulching	( )	(h) Water Harvesting	( )
(d)Mixed farming	( )	(i) Crop rotation	( )
(e)Mixed cropping	( )	(j) Optimum use of soil organic matter	( )

53. Since you adopted these practices have you been practicing the technologies on your maize farm? Yes ( ) No ( )

If No ! what are your reasons for discontinuance of the technology (ies)?

54.Indicate your most important reason for adoption or non-adoption of the following technologies

Characteristics of Improved Technologies	Adoption (√) Non Adoption (x)	Reasons
Use of cover cropping		
Minimum tillage		
Mulching		
Mixed farming		
Mixed cropping		
Crop rotation		
Optimum use of soil organic matter		
A forestation		
Use of drought tolerant crop varieties		
Water Harvesting		

55. Reasons for non-adoption of each of the technologies against climate change (tick reasons)

Reasons given	Type of Recommended technologies									
	Cover crops	Min tillage	Mulch	Mixed farming	Mixed cropping	Crop rotation	Organic matter	Afforestation	DTM	Water harvest
Tech not available										
Not aware										
No Land										
High labour										
Preparation difficulty										
Breeding space for weeds/diseases										
Bulkiness										
High cost										
No weeds										

Section E: Factors Affecting Adoption of technologies

56. Indicate the degree of agreement on how the characteristics of these technologies have influenced your adoption of climate change maize production technologies.

Relative advantage of the technology		Strongly Agreed	Agreed	Undecided	Disagreed	Strongly disagreed
The climate change maize production technology is cheaper than the traditional technologies?						
The climate change maize production technology provide more income as compared with the traditional technologies						
The improved technologies require less labour and shorter time as compared with traditional methods?						

Technologies	**Compatibility**				
Use of cover cropping	Very compatible	Compatible	Undecided	Less compatible	Not compatible
Minimum tillage					
Mulching					
Mixed Farming					
Mixed Cropping					
Crop Rotation					
Optimum use of soil organic matter					
A forestation					
Use of drought tolerant crop varieties					
Water Harvesting					

Technologies	**Complexibility**				
Use of cover cropping	Very compatible	Compatible	Undecided	Moderately compatible	Less compatible
Minimum tillage					
Mulching					
Mixed Farming					
Mixed Cropping					
Crop Rotation					
Optimum use of soil organic matter					
A forestation					
Use of drought tolerant crop varieties					
Water Harvesting					

Cost	Improved Technologies	Strongly Agreed	Agree	Undecided	Disagreed	Strongly disagreed
The climate change maize production technologies are not costly to obtain	Use of cover cropping					
	Minimum tillage					
	Mulching					
	Mixed farming					
	Mixed cropping					
	Crop rotation					
	Optimum use of soil organic matter					
	A forestation					
	Use of drought tolerant crop varieties					
	Water Harvesting					

Section F: Effect of adoption of climate change maize production technologies

57. How does the last season maize hectarage compare with the previous ones and why

1) Same	2) Large	3) Smaller
Reason	**Reason**	**Reason**
1) Rainfall pattern unchanged 2) Pests and diseases 3) Weeds 4) Yield 5) Labour force unchanged 6) Land size unchanged 7) Not interested in expanding	1) Enough seed 2) Enough labour 3) Enough cash to buy inputs 4) Enough land to expand 5) Interested in expanding 6) Better rainfall 7) Weeds	1) Inadequate seed 2) Reduced labour force 3) Reduced cash for inputs 4) Reduced land available 5) Interest in intensive farming 6) Poor rainfall/drought 7) Floods 8) Pests and diseases

Effect of adoption on output:

58. What is the quantity of maize obtained in 2007? (100kgs bag) _____

59. What is the quantity of maize obtained in 2008? (100kgs bag)_____

60**.** What is the quantity of maize obtained in 2009? (100kgs bag)_____

Effect of adoption Income:

61. What is the estimated amount you realized from the sale of your maize in the last 3years?

Year	**(₦)**
2009	
2010	
2011	

Effect of adoption on farmers Level of Living:

62. Household Assets

At present, how much/many of the following does this household own that are usable/repairable? (For value per unit, ask for the current value of the asset).

Agricultural asset			Value per unit	Agricultural asset		Quantity /number	Value per unit
Asset		Qty	Value (₦)	Asset		Qty	Value (₦)
1	house (residential)			**21**	Donkey		
2	Stores			**22**	Oxen		
3	Poultry houses			**23**	Animal traction plough		
4	Car			**24**	Water pump (maker)		
5	Truck			**25**	Truck		
6	Wheel barrow			**26**	Tractor		
7	Chaff cutter			**27**	Trailer		
8	Radio			**28**	Ploughs for tractor		
9	TV			**29**	Harrow/tiller		
10	Bicycle			**30**	Ridger		
11	Battery			**31**	Planter		
12	Land line telephone			**32**	Boom sprayer		
13	Mobile phone			**33**	Sheller		
15	Pestle and motar			**34**	Generator		
16	Water tanks			**35**	Power saw		
17	Beehive			**36**	Grinder		
18	Water pump (powered)			**37**	Cattle dip		
19	Well			**38**	Cane crusher		

Contribution of the technologies to your level of living

63. Has the adoption of any of the climate change maize production technologies changed your production output? Yes, ( ) No ( )

If yes by what percentage?_____

What of your Income? (%)_____

What of your Level of Living? (%) ____

64.What do you think you have derived from adoption of climate change coping strategies?

		Agreed	Disagreed
A	More income		
B	Increase in yield		
C	Effectiveness in crop production		
D	Efficiency in crop production		
E	Reduced risks of drought occurrence		
F	Increased security to crop production		
G	Reduced erosion rate in the farm		
H	Increase soil fertility status		

Section G: Constraints with coping strategies

65. List three most serious constraints for improving your maize production (e.g. finance for production, output marketing, input markets , health, soil condition, transportation etc.) :

(a) _____
(b) _____
(c) _____

66. What are the challenges you face with regards to coping to climate change?
……
……
..

67. In your own opinion how best do you think climate change problems could be tackled?
……
.
……
.

Thank you!

APPENDIX II

Questionnaire for Non-Adopters

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY, ZARIA

Title: Title: **Adoption of Technologies against Climate Change for Maize Production in North-West Agro-Ecological Zone Nigeria**

Tick the box (√) or complete the spaces where necessary.

Section A: Socio-Economic Characteristics

1. Name of farmer_____
2. Local Government Area: _____
3. Age of Farmer_____
4. Household size (Number)_____
5. Highest level of Education (years):

   (a) No formal education ( )

   (b) Adult education ( )

   (c) Primary ( )

   (d) Secondary) ( )

   (e) Tertiary education ( )

   (Total No. of years in school_____)

6. Major occupation: _____
7. Secondary occupations: _____

   _____

8. Years of farming experience :_____
9. How long have you been into maize farming?(No. of years) _____
10. Size of farm put into maize production in 2011_____ (ha)
11. How many bags (100kgs) of maize did you realized from your maize harvest in the 2011cropping season? _____kgs
12. How many bags (100kgs) did you sell _____kgs

13. Income realized from the sales of maize in 2011_____(₦)

14. Major source of income? _____

15. Secondary sources of income?_____

16. Sources of labour for your farm operations?
    (i)Hired labour ( )
    (ii)Relations ( )
    (iii)Friends ( )
    (iv)Cooperatives ( )
    (v)Community ( )

17. Land tenure status:

    (i) Purchase ( )
    (ii) Inheritance ( )
    (iii) Gift ( )
    (iv) Lease ( )

Institutional Affiliation of Respondent

Social Organizations/ Farmers Associations

18. Do you belong to any social organization/farmers association (s)? (Yes) (No)

    If yes

19. Name the organization(s) you belong to
    a)_____
    b)_____
    c)_____

20. How many years have you been a member to each of these associations?

    a)_____
    b)_____
    c)_____

21. Main activity of the group(s)

    (a) Production

    (b) Processing

    (c) Social

    (d) Savings

    (e) Kinship

    (f) Other (specify)_____

22. Number of meetings attended for each in the last one year?
    a) _____
    b) _____
    c) _____
23. List the most important benefit (s) derived from membership of association
    _____
    _____
    _____
    _____
24. Assessment of benefits from association
    (a) Very beneficial

    (b) Beneficial

    (c) Fairly beneficial

    (d) Not beneficial

Extension Delivery System

25. What are your frequent sources of extension messages?

    (i). Agric extension agent ( )

    (ii) Extension bulletins ( )

    (iii) Newspaper ( )

    (iv). Radio ( )

    (v) Television ( )

    (vi) Demonstration ( )

    (vii) Field day ( )

    (viii) Friends ( )

    (ix) Relatives ( )

    (x) Ago-dealers ( )

26. Were you visited by any extension worker during the 2011 season? Yes ( ) No ( )

    If yes

27. How many times were you visited?

    (0) None at all ( )

    (a) Once in a year ( )

    (b) On quarterly ( )

(c) Monthly ( )

(d) Fortnightly ( )

(e) Weekly ( )

Credit Facilities

28. Did you receive any cash and/or input (formal and informal credit in the year 2011 cropping season for crop or livestock production? Yes ( ) No ( )

29. If no please say why

(0) = N/A ( )

(i) no source of credit in vicinity ( )

(ii) Did not look for credit ( )

(iii) No collateral to guaranteed credit ( )

(iv) High interest rate ( )

(v) others (specify)_____

If yes

30. What was your major source of fund/credit for farming during the last farming season?

(a) Bank ( )

(b) cooperative ( )

(c) friends/relations ( )

(d) self ( )

(e) Government agencies ( )

(f) Money lender ( )

(g) others (specify) _____

Section B. Perception of Effect of Climate Change on Maize Production

31. Has your Farm been affected by serious climate related problems in the last ten years?

Yes ( ) No ( )

32.If yes indicate as follows:

Nature of effects	SA	AG	NU	DA	SD
Severe drought and increase temperature					
Too much rain /flood on maize farms					
Hail storm					
Pest/disease infestation					
Low harvest					
Dangerous weeds					
Death or total loss of crops					
Decrease yield					
Short season length					
Decrease water supply to maize					
Excess use of fertilizer					
Reduce cultivable maize land					

Please indicate the following as it relates to your maize production

Specific problems	**Year it occurred in the last 10years**	**Has this risk/problem affected maize directly? (1=Yes, 2=No)**
Drought		
Too much rain or flood		
Frost or hailstorm		
Plant pests and diseases		
Livestock diseases		
Dangerous weeds		
Death or loss of livestock		

33. Do you agree that the rainfall pattern in Nigeria has change of recent? Yes ( ) No ( )

34. If Yes., To what extent do you agree that the rainfall pattern in Nigeria has change over the last few years?

(i) Very much ( )

(ii) Much ( )

(iii) Little ( )

(iv) Very little ( )

(v) Not at all ( )

35. Specifically to what extent have the characteristics of rainfall pattern in Nigeria change?

Characteristics of rainfall pattern	Very much	Much	Little	Very little	Not at all
To what extent has drought change?					
To what extent has too much rain or flood change?					
To what extent has early rain change?					
To what extent has late rainfall change?					
To what extent has early cessation of rainfall change?					
To what extent has late cessation of rainfall change?					
To what extent has short duration of rainfall change?					

36. Do you agree that the temperature in Nigeria has changed Yes ( ) No ( )

37. If yes., what form of changes has taken place in respect of air temperature in Nigeria in the last few years?

(i) hotter ( )
(ii) cooler ( )
(iii) No change ( )

(iv) moderate ( )
(v) I don't know ( )

38. How often do you experience extreme weather events of recent? compared with 10years ago?

(i)Very often ( )

(ii) Often ( )

(iii) Rarely ( )

(iv) Never ( )

39. How prone are we to drought, especially considering weather pattern in recent times?

(i)Very prone ( )

(ii) prone ( )

(iii) Less prone ( )

(iv) Not prone ( )

40. What can you say about the characteristics of weather events in recent times?

(i)Same ( )

(ii) Changing ( )

(iii) I don't know ( )

41. Recent weather trends have serious undesirable effects on you maize production?

i)Strongly agreed ( )

(ii) Agreed ( )

(iii) Disagreed ( )

(iv) Strongly disagreed ( )

(v) Don't know ( )

42. Indicate how climate change exerts undesirable effects on your maize production practice

Undesirable effects	Strongly agreed	Agreed	Disagreed	Strongly disagreed	Not At all
Decreased yield					
Short season length					
Decreased water supply					
Excess use of fertilizer					
Pest and Disease infestation					
Flooding of land					
Reduce grazing land					

Section C. Crop Production Risk Coping Strategies

43. Indicate your crop production risk coping strategies?

Coping strategy	**Tick if applicable**	**Effects on your**	**Maize**	**Output**
Adjustment of planting dates		High	Moderate	Low
Agro-forestry				
Afforestation				
Reforestation				
Use of Ramia chop wood				
Rain water harvesting				
Mixed cropping				
Minimum tillage				
Composting of Organic waste				
Irrigation				
Intercropping				
Crop rotation				
Integrated crop/livestock Management				
Drought tolerant crops				
Flood Tolerant crops				
Animal traction				
Crop diversification				
Disease tolerant crops				
Leaving crop residue in the field				

44. List three most serious threats for livelihoods of your household? (e.g. droughts, food insecurity, etc.)

(i)_____

(ii)_____

(iii)_____

45. List three most serious constraints for improving the livelihoods of your household? (e.g. production, output marketing, input markets, health, soil condition, transportation; etc.)

(a)_____

(b)_____

(c)_____

46. Indicate the most important strategies you use to reduce or eliminate production failure risk?

i) Increase more crop/ animal production ( )

ii). Involve in Non-agric. activities ( )

iii. Buying and storing more agric produce ( )

(iv). Participate in politics ( )

(v) Involve in buying and selling animals ( )

47. What are the most important coping mechanisms against food shortage in your household?

i	Reduced frequency of food intake	vi.	Withdrawing children from school
ii	Reducing other expenditure	vii.	Selling small animals
iii	Selling Cattle	viii.	Selling farm equipment
iv	Selling other assets	ix.	Working more off-farm
v	Working at food-for-work	x.	Receiving food acid

Section D. Level of Awareness and Adoption of Improved Maize Production Technologies

48. Which of the following types of improved maize production technologies have you heard of?

Use of cover cropping	( )
Minimum tillage	( )
Mulching	( )
Mixed farming	( )
Mixed cropping	( )
Crop rotation	( )
Optimum use of soil organic matter	( )
A forestation	( )
Use of drought tolerant crop varieties	( )
Water Harvesting	( )

49. Tick any of the under listed sources through which you first obtained information on improved maize production technologies.

a)	Friend/Relations	( )
b)	Television	( )
c)	Radio	( )
d)	Extension Agents	( )
e)	Social groups (e.g. town meetings	( )
f)	Newspapers	( )
g)	Agricultural show	( )
h)	Agro dealers	( )

50. Reasons for non-adoption of each of the technologies against climate change (tick reasons)

Reasons given	Type of Recommended technologies									
	Cover crops	Min tillage	Mulch	Mixed farming	Mixed cropping	Crop rotation	Organic matter	Afforestation	DTM	Water harvest
Tech not available										
Not aware										
No Land										
High labour										
Preparation difficulty										
Breeding space for weeds/diseases										
Bulkiness										
High cost										
No weeds										

56. Household Assets

At present, how much/many of the following does this household own that are usable/repairable? (For value per unit, ask for the current value of the asset).

Agricultural asset			Value per unit	Agricultural asset		Quantity /number	Value per unit
Asset		Qty	Value (₦)	Asset		Qty	Value (₦)
1	house (residential)			21	Donkey		
2	Stores			22	Oxen		
3	Poultry houses			23	Animal traction plough		
4	Car			24	Water pump (maker)		
5	Truck			25	Truck		
6	Wheel barrow			26	Tractor		
7	Chaff cutter			27	Trailer		
8	Radio			28	Ploughs for tractor		
9	TV			29	Harrow/tiller		
10	Bicycle			30	Ridger		
11	Battery			31	Planter		
12	Land line telephone			32	Boom sprayer		
13	Mobile phone			33	Sheller		
15	Pestle and motar			34	Generator		
16	Water tanks			35	Power saw		
17	Beehive			36	Grinder		
18	Water pump (powered)			37	Cattle dip		
19	Well			38	Cane crusher		

Section G: Constraints with coping strategies

57. List three most serious constraints for improving your maize production (e.g. finance for production, output marketing, input markets , health, soil condition, transportation etc.) :

(a) _____

(b) _____

(c) _____

66. What are the challenges you face with regards to coping to climate change ?

…….
……
..

67. In your own opinion how best do you think climate change problems could be tackled?

…….
.

…….
.

Thank you!

APPENDIX III

Lirkert scale of respondents perceptions of effects of climate change on maize production (n -159)

Step 1 = Weighted score for a Variable = Response frequency X scale of variable

Step 2= Total weighted score for a variable = total scores for a variable scale

Step 3 = Mean scores = Divide total weighted scores by total respondents (n)

Step 4 = Percentage score = Mean score /scale X100

Step 5 = Average mean scores = P score

Nature of effects	SA (5)	AG (4)	UND (3)	DA (2)	SD (1)	Weighted score	Percent	Mean score	P.Score
1.Severe drought	122	10	12	11	4	712	89.4	4.47	3.09
2.Too much rain /flood on maize farms	66	33	18	14	28	572	71.8	3.59	
3.Pest/disease infestation	12	48	64	9	19	498	62.6	3.13	
4.Decreased yield	18	20	32	60	9	495	62.2	3.11	
5.Increased weed incidence	68	39	2	27	23	530	66.6	3.33	
6.Death or total loss of crops	3	14	52	39	51	356	44.6	2.23	
7.Insufficient rainfall	11	18	21	72	37	371	46.6	2.33	
8.Limited irrigation water	24	19	9	57	50	437	54.8	2.74	
9.Excess use of fertilizer	48	42	3	30	36	513	64.4	3.22	
10.Reduced cultivable maize land	15	18	2	79	45	356	44.6	2.23	

Severe drought: $\text{Mean score} = \frac{weightedscore}{totalresponse} = \frac{712}{159} = 4.5$

$\text{Percentage score} = \frac{4.47}{5} x100 = 89.4$

Too much rain/ flood: $\frac{572}{159} = 3.59 \frac{3.59}{5} x100 = 71.8$

Pests/diseases.: $\frac{598}{159} = \frac{3.13}{5} = 62.6$

Decreased yield: $\frac{495}{159} = \frac{3.11}{5} x100 = -62.2$

Increased weed incidence: $\frac{530}{159} = \frac{3.33}{5} x100 = -66.6$

Death or total loss of crops: $\frac{356}{159} = \frac{2.23}{5} x100 = -44.6$

Insufficient rainfall: $\frac{371}{159} = \frac{2.33}{5} x100 = -46.6$

Limited irrigation water: $\frac{437}{159} = \frac{2.74}{5} x100 = -54.8$

Excess use of fertilizer: $\frac{515}{159} = \frac{3.22}{5} x100 = -64.4$

Reduced cultivable maize land: $\frac{356}{159} = \frac{2.23}{5} x100 = -44.6$