USMANU DANFODIYO UNVERSITY SOKOTO

(POSTGRADUATE SCHOOL)

ASSESSMENT OF FARMERS'AWARENESS AND ADAPTATION MEASURES TO CLIMATE CHANGE IN THE NORTHERN ZONE OF SOKOTO STATE AGRICULTURAL DEVELOPMENT PROJECT

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BY

UBANDOMA, GARBA AHMED
(ADM NO.O9/211608005)

DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT

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CERTIFICATION

This dissertation by Ubandoma, Garba Ahmed has met the requirements for the award of the degree of Master of Science (Agricultural Extension) of Usmanu Danfodiyo University, Sokoto, and is approved for its contribution to knowledge.

---------- Date …….

Dr. R .S. Adisa

External Examiner

---------- Date …… …

Prof. B.F. Umar

Major Supervisor

---------- Date …….....

Dr. B.Z. Abubakar
Co-Supervisor I

---------- Date …….

Dr. S.D. Abubakar
Co-Supervisor

---------- Date …….....

Prof. B. F. Umar
Head of Department

DEDICATION

This dissertation is dedicated to the Almighty Allah who made this study possible, my late father Alhaji Ahmad Aliyu Ubandoma, my beloved mother Hajiya Ramatu Ahmad Ubandoma and the entire Ubandoma's family whose support and encouragement cannot be quantified.

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LIST OF ACRONYMS AND ABBREVIATIONS

APMEU: Agricultural Project Monitoring and Evaluation Unit

BNRCC: Building Nigeria's Response to Climate Change
CEEPA: Centre for Environmental Economics and Policy in Africa
CERD: Centre for Energy Research and Development
CERT: Centre for Energy Research and Training
CIDA: Canadian International Development Agency
CO_2:: Carbon Dioxide
CERD: Centre for Energy Research and Development
CERT: Centre for Energy Research and Training
CSD: Commission for Sustainable Development
ENSO: Elnino- Southern Oscillation
EPIC: Erosion Productivity Impact Calculator
FACU: Federal Agricultural Coordinating Unit
FADU: Farmers Development Union
FAO: Food and Agriculture Organization
FSC: Farmers Service Centre
GDP: Gross Domestic Product
IACC: Impact and Adaptation to Climate Change
IFOAM: International Federation of Organic Agriculture Movement
IITA: International Institute of Tropical Agriculture
IPCC: Intergovernmental Panel on Climate Change
LGAs: Local Government Areas
NAERLS: National Agricultural Extension and Research Liaison Services
NARES: National Agricultural Research and Extension System
NARS: National Agricultural Research System
NASPA: National Adaptation Strategy and Plan of Action
NASPA-CCN: National Adaptation Strategy and Plan of Action on Climate Change for Nigeria
NCRI: National Cereals Research Institute
NEST: Nigerian Environmental Study Action Team
NISER: Nigerian Institute of Social and Economic Research
NGOs: Non-governmental Organizations
NIMET: Nigerian Meteorological Agency
PCU: Project Coordinating Unit
REFILS: Research-Extension-Farmers-Input-Linkage System
SADP: Sokoto State Agricultural Development Project
SCCU: Special Climate Change Unit
SSA : Sub-Saharan Africa
T&V: Training & Visit
UNFCCC: United Nations Framework Convention on Climate Change
VEAs: Village Extension Agents
WBGU: World Bank Group Union
WOFAN: Women Farmers Advancement Network

ABSTRACT

The study assessed the awareness and adoption of climate change and adaptation measures among arable crop farmers in the northern zone of Sokoto State Agricultural Development Project. Five out of the twelve Local Government areas in the zone were purposively selected using multistage random sampling techniques. Two hundred and forty respondents were randomly selected for the study from the list of registered farmers in Sokoto State Agricultural Development Project (SADP). The random or the purposive selection which was based on their poor climatic conditions, drought and subsequent long period of dry spells in the rainy season. Primary data were collected with the aid of a structured questionnaire. Analysis of the data was through the use of descriptive statistics, regression analysis and Chi-square analysis. The results showed that all of the respondents were male and married with a mean age of 31 years. The results also showed that 65% had no formal education. Furthermore, the household size has a mean of 6 persons, farm size has a mean of 2.5ha, farming experience has a mean of 12 years and annual income has a mean of N14, 742.92k. The adopted adaptation measures were: early planting (100), planting more than one crop (100%), using cover crop (92.9%), using soil conservation techniques (41.7%) and using early maturing crops (35.4%). The socio-economic factors that were significantly related to adoption were: annual income, farm size and farming experiences. Constraints to adoption of adaptation measures include: Inadequate operating capital, Illiteracy, Inadequate market and Poor access to extension services. The need for farmers to form cooperatives societies, provision of adequate extension support services, encouraging formal education through literacy programmes, provision of rural infrastructures, organizing seminars/ workshops on climate change adaptation measures, control of removal of trees and creating more rangelands were offered as recommendations.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

According to Ayoade (2006), climate is the mean state of atmosphere of an area over a defined period of 30 years, while climate change as defined by Anon (2009) is long term significant environmental changes in the average weather that a given region experiences. Average weather includes temperature, precipitation, wind, humidity, evaporation, pressure and solar radiation. It involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. These environmental changes include higher temperatures and altered precipitation patterns, increased frequency and magnitude of extreme weather events, such as droughts, floods and storms. These have short and long term socio-economic and political consequences including food insecurity, migration, conflicts over resources, damage to farms and increased spread of endemic water and vector- borne diseases (Intergovernmental Panel on Climate Change, (IPCC. 2007).

Climate change is perhaps the most serious environmental threat facing mankind world-wide. It affects crop production in several ways, one of which is its direct impact on food production. Climatic change, which is attributable to natural climate cycle and human activities, has adversely affected agricultural productivity in Africa (Ziervogel *et al*,.2006). As the planet gets warmer, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick, 2009), which results in poor and unpredictable crop yields, thereby making farmers more vulnerable, particularly in Africa (United Nations Framework Convention on Climate Change,

UNFCCC, 2007). Farmers, who constitute the bulk of the poor in Africa, face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick, 2009). It is projected that crop yields in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change (Jones and Thornton, 2002). This is particularly because African agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather. Unfortunately, just as climate change is negatively affecting crops productivity, the steady increasing human population has led to a rise in the demand for food which caused more land to be put under agricultural cultivation, there will be more pressure on natural ecosystems (Ayoade, 2006; Explore (2005). As the people of Africa strive to overcome poverty and to advance economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development (Zoellick, 2009). There is therefore the need for concerted efforts towards tackling this menace.

In Nigeria, higher temperatures, long droughts, increasing frequent and violent storms are predicted to exacerbate the current challenges faced by agricultural production system in Nigeria. Already, the climate change rate is gradually exceeding the adaptive capacity of a broad range of crops and forage varieties. Thus, in a long-run, agriculture and agricultural practices will have to adapt to changes to ensure food security for human survival.

It is in the light of the above discussion that this study assessed the awareness of climate change and the adaptation measures adopted by farmers in Sokoto state.

1.2 Problem Statement

According to Enete *et al.* (2011) most of the agricultural research institutes like the International Institute of Tropical Agriculture (IITA), National Cereals Research Institute(NCRI), etc. have tended to concentrate attention on assessing the sensitivity of various attributes of crop systems (e.g. crop yields, pests, diseases, weeds, etc) - the bio-physical aspects of food production, with little or no regard to the socioeconomic aspects. These partial assessments, most often consider climate change effects in isolation, providing little insights into the level of awareness of the farmers on the issue, how they are coping with climate change, etc. However, to better address the food security concerns that are central to the economic and sustainable development agenda, it is desirable to also address these aspects of climate change and agriculture. Wisner, *et al.*(2004) report that the vulnerability of agriculture is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and/or recover from environmental change. While the coping capacity and degree of exposure is related to environmental changes, they are both also related to changes in societal aspects such as land use and cultural practices. This could be at the root of the much talked about poverty alleviation and food security for the vulnerable groups in Africa, who are most at risk when agriculture is stressed by climate change.

In addition, there is need for increased awareness, teaching, learning and research by Universities and Research Institutes so as to develop a multi-pronged capacity to tackle the imminent danger posed by climate change which is slowly eroding the gains of

the fight against starvation, hunger and poverty among farming communities in Africa (Anselm, *et al.*, 2011).

It is in the light of the foregoing discussion that this study assessed the awareness of climate change among crop farmers in Sokoto State and the adaptation measures employed by the farmers to alleviate the impact of the change. To achieve this, the following research questions were addressed.

1. What are the socio-economic characteristics of the farmers in the study area?
2. What are the farmers' level of awareness and evidence of climate change in the study area?
3. What are the farmers' sources of information on climate change?
4. What are the causes and effects of climate change on crop production?
5. What are the climate change adaptation measures adopted by farmers?
6. What are the constraints encountered by the farmers' in adoption of adaptation measures?

1.3 Objectives of the Study

The main objective of this study is to assess the awareness of arable crop farmers on climate change and the adaptation measures adopted by the farmers in the northern zone of Sokoto State Agricultural Development Project.

The specific objectives are to:

1. Describe the socio-economic characteristics of the farmers.
2. Examine the farmers' level of awareness and evidence of climate change in the study area.
3. Identify the farmers' sources of information on climate change.

4. Examine the causes and effects of climate change on crop production in the study area.
5. Determine the adaptation measures to climate change adopted by the farmers.
6. Assess the constraints to adoption of climate change adaptation measures by the farmers.

1.4 Justification of the Study

Farmers are the key stakeholders in climate change debate. However, knowledge of rural farmers about climate change has been noted to be abysmally low. In making informed decision about climate change, Olorunfemi (2009) is of the view that timely and useful information is necessary about the possible consequences of climate change, people's perceptions of these consequences of climate change, available options and the benefits of slowing the rate of climate change. Awareness and perceptions of a problem such as climate change shapes action and inaction on the problem.

In today's constantly changing environment, farmers need accessible as well as usable climate services for managing climate risks and exploiting climate resources. It has been argued that the world's climate is changing and it will continue to change at rates unprecedented in human history and that all communities need to enhance their adaptive capacity to face both present and future challenges of climate change (Adger e*t al*., 2003).

By harnessing climate change information and services for decision makers, the agricultural sector will be better placed to provide food for a more crowded and increasing urban world. The findings in this study would therefore contribute to the existing knowledge on climate change and adaptation measures which could provide a

framework on climate change for planning improved agricultural extension services which could motivate farmers to adopt recommended improved agricultural practices. Lastly, it could also serve as a baseline and reference material for further research in the study area.

1.5 Hypotheses of the Study

H_{01}: There is no significant relationship between farmers' socio-economic characteristics and the Adaptation measures adopted by the farmers.

H_{02}: There is no significant relationship between the awareness of climate change and the Adaptation measures adopted by farmers.

1.6 Scope and Limitations

The scope of this study includes the assessment of farmers' awareness on climate change and the adaptation measures adopted by the farmers. The study was limited to five local government areas (Gada, Illela, Isa, Sabon-binni and Tangaza) in the Northern Zone of Sokoto State Agricultural Development Project (SADP). The decision to select the study area was based on its poor climatic conditions, drought and subsequent long period of dry spells in the rainy season. The study, however, determined the socio-economic characteristics of the farmers in the study area.

The major problem encountered in the course of this study was that the farmers looked at it inform of politics that their party members must be included in the selection. To overcome this problem, I have to identify myself with identity card in front of their leaders and informed them that it was pure academic research it has nothing to do with politics.

1.7 Delimitation

The study was delimited to rain-fed crops (millet, sorghum, maize etc.) other types of crops(vegetables, fruits etc.) by the use of irrigation and livestock were not included. Also, farmers who were not registered by the Sokoto State Agricultural Development Project were not covered by the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Concept of Climate Change

Climate change is the result of the influence of many factors including the dynamic processes of the Earth itself, external forces including variations in sunlight intensity, precipitations and temperature, and more recently by human activities (Noma etal.,2009). External factors that can shape climate are often called climate forcing and include such processes as variations in solar radiations in the Earth's orbit and the level of greenhouse gas concentrations(Kolbert,2006). Some climate models indicate that towards 2050, temperatures in the tropical forest areas will increase by up to2^0c from their 1970 levels. Combined with predicted rainfall changes and secondary factors such as increased fire and pest outbreaks, these could provide severe consequences (Noma et al., 2009).

Research suggest that higher mean temperature will increase pest developmental rates and fecundity, the frequency of outbreaks, and lead to expansion in the range of insect pests, diseases and weed species. Altered wind patterns are expected to change the speed of wind borne pests and of bacteria and fungi that are crop disease agents. Higher winter temperature increases the abundance of the striped stem borer and green leafhopper in rice systems (Noma et al., 2009).

In the particularly, fragile arid areas of some developing countries transhumant livestock are both victims of climate change and contributor to it, since they accentuate its impact. As they pass animals degrade plant cover and nibble at young trees in the sahel, herds that leave for more humid zones in the dry season have completely destroyed

shrubs and grasses in some places. Drought coupled with overcrowding reduces the amount of grazing available, forcing herders to take their animals ever further a field and encroach on agricultural land. This will lead to increased land degradation and farmer-pastoralist conflict (Noma et al., 2009).

2.2 Climate Change and Agriculture

Sustainable development indices indicate social, economic, and environmental dimensions. Climate change modifies all these dimensions and therefore alters the potential development pathways. In particular, the effects of climate change in agriculture determine future food security and ultimately influence the inequitable North/ South divide (Iglesias, 2005). According to the Intergovernmental Panel on Climate Change third assessment report (IPCC, 2001), climate change is already happening and will continue to happen even if global green house emissions are curtailed. Many studies on the implications of climate change for agriculture pose a reasonable concern that climate change is a threat to poverty reduction and sustainable development, especially in developing countries. The definition of the key vulnerable production sectors, region, design, evaluation and the implementation of adaptation measures for agriculture define the overall future vulnerability of rural populations. The merits of each approach vary according to the level of impact being studied, and they may frequently be mutually supportive. For example, simple agro-climatic indices often provide the necessary information on how crops respond to varying rainfall and temperature in wide geographical areas; crop specific models are use to test alternative management that can in turn be used as a component for an economic model that analyses regional vulnerability or national adaptation strategies (Iglesias, 2005).

Climate is an essential component of the natural capital. In many regions of the world, climates are extremely variable from year to year, and recurrent drought and food problems often affect entire countries over multiyear periods, Intergovernmental Panel on Climate Change (IPCC, 2001). The persistent drying trend in parts of Africa over the last decades has affected food production including freshwater fisheries, industrial and domestic water supplies and hydropower generation (Iglesias, 2005). Agriculture is strongly dependent on water resources and climatic conditions particularly in regions of the world that are particularly sensitive to climatic hazards such as Africa. Some countries in these regions where economic and social situations are often unstable are extremely vulnerable to changes in environmental factors. It is especially the case in countries where technological buffering to drought and floods is less advanced and where the main physical factors affecting production are less suitable to farming. Crop production is consequently extremely sensitive to year- to- year weather fluctuations (Holden, 2001).

2.3 Sokoto State Agroclimate and Arable Crops Production

Sokoto State occupies an estimated land area of about 28,232.37 square kilometers in the extreme northwest of Nigeria between latitude 10^0 08' to 13^0 55' N and longitude 3^0 30' to 7^0 17' E(Singh and Babaji, 1989).

Climatically, the area experience a long dry (from October to May) and short rainy (from June to September) seasons. The dry season consist of a cold dry spell from February to April (Singh and Babaji, 1989). Rainfall in the area is erratic in nature, small in quantity with an annual mean of 724mm for a period of 6 years from 1998 to 2003 (Sokoto Energy Research Centre, 2003), and of uneven distribution with a peak in

August. The relative humidity and temperature varies during the year (Table 1). The temperature fluctuates roughly between 40^0C maximum and 15^0 minimum(Amborg, 1988). In terms of vegetation, the state falls within Sudan savannah zone. The vegetation is characterized by thorny species with a scatter of acacia species. The river courses are lined with duna palms which are interspersed with a herbaceous cover of annual grasses (Sokoto State Government, 2011).

The soils in the state are well drained but poorly structured with texture ranging from coarse grains in the north to fine in the south. Sandy topsoil with clayey subsoil are common, except along the flood plains of the river valleys where alluvial soils predominate. To the north of the state, especially along the border with Niger Republic, the undulating plains are covered by Aeolian deposits of variable depth. These support light sandy soils. However, due to its geographical location, the state suffers from the scourge of desertification and occasional drought (Sokoto State Government, 2011). Among the common food crops produced in the state are: millet, guinea corn , rice, sugar cane ,beans, wheat, cassava, potatoes, groundnut, cotton, sugarcane and tobacco(Table 2). The fertility of the soil is maintained mostly by the use of organic mature as encouraged by the state extension agent. The crops are usually grown in mixture of millet/beans, millet/groundnut, guinea corn/beans, guinea corn /groundnut along with other crops like pepper, vegetable, garden egg, okra and spinach (Sokoto State Government,2011).

Table 1: Meteorological Data of Temperature, Sunshine, Relative Humidity and Rainfall for Sokoto State (2001-2008).

Years	Temperature (^{0}C)	Sunshine (w/m^2)	Rel. Humidity (%)	Rainfall (mm)
2001	35.40	7.00	43.40	790.70
2002	35.40	7.56	45.00	731.20
2003	37.50	8.12	45.40	768.70
2004	35.70	8.43	45.00	649.50
2005	35.90	8.00	43.90	634.60
2006	35.10	8.20	43.10	716.90
2007	35.90	7.90	42.80	636.20
2008	35.50	8.00	41.40	667.60

Source: Climatic data (Temperature, Sunshine and Rel. Humidity) Supplied by Nigerian Meteorological Agency (NIMET, 2008).

Table 2: Estimated Hectares, Output and Yields of Major Food Crops in Sokoto State (2001-2008).

CROPS		2001	2002	2003	2004	2005	2006	2007	2008
Maize	AREA	11342	10653	11119	10785	9865	10865	11685	11895
	OUTPUT	12476.20	13848.90	14343.51	13481.25	12232.6	13689.9	15190.5	17247.75
	YIELD	1.01	1.3	1.29	1.25	1.24	1.26	1.30	1.45
Millet	AREA	525442	615421	588424	623729	617416	667418	674630	695820
	OUTPUT	478152.22	541570.48	517813.12	573830.68	568022.72	734159.8	944482	1043730
	YIELD	0.91	0.88	0.88	0.92	0.92	1.10	1.40	1.50
Rice	AREA	20241	23114	21716	26402	32417	30217	314227	32284
	OUTPUT	17002.44	21033.74	18241.44	34322.6	49598.01	60434	78567.5	83938.4
	YIELD	0.84	0.91	0.84	1.3	1.53	2.0	2.50	2.60
Sorghum	AREA	27206	30413	150296	165325	133325	163325	172112	183211
	OUTPUT	35367.80	37407.99	96189.44	95888.5	77328.5	111061	189323.2	109119.92
	YIELD	1.30	1.23	0.64	0.58	0.58	0.68	1.10	1.30
Cowpea	AREA	107340	122710	132510	159012	161302	141402	147100	147100
	OUTPUT	93385.8	107984.8	80831.1	119259	120976.5	103223.4	176520	183875
	YIELD	0.87	0.88	0.61	0.75	0.75	0.73	1.20	1.25
Ground nut	AREA	43758	47181	46528	51181	64002	58420	58992	58992
	OUTPUT	36779.4	43406.52	43736.32	47086.52	58241.82	49657	76689.6	79639.2
	YIELD	0.84	0.92	0.94	0.92.	0.91	0.72	1.30	1.35

NOTE: Area = Hectares (ha), Output = Metric Tons (mt), Yield = mt/ha.

Source: SADP, 2008.

2.4 Farm Size, Climate Variability and Arable Crop Production

It is now clear that most adverse climatic and environmental impacts that occur today are manifestation of man's inadvertent modifications to climate on local and to a limited extent, regional scale in some activities of the distant past. Natural and human induced global environmental change belongs to the class of risk with high probability of occurrence and damage potentials that for the time being no one is willing to perceive the threat, Nigerian Environmental Study Team(NEST, 2001). Climate and environmental change processes lead to changes in the biophysical life support system including land surface (vegetation), water resources, soil and atmosphere which constitute the elements that support the long term sustainability of life on earth. Until recently, the effects of man's activities on climate variations were perceived as negligible and so climate was generally taken for granted. There was little thought that the climate could be a problem with severe impacts, Intergovernmental Panel on Climate Change (IPCC, 2007).

Over the years, there has been variability in the reduction of arable land used for cultivation of crops. Studies have shown that the changing climate also comes with it resultant change in land use and land cover leading to the decline in crop output (Schmidhuler and Tubeillo, 2007). Climate change and variability has the potential to affect all natural and human systems and survival. Global climate change may impact food production across a range of pathways by changing overall growing conditions (general rainfall distribution, temperature regime and carbon); by inducing more extreme weather such as floods, drought and storms; and by increasing extent, type and frequency of infestations including that of invasive alien species. The two major climatic variables that affect crop yield and productivity are reduced amount of rainfall, drought and

increased temperature, Intergovernmental Panel on Climate Change (IPCC, 2007). Climate variability can be said to be responsible for limitations in land availability for cultivation of crops through landslides and severe erosion caused by wind and water reduction in soil fertility etc.

2.5 The Socio-Economic Implications of Climate Change

According to Akoroda (2010), agriculture is Nigeria's biggest employer of labour, accounting for about 60 percent of the workforce, working mainly in small holdings and using basic tools. Together with livestock rising, it provides a third of her Gross Domestic Product (GDP) . Nigeria's soil and climate allow cultivation of a wide variety of crops, including cassava(of which Nigeria is the largest world producer), millet, sorghum and maize and other cash crops like rubber, coffee, cocoa and cotton(Agricultural Report, 2007). Nevertheless, agriculture in Nigeria in recent times shows a continuous decline in exportation and increase in importation of agricultural products into the country. The share of Nigeria's agricultural products in total exports plumed from over 70 percent in the 1960's to less than 2 percent in 2010. The major contribution to the decline has been linked with the negative effects of climate change on crop production in Sub-Saharan Africa (SSA). It is predicted that the majority of Nigeria and some other African countries will have novel climates over at least half of their current crop year by 2050 (IPCC, 2007). Higher temperatures, long droughts and increasingly frequent and violent storms are predicted to exacerbate the current challenges faced by agricultural productions system in Nigeria. Already, climate change rate is gradually exceeding the adaptive capacity of a broad range of crops and forage varieties, animal breeds and tree populations used in Nigeria, ten years earlier than the prediction of Intergovernmental

Panel on Climate Change climate model prediction of 2020 (IPCC, 2007). Consequently, food production and access to food in many part of the country is becoming more expensive, some cases scarce, severely compromised, exacerbating food scarcity problems and malnutrition, poverty, hunger, diseases and communal conflicts resulting from the loss of 92,000 hectares of land to drought and desertification (Commission for Sustainable Development, 2008).

This is so because over the years unpredictable weather conditions have affected farming populations, land fertility and struggle for livelihood. Climatic variation and change come to play a major hindrance in the informal agricultural labour market vis a vis the employment potential it had in the past especially among inhabitants in Northern Nigeria. The agricultural sector is being relegated due to poor government attitude towards the sector, youths abandoning it in search of white collar jobs and other survivalist jobs. This has brought about massive migration to urban and border towns. The 2009 National statistics puts the unemployment rate in Nigeria at 4.9 percent signifying 2 percent increase from 2.9 percent in 2005(National Bureau of Statistics, 2009). The corollary effect of climate change has been observed as playing a negative impact in Nigerian families financial needs at home. Evident is the increasing level of child labour through the *Almajiri's* system to alleviate poverty especially among the illiterates rural populace (Akoroda, 2010).

2.6 Awareness of Climate Change and its Link with Agriculture

The awareness of climate problems and the potential benefits of taking action is important determinant of adoption of adaptation measures to climate change (Hassan and Nhemachena,2008). Maddison (2006) argued that farmers' awareness of change in

climate attributes (temperature and precipitation) is important to adaptation decision making. For example, Araya and Adjaye (2001) stated that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures. It is expected that improved knowledge and farming experience will positively influence farmers' awareness and decision to take up adaptation measures. Improved education and disseminating knowledge is an important policy measure for stimulating awareness and local participation in various development and national resource management initiatives. Farming experience improves awareness of change in climate, the potential benefits and willingness to participate in local natural resource management activities. However, Maddison (2006) stated that educated and experienced farmers have more knowledge and information about climate change and the agronomic practices that they can adopt in response.

2.7 Farmers' Activities Contributing to Climate Change

Climate change is a natural process but recent trends related to climate change are alarming mainly due to anthropogenic reasons (Khanal, 2009). Agriculture is an important contributor of greenhouse gas emissions at the global scale. According to World Bank (2008), agriculture contributes about half of the global emissions of two of the most potent non-carbon dioxide greenhouse gases: nitrous oxide and methane. FAO (2008) reported that agriculture contributes over 20% of global anthropogenic greenhouse gas emissions. The ongoing build-up of greenhouse gases in the atmosphere is prompting shifts in climate across the globe that will affect agro-ecological and growing conditions. Application of fertilizers, rearing of livestock and related land clearing are some

agricultural activities that influence levels of greenhouse gases in the atmosphere and the potential for carbon storage and sequestration (Mark, et al. 2008). The report of World Bank (2008) also showed that the use of livestock manure, nitrogenous fertilizers, irrigated paddy, burning of biomass and ruminants' centric fermentation and animal waste treatment are responsible for producing most agricultural nitrous oxide and methane emissions. IFOAM, (2007) highlighted that conventional agricultural activities of farmers contribute to climate change because it: (a) uses synthetic fertilizers and pesticides that require significant amount of energy to manufacture; (b) applies excessive amounts of nitrogen fertilizer that is released as nitrous oxide; (c operates intensive livestock holdings that overproduce manure and methane; (d) relies on external soy-based animal feeds that require the burning of huge amount of fuel that releases carbon monoxide to the atmosphere thereby creating climatic problems; (e) mines the earth of the nutrients needed to sustain production thereby leading to the clearing of rainforest and slash and burn techniques that reduce carbon storage and release huge amounts of carbon dioxide from burning vegetation.

As a result, it is of interest to stakeholders in the agricultural sector to understand the kinds of impact their agricultural activities will have on sustainable food and crop production due to effect of climate change (Mark *et al*., 2008).There will undoubtedly be shifts in agro-ecological conditions that will warrant changes in processes and practices and adjustments in widely accepted truths in order to meet daily food requirements.

2.8 Patterns of Climate Change Impact on Agriculture

The Intergovernmental Panel on Climate Change, IPCC's Fourth Assessment Report summary for Africa describes a trend of warming at a rate faster than the global average,

and increasing aridity. Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production (IPCC, 2007). That is, socio-economic factors, international competitions, technological development as well as policy choices will determine the pattern and impact that agro climatic change will have on agriculture (Brussel, 2009). In all, Khanal (2009) classified the patterns of impact of climate change on agriculture into biophysical and socio-economic impact. The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges. The socio-economic impacts result in 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. 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 impacts of climate change on 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 evapotranspiration, photosynthesis and biomass production; and (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. Rises in temperature for example helps to grow crops in high altitude areas and towards the poles. In these areas, increases 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 (Khanal, 2009). The warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms. 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. Khanal (2009) stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crops. The negative effects 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, the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question. This is likely to increase the dependence on food importation and the number of people at risk of famine.

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 (Khanal, 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 GDP. A decrease of up to 30% in world food production due to effects of climate change on agriculture is generally predicted. This is expected to undermine the systems that provide food security (IPCC, 2007). While farmers in some regions may benefit from longer growing seasons and higher yields, the general consequences for Africa are expected to be adverse and 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 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). Maize production is expected to decrease under possible increased [El Nino-Southern Oscillation (ENSO] conditions which are expected in southern Africa (Stige *et al*., 2006).

A South African study undertaken by the University of Pretoria and focusing at the provincial level, found a significant correlation between higher historical temperatures and reduced dry land staple production, and forecast a fall in net crop revenues by as

much as 90% by 2100. The study found small-scale farmers to be worst affected by the decrease (Maddison, 2006).A study in Nigeria by Adejuwon (2006) applied the Erosion Productivity Impact Calculator (EPIC) crop model to give projections of crop yield during the 21st century. The study modeled worst case climate change scenarios for maize, sorghum, rice, millet and cassava. The indications from the projections are that, in general, there will be increases in crop yields across all low land ecological zones as the climate changes during the early parts of the 21st century. However, towards the end of the century, the rate of increase will tend to slow down. This could result in lower yields in the last quarter than in the third quarter of the century. The decreases in yield could be explained in terms of the very high temperatures which lie beyond the range of tolerance for the current crop varieties and cultivars.

Under current climate conditions with those projected for 2050, forecast a decrease in national production of many crops, ranging from 11% for rice to 28% for soybeans (Eid *et al*., 2006). Other potential impacts linked to agriculture include erosion that could be exacerbated by expected increased intensity of rainfall and the crop growth period that is expected to be reduced in some areas (Agoumi, 2003). Changes are also expected in the onset of the rainy season and in the variability of dry spells (Reason *et al.*, 2005). Thornton *et al*. (2006), mapped climate vulnerability with a focus on the livestock sector. The areas they identified as being particularly prone to climate change impacts included arid-semiarid rangeland and the drier mixed agro-ecological zones across the continent, particularly in Southern Africa and the Sahel, and coastal systems in East Africa. An important point they raise is that macro-level analyses can hide local variability around often complex responses to climate change.

2.9 Indigenous Climate Change Adaptation Practices Used by Farmers

Adaptation is an adjustment made to a human, ecological or physical system in response to a perceived vulnerability. Specifically, Intergovernmental Panel on Climate Change (IPCC, 2001) described adaptation to climate change as adjustment in natural or human systems in response to actual or expected climatic stimuli and their effects which moderates harm or exploits beneficial opportunities. Adaptation is an important component of climatic change impact 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. Agricultural adaptation option are categorized 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. In the short run, autonomous farm level adaptation may be sufficient but in the longer run, adaptation in the form of technological and structural changes will be necessary. This will require planned strategies based on analysis of local and regional conditions (Brussel, 2009).

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 Food and Agricultural Organization (FAO, 2008).

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. Anselm *et al* (2011) 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.

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.

Indigenous knowledge arises out of continuous experimentation, innovation and adaptation, blending many knowledge systems to solve local problems United Nations Framework Convention on Climate Change (UNFCCC, 2007). Climate change is global phenomenon while adaptation is largely site specific. A common disadvantage for local coping strategies is that they are often non documented but rather handed down through oral history and local expertise. As site specific issues require site specific knowledge, experience has shown that identified adaptation measures do not necessarily translate into change because there are context specific, social, financial, cultural, psychological and physiological barriers to adaptation Intergovernmental Panel on Climate Change (IPCC, 2007). However, it is very important to clearly understand what is happening at community level because farmers are the most climate vulnerable group.

2.10 Problems Encountered by Farmers in Climate Adaptation

In carrying out adaptation measures to reduce the effects of climate variations on agricultural production, the farmers encounter some obvious challenges or problems. Mark *et al*. (2008) argued that a lack of adaptive capacity due to constraints on resources like access to weather forecasts or better seed varieties may result in further food insecurity. The result of a study conducted by Centre for Environmental Economics and Policy in Africa (CEEPA) across African countries showed that lack of access to credit or saving, water, appropriate seeds, security of property rights, market access and lack of adequate information about climate change are some of the major problems encountered by farmers in adapting to the effects of climate change (Eid *et al*., 2006). According to Deresso (2008), the analysis of barriers to adaptation to climate change in the Nile basin of Ethiopia indicates that there are three major constraints to adaptation by farmers. These, as reported by the author are lack of information, lack of money, shortage of labour, Eid *et al*.(2006) added that farm size, tenure status, level of education of the farmers and access to extension service are major determinants of speed of adoption of adaptation measures to climate change.

Most of the problems or constraints encountered by farmers in adaptation to climate change are associated with poverty (Deressa, 2008). For instance, lack of information to adaptation options could be attributed to the fact that research on climate change and adaptation options have not been strengthened in the country and thus information is lacking in the area. Lack of money hinders farmers from getting the necessary resources and technologies which assist in adapting to climate change. Adaptation to climate change is costly (Mendelsohn *et al*, 2000) and this cost could be revealed through the

need for intensive labour use. Thus, if farmers do not have sufficient family labour or the financial capacity to hire labour, they cannot adapt to climate change. Shortage of land has been associated with high population pressure. High population pressures forces farmers to intensively farm over a small plot of land and make them unable to conserve from further damages by practices such as planting trees which competes for agricultural land.

According to FAO (1997), poor irrigation potential can most probably be associated with the inability of farmers to use the already existing water due to technological incapability. Most African farmers are resource poor and cannot afford to invest on irrigation technology to adapt to climate change in order to sustain their livelihood during harsh climate extremes such as drought which often causes famine.

2.11 Theoretical Framework and Model of the Study

The background information for this study emanated from the economic behavior of the peasant society in farm production. Theoretically, the peasant is assumed to be an individual economic unit who is to modify his production objectives, taking into account his limited available farm resources and the risk he attaches to uncertain outcomes (Lawal, 2002).

Ellis (1993) describes peasants as households which derive their livelihoods mainly from agriculture, utilize family labour in farm production and are characterized by partial engagement in inputs and outputs markets which are often imperfect or incomplete. Embedded in this definition are the features attributed as peasant characteristics by Olaide and Heady (1982) based on empirical research into the peasant economic behavior.

Among the features are:

- Predominant dependence on agriculture as the means of livelihood.
- Bulk of labour force, management and farm finance essentially comes from household resources.
- The peasants are resource poor
- Peasants are generally subsistence farms but are not removed from the market due to existence of marketable surplus.
- There is usually low level of resources utilization, productivity and capital investment.
- Peasant farmlands are often scattered in small plots with average range size usually between 1-5 acres.
- The peasants are characterized by a full utilization of available capital assets but not full exploitation of potential for capital formation.

Based on this description of peasants by Ellis (1993), farmers with all or some of these features are in essence, peasant households. With these features in view, it is pertinent to examine the characteristics features of Nigerian farmers in order to ascertain whether or not Nigerian farmers are peasants and to determine whether or not they transit from purely subsistence agriculture towards integration into market economies or undergo a continuous process of adaptation to the changing world around them.

Relating this ideal to an overview of the biographic and socioeconomic characteristics of the Nigerian farmers and productivity, Igben (1988) indicates that most Nigerian farmers are peasants because of their primary objectives of producing

enough food to meet home consumption needs after which marketable surplus is disposed to earn income with which other non-farm needs of the households are met. Thus, Nigerian farmers are neither purely subsistence nor full commercial farmers because of their partial integration into the market which in turn fits them into peasantry (Friedmann, 1980). The connection of the peasants with market by farm surplus helps market price to substantially but not wholly influence the allocation of family resources employed in farming and complementary non-farm activities (Olaide and Heady, 1982). Such market provides both opportunities leading to high standard of living or diverse consumption and pressures for the peasant by exposing them to the possibility of ruin due to market fluctuation. According to Ellis (1993), such market fluctuation put the peasant in the face of price uncertainty. Lawal (2002), stress that peasant farmers are generally resources poor or low resourced especially in developing countries which Nigeria is one. The poor state of the peasant household accounts for the low levels of resources utilization, productivity and capital investment (Olaide and Heady, 1982). This condition is a noticeable feature of Nigerian farmers with the exception of few ones with high socioeconomic status. The poor state of the farmers notwithstanding, they rely predominantly on agriculture as means of livelihood, with full utilization of the available capital assets in the farm production.

Essential inputs in the farm production include land, labour and seeds. Adeyeye (1988), indicates that majority of Nigerian farmers operate relatively small farms with several of such farms scattered over a wide range of geographical area because of non availability of continuous land and for tactical reasons. Most farms are not more than

5 acres but most typical farm size average 2.7 acres. According to Beets (1990), peasant households operate highly intensive cropping systems with heavy reliance on family labour. This is the case with farmers in Nigeria as indicated by Igben (1988), with the male adult contributing more labour than other members of the family.

The peasant economic behavior is not solely influenced by the socioeconomic status of the peasants but the social context in which they operate counts as well. Wolf (1966) indicates that peasant farmers are not isolated society but represent a social group which are always part of large economic systems. The legal institutions, cultural norms and the existing forces of production conditioned the behavior and production system of the peasant. Control over means of production and what happens to output is an important concept in the peasant behavior. In line with Marxian theory, land which is a major factor in farm production is often owned and controlled by one social class, the feudal lords (Ellis, 1993). Farm producers are thus, conscious of the limits and constraints that exist in the natural system and as such adjust to the societal rule (Thandee, 1986). Constraints of this nature may not allow for full exploitation of the potential for capital formation thereby restricting the peasants to their traditional farming systems (Lawal, 2002).

Ekong(2003), stated that a model is simply an attempt at classifying the major elements of an entity or phenomenon with regards to their functions and inter-relationship in order to observe more closely how the elements function within the entity. A model is a construction that shows relationship existing among variables. These relationships are depicted schematically or mathematically. Theoretical model refers to a broad system of explanation which is found not so much on prior research

findings but largely on untested and unproved assumptions about social realities (Ekong, 2003). The conceptual model of the relationships envisaged for this study includes the independent variables, dependent variables and intervening variables. The independent variables consist of climatic factors, economic factors, socio-economic factors and adaptation measures. The dependent variable in the model is the resulting adoption of climatic change adaption measures by the farmers. The intervening variables are the cultural norms and values, government policies, research institutes and extension services. All these factors in one way of the other influence the adoption of adaptation measures.

2.12 Explanation of the Framework

The model indicate climatic factors as the most important elements which significantly conditions the adoption in a given agroeccological environment. Climatic factors (Rainfall etc) is the primary source of water for crop growth and development. The amount of rainfall and its distribution in a farming season can have a great influence on the type of adaptation measures to adopt by the farmer. The duration and cessation of rainfall determine the length of growing season, crop types and adaptation measures adopted.

Structuring of the farming systems takes place based on decision of farm household. Such decision depends not only on the natural environment of the farmer but also on the social and economic characteristics of farm families. The economic factors such as land, farm inputs (factors of production) and output as well as prices of such inputs and outputs determine the kinds of crop and production capacity of the farm household. Available farmland and its fragmentation, household size, farming experiences, level of income and

social status of the farm families are the socio-economic characteristics that provide basis for day to day decision on which crop to produce and the adaptation measures to adopt in the farm. The exogenous factors which include cultural norms and value, government policy and extension services interact with one another in shaping the farming decision along with adoption.

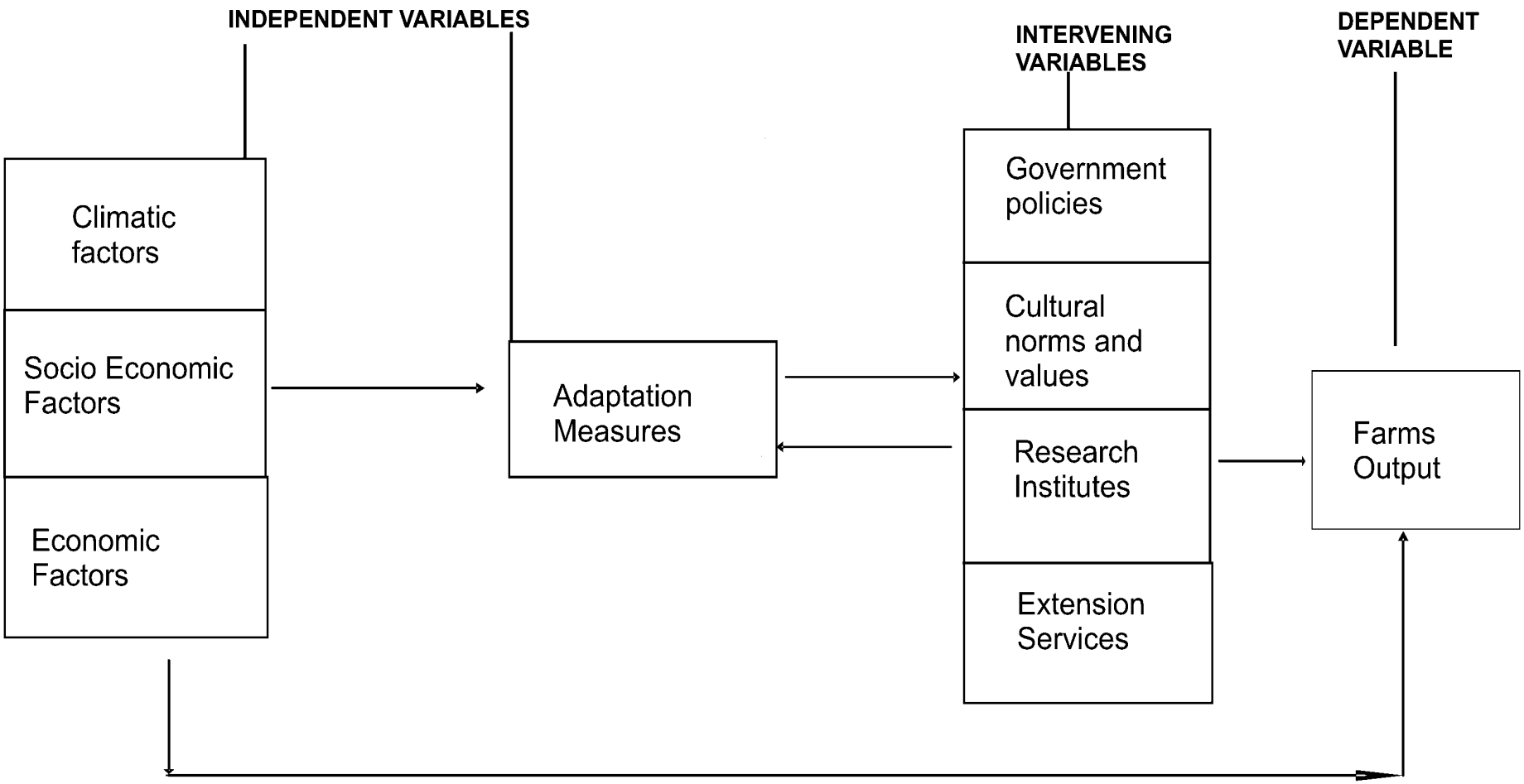


Figure 2.1:- Conceptual framework of factors influencing the adoption of adaptation measures

CHAPTER THREE

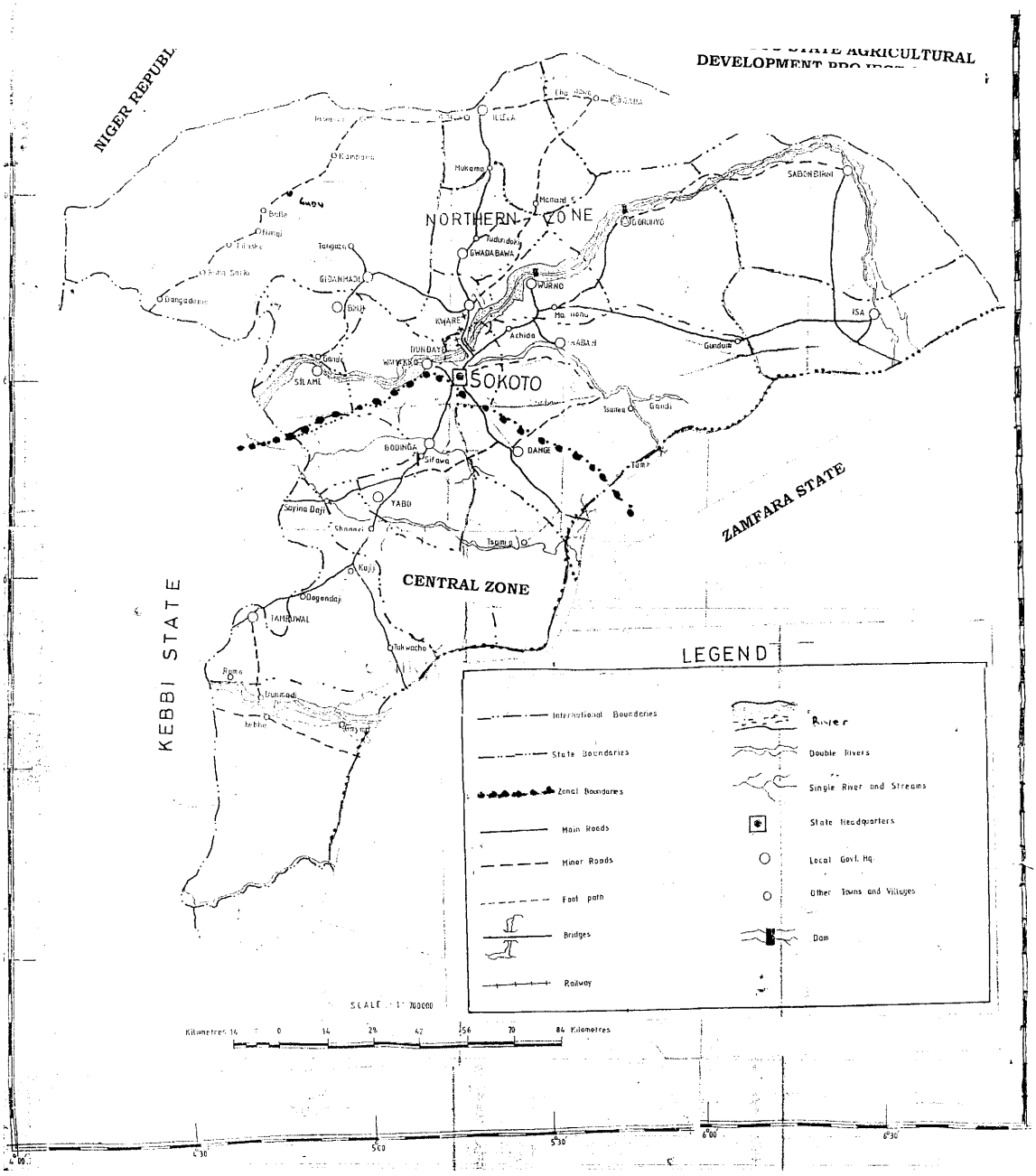
METHODOLOGY

3.1 Description of the Study Area

Sokoto State is located in the extreme northwest of Nigeria between latitude 10^0 08^1 to $13^0 55^1$N and longitude 3^0 30^1 to 7^0 15^1 E (Singh and Babaji, 1989). Sokoto state has an area of 28,232.37 square kilometers and estimated population of 4,244,399 people (Sokoto State Government, 2011).

Climatically, the area experiences a long dry (from October to May) and short rainy (from June to September) seasons. The dry season consists of a cold dry spell (Hammattan) roughly from November to January, followed by a hot dry spell from February to April (Singh and Babaji, 1989). Rainfall in the area is erratic in nature, small in quantity with an annual mean of 724mm for a period of 6 years 1998 to 2003(Sokoto Energy Research Centre, 2003), and of uneven distribution with a peak in August. The temperature during the year fluctuates roughly between 40^0C maximum and 15^0 minimum (Arnborg, 1988). In terms of vegetation, the state falls within Sudan savannah zone. This is open tsetse fly-free grassland suitable for the cultivation of grain crops and animal husbandry (Sokoto state government website).

The State shares borders with Niger Republic to the North, Katsina and Zamfara States to the East and Kebbi State to the South (Figure 3.1). The twenty three (23) local government areas of the state are occupied by Hausa and Fulani speaking tribes (sokoto state government website). Sokoto state is essentially an agricultural production state with traditional mode of production predominantly for subsistence. The main crops produced in the state are millet, guinea corn, rice, beans, wheat, groundnut etc. Fruits vegetables include: mangoes, onion, spinach etc(Bartholomew, 2005).



3:1 Map of Sokoto state
Source: SADP

3.2 Sampling Technique and Sample Size

The arable crop farmers in the Northern operational zone of the State Agricultural Development Project purposively constituted the sample frame for the study. The selection of the zone was based on the assumption that the effect of climate change will be more pronounced in communities in the zone because of its poor climatic conditions, drought and subsequent long period of dry spells in the raining season compared to the Western zone of the state, (Iliya *et al.,* 2009). A multistage random sampling technique was used to select the respondents. In the first stage, the five frontline Local Government Areas namely: Gada, Illela, Isa, Sabon-binni and Tangaza in the zone were purposively selected to constitute the blocks. This is because each local government area represents a block of itself with eight circles each. In the second stage, eight circles were selected from each of the selected blocks to make a total of forty circles for the study. In the final stage, six farmers were selected randomly from each of the selected circles to make a total of two hundred forty respondents for the study (Table 3). In each of the selected circles, a list of registered farmers was obtained from the village extension agents (VEAs). The list obtained was used to randomly select the farmers. Below are the selection procedures.

Table 3: Sample Size and Location of the Study Area

Local Government Area	Block	Circle	Number of farmers selected
Gada	Gada.	Gada, Gidan- dabo, kadassaka, Sagara, kyadawa,Safiyal magori, Tafakwallo, Wauru	6 farmers from each circle.
Illela	Illela	Amarawa, Araba, Gatti, Bakin-dutsi Illela, Dan-boka, Kalmalu, Lafani.	6 farmers from each circle.
Isa	Isa	Bafarawa, Bargaja, Gazau, Kamarawa, Kurar-mota, Tsabre, Turba, Isa.	6 farmers from each circle.
Sabon-binni	Sabon-binni	Gangara, Gatawa, Kalgo Kurawa, Tara, Sabon-binni A Sabon-binni B, Sardauna.	6 farmers from each circle.
Tangaza	Gidan-madi	Gidan-madi,Rini,Sutti, Kwannawa, Maganho,Tangaza,Kwacce—huru,Ruwa-wuri	6 farmers from each circle.
Total		40 circles	240 farmers

March/ April, 2013.

3.3 Method of Data Collection

Both primary and secondary data were used for the study. Primary data were collected(March/April,2013.) using a structured questionnaire that was administered to obtain information on farmers' socio-economic characteristics, farmers' production enterprises, farmers' knowledge on climate change, farmers' sources of information on climate change, farmers' adaptation measures constraints to the adoption of adaptation measures and farming activities embarked upon by the farmers. Secondary data were obtained from textbooks, journals, internet, magazines and other literatures relevant to the study.

3.4 Measurement of Study Variables and Operational Definitions

The major variables in this study include: farmers' socio-economic factors, farmers' awareness and effects of climate change, sources of information on climate change, adaptation measures adopted by farmers and constraints to the adoption of adaptation measures.

1. Socio-Economic Factors

(a) Age: This is the number of years that have been spent from childhood to adulthood by the farmer. It was measured in the following categories: < 25 years, 25-30 years, 31-36 years, 37-42 years and >42 years.

(b) Gender: Gender conceptualized as sex which will either be male or female. It was measured as dummy variable with 1 = male, 2 = female.

(c) Household Size: This refers to the number of individuals living together in a household. It was measured in the following categories:<2 persons, 2-4 persons, 5-7 persons, 8-10 persons and >10 persons.

(d) Educational Status: This was measured on the basis of years spent in formal school in the following categories: Informal education = 1, Primary education = 2, Secondary education. =3, Tertiary education = 4.

(e) Occupation: This refers to the respondent's major source of income or livelihood. It was measured as a dummy variable with 1 = part-time farming, 2 = full- time farming.

(f) Farming Experience: This refers to the number of years a farmer was engaged in arable crop production. It was measured in the following categories: <5 years, 5-10 years, 11-16 years, 17-22 years and >22 years.

(g) Farm Size: This refers to the total area of farmland available to farmers for cultivation of crops. It was measured in the following categories: < 1 ha, 1-3 ha , 4-6 ha, 7-9 ha, 10- 12 ha and > 12 ha..

(h) **Farm Source**: This refers to how the farmers were able to acquire the farmland being used for farming. This was measured in terms of : Purchased = 0, Inherited = 1 and Leased = 2 .

(i) **Farmers' level of income:** This refers to the amount of money (in Naira) realized from the sale of farm output per annum. It was measured in the following categories: < N10,000, N10,000-N15,000, N16,000-N21,000, N22,000- N27,000, N28,000-N33,000 and>N33,000.

2. **Farmers Production Enterprise**

i. **Crop enterprise**: This refers to whether the respondents produce mainly arable crops or other permanent crops are produced along with arable crops. It was measured as follows: (a) Arable crops only, (b) Arable and Permanent crops.

ii. **Types of crop produced:** This requires the listing of crops produced by the farmers.

iii. **Production Purpose:** This described the reason why the above crops are produced by the farmers: (a) consumption, (b) marketing, (c) both.

iv. **Determinants of choice of crops**: This refers to factors considered by the farmers before producing specific kind of crops. This was measured as follows: (a) Climate pattern, (b) Types of crops available, (c) Cultural norms.

3. **Climate Change Awareness**

(a). **Awareness of climate change** : Farmers' awareness of climate change was determined using two parameters as follows: Aware = 1 and Unaware = 0.

(b) **Duration of climate change experience**: Farmers' knowledge of the duration of climate change experience was measured in the following categories: < 6 years, 6-10 years, 11-15 years, 16-20 years, 21-30 years and > 30 years.

(c) **Farmers' evidence of climate change**: This was determined using the following: Late commencement of rainfall, Early cessation of rainfall, Flood, Drought, Erosion, Heavy wind, Heat stress, Early drying up of streams and rivers, poor crop yields.

(d) **Farmers' knowledge of causes of climate change**: knowledge of causes of climate change was determined as follows: Bush burning, Agricultural activities, Deforestation, Burning of fossil fuel, over-grazing and Burning of crop residues.

(e). **Sources of information**: Farmers' sources of information on climate change were determined as follows: Friends, Relatives, Radio, Television, Print media and Extension Agents.

(f) **Farmers' knowledge on the effects of climate change**: This was determined as follows: yes = 1, no = 0.

(g) **Effects of Climate Change**: Farmers' knowledge of the problems associated with climate change was determined using the following: Altering the crops growing season, Altering the crops planting date, Altering the crops harvesting date, Increased Infestation of pests, weeds and diseases, Reduced crop yield.

(h) **Adaptation measures**: Farmers' knowledge on adaptation measures was measured as follows: Yes = 1 , No = 0.

(i). **Climate Change Adaptation Measures:** This refers to the measures/ actions taken by farmers to reduce the effect of climate change during crop production period. This was measured as an index with a total maximum score of 16. As indicated :(1) Using early maturing crops (2) Planting more than one crop (3) Early planting (4) Using

resistance Crop varieties (5) Using crop rotation (6) Using irrigation (7) Change crop intensity (8) Crop diversification (9) Diversifying from farming to non-farming activities (10)Adjusting the timing of farm operations (11) Soil conservation techniques (12) Recycling or storing water (13) Varying the sowing/planting dates (14) Using cover crops (15) Reduced tillage practices (16) Migration (Mark *et al*, 2008, Hassan and Nhemachena 2008 and Brussel,2009).

(j). **Constraints to Adoption of Adaptation Measures by the Farmers:** This refers to the problems encountered by the farmers in the adoption of adaptation measures. This was determined using the following: Lack of information, Inadequate operating capital, Shortage of labour, Farm size, Land tenure, Illiteracy, Poor access to extension services and Inadequate market.

3.5 Method of Data Analysis:

Both descriptive and inferential statistics were used to analyze the data obtained for the study. Descriptive statistics such as frequencies, percentages and mean/mode were used to achieve objectives one to six. The inferential statistics such as regression analysis and chi-square were used to test the hypotheses in order to make inferences and reasonable conclusion about the variables considered.

3.6 Model Specification

The models used for the study were Regression and Chi-square analyses.

3.6.1 Regression Analysis

Regression analysis was used to determine the effect of Socio-economic characteristics on the number of adaptation measured adopted. Hypothesis (H_1) was analyzed with the use of regression analysis.

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + U$$

Where: Y = Adoption (adaptation measures adopted by the farmer)

X_1 = Age of the farmer (years)

X_2 = Sex (dummy 1=male, 2=female)

X_3 = Marital status (dummy 1= single, 2= married)

X_4 = Household size (number)

X_5 = Educational status (number of years spent in formal school).

X_6 = Annual income (naira)

X_7 = Occupation (dummy 1= part-time farming, 2= full-time farming)

X_8 = Farm size (hectares)

X_9 = Farming experience (years)

a = constant

b_1 - b_9 = Regression coefficients of the variables

U = Unexplained variables (Olayemi, 1998).

The criteria used in the selection of the lead equation in the above model are:

(i) Satisfaction of the apriori expectation (the apriori expectation has to do with the signs of the regression coefficients and plausible magnitude as dictated by theoretical considerations).

(ii) Relative magnitude of R^2

(iii) When there are more number of factors that had statistically significant regression coefficients

(iv) Relative magnitude of F- value of the models (Olayemi, 1998).

3.6.2 Chi-Square Analysis

Chi-square analysis was used to determine the relationship between the awareness of climate change and the adaptation measures adopted. Hypothesis (H_2**)** was analyzed with the use of Chi – square(X^2)

$$X^2=\sum (O - E)^2 / E$$

$$df = (r-1)(c-1)$$

Where: X^2= Chi-square

$\sum$ = summation of…….

O = Observed frequency

E = Expected frequency

df = degree of freedom

r = number of rows

c = number of columns (Ladipo,2004).

When X^2calculated is greater than X^2tabulated, null hypothesis (Ho) is rejected.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter deals with the presentation of research results and discussion. The findings of this study have been presented and discussed in this chapter as follows:

4.1. Socio-economic Characteristics of the Respondents

This gives information on Age, Sex, Marital status, Household size, Educational status, Occupation, Farm size, Farm source, Farming experience and Level of income per annum .

4.1.1 Age Distribution of the Respondents

This has to do with the number of years an individual has attained. Age of a farmer is one of the important factors that determine his production level because experience counts in every human endeavor. It influences the amount of effort put into any economic activity since it is the age group that contributes significantly to human labour in an agrarian community. Musa (2010) asserted that physical labour productivities of farmers depend on these important factors namely: age, sex and health status of the individual. In the same way, Adubi (1992) stated that age has a significant influence on decision- making process of farmers with respect to risk aversion, adoption of important agricultural technology and other related decisions. The results as presented in Table 4 show that the farmers' age ranged between 25 and 42 years. Majority (52.1%) of the respondents were within the age range of 31-36 years with a mean of 31 years. This implies that majority of the respondents were in the middle or active age group. At this age, the young people tend to withstand stress and put more time and efforts in

various farming activities. This would probably results into an increased in agricultural output. The result of this study agreed with the findings of Owolabi (2012) in which they reported that this age group tends to be very productive. This is in line with Ogunbameru et al. (2008), that age is a factor that determines the quality and quantity of work done. It is believed that tasks could be done better if handled by young and energetic people.

4.1.2 Sex

This has to do with being male or female. Generally, farmers require much energy in order to meet up with various activities in the farm. Men are likely able to supply and withstand stress than women. Results in Table 4 shows that the entire respondents were male. This implies that men dominate women in terms of farming activities in the study area. This is in line with findings of FAO (2009), which stated that men participated fully in farming activities whereas women engaged mostly in processing and selling of farm products in most North-West of Nigeria. Also, Lawal.(2002) stated that farming occupation belongs to men and that cannot be unconnected with the rigors involved and the nature of farming operations. Furthermore, it is also well known that men are mostly the owners of the factors of production and farming is a laborious activity that could be handled more effectively by men.

4.1.3 Marital Status

Marital status is likely to affect the level of commitment of the farmers. The results on marital status (Table 4) show that the entire (100%) the respondents were married. This connotes that marriage is highly valued in the study area. This ensures increase in the size of family which in turn provides more hands in the farming

activities. Married people are also more involved in community development programmes. These findings shows that most of the arable crop farmers are married and that agriculture is very much practiced by married people to make end meet and cater for their children.

4.1.4 Household Size

. This has to do with the total number of individual members of a household. It is measured by the total number of persons in a household. It is an important socio-demographic characteristic of farming in that it determines how much of family labour is at disposal of the farmer. Table 4 shows that 30.0% of the respondents had a household size in the range of 5-7 persons while 25.8% had 8-10 persons respectively. It was also found out that the mean household size in the study area was 6 persons. This implies that there will be more people to serve as family labour in the farm. This is in line with the findings of Lawal .(2002), that the adduced reason for such large household size was to avoid one hundred percent dependence on hired labour during the farming season thereby saving or reducing the cost of production resulting from labour input. Given the poor economic condition of the small farmer, the use of household members as farm labour is an ideal option. In the same vein, Ogunbameru *et al* (2008) found a significant relationship between household size and farm labour. However, Ekong (2005), reported that labour availability through large household size may not be a guarantee for increased efficiency since most of the time, family labour may be underutilized given the same scale of food production activities.

4.1.5 Educational Status

This refers to the knowledge acquired through formal training in an organized institution of learning. It determines to what extent the farmers can accept new innovations in the course of agricultural production. Farmers without basic education would likely be irresponsive to modern agricultural extension programmes. Results in Table 4 show that 65.0% of the respondents had no formal education, 12.0% acquired primary education, and 13.8% acquired secondary education while 9.3% acquired tertiary education. Based on these findings, it could be seen that 65% of the farmers in the study area were non-literate. This means that majority of the farmers would not be able to take full advantage of opportunities in the modern day agricultural practices. Education being the veritable weapon for transforming the life of a man could assist in the realization of human potentialities. Low level of education was found to be very common among the farmers in Nigeria because they could not see any link between high level of education and farming. This notion has contributed to low level of agricultural outputs in the country since farming occupation lies in the hands of less educated farmers (Lawal, 2002). Ogunbameru *et al*. (2008) stated that the level of education attained is one of the important socio-economic factors in the overall capital accumulation and investment in agricultural enterprises. Njoku (1991) and Sabo (2011), in separate studies noted that the more educated a farmer is the more the chances he or she will utilize available opportunities and adopt innovations than the uneducated.

4.1.6 Respondents' Occupation

This refers to the respondents' major means or source of income or livelihood. The respondents' occupation was viewed in this study as full-time or part-time

farming. The results in Table 4.1 show that 69.2% of the respondents engaged on full-time farming as their primary occupation while the remaining 30.8% took up farming on part-time basis as their secondary occupation to augment their living. This implies that the respondents engaged in farming to meet up family food security. In line with this findings, Lawal (2002) noted that farming is still an important sector of the nation's economy that can be relied upon to at least provide immediate need of household food supply.

4.1.7 Farm Size

This refers to the total area of farmland cultivated by a farmer. The results in Table 4 show that majority (37.5%) cultivates about 1-3 ha with a mean farm size of 2.5 ha in the study area. These results implied that majority of the farmers in the study area are small scale farmers with small and fragmented farm holdings from generations to generations. As indicated by Upton (1996), a tropical farm household had frequent access to a large area of farmland though, cultivates a relatively small area of farmland. The implication of this result was that the respondents would not be able to engage in a large scale production or to have access to bigger credit facilities to improve on their level of output. This is in line with the findings of Musa (2010) that most farmers in Nigeria still produce at a subsistence level.

4.1.8 Source of Farmland

This refers to the way in which a farmer acquired the farmland. Farmland acquisition could be in form of inheritance, purchase or lease. Farmland is one of the production and agricultural inputs needed for crop production under the managerial control of the farmer. The extent of such land use depends on the right of control enjoyed by the farmer (Lawal, 2002). The results in Table 4 revealed that majority

(97.9%) of the respondents in the study area exercise control over their farmland by virtue of inheritance. This implies that in the rural areas, farmland is acquired by inheritance. Large scale farmer who wants to invest in agriculture in the study area might find it difficult to purchase farmland. This is because farmlands were continuously transferred from generations to generations. Furthermore, the implication of this result was that there will no improvements on agricultural output since the farmlands were fragmented continuously, production will remain subsistence in the study area. Farm size is an important factor in farming as it affects not only the crop output but also the level and type of input to use. According to Musa (2010) farm size is an important determinant in the allocation of resources like basic inputs and labour which will eventually impact on the final output and returns.

4.1.9 Years of Farming Experience

This refers to the total number of years a farmer spent on arable crop farming occupation. Farming experience is expected to help the farmer in boosting his production through the knowledge he acquired over the years. Nwaru (2004) reported that farmers would always count on their experience in allocating their resources in production. The results in Table 4 show that the experiences of the farmers ranged between 5 and 22 years. The farmers (27.5%) in the study area had farming experience between 17-22 years. It could be seen that 12.5% of the farmers had more than 22 years of experience with a mean of 12 years in arable crop farming. The implication of this result was that the respondents were conversant with their prevailing climatic conditions. This will go a long way in assisting them in determining time of farming operations that will favour their outputs. According to Lawal (2002) experiences acquired so far in farming by the farmers have been of

tremendous contributions to the sustainability of their farming occupation in view of the prevailing agroeccological conditions. Farming experience improves awareness of climate change, the potential benefits and willingness to participate in local natural resources management activities. Illiya *et al*.(2009) observed that farmers good knowledge of their physical environment and their cultural peculiarities most probably explain their success in farming. Furthermore, the results also show that most of the farmers have been in farming profession for quite some period of time and are likely to be capable of managing risk well (Ridler *et al.*, 2001).

4.1.10 Respondents' Level of Income Per annum

This refers to the total amount of money realized from the sales of farm output at the end of every harvesting season. The integration of the small farmers into the market according to Lawal (2002) has been a motivation for them to sell part of their farm produce in order to realize farm income that can be used to meet their non-farm needs. The result in Table 4 show that most of the respondents (56.2%), had an annual income of above N33, 000 while 12.9% had between N1, 000-N15, 000. The respondents had a mean farm income per annum of N14, 472:92K. This implies that respondents in the study area were operating below the poverty line of N65, 210:00K as indicated by Agbamu and Idowu (2000). The implication of this result was that the respondents will find it difficult to cope with the farm and family expenses. This in a long –run will not allow the respondents to invest in agriculture in order to increase on their outputs.

Table 4: Socio-economic Characteristics of the Respondents (n=240)

Variables	Frequency	Percentage	Mean/Mode
Age (years)			
< 25	14	5.8	
25-30	71	29.6	
31-36	125	52.1	31 years
37-42	29	12.1	
>42	1	0.4	
Sex			
Male	240	100.0	Male .
Marital Status			
Married	240	100.0	Married
Household Size(persons)			
< 2	7	2.9	
2-4	49	20.4	
5-7	72	30.0	6 persons
8-10	62	25.8	
>10	50	20.8	
Educational level			
No formal education	156	56.0	
Primary education	29	12.0	
Secondary education	33	13.8	No formal education
Tertiary education	22	9.2	
Occupation			
Part-time farming	74	30.8	Full-time farming
Full-time farming	166	69.2	
Farm size (hectares)			
<1.00	89	37.1	
1.00-3.00	90	37.5	
4.00-6.00	26	10.8	2.5 Hectares
7.00 9.00	10	4.2	
10.00-12.00	3	1.3	
>12.00	22	9.2	
Farm source			
Inherited	235	97.9	
Purchased	5	2.1	Inherited
Farming experience (Years)			
<5	20	8.3	
5-10	61	25.4	
11-16	63	26.3	12 Years
17-22	66	27.5	
>22	30	12.5	
Level of income (N)			
<10,000	47	19.6	
10,000-15,000	31	12.9	
16,000-21,000	14	5.8	N 14,472:92 K
22,000-27,000	3	1.3	
28,000-33,000	9	3.8	
>33,000	136	56.7	.

Source: Field survey March/April, 2013

4.2 Respondents' Production Enterprise

This provides information on the types of arable crop produced, crop enterprise, production purposes and determinants of crop choice in the study area.

4.2.1 Arable Crops Produced

Table 5 show the major arable crops produced. The common arable crops produced by the respondents include: millet (100%), sorghum (97.1 %), beans (93.3%), ground nut(40.8 %), rice(38.8 %) maize(30.0%) and cotton(8.3%). This shows that millet is the most widely cultivated arable crop followed by sorghum. This implies that the type of crops produced in the study area is a reflection of the existing climate in the area. These findings supported the view of Anonymous (2009), that millet (Pennisetum glaucum) and sorghum (Sorghum bicolor) are the earliest plants and for over ten thousand years have been the staple food for human societies. West Africa is the largest millet producer in Africa providing 70 % of African total production (Romain, 2001). Furthermore, Sokoto State is reported to be a leading state in the production of millet in Nigeria (NAERLS, 2008).

4.2.2 Crop Enterprise

Table 5 reveals that the entire respondents (100 %) cultivated only arable crops in the study area. This could not be unconnected with the prevailing climatic conditions in the area. This implies that the crops produced in the study area are thse crops that can grow, matured and harvested within the prevailing climatic conditions. Farming in the area is predominantly on the upland as only few farmers own fadama farms (Iliya *et al.*, 2009).

4.2.3 Production Purpose

Table 5 shows that majority (83.3%) of the respondents in the study area cultivated their crops mainly for household consumption only 16.67 % market their crop pr0duce. This implies that the production is purely for subsistence.. Millet and sorghum are eaten in a variety of forms depending on the locations as thin and thick fermented porridge in Africa (Anonymous, 1996).

4.2.4 Determinant of Crop Choice

Table 5 reveals that most of the respondents (91.7 %) chose their crops on the basis of climate pattern. These supported the idea of Iliya *et a*l (2009) that the northern zone has poor climatic conditions, drought and subsequent long period of dry spells in the raining season compared to the western zone of the state. On the basis of that, the respondents in the study area choose crops that are drought tolerant and can grow and mature within the shortage period of the rainy season.

Table 5: Distribution of Respondents by Production Enterprise

Variables	Frequency	percentage
Arable crops produced		
Millet	240	100.0
Sorghum	233	97.1
Beans	224	93.3
Ground nut	98	40.8
Rice	93	38.8
Maize	72	30.0
Cotton	20	8.3
Crop enterprise		
Arable crop only	240	100.0
Production purpose		
Household consumption	200	83.3
Marketing and consumption	40	16.7
Determinants of crop choice		
Climate pattern	220	91.7
Types of crop available	15	6.3
Cultural norms	5	2.1

Source: Field Survey March/ April, 2013.

4.3 Awareness, Evidence and Duration of Climate Change as observed by the Respondents

This section provides information on the level of awareness, evidence and the duration of climate change in the study area as observed by the respondents.

4.3.1 Awareness of Climate Change

Table 6 shows that the entire respondents (100.0 %) were aware of climate change. The implication of this result was that the respondents most likely find ways

of adoption to climate change in their area in order to be successful in their farming activities. Hassan and Nhemachena(2008) is of the view that the awareness of climate problems and the potential benefits of taking action is important determinant of adoption of adaptation measures. Also, Ani, (2007) and Yakubu(2011), recognized awareness as the first stage in the adoption process.

4.3.2 Evidence of Climate Change

Table 6 reveals that the respondents know the evidence of climate change in the study area. Moreover, most of them were aware of the late commencement of rainfall(97.9 %), early cessation of rainfall(95.8 %), poor yield(94.6 %) , drought(93.8 %), heavy wind(90.4 %), desertification(87.1 %), early dryness of small streams and rivers(85.0 %), erosion(62.1 %), flood(60.4%) and heat stress(56.3%). This implies that the respondents knew exactly when to commence their farming activities in their area. These findings supported the idea of Iliya *et al.* (2009) that farmers being good observers have in their traditional societies been watching changes in plants, trees and crop phrenology in relation to climate.

4.3.3 Duration of Climate Change

Table 6 shows that the respondents have noticed climate change in their area for a number of years with an average of 10.8 years in witnessing the occurrence of climate change in the study area. The implication was that the number of years acquired by the respondents in witnessing the occurrence of climate change in the study area would enable them to know the adaptation measures to adopt. These findings were in line with Iliya *et al.* (2009), that farmers' good knowledge of their physical environment and their cultural peculiarities most probably explain their success. It is expected that improved knowledge and farming experience will

positively influence farmers' awareness and decision to take up adaptation measures (Araya and Adjaye, 2001).

Table 6: Awareness, Evidence and Duration of Climate Change

Variables	Frequency	percentage	Mean
Awareness of climate change	240	100.0	
Evidence of climate change			
Late commencement of rainfall	235	97.9	
Early cessation of rainfall	230	95.8	
Poor yield	227	94.6	
Drought	225	93.8	
Heavy wind	217	90.4	
Desertification	209	87.1	
Early dryness of small streams	204	85.0	
Erosion	149	62.1	
Flood	145	60.4	
Heat stress	135	56.3	
Duration of climate change(years)			
<6	54	22.5	
6-10	70	29.2	
11-15	65	27.1	10 8 years
16-20	33	13.3	
21-30	15	6.3	
>30	3	1.3	

Source: Field Survey March/ April, 2013.

4.4 Respondents' Sources of Information on Climate Change

This presents the sources of information on climate change to the respondents in the study area. Table 7 shows that the respondents got climate change information from the following: friends(95.8 %), relatives(93.3 %), radio(67.1 %), extension agents (22.5 %), print media(7.9 %) and television(6.7 %). These findings supported the view of Adamu (2011) that newspapers, magazine, radio and television are generally the least expensive media to communicate message to large number of people simultaneously. Knowledge and information from agricultural research are essential for improving food security. However, useful agricultural knowledge and information must be effectively communicated to farmers (F.A.O., 2009). Improved education and disseminating

information is an important policy measure for stimulating awareness and local participation in various development and natural resource management initiatives.

Table 7: Respondents' Sources of Information on Climate Change

Source of information	Frequency	percentage
Friends	230	95.8
Relatives	224	93.3
Radio	161	67.8
Extension Agents	54	22.5
Print media	19	7.9
Television	16	6.7

Source: Field Survey March/ April, 2013..

4.5 Causes and Effects of Climate Change

This provides information on the causes and effects of climate change on the basis of respondents' level of understanding.

4.5.1 Perceived Causes of Climate Change among Respondents

Results in Table 8 reveal that the causes of climate change are: overgrazing(99.2 %),deforestation(90.0 %), agricultural activities(88.3 %), bush burning(28.3 %), burning of crop residues(7.5 %) and burning of fossil fuel(3.3 %). This implies that the productivity in the study area will be low. There will be reduced crop yield and increased hunger. These findings supported the view of Noma et al.(2009) that climate change is the result of the influence of many factors including the dynamic processes of the Earth itself, external forces including variations in sunlight intensity, precipitation and temperature and more recently by human activities. Agriculture is an important contributor of green- house gas emissions at the global scale. According to World Bank (2008), agriculture contributes about half of the global emissions of two of the most potent non-carbon dioxide green- house gases: nitrous oxide and methane. Application of

fertilizers, rearing of livestock and land clearing are some of the agricultural activities that influence levels of green house gases in the atmosphere and the potential for carbon storage (Mark et al., 2008).

4.5.2 Effects of Climate Change

Table 8 shows that the entire respondents (98.8 %) perceived that the effects of climate change were attributed to altering crops growing season, reduced crop yield(97.5 %),altering crops planting dates(94.2 %),infestation of pests, weeds and diseases(90.4 %) and altering harvesting dates(85.4 %). The implication of this result was that the crop cultivation and other related farm operations will be done late and the crop yield will be low as a result of infestation by pests and diseases in the study area. These findings supported the idea of Mark *et al.* (2008) that some of the direct effects of climate change on agricultural systems are seasonal changes in rainfall and temperature which could affect agro-climatic conditions, altering growing seasons, planting and harvesting dates, water availability and pests.

Table 8: Perceived Causes and Effects of Climate Change

Variables	Frequency	Percentage
Causes of climate change		
Overgrazing	238	99.2
Deforestation	216	90.0
Agricultural activities	212	88.3
Bush burning	68	28.3
Burning of crop residues	18	7.5
Burning of fossil fuel	8	3.3
Effects of climate change		
Altering crop growing season	237	98.8
Reduced crop yield	234	97.5
Altering crop planting date	226	94.2
Infestation of pests, weeds and diseases	217	90.4
Altering crop harvesting dates	205	85.4

Source: Field survey March/April, 2013.

4.6 Adaptation Measures Adopted by the Respondents

This provides information on the type of climate change adaptation measures adopted by the respondents in the study area. Table 9 shows that majority (100.0 %) of the respondents adopted using early planting and planting more than one crop while using cover crops (92.9 %), using soil conservation techniques (41.7 %),using early maturing crops (35.4 %),using irrigation (30.8 %), migration (14.6 %), using resistance crop varieties(9.2 %), varying the sowing/ planting dates (8.3 %),change crop intensity (6.3 %), reduced tillage practices (5.0 %), adjusting the timing of farm operations (4.6 %), diversifying from farming to non-farming activities (2.9 %) using crop rotation (2.5 %) and crop diversification (1.3 %). The implication of this result was that the respondents in the study area knew the benefit of adaptation measures that was the main reason they adopted it.

These research findings supported Hassan and Nhemachena(2008) who reported that the adaptation measures farmers perceived as appropriate include: crop diversification, using different crop varieties, varying the planting dates, harvesting dates, increasing the use of irrigation, soil conservation techniques, shading and shortening the length of the growing season and diversifying from farming to non-farming activities. Also, growing a variety of crops on the same plots or on different plots, thus reducing the risk of complete crop failure since different crops are affected differently by climate change Others include adjusting the timing of farm operations to reduce risks of crop damage, change crop intensity, change crop mix and migration to diversify income opportunities (Anselm *et al*, 2011).

Table 9: Adaptation Measures Adopted

Variables	Frequency	Percentage
Early planting	240	100.0
Planting more than one crop	240	100.0
Using cover crops	223	92.9
Using soil conservation techniques	100	417
Using early maturing crop	85	35.4
Using irrigation	74	30.8
Migration	35	14.6
Using resistance crop varieties	22	9.2
Varying the sowing/planting dates	20	8.3
Change crop intensity	15	6.3
Reduced tillage practices	12	5.0
Adjusting the timing of farm operations	11	4.6
Diversifying from farming to non-farming activities	7	2.9
Using crop rotation	6	2.5
Crop diversification	3	1.3

Source: Field survey March/April, 2013.

4.7. Respondents' Constraints to Adoption of Adaptation Measures

This provides information on the constraints to adoption of adaptation measures faced the respondents. Table 10 reveal that lack of finance (97.9 %), farm size (96.7 %), lack of extension services(62.5 %), lack of information on climate change (61.7 %), lack of education (52.5 %) and lack of market (9.2 %). As a result of small and fragmented farm size , it implies that the respondents cannot improve on their output. In addition to that, the respondents were not conversant with the modern ways of farming as a result of inadequate extension services coupled with poor educational status. Therefore, the respondents kept on operating and producing at subsistence level from generations to generations. Also, adoption of adaptation measures would be difficult especially those that require finance and technical knowhow. These research findings supported the result of a study conducted by (Eid *et al* (2006), as reported, lack of money, shortage of labour, farm size, tenure status, level of education of the farmers, inadequate information on climate change and access to extension service are the major determinants of speed of adoption of adaptation measures to climate change

Table 10: Constraints to Adoption of Adaptation Measures

Constraints	Frequency	percentage
Lack of finance	235	97.9
Farm size	232	96.7
Shortage of labour	226	94.2
Lack of access to extension service	150	62.5
Lack of information on climate change	148	61.7
Lack of education	126	52.5
Lack of market	22	9.2

Source: Field survey March/April, 2013.

4.8 Regression Analysis

Results of the regression analysis of the influence of socio-economic characteristics on the adaptation measures adopted by the respondents are shown in Table 11. The R^2 value which measures the variation in the dependent variable (Y) that is explained by the independent variables was 0.44. This means that 44% of the variation in the dependent variable is explained by the independent variables. The F-value which measures the level of significance of all the explanatory variables in the regression model was 2.517 and it was significant at 5%. The significant and positive F-value was an indication that the model was fit and suitable for the data.

The positive relationship between household size and adoption implies that the larger the size of a farmer's household the higher the adaptation measures adopted. This is in agreement with *a priori* expectation. Large household size provides the farmers with access to more family labour which is expected to increase their levels of operations and consequently their adaption level.

The coefficient for annual income was found to be positive and significant at 5%. This implies that as the income increases, the adaptation measures adopted would also increase. This finding supports Owolabi (2012), that wealthy farmers have the resources to adopt innovations if they believe they will be profitable.

Farming as primary occupation was also found to be positive, the adoption could be as a result of considering farming as their means of livelihood. They adopt the adaptation measures to minimize the effects of climate change on their crops so that they can maximize outputs. This finding supports Hassan and Nhemachena (2008) that the awareness of climate problems and the potential benefit of taking action are important determinants of adoption of adaptation measures. In the same vein, Iliya et al(2009) states

that farmers' good knowledge of their physical environment and cultural peculiarities most probably explain their success.

Farm size was also positive and significant at 5%. The positive coefficient of farm size suggests that as farm size increases, adoption would increase. Much empirical adoption studies focus on farm size as the first and probably the most important determinant. This is because farm size can affect and, in turn be affected by other factors influencing adoption. Farm size affect adoption costs, risk perceptions, human capital, credit constraints, labour requirements, tenure arrangement and more (Anselm *et al*. 2011). The same scholar stated that with small farm, it has been argued that large fixed costs become a constraint to adoption, especially if the technology requires a substantial amount of initial set-up costs.

The coefficient obtained for farming experience was also found to be positive and significant at 5%. This implies that increase in years of farming experience would increase the level of adoption. This finding supports (Anselm *et al*. 2011) who found years of experience significantly associated with adoption of agricultural technologies among farmers of Kama district in Eastern Nigeria.

However, the age and the educational status of the respondents in the study area show positive relationship with adoption. This implies that age influences the amount of effort put into any economic activity since it is the age group that contributes significantly to human labour in an agrarian community. Adubi (1992) stated that age has a significant influence on decision making process of farmers. The educational status has negative relationship with the number of adaptation measures adopted. This was because people with higher level of education in the study area are usually public servants who may take farming as part-time occupation. These people are less likely to adopt climate

change adaptation measures because they have other major sources of income. Low level of education was found to be very common among the farmers in Nigeria because they could not see any link between high level of education and farming (Lawal, 2002).

Table 11: Analysis of the Effects of Socio-economic Characteristics and the number of Adaptation Measures Adopted

Variables	Regression Coefficient	Standard Error	t-value	R^2	F-value
Constant	6.907	0.743	9.295	0.44	2.517 **
Age	0.012	0.023	0.505		
Household size	0.012	0.013	0.927		
Educational status	- 0.001	0.011	- 0.505		
Annual Income	0.07	0.000	2.184**		
Occupation	0.250	0.270	0.928		
Farm size	0.004	0.002	2.411**		
Farming experience	0.014	0.011	1.318**		

** = Significant at 5%

4.9. Chi-Square Analysis

This discusses the relationship between awareness and adoption of adaptation measures. Table 12 shows the Chi-square test of the relationship between the awareness of climate change and adoption of adaptation measures by the respondents in the study area. These results indicate a significant relationship between awareness and adoption of adaptation measures. This implies that farmers in the study area depend on awareness of adaption measures to determine the adoption of adaptation measures.. Furthermore, the more the farmers' awareness of the adaptation measures, the more the adoption (Ani 2007 and Yakubu, 2011) recognized awareness as the first stage in adoption process.

Table 12: Chi-square Analysis of the Relationship between Awareness and Adoption of Adaptation Measures

Variable	X^2tab.(0.05)	Df	X^2cal.	Decision
Awareness/ Adoption of Adaptation measures	5.99	2	12.69	Reject Ho

Source: Field survey March/ April, 2013

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The main objective of this study was to assess the awareness of climate change and adaptation measures adopted by arable crop farmers in the northern zone of Sokoto State Agricultural Development Project. The specific objectives were to: (i) describe the socio-economic characteristics of the farmers, (ii) examine farmers' evidence and level of awareness on climate change, (iii) identify the farmers sources of information on climate change, (iv) examine causes and effects of climate change on crop production, (v) investigate the adaptation measures to climate change adopted and (vi) assess the constraints to adoption of climate change adaptation measures by the farmers in the study area. A multistage random sampling technique was used to select the sample size of 240 arable crop farmers from the five purposively selected Local Government Areas namely: Illela, Isa, Gada, Sabon-birni and Tangaza of Sokoto State. The selection was based on their poor climatic conditions, drought and subsequent long period of dry spells during raining season.

Data for the study were collected with the aid of a structured questionnaire. The data were analyzed through the use of descriptive statistics namely: frequencies, percentages and means. Regression analysis was used to determine the effect of socio-economic characteristics on the adaptation measures adopted by the farmers. Chi-square analysis was also used to determine the relationship between awareness and adoption of adaptation measures.

The results of the study revealed that most of the respondents were between the ages of 31-36 years old, indicating that they were at their middle age, active and energetic.

Most of the respondents were also male, married and had no formal education. The mean years of farming experience was 12 years while the mean of household size was 9 persons. Farming was considered as the primary occupation (69.2%) with farmland (97.9%) acquired through inheritance. The mean income per annum was N14, 472:92K. The results also revealed that millet was cultivated by all the respondents followed by sorghum and beans. The crop choice and production was determined by the prevailing agroeccological conditions. Majority (83.33%) of the crop produced were mainly for household consumption only (16.67%) was used for marketing.

The entire respondents were aware of climate change and its evidences. Moreover, 97.92% of the respondents were aware of late commencement of rainfall, 95.83% early cessation of rainfall, 94.58% poor yield, 93.75% drought, 90.42% heavy wind, 87.o8% desertification, 85.0% early dryness of small streams and rivers, 62.08% erosion, 60.42% flood and 50.25% heat stress. However, the mean duration of climate change experience in the study area was 10.78 years. Majority (95.52%) used friends as their source of information on climate while93.33% relatives, 67.08% radio, 22.05% extension agent, 7.92% print media and 6.6% television.

The results further revealed the causes of climate change in the area was attributed to 99.27% overgrazing, 90.0% deforestation, 88.3% agricultural activities, 28.3% bush burning and 7.5% burning of crop residues. In addition the effects of climate change according to the respondents includes: altering of crop growing season, reduced crop yield, altering crop planting dates, and lastly altering crop harvesting dates.

The results, in addition, revealed the adoption of the following adaptation measures: Using early maturing crops, Planting more than one crop on same piece of land, Using early planting, Using resistance crop varieties, Using crop rotation, Using irrigation,

Varying the sowing/ planting dates, Using cover crops, Reduced tillage practices, Using soil conservation techniques, Diversifying from farm to non-farming activities and Adjusting the timing of farm operations. Among the constraints identified by the respondents were Lack of finance, Farm size, Lack of access to extension service, Lack of information on climate change, Lack of education and Lack of market. The need to farmers to form cooperatives societies, provision of adequate extension support services, encouraging formal education through literacy programmes, provision of rural infrastructures, organizing seminars/ workshops on climate change adaptation measures, control of removal of trees and cresting more rangelands were offered as recommendations.

The socio-economic factors affecting the adoption of adaptation measures were determined by employing the multiple regression analysis which revealed the coefficient of determination of 44%. This indicates that 44% of the variation was explained by the variation in the factors that were included in the model. The significant and positive F-values showed that the model was fit and suitable for the data. All the variables included in the model were positively related to the adoption of adaptation measures with the exception of respondents' educational status that was negative. The result of the Chi-square analysis between awareness and adoption shows a significant relationship between awareness and adoption at 5%.

5.2 Conclusions

The awareness of climate problems and potential benefit of taking action is important determinant of adoption of adaptation measures to climate change. Among the socio-economic characteristics of the respondents: household size, annual income, occupation, farm size and farming experience played an important role in adoption of climate change

adaptation measures. However, annual income, farm size and farming experiences were significantly related to adoption. The results of multiple regression and chi-square analyses employed indicated that climate change had impact on crop production in the study area. The positive relationship between the socio-economic variables shows that if those variables are improved, adoption will improve thereby boosting crop output which in turn increase farmers' income and improve their standard of living. The constraints faced by the respondents in adoption of climate change adaptation measures includes: Inadequate operating capital, Poor access to extension service, Lack of information on climate change, Illiteracy and Inadequate market.

5.3 Recommendations

Based on the findings, the following were recommended.

1. Farmers should form themselves into co-operatives to enhance their accessibility to credit facilities and other micro-finance agencies under the supervision of the Agricultural Development Projects (ADPs).
2. Provision of adequate extension and support service should be provided by the Government with a view to informing farmers on better ways of adoption to climate change during crop production.
3. Farmers should be encouraged to form societies to enhance their information gathering center as well as learning effectively from each other.
4. The farmers should endeavor to obtain formal education through literacy programme. This is because education has proved to be one of the determinants of better utilization of farm modern practices from research institutes.

5. Government should make rural areas habitable by providing rural infrastructures to curtail the movement of young farmers to urban areas leaving farming in the hands of aged farmers that are less active.
6. Organizing seminars and workshops on climate change adaptation measures by the stakeholders (extension agents, non-governmental organizations, researchers and farmers) and its advantages given more publicity. This will further encourage farmers to invest their resources in climate change adaptation for increased crop productivity which will increase the farmers' income and improve their standard of living.
7. Government should control the removal of trees and provide more rangelands for the use of livestock.
8. There is the for further studies in the other zone (Western Zone) on farmers' awareness and adaptation to climate change to ascertain the level of awareness and adaptation in the State.
9. There is also the need for further studies in the level of climate change effects on the major crops produced in the State.

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APPENDICES

Appendix I: questionnaire

USMANU DANFODIYO UNIVERSITY SOKOTO
FACULTY OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT
QUESTIONNAIRE FOR SOKOTO STATE ARABLE CROP FARMERS
TOPIC: ASSESSMENT OF FARMERS' AWARENESS AND ADAPTATION TO CLIMATE CHANGE IN THE NORTHERN ZONE OF SOKOTO STATE AGRICULTURAL DEVELOPMENT PROJECT

SECTION A: FARMERS' PERSONAL DATA

1. Farmer's Village……
2. Farmer's age …….
3. sex : (a) Male ( ) (b) Female ( )
4. Marital status: (a) Married ( ), (b) Single ( ), (c) Widowed ( )
5. Household size ……
6. Educational status ……
7. Level of income per annum …….....
8. Are you a full time or part-time farmer: (a) Full time ( ), (b) Part-time ( )..
9. What is the size of your farm? ……
10. How did you acquire the farmland? : (a) Purchased ( ), (b) Gift ( ), (c) Leased ( ), (d) Inherited ( ), (e) Government ( )
11. Your farming Experience …….

SECTION B: FARMERS' PRODUCTION ENTERPRISE

1. What type of crop enterprise do you produce in your farm? : (a) Arable crops only ( ), (b) Combination of arable and permanent crops ( ).

2. List the crops you produce in your farm :

……

……

3. What determines the choice of crops produced in your farm? : (a) Household consumption needs ( ), (b) Market demands/ profitability of the crop ( ), (c) Climate pattern ( ).

4. Kindly indicate what determine the choice of cropping system in your farm: (a) Climate pattern ( ), (b) Types of crop available ( ), (c) Cultural norms ( ).

SECTION C: FARMERS' AWARENESS OF CLIMATE CHANGE

1. Are you aware of climate change? (a) Yes ( ), (b) no ( ).
2. If yes, for how long have you observed this change? (a) one year ( ), (b) two years ( ), (c) three years ( ), (d) four years ( ), (e) many years (specify) ( ).
3. What are your evidences that there is climate change in your area? Multiple responses are possible.

(a) Late commencement of rainfall ( )

(b) Early cessation of rainfall ( )

(c) Desertification ( )

(d) Flood ( )

(e) Drought ( )

(f) Erosion ( )

(g) Heavy wind ( )

(h) Heat stress ( )

(i) Early dryness of streams and rivers ( )

(j) Poor yield ( )

4. What do you think are the causes of climate change? Multiple responses are possible.

(a) Bush burning ( )

(b) Agricultural activities ( )

(c) Deforestation ( )

(d) Burning of fossil fuel ( )

(e) Over grazing ( )

(f) Continuous cropping ( )

(g) Burning of crop residues ( )

5. Do you know the effects of climate change on your crop production? (a) Yes ( ), (b) no ( )

6. If yes, what are the effects of climate change on your crop production? Multiple responses are possible.

(a) Altering crops growing season ( )

(b) Altering crops planting date ( )

(c) Altering crops harvesting date ( )

(d) Reduced crops yield ( )

(e) Infestation of pest, weed and diseases ( )

SECTION D: CLIMATE CHANGE ADAPTATION MEASURES

1. Do you adopt adaptation measures against the effects of climate change in your farm? (a) Yes ( ), (b) ( )

2. If yes, which of the adaptation measures do you adopt? Multiple responses are Possible.

(a) Using early maturing crops ( )

(b) Planting more than one crop ( )

(c) Early planting ( )

(d) Using organic manure ( )

(e) Using resistance varieties ( )

(f) Using crop rotation ( )

(g) Using irrigation ( )

(h) Using mulching ( )

(i) Varying the sowing/planting dates ( )

(j) Using cover crops ( )

(k) Reduced tillage practices ( )

(l) Monitor pathogens, vectors, pests and diseases ( )

(m) Crop diversification ( )

(n) Using soil conservation techniques ( )

(o) Shading and shelter ( )

(p) Diversifying from farming to non-farming activities ( )

(q) Crop insurance for risk coverage ( )

(r) Improving the effectiveness of pests and diseases control ( )

(s) Adjusting the timing of farm operations ( )

(t) Change crop intensity ( )

(u) Recycling or storing water ( )

(v) Migration ( )

SECTION E: CONSTRAINTS TO ADOPTION

1. What are your constraints in adopting the adaptation measures in your farm? Multiple responses are possible.

(a) Lack of information on climate change ( )

(b) Lack of finance ( )

(c) Shortage of labour ( )

(d) Farm size ( )

(e) Land tenure system ( )

(f) Lack of education ( )

(g) Lack of access to extension services ( )

(h) Lack of market ( )

SECTION F: SOURCE OF INFORMATION

1. What are your source(s) of information on climate change? Multiple responses are possible.

(a) Friends ( )

(b) Relatives ( )

(c) Radio ( )

(d) Television ( )

(e) Print media ( )

(f) Extension agents ( )

Thank you, sir.