ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON LAND USE/LAND COVER IN KOGI STATE, NIGERIA

BY

DAOU, Assitan
MTech/SNAS/2013/4217

WEST AFRICAN SCIENCE CENTRE ON CLIMATE CHANGE AND ADAPTED LAND USE
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

SEPTEMBER, 2015

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THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSISTYY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY (M.TECH) IN CLIMATE CHANGE AND ADAPTATED LAND USE

SEPTEMBER, 2015

DECLARATION

I, hereby declare that this thesis titled: "Assessment of the Impact of Climate change on Land Use/Land Cover in Kogi State, Nigeria" is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

DAOU, Assitan ……………………………

MTech/SNAS/2013/4217 SIGNATURE AND DATE

FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA, NIGERIA

CERTIFICATION

This thesis titled: Assessment of the Impact of Climate Change impact on Land Use/Land Cover in Kogi State, Nigeria carried out by DAOU, Assitan (MTech/SNAS/2013/4217) meets the regulation governing the award of Degree of Master of Technology of the Federal University of Technology Minna, and it is approved for its contribution to scientific knowledge and literacy presentation.

Prof. J. M. Baba ………………………
Supervisor Signature & Date

Dr A. A. Okhimamhe ….....………………….
Director, WASCAL Signature & Date

Prof. M.G. M. Kolo ………………….
Dean, Postgraduate School Signature & Date

DEDICATION

This project is dedicated to my loving, caring and industrious family whose effort and sacrifice has made my dream of having this degree a reality. Words cannot adequately express my deep gratitude to you. I pray you will live long to reap the fruits of your labour.

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ABSTRACT

Climate change and variability pose serious risks to rain-fed agricultural land use in the semi-dry agro-ecological zones of Nigeria. Kogi State, is not an exception. Rainfall is becoming more unpredictable and unreliable both in its timing and its volume and growing seasons are changing, ecological zones are shifting. Therefore, this study was conducted to find out the impact of climate change on agricultural land use in Kogi State in order to implement better adaptation strategies for smallholders. For this purpose, forty years (1975-2014) rainfall and temperature data from NIMET, Landsat images (1987, 2001 and 2014) and questionnaire on farmer's perception were used. Focused variables calculated were: Standardized anomalies, means for both temperature and rainfall. Landsat images were used to assess Land Use/Land Cover (LULC) types between 1987 and 2014. A questionnaire was administrated to investigate farmer's perception on climate change and agricultural land use. Data collected were analysed using SPSS 20. Excel 2013 and Envi5.1. The magnitude of the change rate between 1987 and 2001, 2001 and from 2987 to 2014. It obvious that only water body did not experience a major change. It was observed that a decrease in natural vegetation within the period of 1987-2001 (15) and from 1987 to 2014 (29). This indicate the practice of deforestation in the study area for residential purpose and farming. Binary Logit Model was used to determine the significant factor that affects farmer's decision to change land use under cultivation. Results show a slight increase in both temperature and rainfall up to 0.4 and 0.10 respectively. Lowest and highest temperatures were recorded in 1989 and 2005 respectively with values of 27.3^0C and 29.2^0C. The period of 1975 to 1997 is characterized as the cool years as the values were below the normal (zero) except years 1980, 1983, 1987, 1990 and 1996, while from 1998 to 2013 mean annual temperature was above the normal. The average rainfall is 1218.5 mm. The study area has experienced successive dryness years from 1975 to 1985 with a wet year occurring in 1978. The dry year was 1977 while the wetness was 1999 with respective standardized value of -1.82 (moderate dryness) and +2.23 (extreme dryness). The statistic of land use and land cover map shows that between 1987 and 2001 (15 years), the built up area had increased by 41.565 hectares. While farmland decreased by -27577 hectares between 1987 and 2001. Between 2001 and 2014 only built up area increased tremendously by 10.68% within the period. In terms of adaptation strategies, seven (7) adaptation strategies were employed by farmers, viz: changing planting dates, implement soil conservation schemes and change crop variety at 31%, 22% and 21% respectively in response to change in rainfall. Logit regression model reveals that change in rainfall patterns (Fpr. = 0.122) has no significant impact on farmers' decision to change land use under cultivation at 5% level of significance. However, number of family member schooling (Fpr. = 0.01), household farming experience (Fpr. = 0.00) and access to credit (Fpr. = 0.00) have significant impact on farmers' decision to change land under cultivation. These results will be useful for agricultural planning in the study.

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PLATE

ABBREVIATION

ADP	Agricultural Development Project
FAO	Food and Agricultural Organization of the United Nations,
GDP Gross	Domestic Product
GIS	Geographic Information Systems
GLCF	Global Land cover Facility
GPS	Geographic Positioning Systems
IPCC	Intergovernmental Panel on Climate Change;
KOSEEDS	Kogi State Economic Empowerment and Development Strategy
LGA	Local Government Area
LULC	Land Use Land Cover
NBS	National Bureau of Statistics
NEST	Nigerian Environmental Study Team
NIMET	Nigerian Meteorological Agency
NPC	National Population Commission
SPSS	Statistical Package for Social Science
UNFCCC	United Nations Framework Convention on Climate Change
WASCAL	West African Science of Climate Change and Adapted Land Use

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Agriculture plays an important role on the environment in the process of providing employment and source of livelihood for the increasing population (Aigbokhan, 2001; Onyeahialam, 2002). The sector accounts for about 40 percent of Gross Domestic Product (GDP) and provides employment, both formal and informal, for about 60 percent of Nigerians (Olagunju, 2007; Odoemelam, 2011).

Climate is the first determinant of agricultural productivity. Given the fundamental role of agriculture in human welfare, concern has been expressed by federal agencies and others regarding the potential effects of climate change on agricultural productivity (Apata, Samuel and Adeola, 2009). Interest in this issue has motivated a substantial body of research on climate change and agriculture over the past decade (Lobell, Tebaldi, Mastrandrea, Falcon and Naylor, 2008; Fischer, Shah and Velthuizen, 2002).

Intergovernmental Panel on Climate Change (IPCC, 2007) revealed that climate change will have a strong impact on Nigeria-particularly in the areas of agriculture; land use, energy, biodiversity, health and water resources. Nigeria, as part of Sub-Saharan Africa countries, is highly vulnerable to the impacts of Climate Change (IPCC, 2007; NEST 2004). It has already experienced weather events in terms of floods, droughts, heat waves and tropical cyclones that are more frequent or intense than previous experiences and the resulting impacts point to the consequences on the environment, production systems, and livelihoods (Dai, Trenberth, and Qian, 2004; Trenberth, Jones, Ambenje, Bojariu, Easterling, Klein and Zhai, 2007).

According to World Bank (2008) 75% of the world's poor live in rural areas in developing countries and most of them depend on agriculture for their livelihoods. Increased rainfall could result in water-logged soils unsuitable for agriculture. This would lead to soil erosion and loss of soil nutrients important for plant growth. Hence the effect of climate change may reduce agricultural land use due to submergence of coastal regions and increased aridity in the tropical high agricultural regions (Ngaira, 2007).

1.2 Statement of the problem

Climate change and variability pose serious risks to rain-fed agricultural land use in the semi-dry agro-ecological zones of Africa. Rainfall variability has significantly impacted on the rural poor (Allamano, Claps and Laio, 2010) who rely mostly on natural rainfall for crop production. The frequency of the climatic extremes has increased in the past century, significantly reducing land put under crops, and hence crop yields (Tadross, Jack and Hewitson, 2005). The effects of climatic extremes are compounded by the fact that rain-fed agriculture is commonly practiced in developing countries where it difficult for farmers to adapt (Agrawal and Perrin, 2008).

Facing the prospects of tragic crop failures which reduced agricultural productivity, increased hunger, poverty, malnutrition and diseases (Zoellick, 2009; Obioha, 2008). Due to these environmental threats resulting to declining crop yields, some farmers in Nigeria are abandoning farming for non-farming activities (Apata, Ogunyinka, Sanusi and Ogunwande, 2010). Hence, concerted efforts toward tackling these issues are necessary.

Kogi State, the study area, as part of north central Nigeria, is vulnerable to the impact of climate change. Rainfall is becoming more unpredictable and unreliable both in its timing and its volume and growing seasons are changing, ecological zones are shifting. (Brett, 2009; Ngaira, 2007; Ajadi, Adeniyi and Afolabi, 2011) leading the abandonment of farming activity to non-farming activity in many rural communities.

1.3 Justification of the study

Climate change and change constitute a major limiting factor in crop production whereby agricultural practice is based on rain - fed agriculture. Changes in the characteristics of rainfall occasioned by global warming has led to rainfall variability and uncertainties. This is true in area where agricultural remain traditional according to Adebayo (1997). Although there are numerous recent regional and national studies of climate change and variability on agricultural productivity and adaptation strategies in Nigeria (Obioha, 2008, Anselm and Taofeeq, 2010), there has been little focus on the views and perceptions of the smallholder farmers about climate change and variability and their effect on specific agricultural land use systems.

Adaptation to climate change involves the identification of mechanisms that farmers can implement within their circumstances that can offset the unpredictable nature of climate. Individual perception of the risks associated with climate variability is fundamental in determining their ability to adapt as perception is usually translated into agricultural decision making process (Bryant, Smit, Johnston, Smithers, Chiotti, and Singh 2000). However, Maddison (2006) and Fosu-Mensah, Vleck and Manschadi, (2010) noted that not all of the farmers who perceive climate change actually respond by taking adaptation measures.

Regarding the fundamental role of agriculture as a main source of income for about 80% of the population (NBS, 2006; KOSEEDS, 2006) in the study area (Kogi State) and the challenges that farmers are facing due to the adverse effect of climate change; This, study needs to be carried out in areas whereby agriculture is highly dependent on rainfall agriculture, especially in those areas where there is no much information about the climate change issue.

Furthermore, the choice of Kogi State is based on the fact that, the State is among the major four food potential growing regions in Nigeria mainland; if these area is vulnerable to climate change and variation the growth of Nigeria economy may be impaired.

1.4 Aim and objectives

1.4.1 Aim

This study aims at examining the impact of climate change on agricultural land use and to examine farmers' views on agricultural land use change under current climatic pattern in three Local Government Areas in agricultural zone C of Kogi State (Adavi, Ajaokuta, Okehi).

1.4.2. Objectives

The objectives are to:

i. Analyse the trends of climatic parameters (rainfall and temperatures) for a forty year period in the study area (1975 to 2014);
ii. Map out changes in agricultural land use in the study area for three decades (1987 to 2014);
iii. Investigate farmers' perception on climate change and agricultural land use.

To achieve the aim of the study these pertinent questions need to be answered:

i. What are the trends of rainfall and temperature from 1975 to 2014?
ii. What are the changes in agricultural land of the study area from 1987 - 2014?
iii. How do farmers perceive climate change and agricultural land use change?

1.5 Scope and limitation of the study

This study was conducted in central Kogi State, comprising Adavi, Ajaokuta and Okehi local government areas. Focus was on smallholder farmers' perception on climate change and agricultural land use for the past forty years (1975-2014) and the adaptation strategies adopted by the local farmers.

Assessing the impact of climate change on agricultural land use requires secondary data on crop area under cultivation, which was not available. Hence three satellite images were downloaded to determine the spatial changes that had occurred in agricultural land in the study area for from 1987 to 2001 and from 2001 to 2014.

1.6 Study area

1.6.1 Location

The study area is located in north central Nigeria within latitudes 6^o30 N to 8^o50 N and longitudes 5^o20 E to 8^o00 E (Figure 1.1), which occupies 30,354.74 km^2 (Table 1.1). Kogi State is the most centrally located of all the states of the federation (Ibitoye, 2006).The State was created out of Kwara and Benue States along with eight other states on the 27^{th} of August 1991. It has twenty one local government areas and is divided into three senatorial districts namely: Kogi East, Kogi Central and Kogi West. Kogi East comprises Ankpa, Bassa, Dekina, Ofu, Omala, Olamaboro, Ibaji, Idah and Igalamela-Odolu LGAs. Kogi Central comprises: Ajaokuta, Okene, Okehi, Adavi and Ogori-mangogo LGAs, while Kogi West Comprises: Kabba-Bunnu, Ijumu, Lokoja, Kogi, Yagba-West, Yagba-East and Mopa-Amuro local government areas (LGAs).

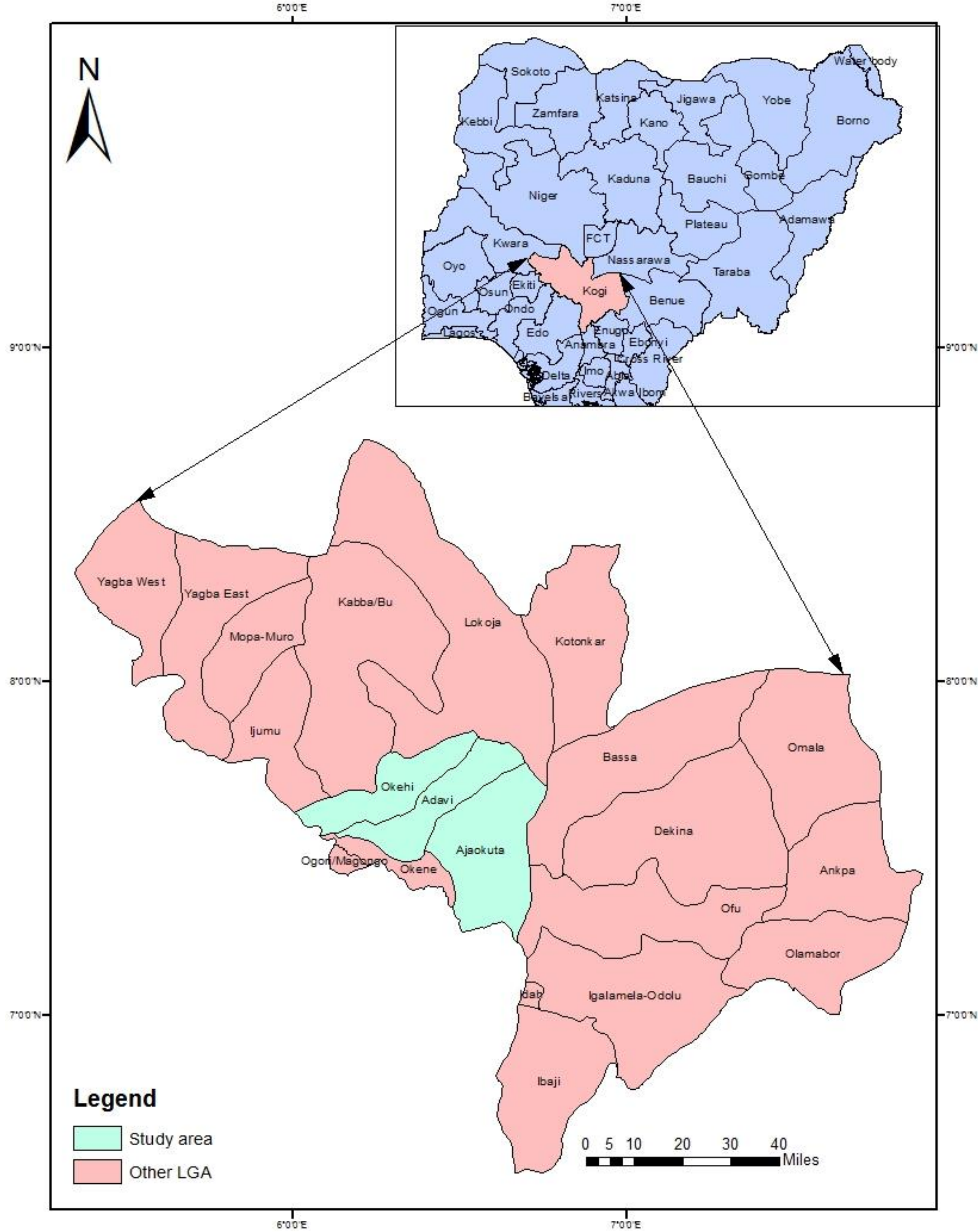


Figure 1. 1 Nigeria showing the study area

Source: Author

1.6.2 Population

The population was 3,278,487 people in 2006, which comprised 1,691,736 males and 1,586,750 females (NPC, 2006). In Kogi State, 70 percent of the population resides in the rural area with about 80 percent being farmers (NBS, 2006). This population is made up of various ethnic groups, which include; Kigali (40.93%), Yoruba (10.73%), Nupe (4.85%) and Bassa Komo (4.07%) speaking people (Ibitoye, 2006).

Table 1.1 The Distribution of Land mass, by LGA, Kogi State, 2012

Serial No	Local Government Area (LGA)	Land Area (km^2)	Share of LGA in Total Kogi State Land Mass (%)	Population density (persons per Km^2)
1	Adavi	708.07	2.33	366
2	Ajaokuta	1427.44	4.70	102
3	Ankpa	1244.80	4.10	255
4	Bassa	1769.23	5.83	94
5	Dekina	2487.55	8.19	125
6	Ibaji	1519.27	5.01	100
7	Idah	39.79	0.13	2,393
8	Igalamela/Odolu	2250.85	7.42	78
9	Ijumu	1191.91	3.40	119
10	Kabba/Bunu	2702.85	8.90	64
11	Lokoja	3518.10	11.59	39
12	Kogi/KK	1483.56	4.89	158
13	Mopa Muro	891.78	2.84	59
14	Ofu	1670.27	5.50	137
15	Ogori Magongo	101.01	0.33	471
16	Okehi	675.46	2.23	395
17	Olamaboro	1285.61	4.24	147
18	Omala	1670.27	5.50	77
19	East Yagba	1667.22	5.49	106
20	West Yagba	1618.25	5.33	103
21	Total	30,354.74		130

Source: Underlying data from Office of Kogi State Surveyor General, Lokoja

1.6.3 Geology

Kogi state has two main rock types, namely, basement complex rocks of the Precambrian age in the western half of the state and extending slightly eastwards beyond the lower Niger valley and the older sedimentary rocks in the eastern half. The various sedimentary rock groups extend along the banks of Rivers Niger and Benue and south-eastwards through Enugu and Anambra states, to join the Udi Plateau (Iloeje, 1972).

1.6.4 Relief and drainage

The land rises from about 300 metres along the Niger-Benue confluence, to the heights of between 300 and 600 metres above sea level in the uplands. Agbaja Plateau, which ranges from 335 to 366 metres above sea level, and the much higher OkoroAgbo hills at Ogidi in ljumu LGA are some of the predominant to landforms of the state. The state is drained by the Niger and Benue rivers and their tributaries.

The confluence of the Niger and Benue rivers which could be viewed from the top of Mount Patti is located within the state of The Benue river is navigable as far as Garua in the rainy season floods, but up to Makurdi in Benue State in the dry season (Iloeje, 1972).

The bigger rivers have wide flood plains such as the portion of the lower Niger in Kogi state, which is more than 1,600 metres wide at Lokoja, while the in small streams have narrow valleys. The general rain is undulating and characterised by high hills, Jos plateaus and numerous inselbergs and elongated a ridges (Iloeje, 1972).

1.6.5 Climate

The climatic cover of Kogi State is tropical, which is divisible into two major seasons; dry season and rain season. The rainy season lasts from April to October. The dry season, which lasts from November to March, is very dusty and of cold as a result of the north-easterly winds, which brings in the harmattan (Ibitoye, 2006). The state has an annual rainfall of between 770 mm and 1,770 mm. Annual mean temperature is between 28^{o} C and 35^{o} C.

16.6 Soils

The flood plains of the Niger and Benue river valleys in Kogi State have the hydromorphic soils which contain a mixture of coarse alluvial and colluvial deposits (Areola, 1985). The alluvial soils along the valleys of the rivers are sandy, while the adjoining laterite soils are deeply weathered and grey or reddish in colour, sticky and permeable.

1.6.7 Vegetation

The vegetation of the area is typical of the derived savannah (Kogi State Website, 2015). However, the toposequence is covered with grasses and scattered shrubs. The topography of this land is strongly undulating. The rain forest belt (selva type) covers Dekina, Ofu, Ankpa, Olamaboro, Idah and Bassa local government areas with rich deciduous and occasional stunted trees including palms, Iroko, mahogany, akeeapple and other towering trees. Other LGAs are in the guinea savannah or parkland savannah belt with tall grasses and some trees.

These are green in the rainy season with fresh leaves and tall grasses, but the land is open during the dry season, showing charred trees and the remains of burnt grasses. The trees which grow in clusters are up to six metres tall, interspersed with grasses which grow up to about three metres (Kogi State Website, 2015). These trees include locust bean, shea butter, oil bean and the isoberlinia trees. The different types of vegetation are, however, not in their natural luxuriant state owing to the careless human use of the forest and the resultant derived deciduous and savannah vegetation.

1.6.8 Cultivation

Farming is the predominant occupation of the people of Kogi State. Mixed cropping is the predominant type of farming in the State (Ibitoye, 2006). The land use pattern is fallow-cropping system operated with hoes and cutlasses. After cultivating a piece of land for between 3 to 5years, it is left to fallow for some years and the farmer shifts to a more fertile land. An average farm family in the State cultivates several plots of land totalling between 2 to 3 hectares. The farm holdings are usually fragmented. A typical farm family may have an early yam and rice plots in the low land (fadama), cassava, grains and late yam in the upland. The cultivation of food crops such as cassava, maize, sorghum, rice, yam, cowpea, groundnut and melons predominate in the agricultural practice.

1.6.9 Ecological problems

The ecological problems in the state are not necessarily peculiar to it. Some of these include leaching, erosion and general impoverishment of the soil (Kogi State Website, 2015. These problems are compounded by the annual bush burning of the savannah that further exposes the top soil to more erosion. Floods pose a problem on the flood plains during the rainy season, while aridity is a problem to several areas at short distances from the rivers during the dry season. Much damage is done to land and property as a result of these phenomena.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1 Conceptual framework

2.1.1 Land use/Land cover

According to Green, Cornell, Scharlemann and Balmford (2005) and cover refers to the physical and biological cover over the surface of the land. Land use and land cover change is a term used for the human modification of the earth terrestrial surface. Much of the world's natural land cover has been transformed by human activities, resulting in ecosystem degradation and biodiversity loss worldwide. An estimated 4.7 million km^2 of grassland areas and 6 million km^2 of forest/woodland have been converted to cropland worldwide since 1850 (Lambin, Geist, and Lepers, 2003), and the main purpose for land use change is to obtain food and other essentials.

Land use change is largely driven by the decision of the people and population growth, declining household farm size and income. There have been many studies on land use and cover changes both at regional or local levels (Tsegaye and Farh, 2009; Gete and Hurni, 2001), but most often they deal with quantifying land use/change using remote sensing tools, which give quantitative descriptions but do not explain or provide understanding of the relationship between the pattern of change and there driving forces (Olson, Misana, Cambell, Mbonile and Mugisha, 2004). However studies linking land cover changes with drivers are scarce.

2.1.2 Agricultural land use

The cultivation of land, including horticulture, fruit growing, crop and seed growing, dairy farming and livestock breeding refers to agriculture. Generally in West Africa agriculture production system is based on low input of labour saving-technologies, knowledge that has been communicated and passed down from generation to generation through family members and communities. Its techniques are most often practiced on small family farms and in developing countries. The production is mainly for subsistence, less than 50% is sold. Crops are mixed, often using multiple varieties of the same crop, and are sometimes planted in associated groups. For example, vine-based beans might be planted with corn. Crop timing is based on traditional experience, and tilling and other farm techniques are based on proven traditions (Tikai, Kama and Mabogunje, 2007).

Land use is defined as the way in which humans are using the land, which is an effect of an integrated set of biophysical and socio-economic factors (Verburg and Chen, 2000). Land use is the specific activity a piece of land is put into. Various land use patterns emerge after the land has been subjected to use over time. In the rural area for instance, the type of land use include farming, plantation, grazing, etc.

Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO (2005) as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. Land under permanent crops is land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber. This category includes land under flowering shrubs, fruit trees, nut trees, and vines, but excludes land under trees grown for wood or timber. Permanent pasture is land used for five or more years for forage, including natural and cultivated crops.

2.1.3 Climate change and variability

Climate change refers to the fluctuation and changes in mean conditions in climatic parameters. It includes inter and intra-seasonal, inter-annual as well as spatial variations and changes (IPCC, 2001). While the United Nation Framework Conference on Climate Change (UNFCCC, 1992) defined climate change as change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. This means the alteration of the world's climate are causing by humans, through fossil fuel burning, clearing forests and other practices that increase the concentration of greenhouse gases (GHG) in the atmosphere.

Climate variability refers to the climatic parameter of a region varying from its long-term mean. Every year in a specific time period, the climate of a location is different. Some years have below average rainfall, some have average or above average rainfall.

2.2 Review of relevant studies

2.2.1 Climate change

Ekwe, Joshua, Igwe and Osinowo (2014) examined the mathematical study of monthly and annual rainfall patterns in Nasarawa State for 20 years (1993-2012) using data obtained from the archives of Meteorological Observatory at the College of Agriculture, Lafia, Nasarawa State. Statistical techniques like time series analysis, mean and standard deviation were employed to depict the temporal distribution of rainfall over the area. The study shows that 1996 is the wettest year, while 2010 shows a year with the lowest negative rainfall deviation. In analyzing the months for the period, it was noticed that August recorded the highest rainfall value of 2498mm which is the month where clouds pervades the sky. The standardized anomalies results obtained show a fluctuating rainfall pattern across the years over Nasarawa State which makes it hard to freely forecast rainfall trend for a future season.

Abaje, Ishaya, and Usman (2010) study on analysis of rainfall trends used 35 years (1974-2008) rainfall data. The calculated Relative Seasonality Index for the area revealed that rainfall regime is markedly seasonal with a long drier season. In order to identify trends, the rainfall series was divided into 10-year overlapping sub-periods 1974-1983, 1979-1988 through 1999-2008 and the Cramer's test was then used to compare the means of the sub-period with the mean of the whole record period. The results of the test revealed that the sub-period 1974-1983 and 1999-2008 for the months of June and October respectively were significantly drier. The results of the Standardized Anomaly Index revealed that rainfall yield is declining in the study area. The 5-year running mean shows that the declining yield of the annual rainfall started from 1990 to date. The results of the linear trend lines further revealed that the decline in the annual rainfall yield is predominantly as a result of the substantial decline in July, September, and October rainfall, which are the critical months for agricultural production in the area.

According to Omotosho (1985) West African precipitation is strongly dependent on the southwest monsoon flow, which has the unique characteristics of high seasonal, monthly and daily variability in its moisture content and (vertical) depth. These variability are particularly strong in the lowest 1 km of the atmosphere. The strength and direction of the variations generally determine the type, nature, extent and intensity of the resultant weather, particularly the thunderstorms and squall lines which are responsible for over 70% of the total annual precipitation over West Africa.

2.2.2 Land use/land cover

According to Saleh, Badr, El Banna and Shahata (2012) traditional farming systems in Nigeria have started to change due to the presence of Agricultural Development Project (ADP) in the countries. Government policies had great impact on the farmer's agricultural practices and hence, the land use decision. The pattern of political changes, shift in economy, and an increase in population has resulted in an increased urban area. This pattern of urban expansion affects prime agricultural farming areas and it limits the potential of farming in the study area. Thus, converting agricultural areas in the urban and peri-urban areas to an urban status continues due to the process of urbanization. This problem is more pronounce and is also being driven by government developmental activities by taking over large areas of agricultural lands for one project or the other.

Land use and land cover change is a term used for the human modification of the earth terrestrial surface. Much of the world's natural land cover has been transformed by human activities resulting in ecosystem degradation and biodiversity loss worldwide (Green *et. al*, 2005). An estimated 4.7 million km2 of grassland areas and 6 million km2 of forest/woodland have been converted to cropland worldwide since 1850 (Lambin *et al.*, 2003), and the main purpose for land use change is to obtain food and other essentials. Land use can be seen from the perspective of human activities such as agriculture, forestry, building construction, and recently, industrialization which has led to increased human population within urban areas and depopulation of rural areas. The driving forces behind land use pattern include all factors that influences human activity.

Ibitoye (2013) investigated the levels of awareness and use of agricultural insurance scheme in Kogi State of Nigeria. Sigma scoring method was used to determine the levels of awareness and use of agricultural insurance scheme among the rural farmers in study area. It was shown by the findings of that study that farmers in the State are mostly males (95%) with low levels of education and an average farm size of 3.2 hectares. The majority of the farmers belong to low income group with about 55 percent earning less than N100 000 per annum as indicated in the results.

Xie, Zou, Jiang, Zhang, and Choi (2014) investigating the spatial disparities and driving forces of arable land-use intensity using empirical method, showed that chemical fertilizer was the largest component of agricultural inputs and that agricultural diesel oil recorded the highest growth rate. The findings revealed two main input components in arable land use, chemical fertilizer and agricultural diesel oil in agriculture and suggested there is an urgent need to focus on the effects of chemical fertilizer and pesticide inputs on the ecological environment. Okai (1997) asserts that destructive traditional land use and conservation practices have reduced soil fertility levels in the sub-region, which has reflected in declining crop yields.

Spatio-Temporal analysis of land use/cover change of Lokoja by Adeoye (2012) revealed that the natural environments (vegetation, wetland resources, water bodies and mountainous terrain) were being threatened, as they reduced continually in the areal extent over time and space while the social environment (built up area) expanded tremendously. The study discovered that urbanization processes majorly responsible for land use/cover change in Lokoja. He concluded, advanced our frontier of knowledge on land use/cover study by providing information on the status of natural and social environment in Lokoja, a confluence town, between 1986 and 2007 using remotely sensed images and Geographic Information Systems (GIS) technology.

2.2.3 Climate change impact on agriculture

The amount and temporal distribution of rainfall is thus the single most important determinant of national crop production levels from year to year, and rainfall in much of the country is often erratic and unreliable. Rainfall variability and associated droughts have historically been major causes of food shortages and famine in the country (Wood, 1977). Even though drought followed by food insecurity is not a new phenomenon, its frequency of occurrence has increased during recent decades (Tilahun, 1999).

Hamza and Iyela (2012) reviewed land use pattern, climate change, and its implication for food security. It was concluded that 85% of the population is directly supported by agricultural economy. However the productivity of the economy is threatened by land use changes and unsustainable land management practices which had impacted seriously on Ethiopia's rich biodiversity, crop production and livestock grazing lands. Climatic variability like droughts and consequently food shortage and famine, climate change is set to make the lives of the poorest even harder.

Ajetomobi and Abiodun (2010) assessed climate change impacts on cowpea productivity in Nigeria. A statistical model was employed to investigate the relationship between the yield of cowpea and temperature and precipitation for the period 1961 – 2006 at state levels in Nigeria. The results indicated negative and significant relationship between cowpea yield and temperature in six of the twenty states producing cowpea in the country. In addition they found that the relationship between the yield and precipitation were similar to those of temperature in the northern states, except Sokoto. In this study the authors did not specify significant level of the results.

Rowhani, Lobellb, Linderman, and Ramankutty (2011) assessed climate variability and crop production in Tanzania. The impacts of both seasonal means and variability on yields were measured at the subnational scale using various statistical methods and climate data. The results indicate that both intra and inter-seasonal changes in temperature and precipitation influence cereal yields in Tanzania. A 20% increase in intra-seasonal precipitation variability reduces agricultural yields by 4.2%, 7.2%, and 7.6% respectively for maize, sorghum, and rice. This study need to be supported by the climate records in these regions to enhance the understanding of these relationships between climate variability and crop production.

Kumar and Sharma (2013) analysed the impact of climate change on agricultural productivity. The Regression analysis was used to assess the impact of climate sensitivity on crops wise productivity of major food grain and non-food grain crops. Negative impact of climate change on food grain was shown by the finding.

Audu (2012) used descriptive analysis to determine the suitability of rainfall for agricultural policy, planning and implementation in Lokoja with a view to offering useful suggestions for proper agricultural planning in order to ensure food sufficiency. The data used was daily rainfall of 1981– 2010 (30 years). According to the results, the study area is very favourable to crop farming despite the observed frequent dry spells.

Xiao and Ximing studied climate change impact on global agricultural land availability. The study revealed that the possible gains and losses of arable land in various regions worldwide may generate tremendous impacts in the upcoming decades upon regional and global agricultural commodity production, demand and trade, as well as on the planning and development of agricultural and engineering infrastructures.

Wood, Tappan and Hadj (2004) study on understanding the drivers of agricultural land use change in south-central Senegal indicates that land devoted to agriculture, either in active cultivation or short-term fallow, is increasing. Land devoted to agriculture, either in active cultivation or in short-term fallow, is increasing, and the spatial and temporal distribution of land in agriculture implies that land is being actively moved into and out of agricultural land use. The effects of recent in forestry and tenure policy are still quite limited, but there are indications that they could offer significant potential for local control of resources and, in some cases, enable villagers to resist what had previously been uncontrollable outside influences. Successful strengthening and implementation of these policies are, therefore, vital for providing an environment in which Senegalese farmers will be able to intensify agriculture, reduce deforestation or forest degradation. Some of the impacts of climate changes noted by farmers include reduction in soil fertility. In addition to the changes observed above that directly affect agricultural production in a negative way; soil fertility seem to negatively affect crop production to a large extent. Most farmers agreed that soil fertility has been reducing over the years. This has resulted in reduced crop production especially in high attitudes areas. Examples were given by farmers that compare to the past maize harvest has drastically declined, due to reduced soil fertility; hence, if they do not use fertilizer the harvest becomes so low.

2.2.4 Farmers' perception of climate change

Ofuoku (2011) analysed the perception of climate change among rural farmers in central agricultural zone of Delta State, Nigeria. The methods used were based on descriptive statistics and linear regression model to test if education, gender, and farming experience influenced farmers' perception of climate change. It was found that farmers were aware of climate change and the identified causes of climate change were ranging from intensified agriculture, population explosion, increased use of fossil fuel. The effects of climate change on crops and livestock were also identified by the rural farmers. The adaptation used by most of the farmers to climate change were planting of trees, carrying out soil conservation practice, changing planting dates, using different crop varieties, installing fans in livestock pens, and applying irrigation. The results from linear regression analysis revealed that education, gender, and farming experience influenced farmers' perception of climate change. In conclusion, the major barriers to adaptation to climate change included lack of information, lack of money, and inadequate land.

Acquah (2011) assessed farmers' perception and adaptation to climate change to enhance policy towards tackling the challenges climate change poses to the farmers in Ghana by using logistic regression. The results showed that the majority of the farmers perceived increase in temperature and decrease in rainfall pattern. It was also showed that farmers' level of adaptation was relatively high with majority of the farmers using changing planting dates, different crop varieties and soil conservation methods as the major adaptation measures. The findings from Logistic regression estimation finds age, years of farming experience, farm land ownership, farm size and other income generating activity as significant predictors of the probability to pay for climate change policy.

Egeru (2011) examined the role of indigenous knowledge in climate change adaptation in Uganda using semi-structured questionnaires, individual interview, focused group discussion and observation of local traditional rites; reveals that farmers still observe the intensity of East-West blowing winds, colour of the clouds in the East, and plants traits for rainfall prediction and also rely to meteorological information disseminated through radio stations. The authors found that low mastery of indigenous knowledge practices by younger community members and persistently changing weather pattern have challenged community reliance on indigenous knowledge for climate change adaptation.

Oluwatusin (2014) examined the perception of and adaptation to climate change among cocoa farmers in Ondo State, Nigeria. Descriptive statistics were used to analyse the farmers' socio-economics characteristics while Heckman's two-step procedure was used to identify the determinants of respondents' perception and adaptation to climate change. His results revealed that the cocoa farmers' population was ageing and cocoa production in the study area was dominated by men. In order to adapt to climate change, 10 different types of adaptation strategies were used by 83.75% of the farmers while 16.25% did nothing. Age, education, farming experience, household size, farm size, access to extension services, and distance to farm input purchasing market significantly determined whether or not cocoa farmers perceive climate change. He recommended that credit should be made available to the farmers and an effective extension service system should be put in place.

Bello, Salau, Galadima and Ali (2013) assessed the knowledge, perception and adaptation strategies to climate change among farmers of central Nigeria. Data collection was through an interview schedule. Simple descriptive statistics such as frequency counts, percentage and mean scores were used to achieve all the objectives of the study. Most of the respondents relied on radio as their major source of information on climate change. The perceived indicators of climate change by the respondents were excessive high temperatures, low and irregular rainfall pattern as well as low crop yields. Adaptation strategies used in the area included agroforestry practices, crop diversification, early maturing and disease/drought resistant varieties. The Major constraints to adaptation by the respondents were inadequate finance, poor infrastructures, unfavourable government/trade policies and poor technology.

Smithers and Smit (2009) contend that adaptation strategies are affected by environmental perceptions and they are among key elements influencing adoption. Actions that follow perceptions of climate change are informed by different processes such as perception of risk associated with climate change, resource endowments, and cultural values, institutional and political environment and there is no guarantee that having perceptions that climate change has or is occurring would prompt effective adaptation responses.

Chifamba and Mashavira (2011) assessed the adaption and mitigation strategies in sustainable land and water management to combat the effects of climate change. Their results indicated that climate change intersects with sustainable land management efforts directly (by affecting soil function, watershed hydrology, and vegetation patterns) and indirectly (by stimulating changes in land use practices). Although people's adaptive and mitigation strategies may not succeed completely, they form the basis of solutions to natural disaster preparedness. Addressing the threat of increased soil erosion posed by climate change will require better quantification of the problem, greater attention to prioritizing which production systems are vulnerable, and a redoubling of land and water management efforts. Climate change is occurring within a background of plethora of global challenges, such as population growth, urbanization, land and water use, rural- urban migration, and biodiversity depletion. Thus, efforts to adapt to the impact of climate change should do so in a manner that is consistent with these broader development issues. Sustainable land management is crucial to minimize land degradation, rehabilitating degraded areas, and ensuring the optimal use of land resources for the benefit of the present and future generations.

Deressa, Hassan, Alemu, Yesuf, and Ringler (2008) study on farmers' perceptions of climate change in Southern Africa based on multivariate discrete model and long term temperature and precipitation used to identify the farm-level adaptation strategies indicated that farmers are aware that the region is getting warmer and drier. The finding revealed a high correspondence of resource users' perceptions of climate change.

Making the assumption that property rights might determine whether farmers adopt particular strategies, this study aims at modelling farmers' decisions to adapt to climate change by focusing on their property rights – declined as institutional arrangements on land and rights on land – as well as their socio-economic and demographic characteristics. 308 farmers producing maize and adapting to climate change were randomly sampled. The study was conducted by a survey method on respondents using structured interviews based on a questionnaire. A simultaneous modelling using a Multivariate Probit (MVP) model highlighted that socio-economic and demographic characteristics, institutional arrangements on land, and rights on land determine the farmers' decisions to adapt to climate change. The land ownership has a positive effect on the decision to adopt any adaptation strategy. Subsequently, securing farmers' property rights would help to enhance their capacity to adapt to climate change (Yegbemey, Yabi, Tovignan, Gantoli and Kokoye, 2013).

2.2.5 Adaptation to climate change

Climate change is a global challenge that has a particularly strong effect on most developing countries, where adaptive capacity is low and where agriculture, which is highly dependent on climatic factors, is the main source of income for the majority of people. Faced with the various risks of climate variability (drought, winds, crops insects and pests, etc.), farmers have developed adaptation strategies. Adaptation to climate change is one of the approaches considered likely to reduce the impacts of long-term changes in climate variables. It is a process by which strategies to moderate and cope with the consequences of climate change, including climate variability, can be enhanced, developed and implemented (Oksen, 2000). Adaptation is a decision making. Farmers continuously have to make choices about what to plant, how to plant, when to plant. Together, these decisions influence what type of farming system the farmer in question establishes. Decisions that farmers make depend on the natural, cultural and economic conditions but also the climate such as the availability of the rainfall (McCalla, 1998). In the tropics and precisely in West Africa, major agro-ecological zones are arid, semi-arid, sub-humid, and humid. There is, in general, a strong relationship between agro-climatic conditions and cropping systems. Animal grazing systems also differ between arid, semi-arid, humid areas (McCalla, 1998).

To increase the yield farmers practice mixed farming or agro-pastoralism. “Mixing farming, combining crop and livestock activities, holds considerable promise for meeting criteria of environmental sustainability and of improved productivity” (Oksen, 2000). Mixed farming has been viewed as the most promising means to increase the agriculture productivity of semi-arid West Africa (Turner, 1993 cited in Oksen, 2000) as animal would provide the traction power and the manure associated with the agriculture intensification. OECD (2009) reported that agro-pastoralism stems from a strategy adopted by farmers and shepherds to limit the risks associated with the uncertain climate. Farming helps shepherds limit the purchase of cereals during the lean period; farmers, on their part, seek to diversify their activities and capitalize on their income sources by investing in cattle.

The smallholder plantation farming system provides the farmer with a mix of food and cash crops that offer a large degree of self-sufficiency. Furthermore, the mix of trees offers almost complete protection to the soil, sustains the nutrient cycle, and eliminates the need for cultivation implicit in the production of annual food crops (Uchua, 2012). An increasing number of farmers rely on crops with shorter growing seasons and integrate indigenous trees and plants such as *Annona muricata*, *Prunus africana* and *Pygeum africana* in their food crop farms. The farmer's report that traditional technologies for conserving soil fertility, mixed cropping, and multiple cropping are aimed at buffering the farming system against climate variability and increasing farm yield and income (Molua, 2002). Ahenkan and Boon (2010) reported that Planting of economic trees and adopting sustainable farming systems had been identified as important coping strategies by a significant number of farmers in Western Ghana. Through capacity building and sensitization, most farmers have recognized the importance of planting economic trees on their farms to shade their crops.

Nyamadzawo, Wuta, Nyamangara and Gumbo (2013) stated that to reduce the vulnerability to smallholder farmers in semi - arid regions to climate change and variability, and to increase the resilience to climate change there is need to optimize in-field water harvesting techniques so as to improve crop yields. In-field water harvesting is one of the many climate change adaptation strategies that can be adopted by farmers in the semi- arid regions. It can potentially enhance soil water storage, and this will enable crops to survive during mid-season droughts. Improved water harvesting may result in improved crop yields, food security and livelihood among households. Many water conservation techniques are used in semi -arid and arid region: ‘Zai’, half moon, stone bound. In addition, the intra-seasonal rainfall variability in monsoon rainfall distribution often creates water scarcity situations at critical cropping stages. Farmers in this region have adopted a water and soil fertility management technique called “zai” (‘water pocket”). This technique is used in West Africa arid area such as Niger, Mali, and Ghana. Ngigi (2009), shown that in parts of Northern Ghana where prolonged drought has deteriorated the soil, the use of moisture improvement techniques such as ‘zai’ planting methods are common. This technique consists of farmers digging pits in formerly barren land, into which water otherwise could not penetrate, and filling the holes with compost in the dry season. During rainfall, runoff water seeps into the holes and is soaked up by the compost, storing moisture and creating a beneficial environment for plant growth. The compost also attracts termites that dig galleries at the bottom of the holes, allowing further runoff water infiltration and creating deep moisture pockets favorable for plant growth. Farmers use stone contour bunds to reduce the speed of runoff increasing infiltration into the *zai*. Seedlings produced from dry seedbeds are known to have greater resistance to drought.

CHAPTER THREE

3.0 MATERIALS AND METHODS

This, chapter was focused on the methods and analytical techniques used to achieve the three objectives of the study aimed at examining the Impact of Climate Change on Agricultural Land Use in Kogi State, Nigeria.

3.1 Data collection

Primary and secondary data have been used to assess the impact of climate change on agriculture sector. Primary data collected include information on trends in crop production, changes of types of crops for the past ten years, information on livestock keeping, impact of changes in rainfall, temperature and extreme events such as floods and droughts, socio economic data such as income generating activities, employment and information on adaptation strategies farmers are using to cope with climatic changes. Secondary data has also been collected to complement the fresh information collected from the field. The secondary data collected include reviewing of the existing literature to supplement field work, climate data (rainfall and temperature) and land use data from Landsat images.

3.1.1 Climate Data

The main climate data comprised daily rainfall and temperature of a period of forty years (1975-2014) recorded in Lokoja station to attain the first objective of the study. Lokoja meteorological station is the main station in Kogi State that was the reason behind using the station. The lack of data from the three local government areas (Adavi, Ajaokuta and Okehi) was also a reason for not collecting climate data of each local government for more spatial comparative analysis of rainfall and temperature within the study area. The reason for taking only rainfall and temperature of this study area was because they are considered as the most important climatic factors. Rainfall, among other factors, has always dictated how land is used in one way the other. This is especially true for semi-arid areas which rely on natural rainfall for agricultural production (Kori, Gondo and Madilonga, 2012).

3.1.2 Agriculture land use data

Three images from Landsat (1987, 2001 and 2014) with low resolution 30m x 30m were downloaded from Global Land cover Facility (GLCF) web sites for land use/cover change. The images of 1987 and 2001 were Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) with seven bands, while the one of 2014 was Landsat Operational Land with eleven bands (see Table 3.1). Hand held Geographic Positional System (GPS) and topographic maps of 1:50,000 as base map to register the data sets were used to collect ground control points for image classification and accuracy assessment. Three land use/land cover maps were produced corresponding to the three reference years (1987, 2001, and 2014) and the change in land use was computed and plotted using excel.

Table 3. 1 Characteristic of the Landsat images

Satellites Images	Sensor	Path/Row of image	Number of bands	Resolution	acquisition date	Source
Landsat 5	TM	189/55	7	30m	21/12/1987	GLCF
Landsat 7	ETM+	189/55	7	30m	9/01/2001	GLCF
Landsat 8	OLI	189/55	11	30m	23/12/2014	GLCF

Source: GLCF, 2014

3.1.3 The questionnaire and survey

In other to acquired farmers' perception on climate change and agricultural land use, questionnaire and survey were conducted during the field work from April to May 2015.

3.1.3.1 Study population, sampling frame and sample size

The target people for this study were crop farmers. Multi-stage random sampling was used. From the study area, three local government areas were randomly selected. In each local government area, two villages were selected each making a total of six villages. The villages were Osaka and Aku in Adavi local government area; Adu and Ebiya in Ajaokuta local government area; Ihima and Ohoupe in Okehi local government area. Samples of forty farmers from each of the six villages were selected giving a total sample of 240 farmers in all. Structured interview was conducted on these respondents for data collection.

3.1.3.2 Questionnaire administration

A structured questionnaire comprising both open and close ended questions was written in English which was interpreted by resource persons from ADP into local dialect in order to acquire accurate information (Plate I). The questionnaire contained in four (4) sections; Section A was on the demographic and socio-economic details, section B on agriculture land use, C on climate change and finally, D on strategies adopted to deal with climate change (see Appendix A).

Plate I Survey questionnaire administration

Source: Author’s data collection

3.3 Data Analysis

Data analysed were climate data (forty years rainfall and temperature) for objective1, three Landsat image data for assessing land use change (objective2) and questionnaire for the last objective on farmers’ perception.

3.3.1 Climate Data

The daily rainfall and daily minimum and maximum temperature for forty years (1975-2014) were collected from Nigeria Meteorological Agency (NIMET) and computed using

Excel software. Descriptive statistic (mean, standard deviation, coefficient of variation and standardized index) were employed. This was considered to be appropriate approach as many previous studies (Adu, 2012, Kori *et al.*, 2010) seeking at understand temporal variation of climate parameters (rainfall and temperature). The following formula was used to calculate the standardized anomaly index:

$$SAI = (P_t - P_m)/\sigma \qquad 3.1$$

Where SAI is standardized rainfall/temperature anomaly index, P_t is the annual rainfall/temperature in year t, P_m is long-term mean annual rainfall/temperature over a period of observation and σ is the standard deviation of annual rainfall/temperature over the period of observation.

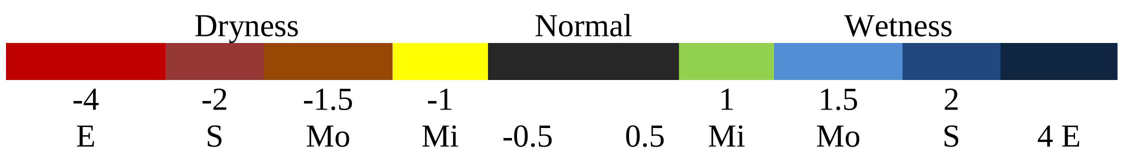


Figure 3. 1 Description of standardized precipitation index
NB: E=Extreme, S= Severe, Mo=Moderate, Mi=Mild

Source: NIMET, 2013

The SAI value provides an average index of relative rainfall based on the standardization of rainfall totals (Abaje, *et al.*, 2010). Figure 3.1 showed the various values of SAI and their indications according to Nigerian Meteorological Agency (NIMET, 2013). The graph of each parameter (rainfall, Maximum and minimum temperature) was plotted in order to examine the nature of the trend. Linear trend lines were plotted using Microsoft Excel 2013.

3.2.2 Agricultural land use change detection

The three images (1987, 2001 and 2014) from Landsat downloaded from GLCF were enhanced and processed using the software Envi classic. Three bands were combined for colour composite; Band 2, 3, 4 for TM (1987) and ETM (2001) while 3, 4, 5 were used for OLI Landsat images (2014). Then Maximum likelihood supervisor was choose for image classification. For the classification accuracy assessment, a sample of fifty (50) ground truth of each land used/cover type were selected using the handheld geographic positional system (GPS) and the topographic sheets of the study area. Each of the classified image (1987, 2001 and 2014) was exported to ArcGis.10 to create a map. The changes occurred in the six land used/cover types from the interval of three years (975-2001-2014) were computed and the graph was plotted to show the trends used excel.13. Six classes were defined land used/cover type as followed: natural vegetation plantation, farmland, exposed surface and water body (Appendix B). Each the land classes were determine using Govendor land use conventional colour (see Table 3. 2)

Table 3. 2 Correspondent colour of land types

Classes	Correspondent colour
Natural vegetation	Dark green
Plantation	Light green
Farmland	Yellow
Exposed surface	Dark brown

Water body	Dark blue

Source: Govender, 2012

For the change analysis change, the following procedure was employed using Excel. 2013:

Overall change = (Final area – Initial Area)

Change rate = (Final area – Initial Area)/Total of Initial Area] * 100 (Adeoye, 2012).

3.2.3 Household questionnaire

Data collected from the survey were edited, coded Excel.13 and the Statistical Package for Social Science (SPSS) software version 20. Excel was used to analyse socio-demographic characteristic of the respondents, spatial variation in agricultural land use within the study area and various adaptation strategies adopted were presented through table and graph.

The logit regression analysis was to evaluate the perception of respondents to change in agricultural land size use under climate change as an adaptation strategies. This model is more interpretable to assess farmers' perception to climate change (Fosu-Mensah, *et. al* 2010); Onubuogu, and Esiobu, 2014). The model is the most appropriate for such study (Long, 1997; Hurlin, 2003).

$$C_i = \frac{P_i}{1-P_i} = e^{Xi\beta} or \ \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{j=1}^{k} \binom{k}{j} \beta_j X_{ij} \qquad 3.2$$

Where;

β_0 is the constant,

β_1, β_2,........... β_k are the coefficients of independent variables X_{1i}, X_{2i},.......X_{ki},

P_i is the probability of event realisation

$1 - P_i$is the probability of event non realization.

For the model implementation, the dependent variable was changing size of land under cultivation while the independent variables were respondent age, sex, village, level of education, family members, family member schooling, family involved in farming activity, experience of the area, member of social group, farming experience, change in rainfall, presence of extension service, access to credit, access to market, soil fertility.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This chapter portrays the findings of study and discussion based on analysis of the data collected on climatic parameters (rainfall and temperature) for a period of forty years (1975-2014). Land use and the questionnaire administrated to the farmers on their perception to climate change its impact on agricultural land use in order to assess the impact of climate change on agricultural land use in Kogi state were presented in this chapter.

4.1 Climate data

Forty years (1978)-2014) climate data (minimum, maximum and mean annual temperature; monthly and annual rainfall) were analysed.

4.1.1 Temperature

Trend and anomaly of minimum, maximum and mean temperatures were plotted, analysed and interpreted.

4.1.1.1 Minimum temperature

Figure 4.1 shows the trend of the mean minimum temperature between 1975 and 2014. The mean annual minimum temperature is 22.9^{o}c with 0.58 standard deviation. The trend line indicates that the minimum temperature was increasing over the study period; the minimum temperature of 22.1^{o}c in 1975 and increased to 22.7^{o}c in 2014. The lowest temperature of 21.4^{o}c was recorded in 1989 while the highest of 24.2^{o}c was recorded in 2010.

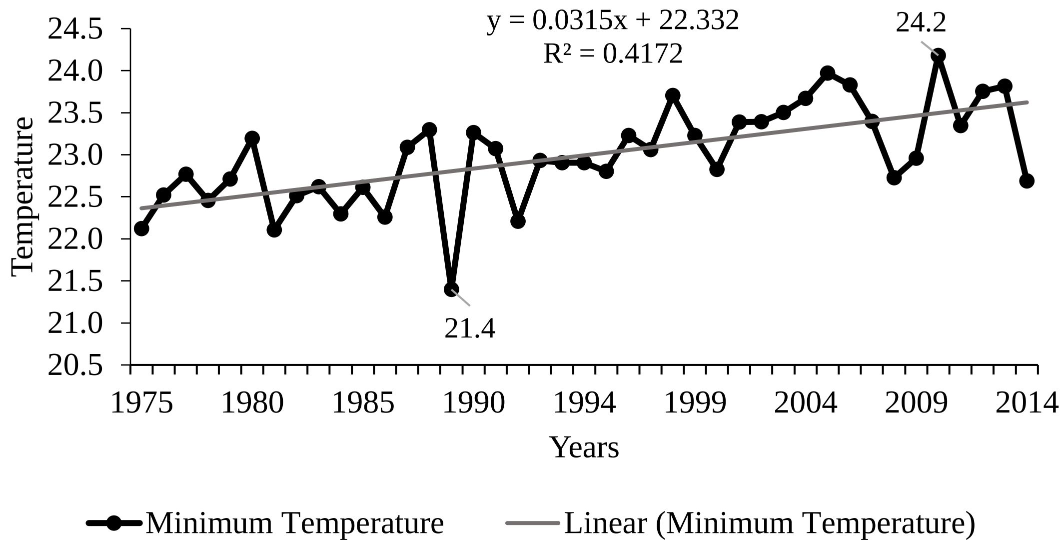


Figure 4. 1 Annual minimum temperature trend

The anomaly value reveals that between 1975 and 1995 the temperature was below the normal expect in the year 19980, 1987, 1988, 1990 and 1991. While from 1996 to 2013 the values are above the normal apart year the 2000, 2008 and 2009. In addition, the cool years occurred in the early two decades (1975-1994) and the warm year occurred in the last two decades (1995-2014) figure 4.2. The warmest year (1989) has a negative value of 2.7 while the coolness year has positive value of 2.0 in the year 2010.

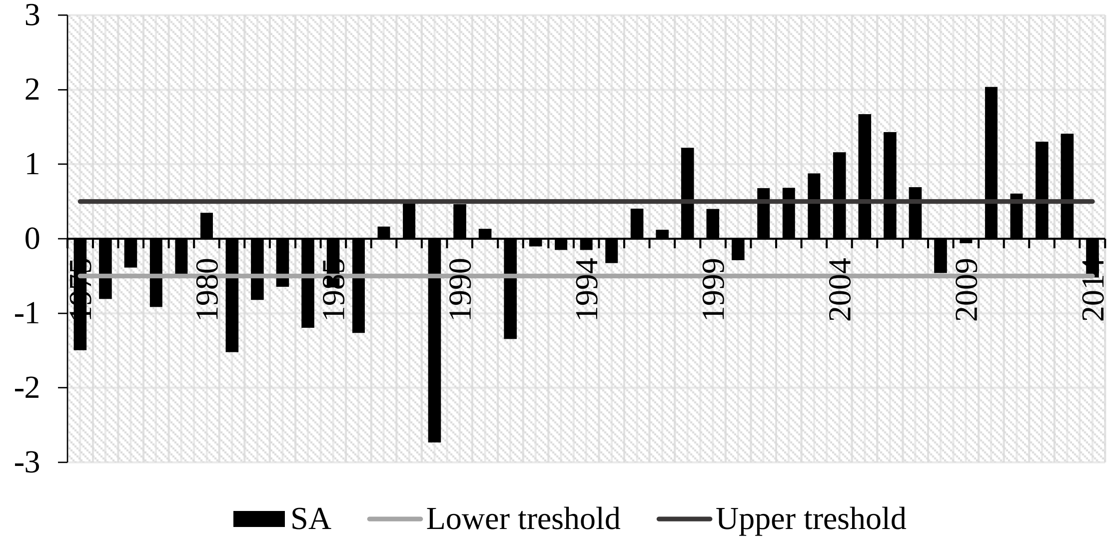


Figure 4. 2 Annual minimum temperature anomaly

4.1.1.2 Maximum temperature

The maximum temperature is between 32.7^{o}c and 34.6^{o}c from 1975 to 2014 were the years 1975 and 1978 have the lowest temperature. The highest temperature was observed in 1987. The mean is 33.5^{o}c with 0.43 of standard deviation and 1.3% of coefficient of variation. This study indicates that though the temperature is fluctuating.

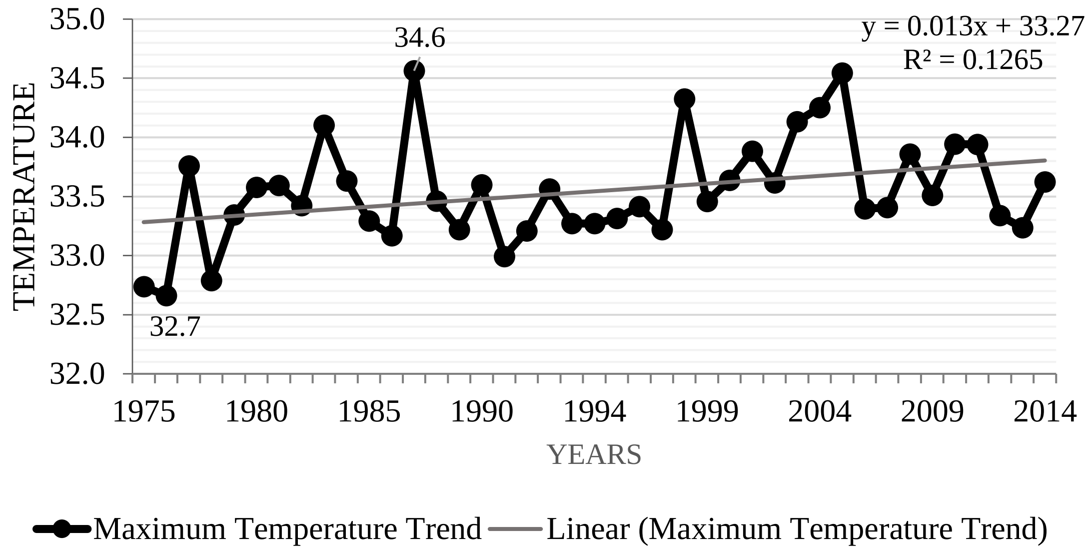


Figure 4. 3 Annual maximum temperature trend

Figure 4.4 shows the anomaly of forty years (1975-2014) maximum temperature. Maximum temperature anomaly line shows that the decrease in temperature from years 1975 to 1993, this period is characterized by more cool years while the period 1994 to 2014 is characterized by more war years. The coolness and warmest year was observed in the two decades within the study period 1976 and 1987 with negative standardized value of 2 and positive standardized value of 2.33 respective.

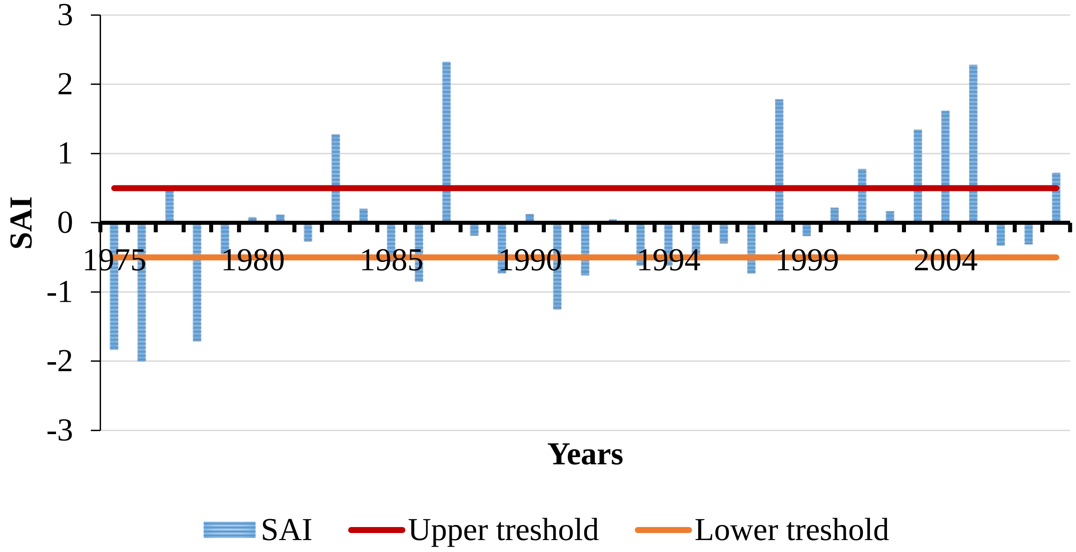


Figure 4. 4 Annual maximum temperature anomaly

4.1.1.3 Annual mean temperature

Figure 4.5 presents the trend of annual mean temperature in the study area over the period of forty years (1975-2014) with fluctuation in the mean from year to year. The mean annual temperature was 27.43^{o}c in 1975 which increased to 28.53^{o}c in 2014. The lowest and highest annual temperature is 27.3^{o}c and 29.2^{o}c respectively in 1989 and 2005. The annual mean is 28.2^{o}c with 0.44^{o}c of standard deviation and 1.5% of coefficient of variation. This mean was similar with the mean by Audu (2012). The $R^{2\ =}$ 0.4 reveals that the increase is not significant. This less than the global mean temperature with an increase of 0.74℃ since recordings commenced in 1860 (IPCC, 2007; Spore, 2008). Hence, it is certain that the earth's temperature is rising. The steady rise in temperature across Nigeria is the cause of global warming. As confirmed by (Audu, 2012) that Global warming is the gradual, but continuous increase in temperature of an area over time. It is caused by both natural and man – made factors. Although, the current trend of global warming has indicated that man – made factors are the most critical factors which result from various activities aimed at making life more comfortable such as industrialization, intensive and extensive farming, use of generating sets and urbanization among others.

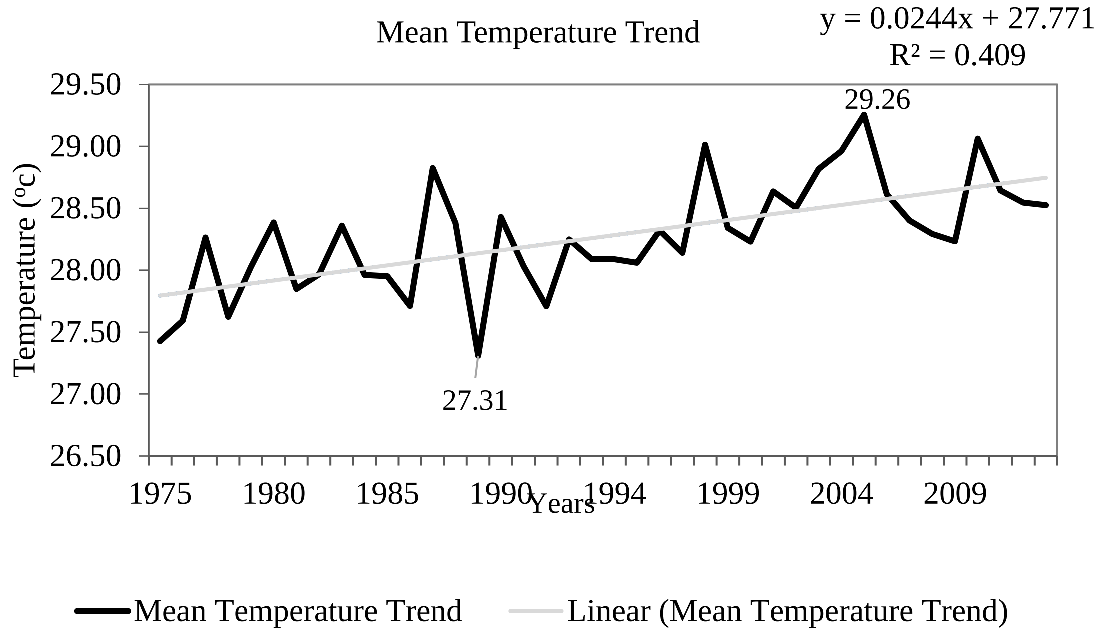


Figure 4. 5 Annual mean temperature trend

The analysis of figure 4.6 further showed the characteristics of mean annual temperature over the study period (1975-2014). The period of 1975 to 1997 is characterized to be the cool years with a standardized values below the normal (zero) except years 1980, 1983, 1987, 1990 and 1996. While from 1998 to 2013 mean annual temperature was above the normal. The highest negative standardized value (-2.1) was observed in 1989 while the highest positive standardized value (2.2) was in 2005. The evidence of sudden increase in air temperature in Nigeria was observed as from the early 1970s until 2005 by Bello, Ganiyu, Wahab, Afolabi, Oluleye, Ig, Mahmud, Azeez and Abdulmaliq (2012). This abrupt increase could be linked to the effect of climate change and its associated global warming previously reported in Nigeria by Ikhile, (2007) and supported by the global trend (IPCC,2007).

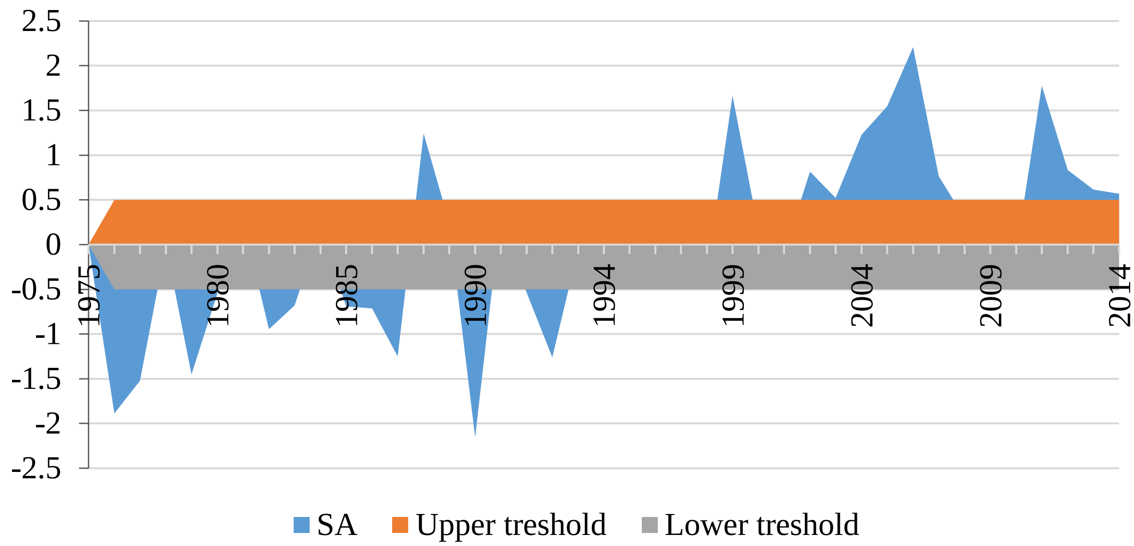


Figure 4. 6 Annual mean temperature anomaly

4.1.2 Rainfall

Forty years monthly and annual rain were analysed and interpreted.

4.1.2.1 Monthly rainfall

Figure 4.7 shows monthly rainfall trend and indicates that the rain season of the study area is from April to October as high amount of rainfall are concentrated within this eight (8) months of the years. The rain normally starts in April (onset) and ending in October (cessation). The onset of rain is the month in which accumulated total rainfall is in excess of 51mm, while the cessation is the date after which no more than 51mm of the rain is expected. Based on this, month with a long – term mean rainfall totalling 102mm and above marks the onset and cessation of rains respectively (Adakayi, 2009).

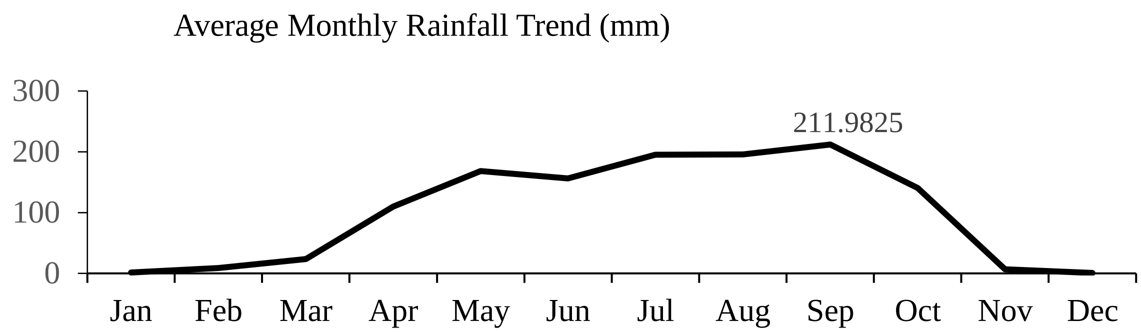


Figure 4. 7 Average monthly rainfall trend

Figure 4.8 illustrates the average decades of rainfall pattern which showed that in the months of April and October cannot be predictable, that is from 1975 to 2014 and there has been change in term of total rainfall distribution. The Figure 4.8 also reveals that the study area experienced high amount of rain at begins and end of rain season in the last two decades (1995-2014) compare to the first decade (1975-1994). The peak of rain was shifted from August to September for the middle two decade (1985-2004) and has returned to August in last decade (2005-2014). This confirmed Bello *et al.* (2012) in their studies stating that rainfall was unpredictability and decreasing, which also differ significantly from 1971-2005. Coastal region experiencing slightly increasing rainfall since the early 1970s and August break (short-dry-season) is currently being experienced more in July as against August in the Savannah ecology. These evidences show that Nigeria, like most parts of the world, is experiencing the basic features of climate change. However, there is continuous rise in agricultural output from 1987 to 2000 before it dropped in 2001.

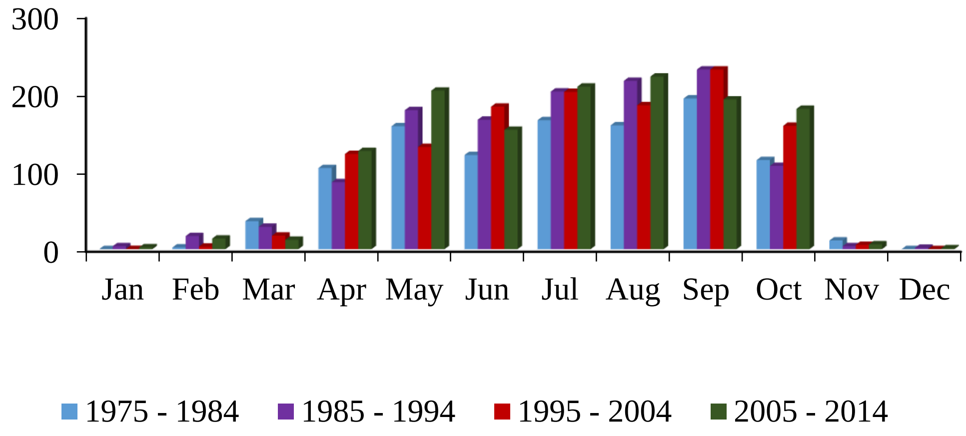


Figure 4. 8 Average decade monthly rainfall trend

4.2.2.2 Annual rainfall

The result presented in Figure 4.9 indicates that there is much variation of rainfall amount from 1975 to 2014. 1977 is the year of the lowest amount of rainfall (771.7mm) and the starting year of rainfall declined in within the period of the study (1975-2014) though the year 1978 were above the mean. Rain increased between 1986 and 1991 and decreased again between 1992 and 2005 while the highest amount of rainfall was occurred in 1999 (1770.4mm). The average rainfall is 1218.5mm with 243.34 and 0.19 of standard deviation and coefficient of variation respectively. This is in concordance with average rainfall (1216.86mm) found by Adu (2012) working with thirty (1981-2010) years climatic data of Kogi State. The trend line indicates that the annual rain has increased over the study period and R^2 value equal to 0.10 indicates that there is no significant increase in rainfall amount from 1975 to 2014.

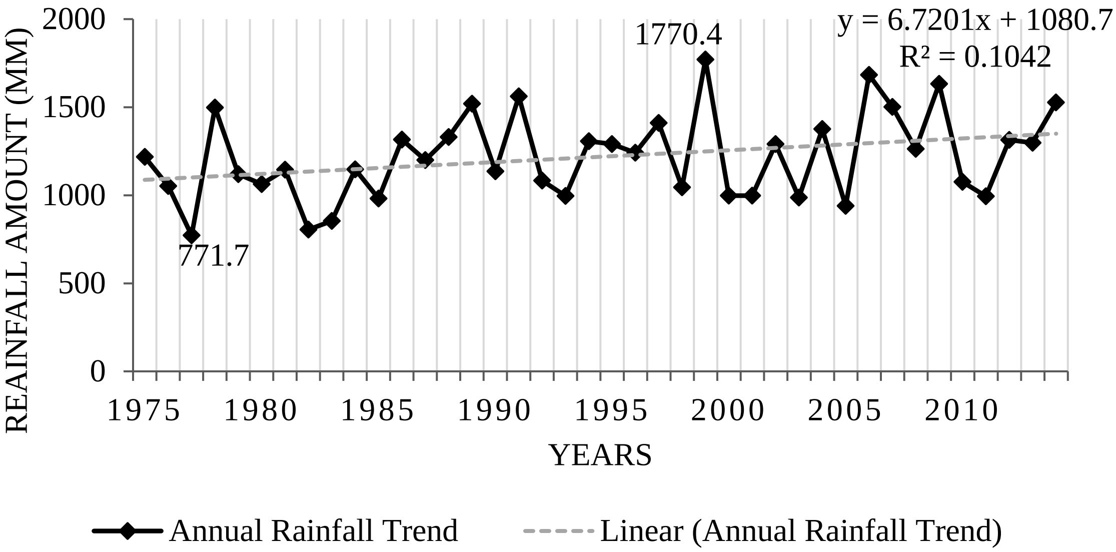


Figure 4. 9 Annual rainfall trend (1975-2014)

Figure 4.10 presents the annual rainfall anomaly which shows that the study area experienced a successive dryness years from 1975 to 1985 with a wet year occurred in 1978. The period of 1994 to 1997, 2006 to 2009 and 2011 to 2014 were mild and moderate years. Based on the criteria of NIMET standardized precipitation index interpretation, the dryness year was 1977 while the wetness was 1999 with respective standardized value of -1.82 (moderate dryness) and +2.23 (extreme dryness).

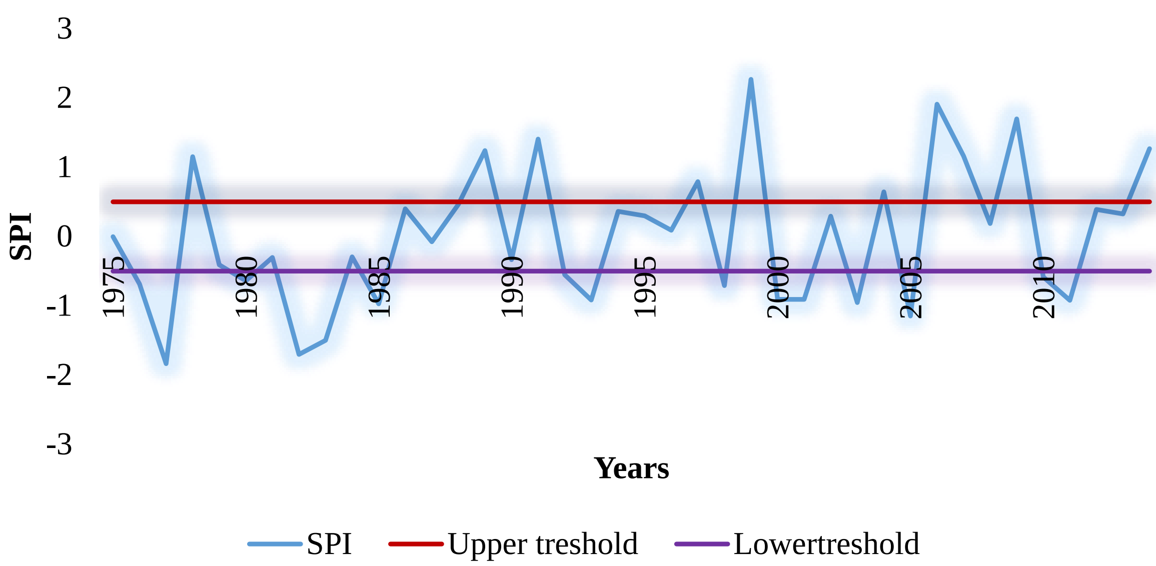


Figure 4. 10 Annual rainfall anomaly

4.2 Agricultural land use

Land use change were analysed and deduced for the second objective.

4.2.1 Land use and land cover in 1987

Table 4.1 and Figure 4.11 describe the statistic drew from land use and cover (LULC) map of 1987 and reveal that more spaces were occupied by exposed surface (58.81%) and farmland (34.33%) represent in dark brown and yellow colour respectively; where the mass land was 3,32753 hectare (ha). Natural vegetation in dark green occupied only 5.22%; water body in dark blue occupied 1.5% while 0.05% occupied by plantation in light green. This indicates that before there were more human activities in the study area before it becomes a state. The high value of exposed surface can be explain by the fact, it includes building up areas, bare soils and rock as it was difficult to differentiate them in the area; because most of the buildings are constructed in top the rock .

Table 4. 1 Surface area of land use/cover type in 1987

Land cover type	Surface area in 1987 (ha)	Proportion (%)
Natural vegetation	17413	5.233
Plantations	180	0.054
Farmland	114242	34.332
Exposed surface	195717	58.818
Water body	5201	1.563
Total	332753	100

Source: Author's data analysis

Figure 4.11 enfaces that settlement and farmlands dominated and scattered in many parts in 1987. Few vegetation were concentrated in the southern part while water body at the edge east.

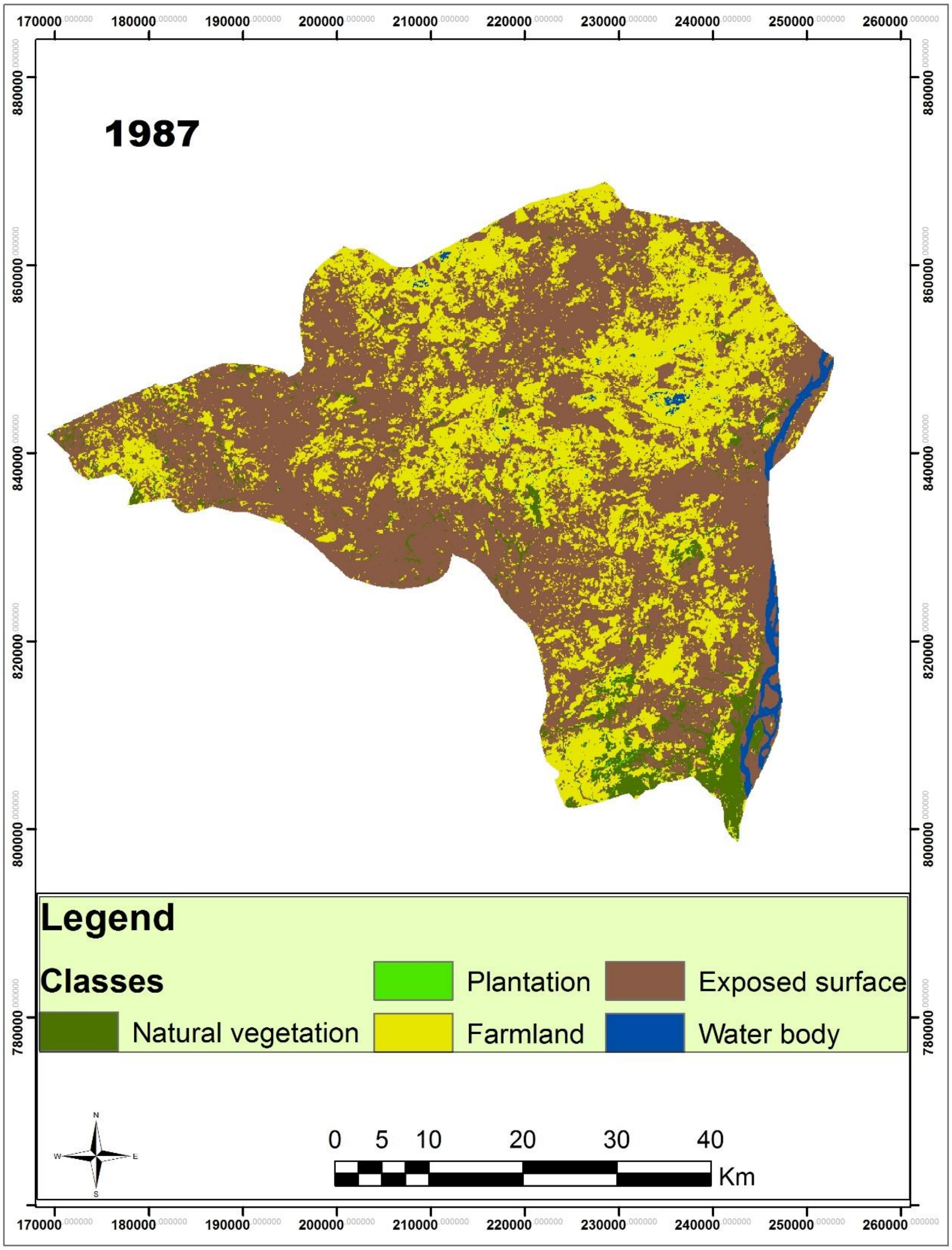


Figure 4. 11 Land use and land cover map of the study area in 1987

4.2.2 Land use and land cover in 2001

Table 4.2 and Figure 4.12 present LULC map of 2001 and indicate that 87.81% was exposed surface. 7.93% farmlands, 2.89% natural vegetation, 1.73 water body and 0.40 plantation.

Table 4. 2 Surface area of land use/cover type in 2001

Land use categories	Surface area in 2001 (ha)	Proportion (%)
Natural vegetation	9638	2.896
Plantations	1331	0.400
Farmland	26399	7.934
Exposed surface	289605	87.033
Water body	5780	1.737
Total	332753	100

Source: Author's data analysis

Figure 4.12 shows that exposed surface in dark brown overtook from the total land cover in 2001 while few farmlands were scattered in some part. It can that the South-east were occupied by farm land and scatter plantations.

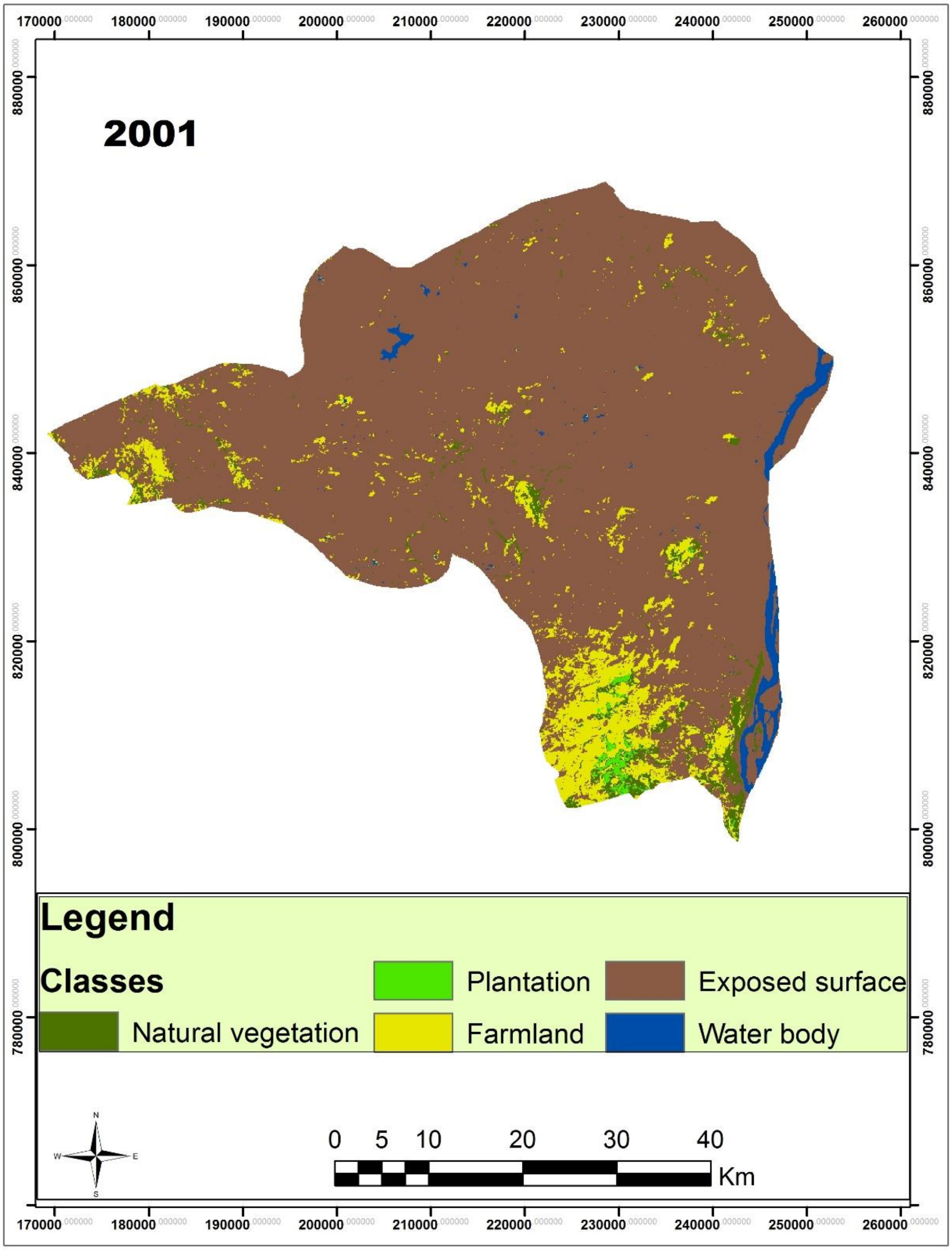


Figure 4.12 Land use and land cover map of the study area in 2001
Source: Author’s data analysis, 2015

4.2.3 Land use and land cover in 2014

The classified image of LULC 2014 illustrations that exposed surface filed 75.94% of the area. 18.92% occupied by farmland, 2.39% were natural vegetation, 1.72% water body while only 1.00% represented plantations (see Table 4.3 and Figure 4.13).

Table 4. 3 Surface area of land use/cover type in 2014

Land use categories	Surface area in 2014 (ha)	Proportion (%)
Natural vegetation	7981	2.398
Plantations	3350	1.007
Farmland	62950	18.920
Exposed surface	252721	75.949
Water body	5745	1.727
Total	332753	100

Source: Author's data analysis

Figure 4.13 demonstrates a concentration of more farmland in yellow colour from the south with the presence of plantation to north-east though the dark brown represented exposed surface tremendously occupied more space. A river at the top north-west.

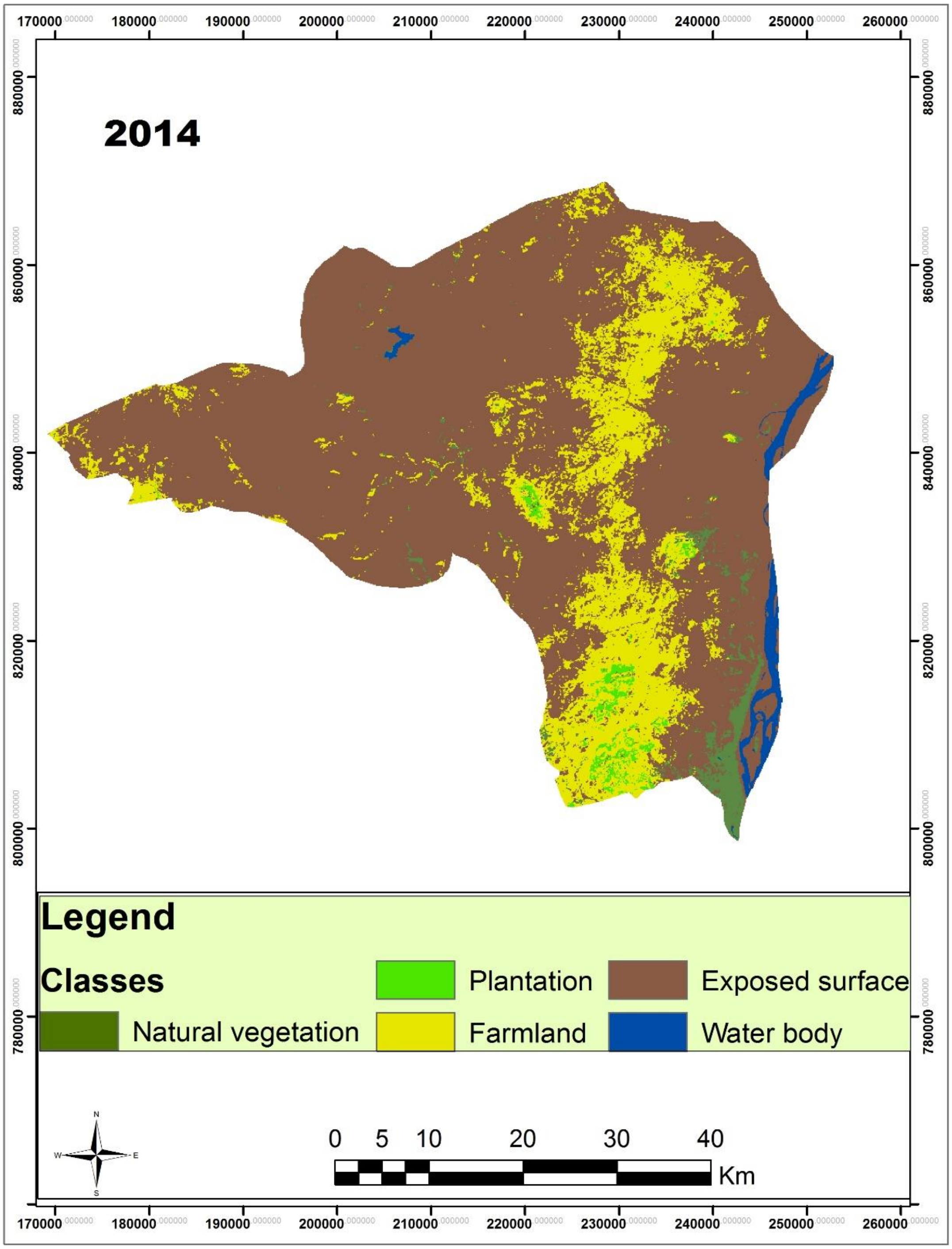


Figure 4. 13 Land use and land cover map of the study area in 2014

4.2.3 Accuracy of the classify images

In order to determine the level of accuracy of the image data, a confusion matrix operation was performed and generated. The accuracy assessment of four temporal data shows that most of the land use types were classified with acceptable level of accuracies and the overall accuracy of the land uses makes the study reliable for planning. The summary of the accuracy assessment of the classified satellite imageries are depicted in Table 4.4. The overall accuracy of Landsat TM of 1987 was 98.13% with kappa of 0.97%. Landsat ETM+ 2001 overall accuracy was 99.50% and kappa of 0.99%. The overall accuracy of Landsat OLI data of 2014 showed 99.51% while the kappa was 0.99%.

Table 4. 4 Accuracy assessment

Satellites Images	Sensor	Number of bands	Resolution	acquisition date	Overall accuracy	Kappa value
Landsat 5	TM	7	30m	21/12/1987	98.13%	0.97
Landsat 7	ETM+	7	30m	9/01/2001	99.50%	0.99%
Landsat 8	OLI	11	30m	23/12/2014	99.51%	0.99%

Source: Author's data analysis

4.2.4 Change analysis

Table 4.5 gives the result of LULC computed. It can see that, from 1987 to 2001 (15 years interval) that 2.34 natural vegetation, 26.40% farmland were lost while a gain in areas occupied by exposed surface (28.22%); 0.35% and 0.17% increase in areas of plantation and water body respectively. It is instructive to note that Landsat has a low resolution of 30m and does not allow to differentiate clearly ground features, also 2001 Landsat image was obtained in January, and the peak of dry season in the study area when vegetation had dried up, and every land cover is opened up. The exposed surface gained more land areas with time. In 1987, 195717 hectares occupied by exposed surface which represent 58.81% constituted of the entire land use area. In 2001, the area exposed surface increased to 26399 hectares and occupied 87.03% of the entire area. This shows that between 1987 and 2001 within these period more bulging were constructed, as it part of exposed surface. An increased of 93888 hectares at rate of 1.8 while farmland has decreased by -87843 hectares between 1987 and 2001 at a rate of -1.760.

Table 4. 5 Change occurred between 1987 and 2001

Land use categories	1987		2001		2001-1987		Rate of change
	ha	%	ha	%	Ha	%	
NV	17413	5.233	9638	2.896	-7775	-2.34	-0.156
Plantations	180	0.054	1331	4.00	1151	0.35	0.023
Farmland	114242	34.332	26399	7.934	-87843	-26.40	-1.760
Exp. S	195717	58.818	289605	87.033	93888	28.22	1.881
Water body	5201	1.563	5780	1.737	579	0.17	0.012
Total	332753	100	332753	100			

NB: NV= Natural Vegetation, Exp. S= Exposed surface

Source: Author’s data analysis

Close examination of Table 4.6 showing the statistic of LULC between 2001 and 2014 (14 years interval) an increase of 10.98% (36557ha) in farmland and 0.60% (2019ha) in plantation areas. Exposed surface which occupied 289605ha in 2001 lost a total -35544ha representing up to 11% of the total area. This, indicates an important gain in farmland within a period of fourteen years.

Table 4. 6 Change occurred between 2001 and 2014

Land use categories	2001		2014		2014-2001		Rate of change
	ha	%	ha	%	ha	%	
NV	9638	2.896	7981	2.398	-1657	-0.498	-0.036
Plantation	1331	0.400	3350	1.007	2019	0.607	0.043
Farmland	26399	7.934	62956	18.920	36557	10.986	-0.785
Exp. S	289605	87.033	239054	75.949	35544	-11.084	-0.792
Water body	5780	1.737	5745	1.727	-35	-0.011	-0.001
Total	332753	100	332753	100			

NB: NV= Natural Vegetation, Exp. S= Exposed Surface
Source: Author's data analysis

Figure 44.14 further exposes the magnitude of the change rate between 1987 and 2001, 2001 and from 2987 to 2014. It obvious that only water body did not experience a blamed change.

It can noticed an important decrease in farmland and natural vegetation within the period of 1987-2001 (15) and from 1987 to 2014 (29). This indicate the practice of deforestation in the study area for residential purpose. Plantation areas are increasing with the time which inform the cultivation of perennial crops (palm tree, plant in, coconut) for commercial purpose as confirm by some respondents during the field survey.

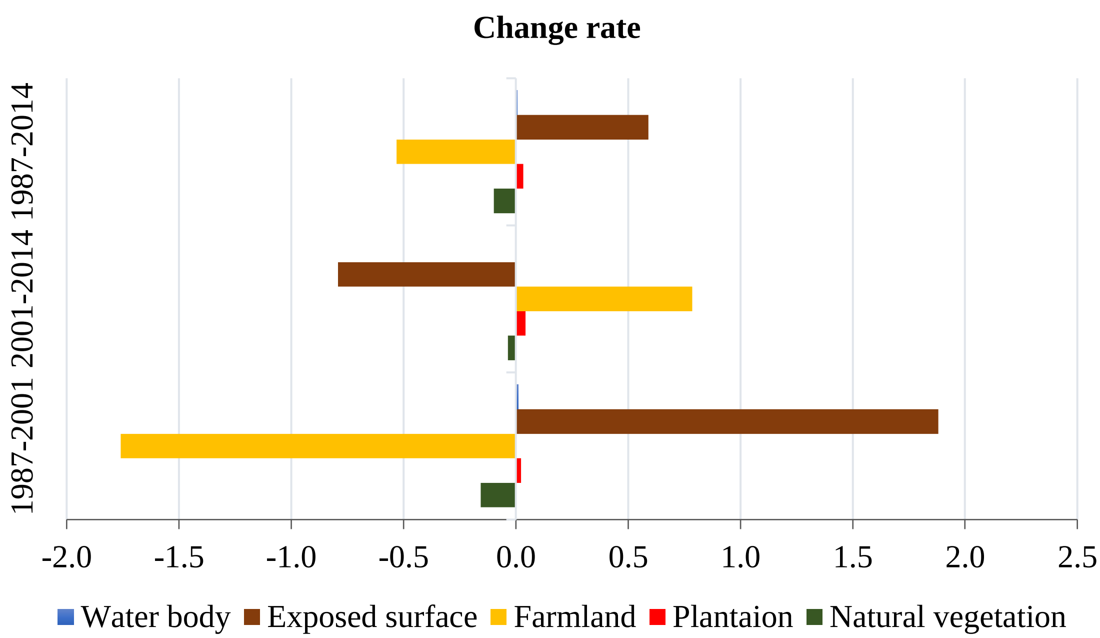


Figure 4. 14 Change rate between 1986 and 2014

4.3 Farmers' perception of agricultural land use under climate change

4.3.1 Socio-demographic characteristic of respondents

Table 4.7 shows the socio-demographic characteristic of the respondent. Among the 240 respondents, 84% were male while 17% were female. 30% of the respondents was between fifty or above age old, 40% between thirty and thirty nine and 40% with forty to forty nine age old. 94% of the respondents were married. 40% were none educated while 1% attained adult school. The average family member were between five to nine, 72% of the respondents family member was schooling while the family involving in the farm activities were between 2 and 4 representing 63%. 63% of the respondent were native and 31% were migrated with twenty to forty years' experience in the study area while 5% represented the migrant with ten to nineteen.

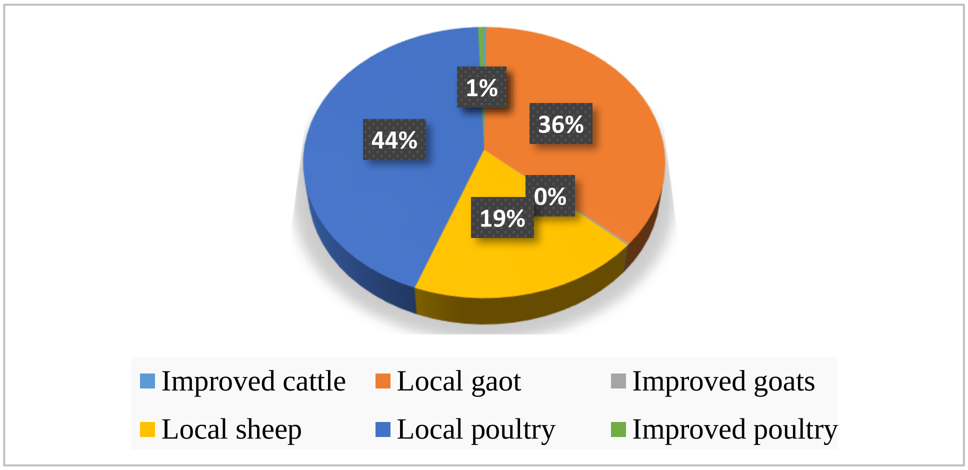
Table 4. 7 Socio-demographic characteristic of respondents

Variable	Criteria	Total (number)	Percentage (%)
Sex	Male	197	82.08
	Female	43	17.92
Age	>=50	72	30.00
	40-49	100	41.67
	30-39	68	28.33
Marital status	Single	3	1.25
	Married	226	94.17
	Divorced	11	4.58
Level of education	Illiterate	97	40.42
	Primary school	77	32.08
	Secondary school	62	25.83
	Adult education	4	1.67
Family members	16-20	6	2.50
	15-16	93	38.75
	9-5	120	50.00
	1-4	21	8.75
Family members schooling	5-10	63	26.25
	1-4	174	72.50
	0	3	1.25
Family member involved in farm activity	5-10	89	37.08
	2-4	148	61.67
	1	3	1.25
Experience of the area	native	152	63.33
	20-40	75	31.25
	10-19	13	5.42
Member of social group	Member	119	49.58
	Not member	121	50.42

Source: Author's data analysis

Besides crop farming, livestock is practicing as second source of income whereby 44% had local poultry, 36% local goats, and 19% had local sheep. The adoption of improved poultry and goats remain very few in the study as shown in figure 4.15.a, among the total the respondents only 1%. Figure 4.15.b shows that among the three local government areas, the respondents from Adavi local government area had the high value to adopt livestock.

a) Percentage of respondent adopting livestock



b) Percentage of livestock per local government areas

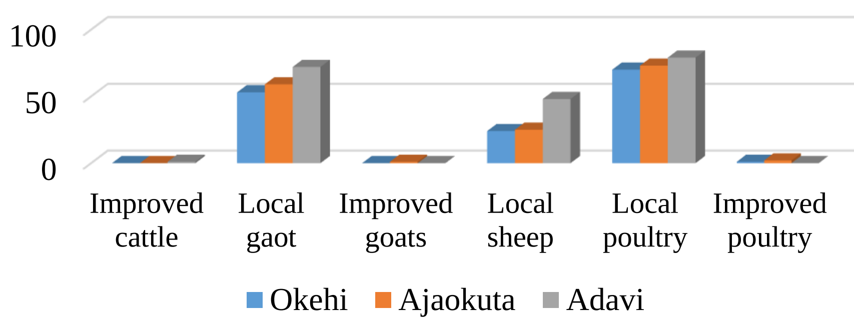


Figure 4. 15 Adoption of livestock

Table 4.8 Presents variation of the household assets in the three local government areas. Among the various household asset 23% of the respondent has radio and 12% has TV. The table show that in Okehi local government area high percentage of the respondent has radio (32%) and TV (23%) compared to Adavi and Ajaokuta.

Table 4. 8 Household assets

Family Asset	Okehi LGA		Ajaokuta LGA		Adavi LGA		Overall total	
	Total	%	Total	%	Total	%	Total	%
Motor vehicle	15	8.88	2	0.87	20	6.35	37	5.17
Motor bike	44	26.04	25	10.82	55	17.46	124	17.34
bicycle	-	-	43	18.61	8	2.54	51	7.13
TV	39	23.08	4	1.73	45	14.29	88	12.31
Radio	55	32.54	43	18.61	69	21.90	167	23.36
Wheelbarrow	10	5.92	8	3.46	59	18.73	77	10.77
Water tank	3	1.78	1	0.43	8	2.54	12	1.68
Water pump	1	0.59	1	0.43	2	0.63	4	0.56
Charcoal stove	2	1.18	68	29.44	46	14.60	116	16.22
Pressure lamp	-	-	36	15.58	3	0.95	39	5.45
Cart	-	-	2	0.87	-	-	2	0.28

Source: Author's data analysis

4.3.2 Agricultural land use change

4.3.2.1 Land tenure system

In the three local government areas land tenure system is based on four land tenure system as stated by the farmers namely inherited land 52.8%, rented land 20.4% and communal 27.08%. Most of the farmers claimed that due to the urbanization and land scarcity land is now rented which were not adopted in the past. Land is general rented to the emigrants of the area by the native or chief of the village. Mostly those land rented are new land and after 3-5 years cultivation the land owner reclaim his land. This is the major constraint of renting land which is one of the factors that undermine agricultural development in the study area; as stated by Mabogunje (2007) that land tenure is vital to adaptation as landowners tend to adopt new technologies quickly than tenants. Land ownership whether of a leasehold or freehold type is crucial for promoting the capabilities of rural producers, enhancing their access to credit, enabling them to invest in farm infrastructure and improved input, and generally improved their productivity. Furthermore, this remind Nweke and Enete (1999) stated that land tenure and fragmentation systems could also limit the capacity of farmers to adapt to climate change. Among most African peoples, farmland is not owned but held in trust by the present generation on behalf of their future descendants. It could be held by individual families, extended families or entire village communities and then fragmented to individual farmers, who only enjoy user rights. This limits the level of individual farmer's investment in the development of a farmland, since the user right could be withdrawn anytime. In addition, the fragmented nature of farmland could hamper the farmers' capacity to adopt innovative farming practices that may be necessary for climate change adaptation. Confirm by IFAD (2010) who reported that about 90% of Nigeria's food is produced by smallholder farmers who cultivate small plots of land, usually less than 1 hectare of land per household.

4.3.2.2 Land management

Cropping system is based on traditional agricultural practices, technique that has been developed over time in a community mainly through accumulation of experiences and intimate understanding of the environment in a given culture.in the study area (Kogi state). From feedback of the respondents, we can understand that 48.33% of land management decision came from the head household while 29.16% came from the clan. Only 12.5% of the respondents mentioned that the entire family to make land management decision. Land management decision is based on the land tenure, access to the fertilizers and type of food according to the respondents.

Table 4.9 reveals that the manual tillage has been the most common land management practices adopt in the study, as most of the respondents mentioned it out of the six land management practice; 60% of the respondent in the last thirty years and 67.92% between 2010 and 2014. Now important number of farmers has abandoned burning land, only 4.58% in the last thirty years compared to 18.33% between 2010 and 2014. Farmers notified that burning land could lead to soil erosion and others fertility problem. Although the manual tillage required more men power compared to mechanized tillage but this practice caused less damage to land, hence less land degradation and adequate for tuber crop cultivation (cassava, yam). Furthermore, in the study area agricultural production is characterized by traditional agricultural technique base on the use of tittle or no new technology technique due to low capital of the farmers.

Table 4. 9 Land management practices adopted

Land management practices	Last thirty years before 2010 (past)		2010-2014 (present)	
	Total	%	Total	%
Burning farm land	11	4.58	44	18.33
Tillage with total residue removal	44	18.33	42	17.50
Irrigation	2	0.83	-	-
Manual tillage	163	67.92	144	60.00
zero tillage	14	5.83	5	2.08
Mechanized tillage	6	2.50	5	2.08
Total	240		240	

Source: Author's data analysis

4.3.2.3 Soil fertility restoration

It can be seen that shifting cultivation, bush fallowing, fertilizer and crop rotation are used by the farmers in the study area. Sifting cultivation was one of the frequently used for maintaining soil fertility. Recently increasing population has driven farmers to abandon shifting cultivation resulting in the use of fertilizers to maintain soil fertility up to 79% of the respondents (see Table 4.10). This, was clear indication that farmers was information in the usage of fertilizers in the areas, was widespread (Okwoche, Obinne and Onungba, 2011). The majority of the farmers received information on fertilizers from extension agents, radio or television.

Table 4. 10 Practice used for fertility restoration

Practices	Last thirty years before 2010 (past)		2010-2014 (present)	
	Total	%	Total	%
Shifting cultivation	208	86.67	32	13.33
Bush fallowing	5	2.08	-	-
Using Fertilizer	6	2.50	190	79.17
Crop rotation	21	8.75	18	7.50
Total	240		240	

Source: Author's data analysis

4.3.2.4 Crop production

Table 4.11 shows that farmers are increasing land under crop, the total land under crop were 993.50 ha and actually is 1029 ha. Cassava, maize, sorghum, yam, rice and millet are food crop cultivated by the respondents mainly produced for the family needs while groundnut and cowpea are cultivated as cash crop. Cassava, maize and groundnut were cultivated by important number of our respondent, up to 30%. This confirm Ibitoye (2006) stating that, these crops are most cultivated in the study area.

Table 4. 11 Land under cultivation

Food crops cultivated	Land under cultivation/ha			
	Last thirty years before 2010		2010-2014	
	(past)	Percentage (%)	(Present)	Percentage (%)
Rice	6.5	0.70	5.5	0.53
Maize	280.5	30.15	300	29.15
Millet	12.5	1.34	23	2.24
Sorghum	114.5	12.31	137.5	13.36
Cowpea	57	6.13	57	5.54
Groundnut	32.5	32.50	45.5	4.42
Cassava	346	37.18	356	34.60
Yam	81	8.70	104.5	10.16
Total	930.5		1029	

Source: Author's data analysis

The minimum and maximum farm size under crop were between 0.5 ha and 8 ha and has increased from 1 ha to 10 ha. But the majority of farm size are 2 to 5 ha either in the past (last thirty years) or present (2010-2014) see Figure 4.16.

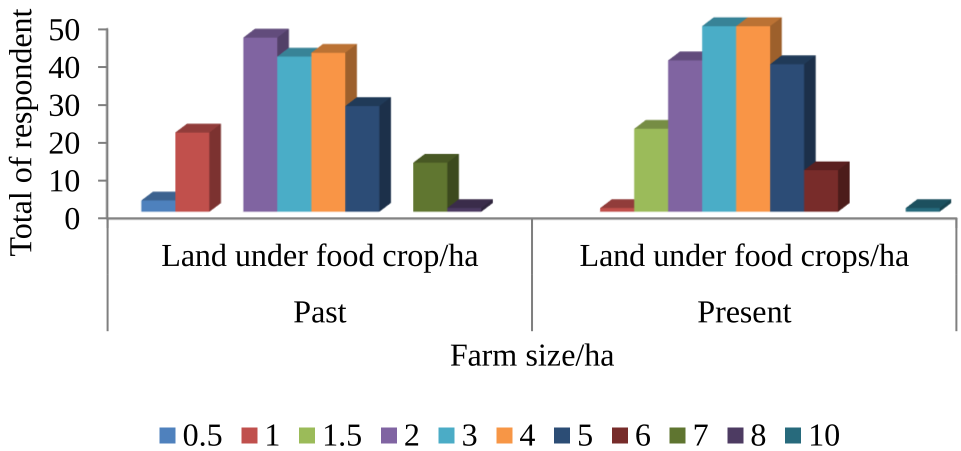
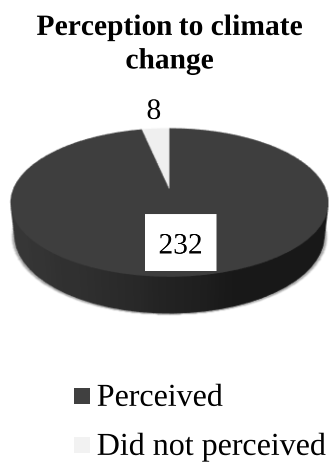


Figure 4. 16 Farm size per hectare (ha)

4.3.3 Farmers response of climate change

4.3.3.1 Significant change noticed in weather condition over the past forty years

The result of administrated questionnaire declares that 232 peoples of the respondent out of 240 perceived climate change and 238 have noticed significant change in weather condition (See Figure 4.17). In Okehi and Adavi local government area 100% of the respondent have noticed significant change in weather condition. As 97% of the respondent perceived climate change this implies that most of the farmers in the study area already knew about the concept of climate change. This confirms the assertion of the Southern African Catholic Bishops' Conference (SACBC, 2010) that most Africans are aware that weather and climate patterns are changing but their understanding of global change is limited.



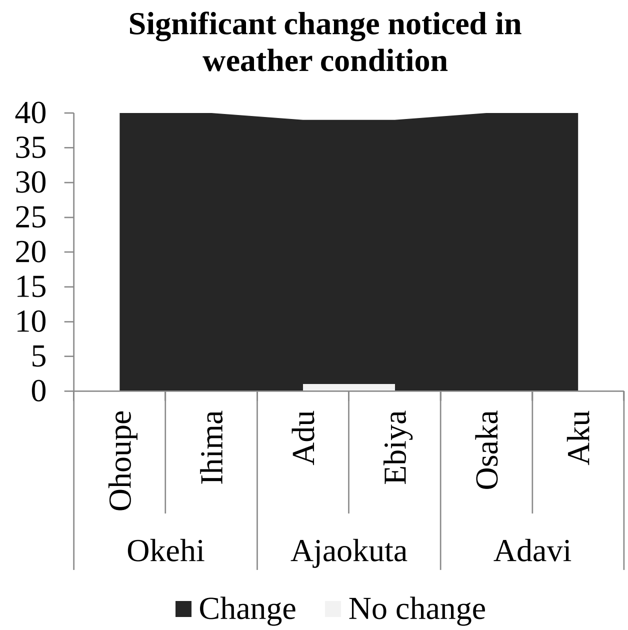


Figure 4. 17 Total of farmers that perceived climate change

Figure 4.18 indicates that among 240 farmers interviewed in unpredictable rains was perceived by the respondent in the three local government areas. The perception of farmers differ from local government area to another as it can in see from (Figure 4.18) in Adavi local government area only the unpredictable rain was perceived by the respondent. In Ajaokuta local government area increase in rainfall timing and increase in heat were perceived while in Okehi decrease in rainfall timing, increase in rainfall timing and decrease in rainfall timing were perceived by important number of the respondent. As the majority of the farmers interviewed have perceived change in rainfall pattern in the study area; this supports Viglizzo, Pordomingo, Castro and Lertora (2003) that rainfall is the key factors of determining the success of crop production and precipitation changes constrain more than changes in temperature (Challinor, Wheeler, Garforth, Craufurd, and Kassam, 2007).

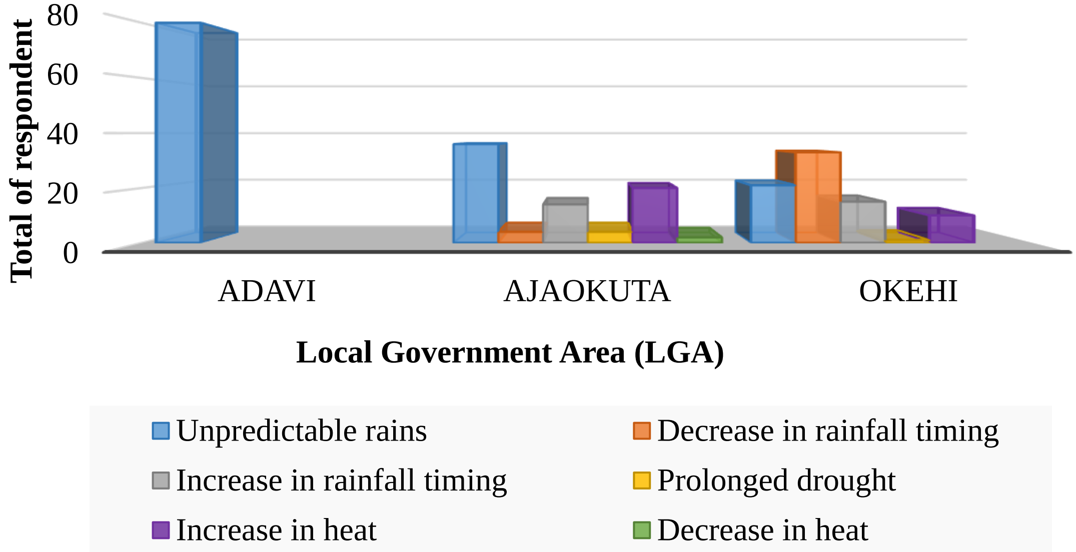


Figure 4. 18 Significant change noticed

4.3.3.2 Farmers' perception of the impact of climate change

Figure 4.19 shows that in the six villages interviewed crop failure was mentioned by the majority of farmers excluding Ebiya whereby the migration was indicated as the main impact of climate change perceived by the farmers. In Ajaokuta, it has noticed the perception of farmers varies, in addition to crop failure, flooding, human disease outbreaks, livestock, famine and migration were also indicated by a number of respondent as the impact of climate. This indicates that farmers in Ajaokuta are more informed about climate change issue, hence famers in Ajaokuta may be more likely to adopt adjustment strategies against climate change effect than farmers in Adavi and Okehi. Farmers indicated that they have observed changes in rainfall seasons and pattern, temperature are higher in some areas than they were before and incidences of extreme events such as floods and drought have increased. In some areas there are no more rains, and when the rains come it is not at the usual time. In most cases rains delay and this result in crops drying out.

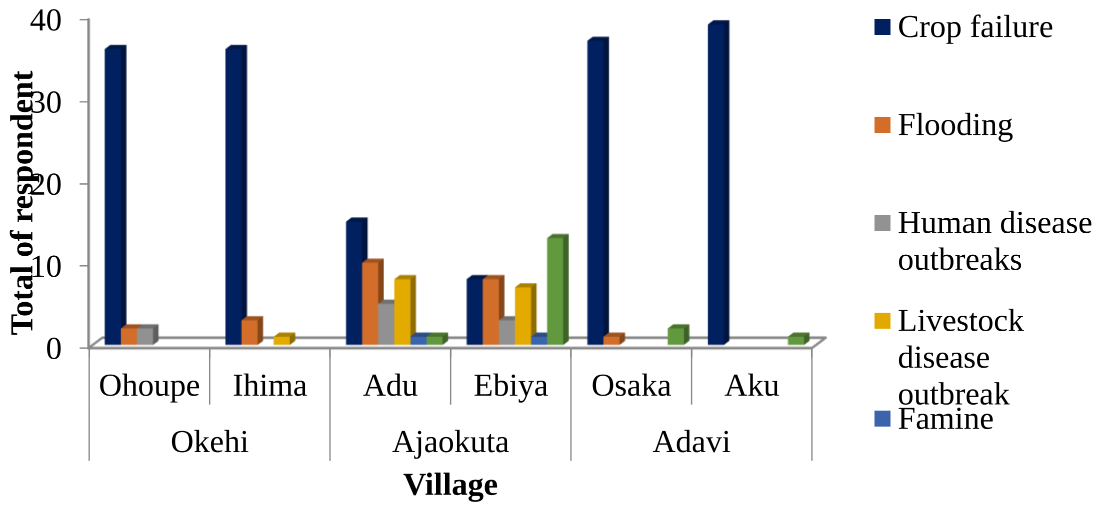


Figure 4. 19: Impact of climate noticed by respondent per village

4.3.3.3 Adaptation strategies in response to climate change

Seven (7) adaptation strategies were adopted by the farmers. Changing planting dates, implement soil conservation schemes and change crop variety were identified as the major adaptation strategies with respective percentages of the respondents 31%, 22% and 21% in response to change in rainfall as indicated in Table 4.12. This implies that farmers in the study area are noticing the variation in climatic variables and have adopted various adaptation options to counteract the negative impact of climate change in the area. Similar results were found by Fosu-Mensah et *al.* (2010) whereby shifting the planting date being the most important adaptation measure. Kurukulasurya and Rosental (2003) noted that the short-term adaptation measures for climate change by farmers include crop insurance for risk coverage, crop/livestock diversification to increase productivity and protection against diseases, adjusting the timing of farm operations to reduce risks of crop damage, change crop intensity and adjust livestock management to new climatic conditions, food reserves and storage as temporary relief, changing cropping mix, permanent migration to diversify income opportunities, defining land use and tenure rights for investments. On a long term note, the authors stated the following as best adaptation options for climate change: development of crop and livestock technology adapted to climate change stress, develop market efficiency, irrigation and water storage expansion, efficient water use, promoting international trade, improving forecasting mechanisms, institutional strengthening and decision-making structures.

Table 4. 12 Adaptation measures adopted

Adaptation measures	Total	Proportion
Change crop variety	146	21.82
Build water harvesting schemes	8	1.195
Implement soil conservation schemes	152	22.72
Diversification of crop types and varieties	22	3.28
Changing planting dates	211	31.53
Changing size of land under cultivation	124	18.53
Irrigation	6	0.89

Source: Author's data analysis

4.3.3.4 Constraints to adopt adaptation strategies

Figure 4.20 shows that greater proportion of farmers (85%) identified lack of capital as major constraint. This could be attributed to high cost of adaptation options. Inadequate fund hinders farmers from getting the necessary resources and technologies which assist to adapt successfully to climate change. Deressa et al. (2008) reported that adaptation options are costly. Hence if farmers do not have sufficient family labour or the financial means to hire labour, they cannot adapt. 9% of the farmers in the study area complained of lack of information as constraint to climate change adaptation options. This could be attributed to dearth in research on climate change as well as poor information dissemination on the part of the government information agencies, thus, information is lacking in this area. Others 3 and 2% of the farmers in the study area complained shortage of labour and poor health respectively, which could be attributed to non-availability of family labour and also attributed to poor health insurance. Ultimately, there is no doubt that these barriers are responsible for poor adaptation to climate change by the farmers as well as poor resource use efficiency and poor output recorded in the area. Fighting these problems will be vital in promoting not just local adaptation option but global modern adaptation practices/options to climate change in the area and beyond.

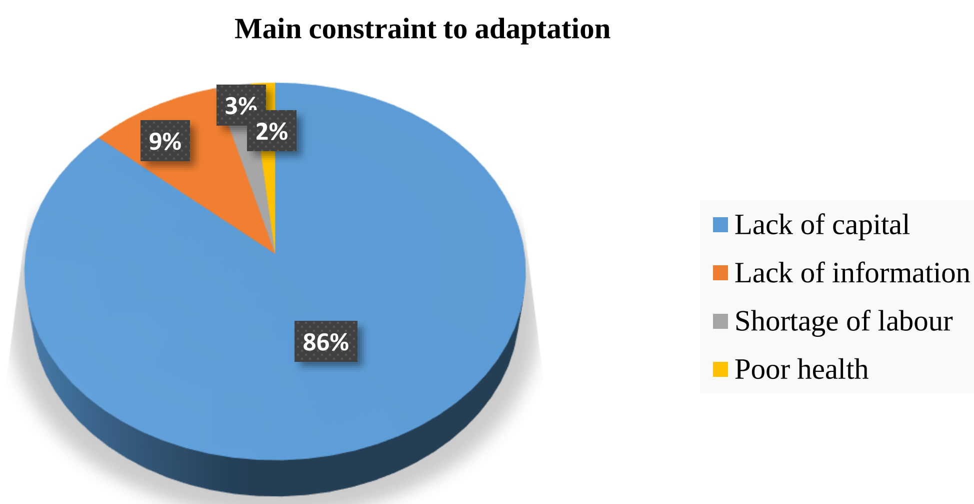


Figure 4. 20 Constraint to adopt adaptation strategies

4.3.4 Factors determining farmers' decision to change land under cultivation

The result of logit model was globally significant (-2log-likelihood =239.09; R^2 of Cox & Snell =0.30; R^2 of Nagelkerke =0.41) with a good prediction (R^2 =75.3%). The coefficients were also globally significant (Test of Omnibus; Chi square =86.34; P<0.001). The household decision to change the land under cultivation was significantly influenced by the number of family member schooling, household farming experience and access to credit. The coefficient was negative with family member schooling suggesting that the higher the family member schooling the lower the probability of household to increase the land under cultivation. Regarding the farming experience and access to credit the coefficient was positive (see Table 4.13). This would indicate that the decision to increase the land under cultivation increase when the household access to credit and farming experience increased.

Though change in rainfall negatively influenced the decision of household to change land under cultivation but it not significant. Such a relationship should not be surprising as empirical evidence from elsewhere that increase in the amount of rainfall translated into decrease in arable land usage (Kori et *al.*, 2012). This reinforces the observations by IPCC (2007) and Allamano (2010) that climate change in West Africa will result in negative impacts on agriculture.   This, by extension, poses serious food insecurity problems to farmers who rely on rain fed agriculture.

Table 4. 13 Factors determining farmers' decision to change land use under cultivation

Variables	Coefficients	Standard Error	Wald x^2 test	P-value
village	0.041	0.128	0.104	0.747
Sex	-0.290	0.506	0.329	0.566
Age	0.422	0.351	1.447	0.229
Level of education	-0.100	0.098	1.054	0.305
Marital status	-0.500	0.844	0.351	0.553
Family members	0.561	0.352	2.532	0.112
FMS	-1.131*	0.445	6.467	0.011
FMIFA	0.106	0.460	0.053	0.818
EA	0.434	0.367	1.401	0.237
Social group	0.324	0.348	0.865	0.352
Farming experience	1.433**	0.290	24.440	0.000
Land tenure	0.129	0.118	1.189	0.276
Extension service	0.458	0.544	0.710	0.400
Access to credit	1.359**	0.376	13.082	0.000
Access to market	-0.071	0.057	1.560	0.212
Change in rainfall	-0.064	0.194	0.108	0.743
Soil fertility	0.750	0.484	2.397	0.122
Constant	-6.383	2.634	5.872	0.015

NB: FMS=Family Member Schooling, FMIFA= Family Member Involving in Farm Activity, EA= Experience of the Area.
*= significant at 5%
**= significant at 1%

Source: Author's data analysis

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

This study aimed at assessing the impact of climate change on agricultural land use in Kogi State using forty years (1987-2014) rainfall and temperature, three (3) Landsat images (1987, 2001 and 2014) and administrated questionnaire to achieve the three specific objectives.

Analyze of climate data that the mean annual temperature has increased from 27.43^{o}c to 28.53^{o}c between 1975 and 2014 in the study area (Kogi State). Lowest and highest temperature were recorded in 1989 and 2005. The period of 1975 to 1997 is characterized has the cool years as the values were below the normal (zero) expect years 1980, 1983, 1987, 1990 and 1996. While from 1998 to 2013 mean annual temperature was above the normal. Average rainfall is 1218.5mm. The rain season is from April to October as high amount of rainfall are concentrated within this eight (8) months of the years in the study area. The pattern of rainfall in the months of April and October has been very unpredictable from 1975 to 2014. The study area experienced high amount of rain at begins and end of rain season in the last two decades (1995-2014) compared to the first decade (1975-1994). The peak of rain was shifted from August to September for the middle two decade (1985-2004) and has returned to August in last decade (2005-2014). The trend line indicates slight increase in rainfall over the study period from 1975 to 2014 the dryness year was 1977 while the wetness was 1999 with respective standardized value of -1.82 (moderate dryness) and +2.23 (extreme dryness). In a nutshell we can say that though, the study area is experience more war there but rainfall is increasing which confirms global warming in the study area.

The magnitude of the change rate between 1987 and 2001, 2001 and from 2987 to 2014. It obvious that only water body did not experience a blamed change. An important decrease in natural vegetation within the period of 1987-2001 (15) and from 1987 to 2014 (29). This indicate the practice of deforestation in the study area for residential purpose and farming. Plantation areas are increasing with the time which inform the cultivation of perennial crops (palm tree, plant in, coconut) for commercial purpose as confirm by some respondents during the field survey. An increase of 10.98% (36557ha) in farmland and 0.60% (2019ha) in plantation areas. Exposed surface which occupied 289605ha in 2001 lost a total -35544ha representing up to 11% of the total area in 2014.

Farmers interviewed claimed an increase in land under crop. The total land under crop were 993.50 ha before 2010 and is actually 1029 ha. Land tenure system is based on four land tenure system as stated by the farmers namely inherited land 52.8%, rented land 20.4% and communal 27.08%. Manual tillage has been the most common land management practices adopt in the study, 60% of the respondent in the last thirty years and 67.92% between 2010 and 2014. Now important number of farmers has abandoned burning land, only 4.58% in the last thirty years compared to 18.33% between 2010 and 2014. Sifting cultivation was one of the frequently used for maintaining soil fertility. Recently increasing population has driven farmers to abandon shifting cultivation resulting in the use of fertilizers to maintain soil fertility up to 79% of the respondents though, important of the respondent stated the difficulty to access fertilizers. The minimum and maximum farm size under crop were between 0.5 ha and 8 ha and has increased from 1 ha to 10 ha. But the majority of farm size are 2 to 5 ha either in last thirty years or present.

Changing planting dates, implement soil conservation schemes and change crop variety were identified as the major adaptation strategies in response to change in rainfall. Lack of capital as major constraint. Logit regression analysis reveals that climate change (rainfall) has no significant impact on farmers' decision to change land use under cultivation while number of family member schooling, household farming experience and access to credit have significant impact. Though change in rainfall negatively influenced the decision of household to change land under cultivation but it not significant.

5.2 RECOMMENDATION

As demonstrated in this study, farmers are well aware about the climate change and its impact on their livelihood but limited to adopt adaptation strategies. Therefore, based on findings from the study, as a recommendation, respondents argued that they need more education on how to deal with climatic changes and if possible, the government could help with machinery and other farming equipment. In addition, they also requested the provision of loans, to assist them diversify their economic activities in other sectors as climate changes affects farm and livestock products.

The climate changes and variations have always been occurring and in recent years the change has been happening at a higher rate than observed before. These changes are predicted to continue at an even higher rate in future. With 80% of Kogi State depending on agriculture for survival there is urgent need to explore various copping strategies, safety nets and policies that will prevent farmers falling into poverty due to lack of food and income from agriculture activities and livestock products. There is also a need of having consistent strategies and improved institutional capacity and planning within different ministries and other stakeholders to address different challenges farmers face due to climate change.

Further research should look at the rainfall pattern (onset, cessation, rainfall timing) in the study area for better agricultural planning.

The following measures should also adopt in order to minimize the adverse effect of current climate events:

- Conservation crop rotation and alley cropping are effective land management practices in response to climate change, this should be advice to the farmers in the study area.
- Furthermore, improving the knowledge and skills of extension service personnel about climate change and making the extension services more accessible to farmers appear to be the key components to rise farmer's adaptation capacity to climate change.
- Enhanced farmers' access to affordable credit will increase their ability to adopt sustainable agricultural land use in response to climate change.

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APPENDICES

Appendix A

QUESTIONNAIRE ON CLIMATE CHANGE IMPACT ON AGRICULTURAL LAND USE IN KOGI STATE, NIGERIA

Questionnaire ID number: ....

Date of interview (dd/mm/yy): ....

Local Government: ....Village.................................Ethnicity...........

	QUESTIONS	ANSWERS
SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS		
A.1	Respondent sex	1= Male 2= Female ☐
A.2	How old are you?	Age =..................... 20= Don't know
A.3	What is your level of education? ***(Only one answer)***	0= None 1= Some primary education 2= Completed primary ☐ 3= Primary 4= Secondary 5= College 6= University 21= Other (specify)...................
A.4	What is your main Occupation? ***(Only one answer)***	1= Crop farming ☐ 2= Livestock farming 21= Other (specify)..............................

A.5	What is your marital status?	1= Single 2= Married 3= Divorced/separated 4= No answer ☐
A.6	Exact number of family members	Numbers..............................
A.7	How many family members are in school?	Numbers.......................
A.8	How many of family members are involved in farm activities?	Numbers:.......................
A.9	Are you a native of this village?	1= Yes 2= No ☐
A.10	If NO, how long have been in this village?	Numbers of years.......................
A.11	Do you belong to any social group?	1= Yes 2= No ☐
A.12	If yes, name of group/groups	....
Nº	**QUESTIONS**	**ANSWERS**

SECTION B: AGRICULTURAL LAND USE CHANGE

B.1	What was/is your total land holding? ***(Only one answer)***	2010-2014	Last thirty years before 2010
		1= <1 ha 2= 1-3 ha 3= 4-6 ha 4= 7-9 ha 5= >/=10ha 20= Don't know ☐	1= <1 ha 2= 1-3 ha 3= 4-6 ha 4= 7-9 ha 5= >/=10ha 20= Don't know ☐
B.2	What was/is the total area of land under food crops?	2014	Last forty years
		Numbers ....ha	Numbers ....ha
B.3	What was/is the location of your land? ***(Only one answer)***	2010-2014	Last thirty years before 2010
		1= Uplands 2= Lowlans 3= Plains 4= River valley ☐	1= Uplands 2= Lowlans 3= Plains 4= River valley ☐

<table>
<tr><td>B.4</td><td>Was/is your soil fertile?</td><td>2010-2014</td><td>Last thirty years before 2010</td></tr>
<tr><td></td><td></td><td>1= Yes
2= No</td><td>1= Yes
2= No</td></tr>
<tr><td>B.5</td><td>If YES, moves to B.7
If NO, have you attempt to improve its fertility?</td><td>2014</td><td>Last forty years</td></tr>
<tr><td></td><td></td><td>1= Yes
2= No</td><td>1= Yes
2= No</td></tr>
<tr><td>B.6</td><td>What did/do you do to maintain restore land fertility?

(Only one answer)</td><td>2014</td><td>Last forty years</td></tr>
<tr><td></td><td></td><td>1= Shifting cultivation
2= Bush fallowing
3= Composting
4= Organic manure
5= Mulching
6= Using fertilizer
7= Crop rotation
21= Other
(specify)...................................</td><td>1= Shifting cultivation
2= Bush fallowing
3= Composting
4= Organic manure
5= Mulching
6= Using fertilizer
7= Crop rotation
21= Other
(specify)............................</td></tr>
<tr><td>B.7</td><td>What was/is the total area of land under each of these food crops?</td><td>2010-2014</td><td>Last thirty years before 2010</td></tr>
<tr><td></td><td></td><td>1= Rice.................ha
2=Maize ....ha
3= Sorghum..................ha
4= Millet.......................ha
5= Cowpea...................ha
6= Groundnut.......................ha
21= Others (specify)

...........................ha
...........................ha</td><td>1= Rice.................ha
2=Maize ....ha
3= Sorghum..................ha
4= Millet.......................ha
5= Cowpea...................ha
6= Groundnut..................ha
21= Others (specify)

...........................ha
...........................ha</td></tr>
</table>

<table>
<tr><td>B.9</td><td>When did/do you start growing these crops?</td><td colspan="2">2010-2014</td><td colspan="2">Last thirty years before 2010</td></tr>
<tr><td></td><td></td><td>Crops</td><td>Start growing</td><td>Crops</td><td>Start growing</td></tr>
<tr><td></td><td></td><td>Rice</td><td></td><td>Rice</td><td></td></tr>
<tr><td></td><td></td><td>Maize</td><td></td><td>Maize</td><td></td></tr>
<tr><td></td><td></td><td>Sorghum</td><td></td><td>Sorghum</td><td></td></tr>
<tr><td></td><td></td><td>Mille</td><td></td><td>Mille</td><td></td></tr>
<tr><td></td><td></td><td>Cowpea</td><td></td><td>Cowpea</td><td></td></tr>
<tr><td></td><td></td><td>Groundnut</td><td></td><td>Groundnut</td><td></td></tr>
<tr><td></td><td></td><td>Others (specify)</td><td></td><td>Others (specify)</td><td></td></tr>
</table>

B.10	How long have been farming ***(Only one answer)***	1= </=5 years 2= 6-10 years 3= 20 years 4= >20 years	
B.11	What was/is the type of land tenure? ***(Only one answer)***	2010-2014	Last thirty years before 2010
		1= Owner 2= Ancestral land 3= Rent 4= communal land 21= Other (specify)...............	1= Owner 2= Ancestral land 3= Rent 4= communal land 21= Other (specify)...............
B.12	Who is in charge of land management decision? ***(Only one answer)***	2010-2014	Last thirty years before 2010
		1= Household head 2= Entire Family 21= Others (specify)	1= Household head 2= Entire Family 21= Others (specify) ....
		2010-2014	Last thirty years before 2010
B.13	What land management did/do you practice? ***(Only one answer)***	1= Burning farm land 2= Tillage with total residue removal 3= Manual tillage 4= Zero tillage 5= Mechanized tillage 6= Irrigation 21= Others (specify)	1= Burning farm land 2= Tillage with total residue removal 3= Manual tillage 4= Zero tillage 5= Mechanized tillage 6= Irrigation 21= Others (specify) ....
B.14	Did/Do you have any extension service assistance?	2010-2014	Last thirty years before 2010
		1= Yes 2= No	1= Yes 2= No
B.15	Was/Is this extension service? ***(Only one answer)***	2014	Last forty years
		1= Government 2= NGOs 3= Private 21= Others (specify).................	1= Government 2= NGOs 3= Private 21= Others (specify).................
B.16	If YES, what was/is the frequency of extension service? ***(Only one answer)***	2010-2014	Last thirty years before 2010
		1= Once a week 2= Twice a week 3= Monthly	1= Once a week 2= Twice a week 3= Monthly

B.18	Did/Do you have access to loan/credit?	2014	Last forty years
		1= Yes 2= No	1= Yes 2= No
B.19	What was/is the distance of your settlement from nearest market?	2010-2014	Last thirty years before 2010
		1= less than one kilometer 2= 1-10 kilometers 3= over 10 kilometers	1= less than one kilometer 2= 1-10 kilometers 3= over 10 kilometers

SECTION C: CLIMATE CHANGE

C.1	Have you noticed any change in weather conditions over 40 last years?	1= Yes 2= No
C.2	If YES, What significant change have you noticed? ***(Only one answer)***	1= Unpredictable rains 2= Decrease in rainfall timing 3= Increase in rainfall timing 4= Prolonged drought 5= Increase in heat 6= Decrease in heat 21= Other (specify)...
C.3	What is the main impact of this change? ***(Only one answer)***	1= Crop failure 2= Flooding 3= Human disease outbreaks 4= Livestock disease outbreak 5= Famine 6= Migration to other places 20= Don't know 21 = Others (specify).. ....
C.4	Do you perceive climate change?	1= Yes 2= No
C.5	If YES, what has happened to the number of hot days over the last 40 years?	1 = Increased 2= Declined 3= More extreme 4=Less extreme ***(Only one answer)***
C.6	If YES, what happened to the number of rainfall days over the last 40 years? ***(Only one answer)***	01 = Increased 02 = Declined 03 = Change in the timing of rains 04 =Decrease in rains and change in timing 05 = Change in frequency of droughts/floods 21= Other (specify)..

		....	
C.7	In which month did/do you experience the first rain (onset)? ***(mention month)***	2010-2014	Last thirty years before 2010
C.8	In which month did/do you experience the last rain (cessation)? ***(mention month)***	2010-2014	Last thirty years before 2010
	SECTION D: CHANGE IN AGRICULTURAL LAND USE FOR CLIMATE CHANGE ADAPTATION		
d.1	What adaptation strategies have you adopted in your farming practices to these long-term shifts in temperature and rainfall? ***Tick adjustments made. (Multiple responses allowed)***	1= Change crop variety	
		2= Build water harvesting schemes	
		3= Implement soil conservation schemes	
		4= Diversification of crop types and varieties	
		5= Changing planting dates	
		6= Changing size of land under cultivation	
		7= Irrigation	
		8= Diversify from farming to non-farming activity	
		21= Others (specify)...	
d.2	What is the main constraints to adaptation measures? ***(Only one answer)***	1= Lack of capital 2= Lack of information 3= Shortage of labour 4= Lack of access to water 5= Poor health 21 = Others (specify)..	☐
d.3	Are there institutions/organizations your community	01 = Yes 02 = NoS	☐

	has worked with to address the effects of climate change on livelihood?					
d.4	If, yes please indicate what type of Institutions/organizations they were? ***(Only one answer)***	1 = Government 2= NGOs 3= Private sector 4= An individual 21= Others (specify)...				
	LIST OF HOUSEHOLD ASSETS					
	Assets Number *(Tick household assets)*					
	Farm equipment		**Other assets**		**Livestock Type and Number**	
	Tractor		Bicycle		Local cattle	
	Oxen plough		Motor bike		Improved cattle	
	Wheelbarrow		Cart		Local goats	
	Water pump		Water tank		Improved goats	
	Jembe		Motor vehicle		Sheep	
			Radio		Local poultry	
			TV set		Improved poultry	
			Pressure lamp		Donkeys	
			Charcoal stove		Others (specify)	
	THANK YOU FOR YOUR CONTRIBUTION					

Appendix B: Land use and land cover type

a) Natural vegetation: Land cover by short and dense forested land.

b) Plantation: Land dominated by perennial crops such as palm trees, coconut, cacao

``

c) Farmland: Land use for farming (crops production, vegetable).

d) Exposed: Refers to building up areas, rock areas and bare soil

d) Water body: comprises Rivers and dams.