THE IMPACT OF CLIMATIC VARIABILITY ON YAM PRODUCTION IN SHIRORO LOCAL GOVERNMENT AREA, NIGER STATE, NIGERIA

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MTech/SPS/2017/7391

DEPARTMENT OF GEOGRAPHY

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ABSTRACT

Climate is described as change as long-term in the statistical distribution of weather pattern over a period of time that ranges from decade to millions of years. Rainfall characteristics in Nigeria have been examined for secular change that is, dominant trend and the results show that there has been a progressive early retreat of rainfall over the whole country spanning up to a half a century now and consistent with this pattern there has also been a significant decline of rainfall frequency. This study assessed the impact of climate variability on yam yield in Shiroro Local Government Area of Niger State. It examined the trends in rainfall over Shiroro Local Government Area (1998-2018); examine the trend of yam yield in Shiroro Local Government Area; Analyse the relationship between rainfall variability and yam yield of Shiroro Local Government area, and examine the adaptive and mitigative measure for effects of climate variability on yam yield. Qualitative and quantitative research approach was used, rainfall records for 30 years (1988-2018) and yam yield record for 20 years (1998-2018) and structured questionnaire was used. Trend, correlation and descriptive analysis were used. Findings revealed that rainfall between 1998 and 2018 have a slightly decreasing trend in the study area and annual yield of yam was observed that 2016 has the highest record of yam yield in the study area with 2923.73 metric tons, followed by 1999 with a 2873.36 metric tons of yam yield. Years 2010 recorded the lowest yield of yield with 2411.45 metric tons. It revealed a positively weak relationship thus r = 0.46 (46%). It means that rainfall variations are very crucial to the yield of yam and has a significant value of 304. Different strategies were adopted to cushion

The effects of rainfall on yam yield and the most used method with 83.1% use early maturing crop variety. The study concludes that rainfall in the study area has been inconsistence (fluctuating). The nature of rainfall in relation to Yam yield for the study period and as of recent years has been making the yields inconsistence (fluctuating).It thereby recommends that there should be climate monitoring stations for every agricultural zones of Nigeria and there should be time to time awareness and enlightment campaign on the causes of climate change in various parts of the country.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Agriculture is the biggest single industry in many less developed countries of the world (Etim, 2014). It plays a significant role as it contributes to the national food security, national social and economic stability and also to the environmental protection of the nation (Ziervogel, 2014). It provides not only food but also raw materials for most manufacturing industries of the country. Most countries, import and export large amounts of agricultural produces which brings about economic development of the world (Diao, 2010).

Crop production is an integral part of agriculture dealing with the cultivation, protection, harvesting and storage of cultivated plants for man's use. It is the sum total of all the activities involved in producing, preparing and processing of agricultural crops (Akanbi *et al.,* 2004). Agriculture being one of the most weather-dependent of all human activities, is highly vulnerable to climate change; a variability that can have direct impact, or influence on the quantity and quality of agricultural production. The climate of an area is highly correlated to the vegetation and by extension the type of crop that can be cultivated. Nigeria's agriculture therefore depends highly on climate, because temperature, sunlight, water, relative humidity are the main drivers of crop growth and yield (Adejuwon, 2004).

Climate is the average weather in a given area over a longer period of time (Adejuwon, 2004). Change in climate and consequent global warming are posing threats to food security in many developing nations including Nigeria because of the climate-dependent nature of agricultural systems and lack of coping capabilities. It is one of the most serious environmental threats facing mankind worldwide. It affects agriculture in several ways, including its direct impact on food production. Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa (Ziervogel, 2014).

Rainfall totals in central Nigeria varies from 1,100 mm (43.3 in) in the lowlands to over 2,000 mm (78.7 in) along the south western escarpment of the Jos Plateau. A hot semi-arid climate is predominant within the Sahel in the northern part of Nigeria. Annual rainfall totals are low. Total annual rainfall at a location is influenced by several variables including the frequency of rain events, the duration of the rainy period and the intensity of rainfall of individual events. Inhomogeneities in the annual rainfall therefore reflect changes in these contributory variables. Adejuwon (2004) fitted linear trends to the annual rainfall series of several locations in Nigeria for the entire period of available data which, in some cases, began in 1922. On the other hand, Hess *et al.* (1995) examined trends in the dates of onset, termination and duration of the rainy season in north-eastern Nigeria based on the standard climatic normal periods. Furthermore, the combined effect of these declines was found to lead to a significant decrease in annual rain days over the whole country. In effect, except farmers change to early maturing crop varieties, streamline their farming calendars with the changing rainfall regime or have access to irrigation water, the secular changes in rainfall frequency for the country pose serious threat to the maturity of annual crops and consequently to food security for the nation. Hence, the volatility of agricultural output due to rainfall fluctuation can mean a large burden for the low-income farming households (John, 2007).

Climate change is also predicted to have adverse effect on the agricultural sector of the poorer parts of the world especially in sub-Saharan Africa (SSA). Most of the crops produced in this area are low-technology based and are therefore heavily susceptible to environmental factors (Adejuwon, 2004). Nigeria one of the largest countries in SSA is the major producer of yams in the world in terms of quantity, producing an average of 31 million metric tons annually. Nigeria produced 60% of the world's yams in 2010, and is the largest contributor to Africa's "yam belt," comprising Nigeria, Ghana, Benin, Côte d'Ivoire, Central African Republic, Cameroon, and Togo. They produce altogether about 92% of the world's yams (Adejuwon, 2004).

Yams have had the second highest production level of any food crop in Nigeria in the past 50 years after cassava. Evans School Policy Analysis and Research (2011) shows that production and area harvested have grown steadily until 2006 and 2007 respectively, after which production and area harvested have shown a decline. In 2010, the gross agricultural production value for yams was $15,041 million USD and accounted for the largest proportion of any crop in the country. Yams are agronomically, annual rain fed crops which grow for 6-12 months depending on the cultivar, ecology and soil properties in the production area (NRCR, 1998). They serve as staple food in many tropical and even sub-tropical countries. World yam production is about 30 million tons annually with 90% grown in the yam production belts of West Africa (FAO, 2002).

Yam production in Nigeria has more than tripled over the past 45 years from 6.7 million tones 1961 to 39.3 million in 2006 (FAO, 2007). This increase in output is attributed more to the large area planted with yam than increase in productivity (Nwosu and Okoli; 2010). Though the cultivated area to yam has increased production, however the growth rate has declined tremendously from the average 27.5% between 1986 and 1990 to 3.5% in the 1996 to 1999 periods (Ekunwe *et. al.,* 2008). This decline in average yield per hectare has been more drastic, - from 14.9% in 1986-1990 to 2.5% between 1996-1999 (CBN, 2002; Agbaje *et al.,* 2005; FAO, 2007).

This trend may not be unconnected with inefficiency of use resourced and other allocations (Nwosu & Okoli, 2010). It may therefore, be important for yam farmers to manage the little resources at their disposal optimally for increased yield and sustainability of yam production (Udoh & Akintola 2001; Etim *et al.,* 2005; Udoh & Etim, 2007). Inefficient use of resource and badly managed utilization can seriously jeopardize and hamper food production, availability and security (Udoh & Etim, 2007).

1.2 Statement of the Research Problem

Climate variability is a threat to agriculture and non-agricultural socio-economic development. Agricultural production activities are generally more vulnerable to climate variability than other sectors. (Kurukulasuriya *et al.*, 2014). Ole *et al.* (2013) asserted that analysis of 9000 farmers in 11 African countries predicted falling in farm revenues with current climate scenarios. Also Butt *et al.* (2013) predicted future economic losses and increased the risk of hunger due to climate variability. It is obvious the combination of high climatic variability poor infrastructure, economic poverty, drought, excess rainfall, poor livestock health, reduced crop yields, low productivity and a range of other problems associated with climate variability will constitute important challenges for Africa countries in particular (Adger *et al.*, 2013).

Shiroro local government faces the threat of desert encroachment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land (Obioha, 2012). This makes people to exploit more previously undisturbed lands leading to depletion of the forest cover and increase in sand dunes/Aeolian deposits. The resource poor farmers therefore faced the prospects of tragic crop failures which reduced agricultural productivity, increased hunger, poverty, malnutrition and diseases (Zoellick, 2009). International Institute for Tropical Agriculture (IITA) have developed various new technologies to produce yams in Africa during dry season. The ecological constraints of the savanna zones have been overcome by the spontaneous effort of farmers to pick out the early maturing cultivars that adapt to short rainfall period. This study investigates the effect of rainfall trend pattern in the study area, analyse the effect of the rainfall trend on yam production in the area and advice on possible measures to take in ameliorating the trend effect.

1.3 Aim and Objectives of the Study

The aim of the study is to assess the impact of climate variability on yam production in Shiroro Local Government Area of Niger State. The specific objectives are to:

i. examine the trends in rainfall over Shiroro Local Government Area (1988-2018);
ii. examine the trend of yam yield in Shiroro Local Government Area (1988-2018);
iii. Analyse the relationship between rainfall variability and yam yield of Shiroro Local Government area, and;
iv. examine the adaptive and mitigative measure used against the against climate change impact on yam production.

1.4 Research Questions

i. What is the trend in rainfall over Shiroro Local Government between 1988-2018?
ii. What is the trend in yam yield in Shiroro between 1988-2018?
iii. Is there any relationship between climate variability and yam yield in Shiroro?
iv. What are the adaptive and mitigative measures used towards addressing the effect of variability in climate?

1.5 Scope of the Study

The study will be carried out in Shiroro Local Government Area of Niger State, is designed to assess the impact of climate variability on yam yield. Contextually, the study will analysed the trend of climate variability over the past twenty years (1998-2018) as well as how climatic variations affect Yam yield in the area. The study will also investigate the relation that exist between climate variation and yam production in the study area.

1.6 Justification for the Study

The unstable conditions of farming can affect the overall productivity of farmers, make them abandon farming for some time, produce at capacities below their best or have little gains for their efforts. Climate variation already poses significant impacts on the agricultural sector and there has been little commitment to make adaptation a national priority in the country. The draw back in adaptation is attributed to low and poor scientific development as most development innovations are not built on indigenous knowledge of farmers, to provide for sustainability of new practices. The associated impacts of climate variation are predominantly negative, with the most severe impacts being experienced in vulnerable communities that accommodate the bulk of Nigerian farmers, practicing farming at subsistence levels with very weak capacity to adapt. Yam production and yield patterns are of economic importance to the livelihood of an average Shiroro farmer, as they have link with income generation and economic sustainability in rural communities in the state.

Adeleke (2014) study on the effects of climate variability on yam production in Benue State, Nigeria, used temperature as the only variable to determine the impact of climate variability on production with an important variable like rainfall being relegated to the background. However, the relevance of rainfall cannot be underestimated because yam needs considerable amount of water to survive. The is deficiency in the work of Adeleke (2014) creates a lacuna in literature which this study intends to fill by exploring how rainfall and temperature and its variability could also impact yam production.

Furthermore, the study will serve as a useful reference material to future researchers who would want to research into similar area. The study will therefore serve as an important document that will guide prospective researchers in their quest to researching into areas related to climate variability impact and adaptation. Finally, even though research on adaptation to climate variability seems to be on the increase there is still the need to conduct further research to enable the sharing of different adaptive strategies adopted by farmers at different places. This analysis will go a long way to influence policy makers to enable them document effective adaptive strategies that will help reduce the negative effect of climate variability on rural farming communities, especially those with similar environmental characteristics.

1.7 Study Area

Shiroro Local Government Area was created in May 1989. It was formally part of Chanchaga local government area. Kuta, the headquarters of Shiroro Local Government also served as a one-time headquarters of Chanchaga Local Government Area, in 1976. Is located on the downstream of Shiroro dam which is on the Kaduna River near Minna, and it is on longitude 6° 51’ 00” E and 6° 75’ 10’’ E longitude and latitude 9° 58’ 00” N and 9° 65’ 25’’ N (Imo *et al.*, 2011). The local government is made up of six districts as shown in the figure 1.1 below namely, Kuta, Galadima- Kogo, Manta, Gussoro, Gurmana, Allawa and Kushaka districts. Shiroro Local Government has an estimated population of 300,000 as at 2018. Gwari language is the major language spoken while other indigenous tribes such as Bassa, Gussoro and Gurmana are also predominant. Other tribes representing the diverse socio-cultural groups are equally found in this area, e.g. the Hausa, Fulani, and Igbo. Because of the rich fertile land of the area, the predominant occupation of the people is farming while other inhabitants earn their living through fishing due to the presence of the Shiroro dam along the Kaduna River.

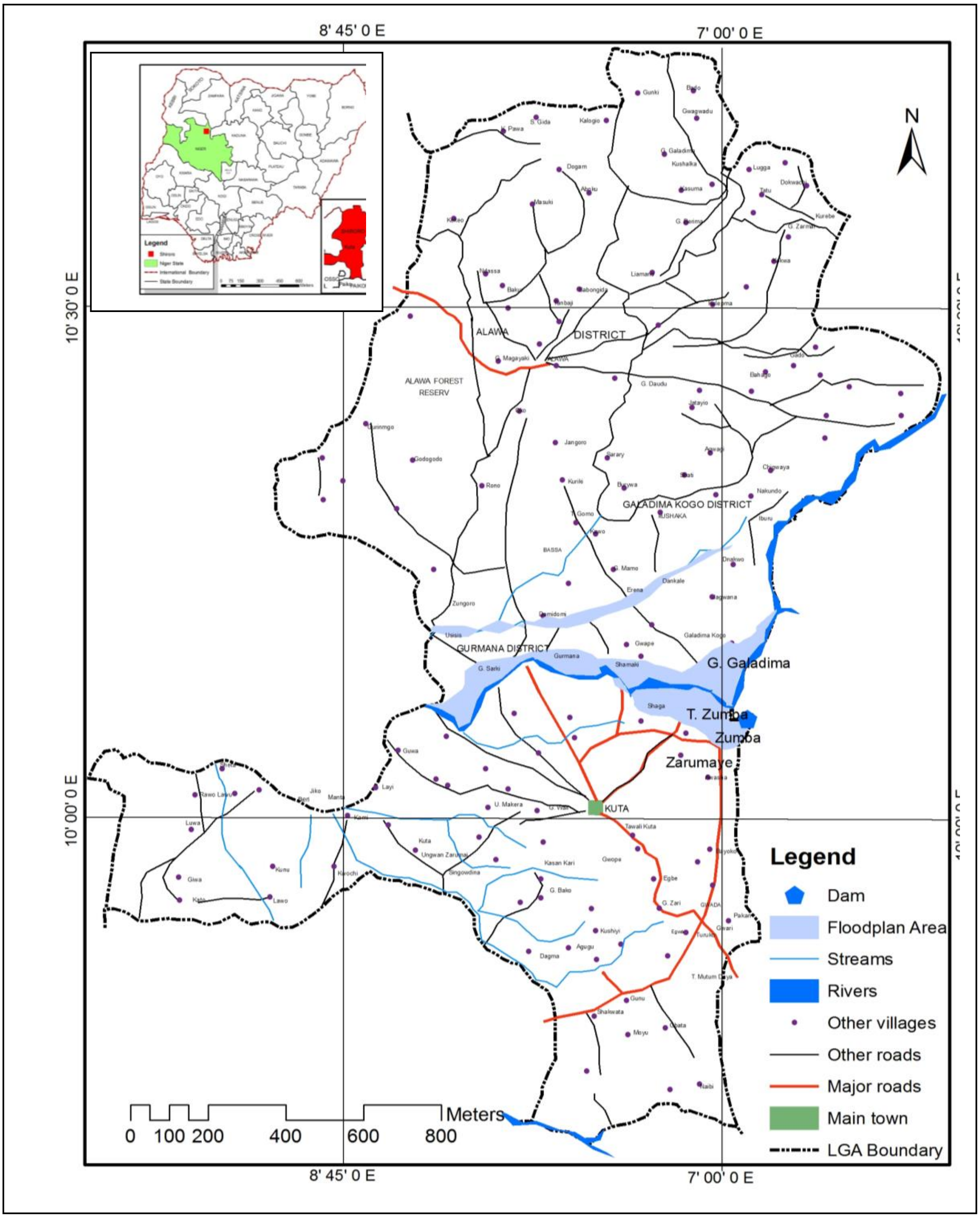

Figure 1.1 The study area
Source: Ministry of Lands and Husing

1.7.1 Climate

Shiroro has a climate, which is tropical and belongs to the tropical wet and dry, with rainfall varying between 1100mm in the north to 1600mm in the southern part of the area. The rainfall began at the end of April and increases in the month of July, August and September.

The maximum temperature of Gussoro is 33^0C and it takes place in the month of April and June and minimum temperature has 28^0C and it occurs in the month of August and September. The average mean temperature was 26.88^0C. The study area experienced high temperature mostly in the month of March, April and May while the remaining months have low temperature.

1.7.2 Soil and geology

Shiroro has rich alluvial soils with great agriculture. Geologically, it consists of hard granitic rock and it is about 2.5 kilometers in length (Imo *et al.,* 2011). Because of the rich fertile land of the area, the dominant occupation of the people in Gusoro is farming while few of the people rely on fishing for their living. The area is blessed with all the desirable resources of mother earth and lots of human resources. The area has gold, columbite and diamond which are commercially viable and rated as the major producer of rice, yam, maize, cottons, beniseed, groundnut, millet and guinea corn in the state.

1.7.3 Drainage system

In Shiroro LGA, Shiroro dam is located on the Kaduna River at the confluence of Dinya and Kaduna Rivers at Shiroro villages in Gussoro. River Kaduna is the major river feeding the lake in which the dam is built and there are 15 tributaries of the Kaduna River within the Shiroro watershed, the major among them being rivers Dinya, Sarkin Pawa, Guni, Erena, and Muyi. These tributaries flow in the north south direction and few in the northwest to southeast direction. There is a problem of low base of rivers and the volume of the rivers swell in volume with ranging torrent while in the dry season they dwindle to dry up.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual Framework

The production function stipulates the technical relationship between inputs and output in the production process (Olayide & Heady, 1982). This function is assumed to be continuous and differentiable in mathematical terms. The concept of efficiency is concerned with the relative performance of the process used in the production process (Upton, 1996). Three types of efficiency were identified. They include: technical, allocative and economic efficiency. Measurement of efficiency according to Ogunjobi (2014) is important for the following reasons: Firstly, it is a success indicator, performance measure by which productive units are evaluated. Secondly, only by measuring efficiency and separating its effects from the effects of the production environment can one explore hypotheses concerning the sources of efficiency differentials. Identification of sources of inefficiency is important to institution of public and private agencies designed to improve performance. Thirdly, the ability to quantify efficiency provides decision makers with mechanism with which to monitor the performance of the production system or units under their control. In some cases, theory provides no guidance or provides conflicting signals concerning the impact of some phenomena on performance. In such situations, empirical measurement provides qualitative as well as quantitative evidence.

2.1.1 Technical efficiency

Technical efficiency is based on expressing the maximum amount of output obtainable from given bundles of production resources with fixed technology. It is the attainment of production goals without wastage (Amaza & Olayemi, 1999). This is regarded as estimating average production function (Olayide & Heady, 1982). This definition assumes that technical inefficiency is absent from the production frontier. Farrell (1957) suggested a method of measuring technical efficiency of a firm in an industry by estimating the production function of firms which are fully efficient (i.e. frontier production function).

2.1.2 Allocative efficiency

Allocative efficiency on the other hand relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices (Coelli *et al*., 2002; Ogundari & Ojo, 2006). Russell and Young (1983) looked at Allocative efficiency (AE) as a condition that exists when resources are allocated within the firm according to market prices. In a materialistic society according to them, this will represent a desirable characteristic when market prices are a true measure of relative scarcity. This will be the case when prices are determined in perfectly competitive markets, but when prices are distorted by monopolistic influences or where some goods remain outside the market system the role of prices in resource allocation is greatly impaired. Lau and Yotopoulos (1989) stated that a farm is said to be allocatively efficient if it maximizes profit, that is, it equates its marginal product of every variable input to its corresponding opportunity cost. A farm which fails to do so is said to be allocatively inefficient.

2.1.3 Economic efficiency (EE)

Economic efficiency in Farrell's frame work, is an overall performance measure and is equal to the product of Technical Efficiency (TE) and Allocative efficiency (AE) i.e. EE = TE ´ AE. The simultaneous achievement of both efficient conditions according to Heady (1952) occurs when price relationship are employed to denote maximum profits for the firm or when the choice indicators are employed to denote the maximization of other economic objectives.

According to Adebayo *et al.* (2012) economic efficiency occurs when a firm chooses resources and enterprises in such a way as to attain economic optimum. The optimum implies that a given resource is considered to be most efficiently used when its marginal value productivity is just sufficient to offset its marginal cost. Thus, economic efficiency refers to the choice of the best combination for a particular level of output which is determined by both input and output prices.

2.1.4 Agricultural production and climate variability

The Agricultural sector has always been an important component of Nigerian economy with over 70% of the population engage in agriculture and agricultural related activities. The sector is almost entirely dominated by small scale resource poor farmers living in rural areas, with farm holdings of 1-2 hectares, which are usually scattered over a wide area. The farms dominated by these small scale farmers are responsible for about 95% of the total production. In addition, small scale agriculture has in the time past suffered from limited access to credit facilities, modern technology farm input and inefficient use of resources (Izekor & Olomese, 2010). Agriculture has played and will continue to play a key role in the Nigerian economy. The sector holds the key to rapid economic transformation, poverty alleviation, stable democracy and good governance. There is no national security without food security. Though Nigeria is still a net importer of food, she provides nearly all the staple food consumed by the Nigerian population and exports substantial quantities of food especially to the Economic Community of West Africa States (ECOWAS) sub-region. The sector recorded a growth rate of 5.4 in 2002 when the estimated growth rate of agriculture GDP in 2003 is 7% (CBN annual report 2001/2003). The output of some major crops namely; sorghum, rice, yam, cassava has increased in year 2002. This improved performance was attributed to the renew support by federal government to the agricultural sector which is reflected in the approval of new agricultural policy in 2002.

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, and climate extremes (e.g., heat waves); changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods (Milius, 2017) and changes in sea level (Hoffmann, 2013).

Climate change is already affecting agriculture, with effects unevenly distributed across the world (Hoffmann, 2013). Future climate change will likely negatively affect crop production in low latitude countries, while effects in northern latitudes may be positive or negative. Peter (2014), Climate change will probably increase the risk of food insecurity for some vulnerable groups, such as the poor. Blancka (2014), Animal agriculture is also responsible for CO2 greenhouse gas production and a percentage of the world's methane, and future land infertility, and the displacement of local species.

Agriculture contributes to climate change both by anthropogenic emissions of greenhouse gases and by the conversion of non-agricultural land such as forests into agricultural land (Milius, 2017). Agriculture, forestry and land-use change contributed around 20 to 25% of global annual emissions in 2010. A range of policies can reduce the risk of negative climate change impacts on agriculture (Oppenheimer, 2014) and greenhouse gas emissions from the agriculture sector (Peter, 2014).

The Intergovernmental Panel on Climate Change (IPCC) has produced several reports that have assessed the scientific literature on climate change. The IPCC Third Assessment Report, published in 2001, concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence. In Africa and Latin America many rainfed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply for even small climate changes; falls in agricultural productivity of up to 30% over the 21st century are projected. Marine life and the fishing industry will also be severely affected in some places.

Climate variability induced by increasing greenhouse gases is likely to affect crops differently from region to region. For example, average crop yield is expected to drop down to 50% in Pakistan according to the Met Office scenario whereas corn production in Europe is expected to grow up to 25% in optimum hydrologic conditions. More favourable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization.

In the long run, the climatic change could affect agriculture in several ways:

- *Productivity*, in terms of quantity and quality of crops
- *Agricultural practices*, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers
- *Environmental effects*, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity

- *Rural space*, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities.
- *Adaptation*, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

They are large uncertainties to uncover, particularly because there is lack of information on many specific local regions, and include the uncertainties on magnitude of climate change, the effects of technological changes on productivity, global food demands, and the numerous possibilities of adaptation.

Most agronomists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there may be enough time for biota adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaption.

But much remains unknown about exactly how climate change may affect farming and food security, in part because the role of farmer behaviour is poorly captured by crop-climate models. For instance, Evan Fraser, a geographer at the University of Guelph in Ontario Canada, has conducted a number of studies that show that the socio-economic context of farming may play a huge role in determining whether a drought has a major, or an insignificant impact on crop production (Fraser, 2008) In some cases, it seems that even minor droughts have big impacts on food security (such as what happened in Ethiopia in the early 1980s where a minor drought triggered a massive famine), versus cases where even relatively large weather-related problems were adapted to without much hardship (Simelton *et al.*, 2009). Evan Fraser combines socio-economic models along with climatic models to identify “vulnerability hotspots” (Monier and Snyder, 2016). One such study has identified US maize (corn) production as particularly vulnerable to climate change because it is expected to be exposed to worse droughts, but it does not have the socio-economic conditions that suggest farmers will adapt to these changing conditions (Harding *et al.*, 2015). Other studies rely instead on projections of key agro-meteorological or agro-climate indices, such as growing season length, plant heat stress, or start of field operations, identified by land management stakeholders and that provide useful information on mechanisms driving climate change impact on agriculture.

Agriculture is a climate dependent activity that places serious burden on the environment in the process of providing the teaming Nigeria population with food and fibres. The effect of climate on agriculture is related to variability in local climates rather than in global climate patterns (Fraser, 2008). Climatic variation is the mean state of climate on all temporal and spatial scales of weather events (Adger *et al.,* 2003). Climate change is often used synonymous with climate variability and yet the two are different. Climate change refers to the long-term significant change in the “average weather” that a given region experiences, while climate variation refers to variation in the mean state and other statistics of climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2007). Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods spanning from decades to millions of years, while climate variation is a short-term fluctuation in weather patterns spanning from years to decades.

Climate variability is the resultant effect in the alterations of ecosystem structures to satisfy human land use and livelihood potentials of the human race. Effects of climate variation are physical, economic, social and cultural, endangering environmentally based livelihoods of the Nigeria population. Climate variability have direct impacts that causes vulnerability to the natural and social systems through changes in average temperatures, temperature extremes and extreme weather events like flooding and droughts.

Adaptation is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderated harm or exploits beneficial opportunities (UNFCCC, 2007). The yam farmers, to a large extent have been able to develop their livelihood strategies in a way that enables them to constantly cope and adapt to the changing climatic conditions, pest attack and agricultural policies in the country. Farmers" ability to adapt to impacts of climate variation depends on factors such as wealth, technology, education, information, infrastructure, access to resources and management abilities. There is need to gain as much information as possible and learn the positions of the rural farmers and their needs about what they know about climate variation and change in order to offer adaptation practices that meet their needs (Lobell *et al.*, 2008).

2.1.5 Projections of impacts

As part of the IPCC's Fourth Assessment Report, Schneider *et al.* (2007) projected the potential future effects of climate change on agriculture. With low to medium confidence, they concluded that for about a 1 to 3 °C global mean temperature increase (by 2100, relative to the 1990–2000 average level) there would be productivity decreases for some cereals in low latitudes, and productivity increases in high latitudes. In the IPCC Fourth Assessment Report, "low confidence" means that a particular finding has about a 2 out of 10 chances of being correct, based on expert judgement. "Medium confidence" has about a 5 out of 10 chances of being correct (Schneider, 2007). Over the same time period, with medium confidence, global production potential was projected to: increase up to around 3 °C; very likely decrease above about 3 °C. Most of the studies on global agriculture assessed by Schneider *et al.* (2007) had not incorporated a number of critical factors, including changes in extreme events, or the spread of pests and diseases. Studies had also not considered the development of specific practices or technologies to aid adaptation to climate change (Parry, 2007).

The IPCC Fourth Assessment Report also describes the impact of climate change on food security. Projections suggested that there could be large decreases in hunger globally by 2080, compared to the (then-current) 2006 level (Smith, 2018). Reductions in hunger were driven by projected social and economic development. For reference, the Food and Agriculture Organization has estimated that in 2006, the number of people undernourished globally was 820 million. Three scenarios without climate change (SRES A1, B1, B2) projected 100-130 million undernourished by the year 2080, while another scenario without climate change (SRES A2) projected 770 million undernourished. Based on an expert assessment of all of the evidence, these projections were thought to have about a 5-in-10 chance of being correct.

The same set of greenhouse gas and socio-economic scenarios were also used in projections that included the effects of climate change. Three scenarios (SRES A1, B1, B2) projected 100-380 million undernourished by the year 2080, while another scenario with climate change (SRES A2) projected 740-1,300 million undernourished. These projections were thought to have between a 2-in-10 and 5-in-10 chance of being correct. Projections also suggested regional changes in the global distribution of hunger. By 2080, sub-Saharan Africa may overtake Asia as the world's most food-insecure region. This is mainly due to projected social and economic changes, rather than climate change.

In South America, a phenomenon known as the El Nino Oscillation Cycle, between floods and drought on the Pacific Coast has made as much as a 35% difference in Global yields of wheat and grain (Parry, 2007). Looking at the four key components of food security we can see the impact climate change has had. Food "Access to food is largely a matter of household and individual-level income and of capabilities and rights" (Wheeler *et al.*, 2013). Access has been affected by the thousands of crops being destroyed, how communities are dealing with climate shocks and adapting to climate change. Prices on food will rise due to the shortage of food production due to conditions not being favourable for crop production. Utilisation is affected by floods and drought where water resources are contaminated, and the changing temperatures create vicious stages and phases of disease. Availability is affected by the contamination of the crops, as there will be no food process for the products of these crops as a result. Stability is affected through price ranges and future prices as some food sources are becoming scarce due to climate change, so prices will rise.

2.1.6 Rainfall variability

Rainfall has continued to be the most important climatic parameter with the highest spatial and temporal variability over most part of Nigeria. the variability and seasonality of rainfall are generally associated with seasonal characteristics of the inter-tropical discontinuity (ITD) and other Meso-scale circulatory features (Akande, 2002).

Rainfall variability has been the subject of much comment, but in reality, comparatively little quantitative analysis of this factor has been undertaken in Sudan Sahel. generalization has been made from often insufficient evidence. various aspect of the rainfall of Sudan Sahel have been studied based on monthly and annual rainfall values. the knowledge of annual rainfall trend variability and periodicities could help in predicting future incidence and probability of rainfall in the region. Hence, it is pertinent to examine some school of thought of various scholars who has conducted studies on such phenomena. This chapter critically review some important previous and recent works of scholars based on content and methodology (Akande, 2002).

Anuforom and Okpara (2003) investigated the general characteristics of rainfall in Nigeria (that is amount, variability onset, cessation etc) and its effect on agricultural production in the four (4) climatic zones of Nigeria. They used 60years of monthly rainfall data and 15years of onset and cessation dates data. They also used 30years of agricultural yield and livestock data. The methodologies they used were the time series and variability analysis. The result showed that I the Sahel and Sudan Savannah climate zone located north of latitude 8^0N, exhibited a 'unimodal' rainfall pattern, while the Guinea Savannah and Tropical rainforest zones located South of latitude 8^0N showed a 'biomodal' pattern. Further results showed some climatic variation which appeared as fluctuations of wet and dry years in an irregular patter. Most rainfall between 1944-1970 and 1991-2001 were above normal for the zone, while the rainfalls between 1972-1975, 1983-1989 (Sokoto, Kano), and 1981-1988 (Maiduguri) were below normal. These were drought years and most of which coincide conform to the EL-NIMO years. The rainfall trend analyses for the four climatic zone show similar characteristics, except that the decreasing and critical over the Sahel region than other zones. They also observed that most of the zones received normal rainfall during the weak (1992-1994), moderate (1991) and strong (1972 and 1982) El-Nino southern Oscillation (ENSO) years. Further result showed that most of the climate zones are already under water stress or water scarcity and exhibits obvious relationship with output of agricultural crop and livestock in the zones.

2.2 Yam Production

2.2.1 Yam production in Nigeria

Nigeria is by far the world's largest producer of yams, accounting for over 70–76 percent of the world production. According to the Food and Agricultural Organisation report, in 1985, Nigeria produced 18.3 million tonnes of yam from 1.5 million hectares, representing

73.8 percent of total yam production in Africa. According to 2008 figures, yam production in Nigeria has nearly doubled since 1985, with Nigeria producing 35.017 million metric tonnes with value equivalent of US$5.654 billion. In perspective, the world's second and third largest producers of yams, Côte d'Ivoire and Ghana, only produced 6.9 and 4.8 million tonnes of yams in 2008 respectively. According to the International Institute of Tropical Agriculture, Nigeria accounted for about 70 percent of the world production amounting to 17 million tonnes from land area 2,837,000 hectares under yam cultivation (Adger, 2003).

Yam, a tropical crop in the genus *Dioscorea*, has as many as 600 species out of which six are economically important staple species. These are: *Dioscorea rotundata* (white guinea yam), *Dioscorea alata* (yellow yam), *Dioscorea bulbifera* (aerial yam), *Dioscorea esculant* (Chinese yam) and *Dioscorea dumetorum* (trifoliate yam). Out of these, *Dioscorea rotundata* (white yam) and *Dioscorea alata* (water yam) are the most common species in Nigeria. Yams are grown in the coastal region in rain forests, wood savanna and southern savanna habitats.

Yam is in the class of roots and tubers that is a staple of the Nigerian and West African diet, which provides some 200 calories of energy per capita daily. In Nigeria, in many yam-producing areas, it is said that "yam is food and food is yam." How profound is that, son? However, the production of yam in Nigeria is substantially short and cannot meet the growing demand at its present level of use. It also has an important social status in gatherings and religious functions, which is assessed by the size of yam holdings one possesses (Oluwatusin, 2006).

Root and tubers crops comprise crop covering several genera. They are stable food crops, being the source of source of daily carbohydrate intake for the large populace of the world. The term refers to any growing plant which store edible materials in subterranean root, corm or tuber (Oke, 1990). Yam is a member of this important class of food. Yam atropical crop in the genus Dioscorea has as many as 600 species out of which six are economically important staple species. These are: Dioscorea rotundata (white guineayam), Dioscorea alata (yellow yam), Dioscorea bulbifera (aerial yam), Dioscorea esculent (Chinese yam), and Dioscorea dumetorum (trifoliate yam). These are perennial herbaceous vines cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America and Oceania. Yam is an important food crop especially in the yam zones of West Africa, comprising Cameroun, Nigeria, Benin, Togo, Ghana and Cote d'Ivoire. This zone produces more than 96% of the total world production which is estimated at about 20-25 million tons per year. Nigeria is the main producer of yam in the world with about 67.7% of the world output followed by Cote d'Ivoire, Ghana, Benin and Togo (FAO, 2010). Available data also shows that yam is one of Nigeria's leading root crop.

Table 2.1: Summary of yam production data of various countries in Africa

Location	**Cultivation area**	**Yield**	**Production**	**Percentage**
World	4, 928	10. 5	51. 778	100. 0
Africa	4, 718	10, 6	49. 833	96. 3
West Africa	3, 045	11. 5	35, 017	07. 7
Nigeria	8 20	8. 5	6, 933	13. 4
Cote d'voire	11,768	10.89	9.87	78.5
Ghana	2 99	11. 9	3, 550	6. 9
Benin	2.05	8.8	1.803	3.5
Togo	6.3	10.2	6.38	1.2

Source: FAO, 2010

As a food crop, the place of yam in the diet of the people of Nigeria cannot be overemphasised. It contributes more than 200 dietary calories per capital daily for more than 150 million people in West Africa while serving as an important source of income to the people. Yam has some inherent characteristics, which make it attractive, first, it is rich in carbohydrate especially starch consequently has a multiplicity of end use. Secondly, it is available all year round making it preferable to other seasonal crops (Izekor & Olomese, 2010). According to Oyenuga (1968), yam contains a higher value in protein (2.4%) and substantial amount of vitamins (Thiamine, Riboflavin and Ascorbic acid) and some other minerals like calcium, phosphorus and iron than any other common tuber crop. It is also comparable to any starchy root crop in energy and the fleshy tuber is one of the main sources of carbohydrate in the diet of many Nigerians. CGIAR (1997), also reported that yam tends to be higher in protein and minerals like phosphorus and potassium than sweet potatoes though the latter is richer in Vitamin A and C. Yam is a preferred food and a food security crop in some sub-Saharan African countries. Yam could be eaten as boiled yam or fried in oil. it can also be processed into yam flour or pounded yam. Moreover, yam is also a source of industrial starch, the quality of which varies with the species. Apart from this, yam also plays vital roles in traditional culture, rituals and religion as well as local commerce of the African people (Coursey,1967).

Yam is reported to be part of the religious heritage of several Nigerian tribe and up to date often play a key role in religious ceremony. Worthy of note is the fact that many important cultural values are attached to yam, especially during wedding and other social ceremonies. In many farm communities in Nigeria and other West African countries, the size of the yam farm that one has is a reflection of one's social stature. Due to the importance attached to yam many communities celebrate the new yam festival annually. Yam production in Nigeria has more than tripled over the past 40 years from 6.7 million tones per annum in 1961 to 27 million tones per annum in 2001 (FAO, 1999). This increase is however attributed to larger hectares of land planted to yam than to increased productivity. This decline in average yield per hectare in Nigeria has been rather drastic dropping from 14.9% in 1986-1990 to -2.5% in 1999 (CBN, 2002).

2.2.2 Yam production in geographic regions

The farmland production system consists of wetland (20% farms are under this category), upland (50% farms in this category) types and a combination of the two types (30% by the balance farms). A study carried out on the efficiency of the three systems to improve crop outputs to meet growing demands for this food crop, indicates that the "wetland yam based enterprises are the most economically efficient with mean economic efficiency of 0.80 followed by upland yam based enterprises with mean efficiency of 0.79." The combination of wetland/upland yam based enterprises is assessed as the least economically efficient, with mean efficiency of 0.76. Hence, it has been recommended that more yams should be grown more on wetlands. Another recommendation made is to adopt the yam minisett technology developed by the International Institute for Tropical Agriculture (IITA) and the National Root Crops Research Institute (NRCRI) (Olayide, 2004).

Although it is grown widely in Nigeria, the area where it is grown most is the Benue State (land area of 802,295 km^2) one of the states in Benue valley of Nigeria where the labour-intensive practices are still the norm and the land holdings are small. In this state especially among Tiv people, the size of the yam farm or the tonnage of yams produced becomes the social status of that farmer. Because of high level of yam production in the State of Benue, Benue State is crowned as the Nigerian Bread Basket. Yams are planted on mounds rather than flat slopes depending on the hydromorphic nature of the soils which are generally of loose soil suitable to grow roots and tuber crops. While yam production issues have been stressed on agronomical practices, a research study carried out on the economic efficiency of this crop grown in this region with small farm holdings, which is labour-intensive, reveals that land, labour and material (fertilizers and chemicals), credit and extension services inputs have a significant bearing on the yield of yam in the region (Olayide, 2004).

Yam is grown on free draining, sandy and fertile soil, after clearing the first fallow. Land is prepared in the form of mound or ridge or heap of 1 metre (3 ft 3 in) height. The yams recommended for such soil conditions in Nigeria are white yam or white guinea yam *(Discorea rotundata)* and water yam or yellow yam *(Discorea alata)*. Planting is done by seed yam or cut setts from ware tubers. One day before planting, the tubers have to be subjected to treatment with wood ash or a fungicide (thiabendazole) to prevent damage to the soils. The setts are planted at an interval of 15–20 centimetres (5.9–7.9 in) with the cut face facing up. Mulching is essential during October–November with dry grass or plant debris weighed down with balls of mud. Dosage of fertilizer application, as essential, is decided after chemical analysis of the soil samples. Manual weeding by hoeing is done three or four times depending on the rate of weed growth. Two Stakes, each of 2 metres (6 ft 7 in) height are used for staking the plants to vine over it; one for two plants with the other used for bracing with the adjacent stakes. Sorghum stovers are also used for this purpose in the savannah land. Pest and disease control is addressed by cultural control and chemical methods; the pests which affect the plant are nematodes such as root knot *Meloidogyne* spp. and yam nematode *(Scutellonema bradys)*, and insects such as yam shoot beetle, yam tuber beetle and crickets. Weeding of the field is essential and maintaining a 2–3 metres (6 ft 7 in–9 ft 10 in) weed free border around the field is to be ensured. Disease resistant [cultivars] are normally recommended for use. Harvesting is done before the vines become dry and soil becomes dry and hard. Generally, a yield of 10–15 tonnes per ha for white yam and 16–25 tonnes for water yam are obtained by following prescribed management practices. The harvested yams are stored by tying them with ropes. They have a shelf life of about 5 months. Warehouses where they are stored should be made rodent proof with a metal base and wire netting. Rotten buds and sprouted buds should be removed (Akande, 2002).

2.2.3 Yam uses in Nigeria

Tuber is the main part of the yam plant which has high carbohydrate content (low in fat and protein) and provides a good source of energy. Unpeeled yam has vitamin C. Yam, sweet in flavour, is consumed as boiled yam (as cooked vegetable) or fufu or fried in oil and then consumed. It is often pounded into a thick paste after boiling and is consumed with soup. It is also processed into flour for use in the preparation of the paste. Its medicinal use as a heart stimulant is attributed to its chemical composition, which consists of alkaloids of saponin and sapogenin. Its use as an industrial starch has also been established as the quality of some of the species is able to provide as much starch as in cereals (Akande, 2002).

2.2.4 Yam rituals and festivals

Ritualism and festivity restriction are also associated with yam, which is the staple in southeastern Nigeria. A yam festival is held every year to mark the harvesting of this crop. The village chiefs and traditional title holders of lands in Nigeria who grow yam make it a religious practice by not consuming yam till it is offered to the gods. During this festival, villagers offer prayers thanking their ancestral gods for the blessings of the land and the women's fertility. The festivity observed in villages is in the form of a parade of traditional dances (Akande, 2002).

2.2.5 Implications of changes in rainfall on crop yields in Nigeria

While efforts to mitigate climate change through negotiations are progressing, suggestions for greater investments in adaptations, with its philosophy of learning to live with climate change, are being heeded. To be able to formulate policies on adaptation strategies, it is necessary to measure and assess the impacts of climate change on the affected human, biological and physical systems (Awoniyi, 2005).

In Nigeria, agriculture is the main source of food and the main employer of labour, employing about 60-70% of the population. Cereals (notably millet and sorghum), groundnuts and beans dominate crop production in the northern part of the country, while the dominant crops in the south are cassava, yam, palm produce, cocoa and rubber. It is a significant sector of the economy and also the source of a lot of raw materials used in the processing industries, as well as a source of foreign exchange earning for the country. It follows therefore that any change in climate is bound to impact on the agriculture sector in particular and other socio-economic activities in general. Climate change could have both positive and negative impacts. The impacts could be measured in terms of effects on crop growth, availability of soil water, soil fertility, soil erosion, incidents of pests and diseases, and sea level rise (Awoniyi, 2005).

2.2.6 Effect of rainfall and yam production

Rainfall variation is a relatively new phenomenon to many people in the sense that it is only about now that it is being better understood. It is however an environmental phenomenon that has taken mankind a long time to understand. A discussion on climate change, at the level of introduction such as this, should start by raising important issues which make the subject matter the critical one it is in the survival of man and his well-being. Climate change touches very much on many sectors as will be seen later. It affects many factors that determine success or otherwise of many agricultural practices. Perhaps its impact on agriculture is very significant and this is understandable. Agriculture is the first occupation of man and has remained a primary and important one ever since. Without good, man will not survive on earth; and without agricultural resources, many industries will close down (Olayide, 2004).

Climate is the mean atmospheric condition of a place over a long period of time say 35 years. The climate of an area can only be determined by considering the climatic elements such as precipitation. (Rain), temperature, wind relative humidity, sunshine, etc. The interaction of these elements will determine the climatic type of the area which latter influence man and his activities; it goes further to the suitability of the environment and plant survival, its growth and yield which makes plant environmental factors very important. Climate is studied in relation to agriculture because of its effects and influence on crop yield; what is planted, where it's planted, how it could be planted and when it's planted. Climate is not the only factor which affects agricultural production; there are other factors such as soil is fertility which is also important to plant growth but no matter how fertile or rich a soil is without favourable climatic conditions, the expected yield would be poor (Olayide, 2004). Although, it is unclear which came first, the word "yam" is related to Portuguese in name or Spanish name which both ultimately derived from the Wolof word yam, meaning "to sample" or to "taste" in other African languages it can also mean "to eat" for instance Doya in Hausa, Isu in Yoruba, an Ji in Igbo.

Yams are primary agricultural commodities in West Africa and New Guinea; they were first cultivated in Africa and Asia about 8000 BC. Due to their abundance and consequently, their importance to survival, yam is highly regarded in Nigeria ceremonial culture and used in vegetable offered during blessing. Yams are the main stable food crops of the people for years even before diffusion of maize and other good crops. Over the years, considerable importance has attached to the crop.

Nigeria's leading root crops both in terms of land under cultivation and in the value of products. To verify this, the 1993 world production of yam put at 28.1 million tones out which 96% came from west Africa the main producers being Nigeria with 71% of the world production, follow by Cote Divoire with 8.1%; Benin: 4.3% and Ghana 3.5%. in the humid tropical countries of West Africa, yam is one of the most highly regarded food products and is closely integrated into the social, cultural, economic and religious aspect of life. Traditional ceremonies still accompany yam production indicating the high status given to the food crop (Olayide, 2004).

2.3 Review of Related Literature

Cline (2012) looked at how climate change might affect agricultural productivity in the 2080s. His study assumes that no efforts are made to reduce anthropogenic greenhouse gas emissions, leading to global warming of 3.3 °C above the pre-industrial level. He concluded that global agricultural productivity could be negatively affected by climate change, with the worst effects in developing countries.

Lobell *et al.* (2008) assessed how climate change might affect 12 food-insecure regions in 2030. The purpose of their analysis was to assess where adaptation measures to climate change should be prioritized. They found that without sufficient adaptation measures, South Asia and South Africa would likely suffer negative impacts on several crops which are important to large food insecure human populations.

Battisti and Naylor (2014) looked at how increased seasonal temperatures might affect agricultural productivity. Projections by the IPCC suggest that with climate change, high seasonal temperatures will become widespread, with the likelihood of extreme temperatures increasing through the second half of the 21st century. Battisti and Naylor (2014) concluded that such changes could have very serious effects on agriculture, particularly in the tropics. They suggest that major, near-term, investments in adaptation measures could reduce these risks.

Jodie (2013) suggests that climate change could cause farm output in sub-Saharan Africa to decrease by 12% by 2080 - although in some African countries this figure could be as much as 60%, with agricultural exports declining by up to one fifth in others. Adapting to climate change could cost the agriculture sector $14bn globally a year, the study finds.

Easterling *et al.* (2012) showed that in the Sahel region of Nigeria there has been a decrease in the heaviest daily precipitation amount. They provided a generalized pattern which is apparent throughout the Sudano-Sahelian zone including the Absissinian plateau.

Dewar and Wallis (2014) under took a Geographical pattering of inter-annual rainfall variability in the Tropics. The analyzed historical records of monthly rainfall totals for 1,492 stations within 30^0N and S of the equator using the methods of L-Moments. The O.1 quantities (QU_{10}) or the proportion of mean annual rainfall expected in the driest year in 10, was selected as the measure of variability. A non-linear regression was fit to the relationship between QU_{10} and mean annual rainfall and regions were categorized into three classes on the basis of the residuals.

Adefolalu (1986) made use of Ogive to determine the onset and cessation in annual rainfall graph. He suggested onset 5days pentad approach to determine onset and cessation dates. Onset at the first point of inflection and cessation marked by the last inflection point to the second time of the graph. He observed that there is a decreasing trend in the mean annual rainfall in Northern Nigeria and is a function of the decreasing frequency of wet spells.

Olofin (1985) wrote on the climate of Sudano Sahellian Zone of Nigeria. He assessed it as a subhumid to semi-arid climate. He considered rainfall, temperature and evapotranspiration as the significant elements in the region that are affecting agriculture.

Adefolalu (1986) in his contribution explained that during the wet season everywhere get wet, the rivers, streams filled up to their paves and in some cases over-flowing their banks.

This can lead to flood. Lack of good water drainage and water channels for easy water flow may lead to water flooding farms, houses and other places which will lead to loss of lives and properties. Ojo (1977) and Obasi and Adefolalu (1987) show that previous studies of climate and its variabilities in Nigeria reveal that apart from the rainfall amount others measure of precipitation effectiveness must include derive parameters like onset and cessation, states of the rain. Also, Adefolalu (1986) implore the use of Length of Raining Season (L.R.S) as another derived parameter to be used.

Harnessing water in dams and reservoir for irrigation and provision of water for drinking has been pursued vigorously in Nigeria, in response to recent droughts of 1983 in the northern parts of the country. Although alternating wet and dry years have always been observed in tropical rainfall data; as mentioned by Oguntoyinbo (1978) and Adefolalu (1972) indicated result in the shortfall in absolute rainfall amount may be less critical than severe abbreviation in the onset, cessation and length of raining season, in this connection, the length of raining season may be more relevant in drought years than just the amount received. As it is common in the tropics, heavy convective showers which account for most of the annual rainfall are observed during both pre- and post-monsoon months while steady and moderate rains dominate during peak monsoon months (Alaka and Maloney, 2012). When such showers are either delayed or cut-short prematurely, the entire rainy season is reduced in duration and even, when sufficiently high rainfall is recorded for the year, the damage done to plant development and life (man and animals alike) will be more disturbing. It is well-known that the three types of drought usually associated with environmental degradation are meteorological, agricultural and hydrological droughts. Hydrological drought is the most severe in relation to water resources as it suggests domination in the amount of under-ground water (lowering of the water table) which takes time to replenish. When total annual rainfall amount do not change but temporal distribution (Fraser, 2008).

This also occur due to long breaks in rainfall in course of a particular planting season, which relates to seasonal vegetation development and a situation in which the demand for water by plant is not met these are agricultural drought (Fraser, 2008). Meteorological drought has been blamed for the large-scale destruction of plant and animal life in drought prone-areas of west Africa usually defined as a diminution in rainfall amount repetitive in nature. Wet and dry spells are to be expected anywhere in West Africa and as previously documented by Adefolalu (1998).

In his study Adefolalu (1986) observe that one can see that both the hydrological and Agricultural drought are once affecting the region, but work is now been carried out on meteorological drought causes, to give an accurate data for both the hydrological and agricultural drought causes, as in the present study, precipitation effectiveness is considered as a function of not only the amount of rainfall but also of spatial and temporal distribution patterns, such characteristic of seasonal rainfall as onset, cessation and length of the rainy season are used to explain how they may constitute important drought indicators in sahelian Africa (Fraser, 2008).

Man continues to interfere with his environment to which this interference affects the ecological balance is not yet clear, studies on rainfall characteristics may reveal consequences of such interference in relation to local convection. It has been hypothesized that with higher albedo, resulting from over-exposure of bare soil to insolation thermal convection is reduced in the sahel In the Niger desert of the Sinai have also confirmed that such reduced convection leads to decrease precipitation, also in their studies of the sahel, Bryson and Baerreis (1975) in the Rajastthan desert of India shows that surface temperature are reduced by as much as 4-5^{o}c due to higher convection.

Climate change is perhaps the greatest challenge facing our planet today (Adebayo and Oruonye, 2012). Some of these challenges manifest themselves in the form of drought, flooding and inundation of coastal lands, low agricultural productivity, alteration of surface and ground water and devastation of ecosystems among others. There is a growing consensus in the scientific literature that over the coming decades, higher temperature and changing precipitation levels caused by climate change will depress crop yields in many countries (Orindi *et al.*, 2006; Stige *et al.*, 2006). Several studies have shown that temperature is rising and rainfall frequency and intensity is fluctuating (Mendelsohn *et al.*, 2000; Paavola, 2006; Ozor & Cynthia, 2010; Mohammed *et al.*, 2013). The world average temperature rise has been given as 0.91oC (Dube & Phiri, 2013).

Available meteorological data in the country shows evidence of increasing air temperatures since about 1920s (NEST, 2003). For example, Anuforom (2010) and Odjugo (2010) observed that within 105 years, temperatures increased by 1.2oC and 2oC in the coastal cities of Niger Delta and northern extreme of Nigeria respectively.

Mohammed *et al.* (2013) observed that in Adamawa State of Nigeria, climatic data (temperature and rainfall) analysis over the past 25 years (1980-2005) shows that temperature has increased by 0.3^0C and rainfall fluctuated over the years (Sawa and Adebayo, 2010; Audu, 2013). In Taraba state, evidence of climate change includes delayed onset date of rains, increase in number of dry days during the raining season and increase in maximum temperature (Adebayo and Oruonye, 2012). This leads to warmer seasons, increased frequency and intensity of weather extreme events such as drought, decline in rainfall amount by about 15-20%, increased incidence of dry spell (Anuforom, 2010 cited in Mohammed *et al.*, 2013). The problems of flood, high temperature and incidences of pests and diseases have also aggravated the farmers' loss which consequently increases the incidence of poverty and malnutrition in the state (Adebayo *et al.*, 2012).

Adger *et al.* (2007) posited that climate variability, poor infrastructure, economic poverty, drought, excess rainfall, poor livestock health, reduced crop yields, low productivity and a range of other problems associated with climate variability will constitute important challenges for Africa Countries in particular. The effect of climate variation is being felt by the whole population but, it will disproportionately affect vulnerable groups and vulnerable population (Lobell *et al.*, 2008).

Africa's population in which Nigeria is a key player in terms of population size and market for agricultural produce domestically is very vulnerable to climatic and non-climatic changes, due to high level of poverty, conflicts and prevalence of diseases. Changes in climate are severely affecting agricultural production in many African countries (UNEP, 2007). Increased temperatures and accompanying decrease in water availability reduce the length of growing seasons and yield potential and hence the areas suitable for agriculture, further adversely affecting food security over the continent (Thornton *et al.*, 2006).

CHAPTER THREE

3.0 MATERIALS AND METHODS

This chapter focuses on the study methodology. The chapter delves into the research approach and design for the quantitative and qualitative studies as well as the types, sources and methods for data collection. It also discusses the sampling procedure, the target population, the sampling technique, sampling design, sampling frame, sample size and data analysis.

3.1 Types and Sources of Data

Data used in this research work were generated from both primary and secondary sources. Primary source involves the use of structural questionnaire, a baseline survey was conducted at Shiroro Local Government Area to determine the extent of yam yield in the area. Annual yield daily of yam production in Shiroro was obtained from Niger State Agricultural Development Programme while the monthly climatic data for 30 years (1988-2018) was collected from NIMET at Shiroro.

Field observations was employed by the researcher to complement the other data collection instruments to get first-hand information on what was happening on the ground regarding their farming activities with particular interest in their adaptation practices. The participant observation technique was employed as the researcher was part of the subjects of the study (farmers) as well as part of the environment to be observed without the farmers knowing the true identity of the researcher.

3.2 Sampling Techniques

Samples were selected using multi-stage sampling technique. The first stage included purposive selection of Yam farmers in Shiroro local government area. This was followed by the selection of the three communities that are well known to be yam farming communities, the three communities are (Gusoro, Kuta and Gwada), while the third stage involved a simple random selection of 50 farmers in each village totaling 150 farmers altogether. The farmer's response was basically on examine the strategies adapted by yam farmers towards the effect of climate variability in their community.

3.3 Methods of Data Analysis

All data collected were subject to statistical analysis. Rainfall data was obtained on monthly basis for 30 years (1988 to 2018) and convert to mean annual values using the statistical technique. Time series analysis was used to calculate and linear trends analysis will be used to check the trends in climatic records. The responses from the questionnaire were analyzed statistically using descriptive statistics. Frequency analysis used to analysis the response of the farmers.

Examination of the trends in climate over Shiroro Local Government Area 30 years (1988 to 2018). Rainfall data of the study was acquired from 1988 to 2018, the daily and monthly record was computed and the mean value determine. Descriptive statistics in SPSS was used to analysis the data and the variation in rain fall was determine. Linear trend as well as line chart was used to analyse the trend of climate variability in the area. The line chart, trend line, trend equation and the degree of variation was used to determine the nature and direction of the trend of the variables under investigation annual rainfall. Again, the inter-annual anomalies for the time series data (rainfall) was calculated to assess the year to year variability of the rainfall variables over (1998 to 2018) in the study area.

Model specification

The model for trend analysis was used in accordance with Diebold (2007) and Okoye *et al.*, (2008).

$$LnY = b0 + b1t + bir + b,rh + ei \quad (3.1)$$

Where,

Y = output of yam (tons/ha); r = rainfall (mm); ei = stochastic error term.

3.3.2 Examine the trend of yam yield in Shiroro Local Government Area

Records on annual yam output was be collected from Niger State Agricultural Development Programme. The annual record of yam yield in the area was computed and the trend of yam production was determined. Linear trend was used to determine the nature and direction of the trend of the variables under investigation.

3.3.3 Analyse the relationship between rainfall variability and yam yield

The relationship between rainfall variability and yam yield was determine using correlation analysis in SPSS. Two variables were used to determine the relationship, mean annual rainfall and yam yield output was correlate together to determine the relationship between rainfall and yam yield.

To establish relationship between the rainfall on yield while controlling the influence of other confounding (independent) variables, the hierarchical multiple regression model will be used. Hierarchical multiple regression will be used when additional independent variables (confounding variables) are introduced into a model to ascertain the contribution of each of the independent variable (predictors) on the dependent variables (Pallant, 2005). The second stage will involve the entry of the major independent variables of prime interest (temperature and rainfall) to assess their contribution in predicting the dependent variable. The entry of all the sets of variables meant that, the Hierarchical model will be assessed in terms of its ability in predicting the dependent measure. At each stage of the process, the hierarchical regression will identify the key variables and eliminated the weaker ones. The Analysis of Variance (ANOVA) will be used to assess the significance of the regression model and the standardized Beta values as well as the P-values will be used to evaluate the contribution of each of the predictors

Model Specification

The study employs multiple linear regression model (Gujarati, 2013), to determine the impact in the relationship between yam production and the variability's that exist between rainfall and temperature in Benue State from 1998 to 2018.

The model is specified as:

$$Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \mu \quad (3.2)$$

Where, Y_i Yam output

at Rainfalls μ

Stochastic term $\beta_0 \beta_1$

and β_2 = constants

3.3.4 Examine the strategies adapted by yam farmers towards the effect of rainfall variability

Structural questionnaire was used to determine the strategies adopted by the farmers towards the effect of rainfall on yam yield. Questions relating to effect of rainfall and strategies adopted was ask. Questionnaire was distributed to yam farmers within the study area, their response was compute and analyzed using frequency analysis. The qualitative data from the Focus Group Discussions and the in-depth interviews was analysed thematically using Dey's (1993) three-step process of transcription, classification and interconnecting. The description will involve transcribing data from the in-depth interviews and FGDs into a mass of text. The classification step will involves relating the transcribed data into their major themes. Finally, the interconnecting step involves making sense of the themes in relation to the study objectives.

Table 3.1 Summary of the research methodology

S/NO	Objectives	Data	Methodology
1	Examine the trend in climate over Shiroro Local Government Area (1988-2018)	Climate data from Shiroro hydrological Station, NIMET	Descriptive Statistics
2	Examine the trend of yam production in the community	Yam production output from Niger State Agricultural Development Project	Descriptive Statistics
3	Analyse the relationship between climate variability and yam production	Rainfall data and yam out	Correlation analysis
4	Examine the adaptive and mitigative measures for effect of climate variability	Field sample using structural questionnaire	Frequency analysis

Source: Author, 2019

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Trend in Rainfall over Shiroro Local Government Area (1988-2018)

The intra seasonal variation of rainfall over Shiroro shows that rainfall generally begins in March / April. It increases in the months of July, August and September. It decrease there after until cessation takes place completely in November. Figure 4.1 shows that about 50% of the annual rainfall total accumulates in three heaviest rainy months of July, August and September and lowest in the months of January, February and December. There is thus a marked dry and rainy season.

Figure 4.2 shows rainfall trend of Shiroro between 1988 – 2018, the deviation of mean annual values of rainfall over thirty (20) years was shown in Figure 4.2. The deviation of rainfall negative between 1997and 2008. Between 1999 and 2011, the deviations are positive over a period of five years. On decadal basis, the years 2001 and 2004 have the highest deviations while the remaining years have very low deviations.

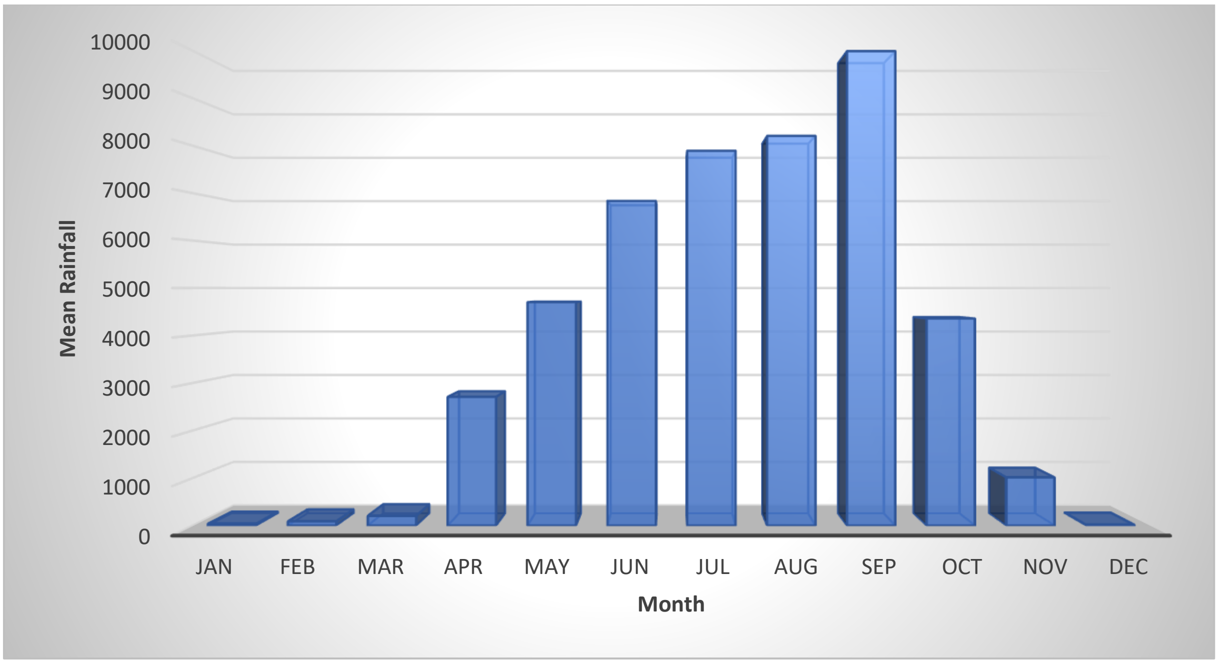

Figure 4.1: Mean Monthly Rainfall of Shiroro
Source: Authors Analysis (2020)

The rainfall deviations increased between 1998 and 1999. On decadal basis, the years 1998, 1999, 2004, and 2006 have positive rainfall deviations while the remaining years have negative and least rainfall deviations. Between the year 2008 and 2016, the rainfall deviations were positive in the year 2008, 2010 and 2011. However, the deviations were lowest in the year 2012 and 2014. The years 2009, 2013, 2015 and 2016 have a negative rainfall deviation within the area. This implies the rainfall between 1988 and 2018 have a slightly decreasing trend (graphically) in the study area.

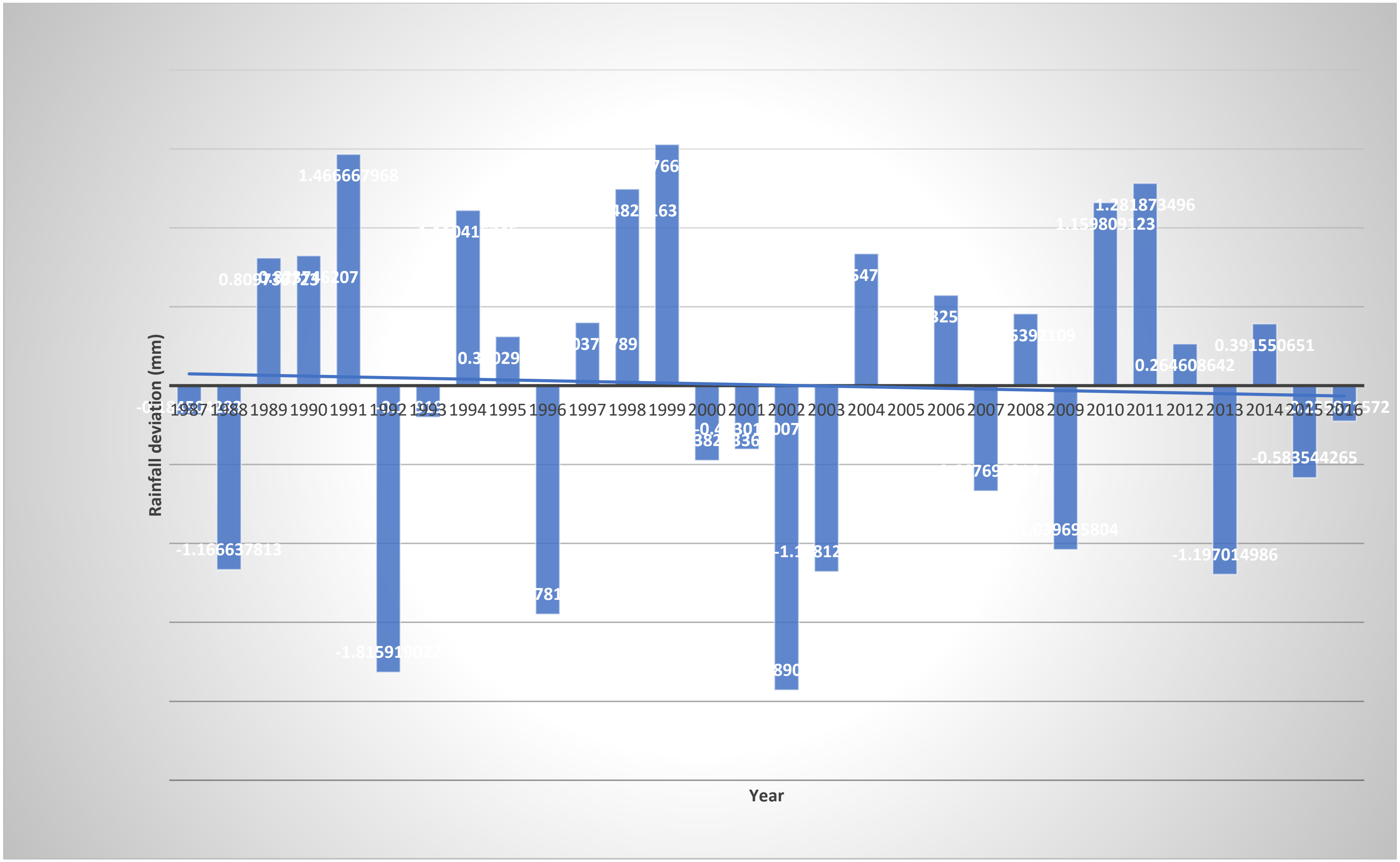

Figure 4.2 Rainfall deviation

Source: Authors Analysis (2020)

Table 4.1 shows the trend of rainfall over thirty year. The months of January, February, March, April, May, July, August, September, November, December have Z values less than 1.96 meaning that these months have insignificant trend. The months of June and October have z values greater than 1.96. This implies that the trends were significant. The month of October has a positive trend while the month of June has a negative trend. On annual basis, the rainfall records have decreasing trend.

Table 4.1 Trend analysis of rainfall between 1988 and 2018 using Mann Kendall test

Month	Tau	S value	Zvalue
Jan	0.0713	31	0.6612
Feb	0.0506	22	0.4629
March	-0.0989	-43	-0.9257
Apr	0.0667	29	0.6172
May	-0.0483	-21	-0.4408
June	-0.2552	-111	-2.4246
July	-0.0345	-15	-0.3086
August	-0.2046	-89	-1.9397
Sept	0.2046	89	1.9397
Oct	0.3195	139	3.0417
Nov	0.1563	68	1.4768
Dec	0.0667	29	0.6172

Source: Authors analysis (2019)

4.2 Trend Yam Yield in Shiroro Local Government Area (1988-2018)

The data on yam yield per tones covers a period of (20) twenty years, the area cultivated in hectare. The variations from the years depicted from this analysis show the reaction of yam yield. Figure 4.3 shows annual yield of yam in the study area, it was observed that 2016 has the highest record of yam yield in the study area with 2923.73 metric tons, followed by 1999 with a 2873.36 metric tons of yam yield. Years 2010 recorded the lowest yield of yield with 2411.45 metric tons.

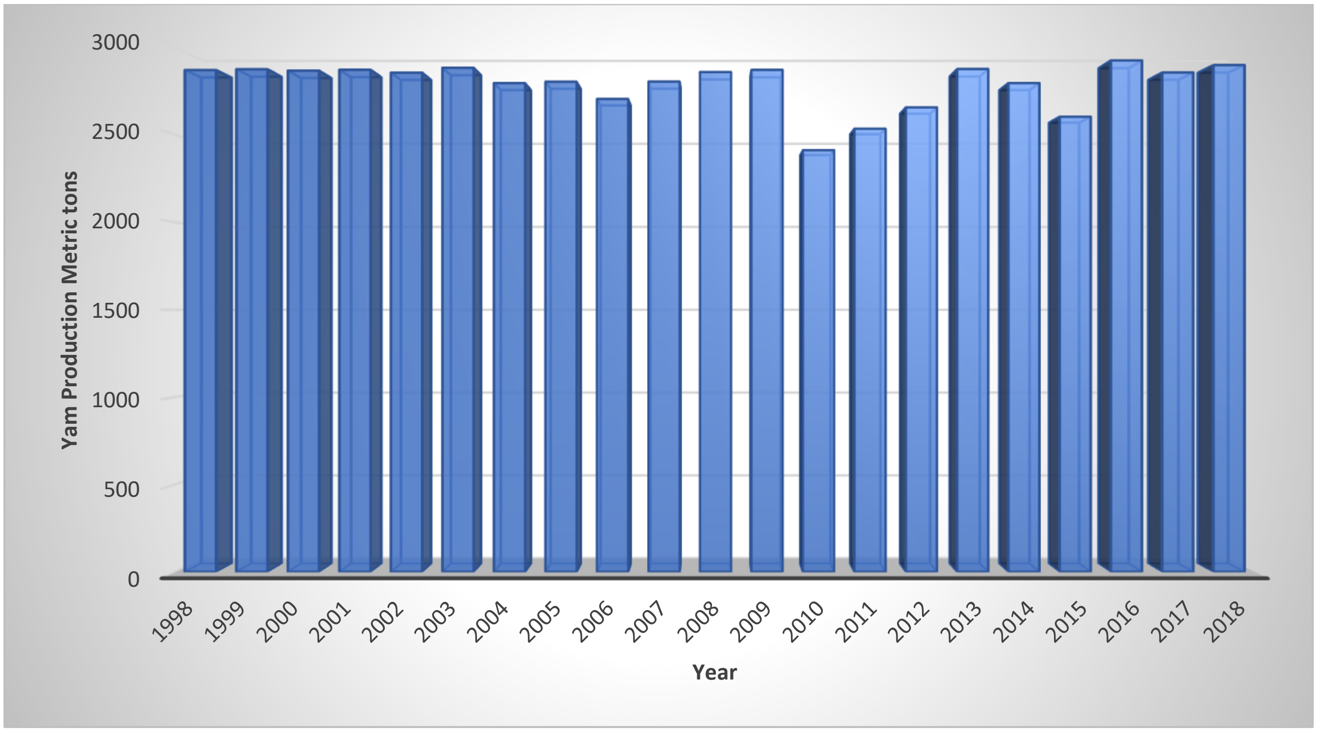

Figure 4.3 Annual yield of Yam in Shiroro Local Government Area

Source: Authors Analysis (2020)

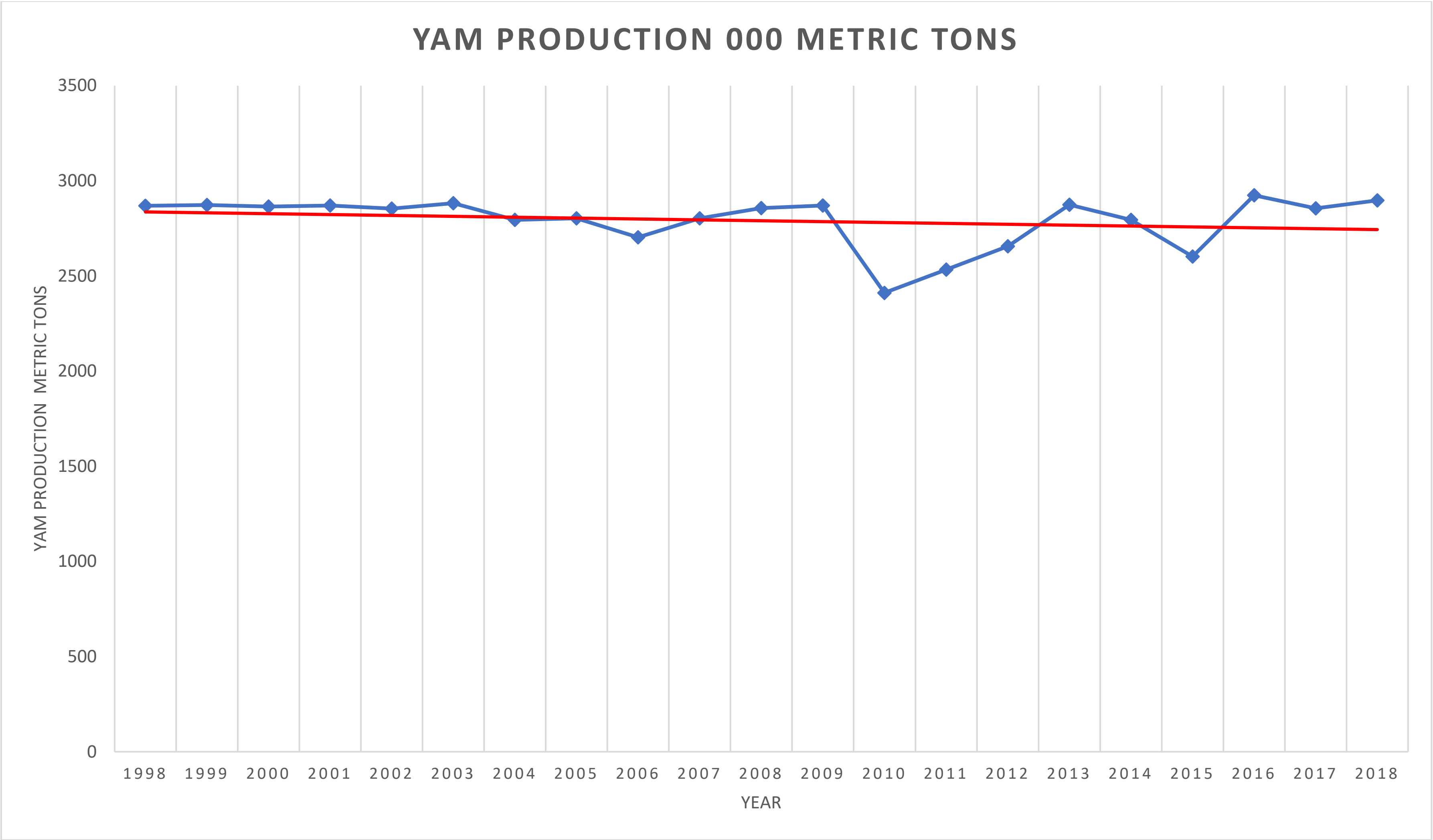

Figure 4.4: Trends in Yam yield

Source: Authors Analysis (2020)

4.3 Relationships between Rainfall Variability and Yam Yield

Table 4.2 Shows annual rainfall totals and annual mean (in mm) for study area from 1998 to 2018 as is been observed with 1,492.8 (mm) both the total rainfall and the mean, the lowest rainfall is recorded in year 2003 with the record of 761.5 mm.

Table 4.2: Monthly Rainfall Total for the Study Area

Months	J	F	M	A	M	J	J	A	S	O	N	D
Sum	0	0	0	1345.9	2140.7	2629.9	2636.1	3608.1	4182.7	2113	31.5	0

It is been observed from Table 4.2 that monthly rainfall total for all the years show a gradual increase of rain from April to June, April records a total rainfall of 1,345 mm. May records 2,140.7mm and June has 2,629.9mm then it progresses to the peak in September with sum amount of 4,182.9mm of planting in order to achieve a maximum yield and output.

Table 4.3: Average monthly rainfall for the study area

Months	J	F	M	A	M	J	J	A	S	O	N	D
Average	0	0	0	84.12	133.70	164.37	164.76	225.51	261.42	132.1	0.93	0

Source: Author's Computation

The average monthly rainfall in for the study area as shown in the Table 4.3 has the same pattern with the total monthly rainfall and the information is the same; but here the differences of rainfall in the study area in between the same months is shown in average.

Table 4.4: Descriptive Statistics

	Mean	Std. Deviation
Yam yield	11.0412	3.02409
Rainfall	96.2082	18.12001

Table 4.4 above shows the average mean of the study variables. Yam yield has the mean of 11.04 with the Standard Deviation of 3.02, Rainfall, Mean 96.20, Standard Deviation 18.12.

Table 4.5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.677[a]	.458	.322	2.48972

a.Predictors: (Constant), rainfall.

Table 4.5 above is the summary of the model which includes, relationships that exist between rainfall and yam yield. This shows a positively weak relationship thus r = 0.46 (46%).

It means that rainfall variations are very crucial to the yield of yam in the study area.

Table 4.6: Dependent Variable: Yam Yield Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-112.339	97.286		-1.155	.271
Rainfall	.052	.049	.313	1.074	.304

The coefficients in Table 4.6 are used to test the predictive values of rainfall. It shows that rainfall has a significant value of 304. The coefficients in the table shows that annual output of yam.

Figure 4.5 shows the relationship between yam yield and average annual rainfall in the study area, the relationships indicates that as the rainfall increases the yam yield also increases.. it indicate strong relationship between the variables with r2 value of 0.881 which is close to 1. It also shows that rainfall has strong influence on yam yield in the area. Although inadequacies of farm inputs like improved seeds, fertilizer, herbicides and the required management are contributing factors to yam yield as indicated by the farmers during oral interview, the importance of adequate rainfall to yam yield cannot be overemphasized. The r2 value of 0.5064 shows that there is no strong variation within the years of yam production.

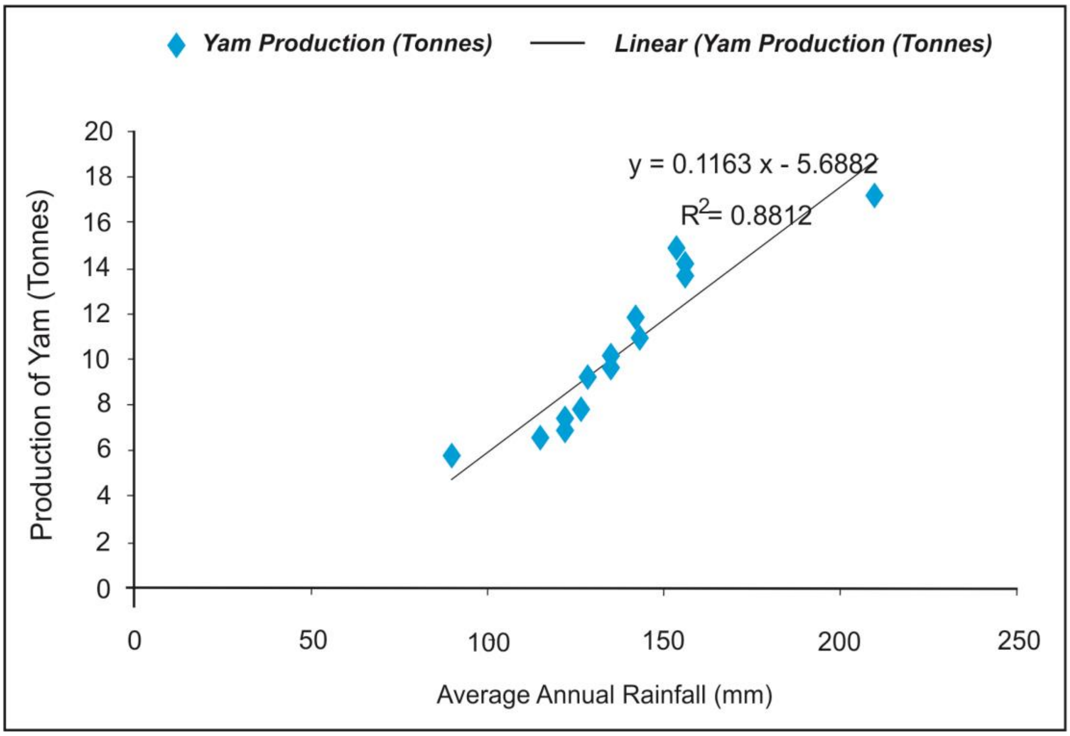

Figure 4.5: The relationship between the annual rainfall and yam yield

4.4 Adaptive and Mitigative Measures for effects of Climate Variability on Yam Yield

Farmers perception on the effect of climate variability on Yam yield in the study area was analysed. Figure 4.6 shows the respondents response on awareness of climate change in the study area. It shows that most of the residents of the study area are aware of climate change in which 78.5% indicated so.

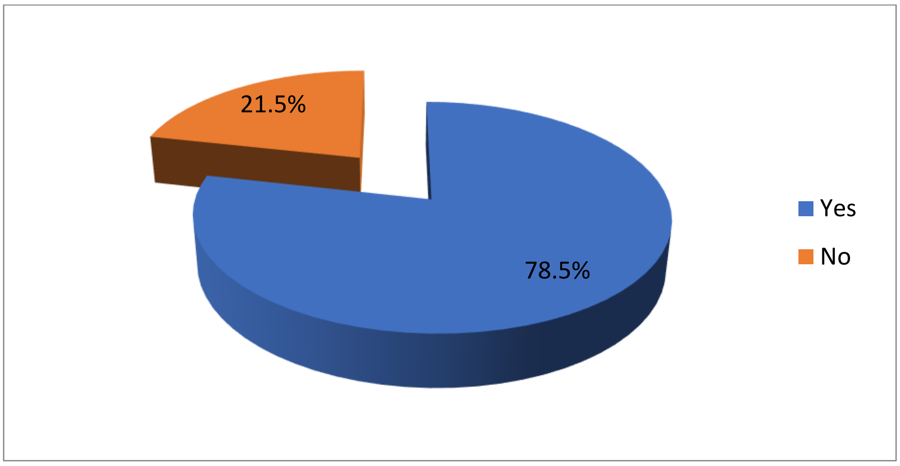

Figure 4.6: Awareness of Climate Change

Figure 4.7 reveal the means by which the residents of the study area got the knowledge of climate change; 26.6% of the residents got the knowledge of climate change through their knowledge of geography; 50.1% of the residents got the knowledge of climate change through ordinary observation of the weather and climate; 19.7% of the residents got the knowledge of climate change through media; and 3.6% of the residents got the knowledge of climate change through agricultural extension officers.

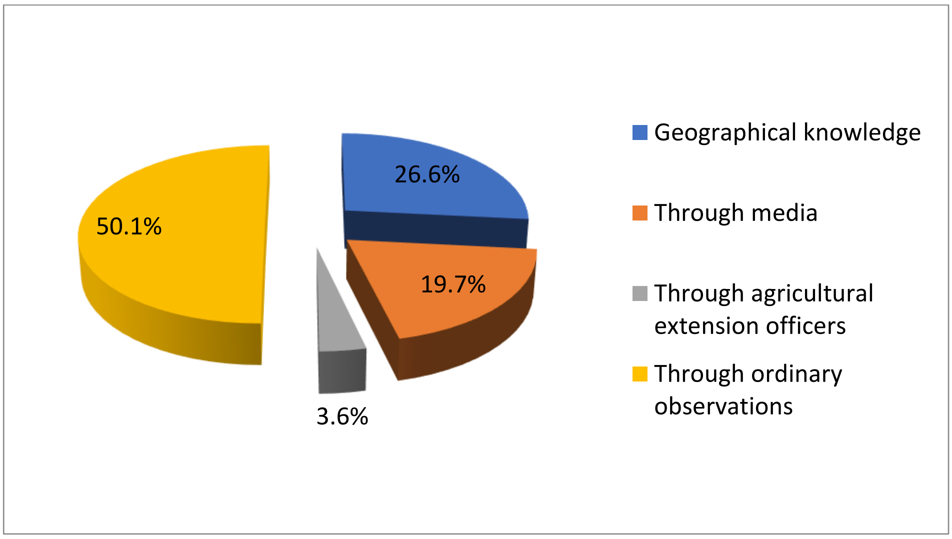

Figure 4.7: Means of been aware of climate change

From Figure 4.8, 58.4% of the respondents stated that the rainfall in the study area as about thirty (30) years was inconsistence (fluctuating). 41.6% of the residents stated that the rainfall in Shiroro as about thirty (30) years back was normal. None of the residents stated that the rain fall was intensive.

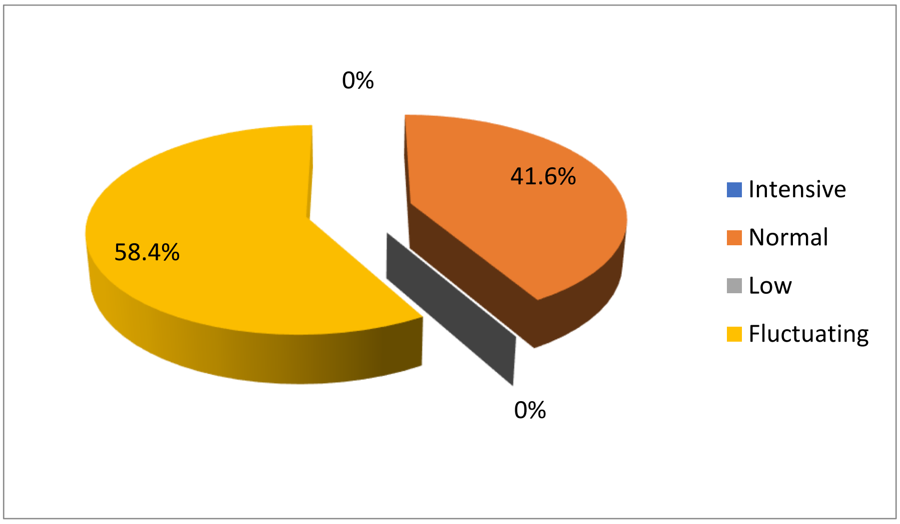

Figure 4.8: Nature of rainfall as about thirty (30) years back

From Figure 4.9, 70% of the respondents stated that the rainfall in the study area as of these recent years is inconsistence (fluctuating). 41.6% of the residents stated that the rainfall in Shiroro as of these recent years is low. None of the residents stated that the rain fall was intensive or normal as of these recent years.

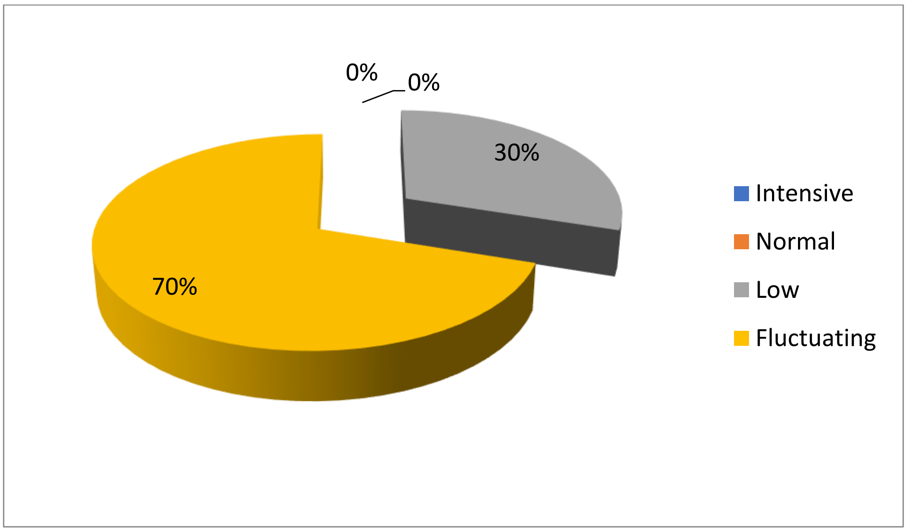

Figure 4.9: The nature of rain fall as of these recent years

4.4.1 Adaptive measures practiced by farmers in the study area

Adaptation to the adverse effects of climate variability is a key issue for all society, especially those in sub-Saharan Africa who are often the most vulnerable and least, equipped to defend themselves. Studies have shown that without adaptation, climate change is generally detrimental to the agricultural sector, but with adaptation, vulnerability can be largely reduced.

Table 4.7 Traditional Adaptation Strategies
Adaptation Strategies

S/N	Indigenous adaptive measures	% Yes	% No
1	Use of organic manure (measures)	75.6	24.4
2	Use of inorganic fertilizer (measures)	69.5	30.5
3	Use of wind breakers (trees) on the farm	47.8	52.2
4	Planting pest and disease resistant seeds	49.6	50.4
5	Use of acclimated crop varieties	23.3	76.7
6	Staggered seed crop planting	57	43
7	Mixed cropping or crop diversification	69.1	30.9
8	Make of contour build around farmland (more with fadama/irrigation farming)	39.1	60.9
9	Use of minor tillage (zero tillage)	28.3	71.7
10	Varying farmland clearance or preparation date	74.2	25.8
11	Cover cropping (legumes, lemon etc.)	83	17
12	Use of water storage (small scale on farm water harvesting)	4.4	85.6
13	Reforestation /afforestation	37.1	62.9
14	Use of early maturing crop variety	68.3	31.7
15	Mulching of moisture protection practices	54.3	45.7
16	Seed preservation /plant seedling for next planting	78	22
17	Use of weather tolerant/resistant seeds	59.4	40.6
18	Mixed farming practices	83.2	16.8
19	Adjusting planting date	71.2	28.8
20	Planting of crop with early rainfall	63.1	36.9
21	Use of recommended planting distance (wider crop spacing)	41	59
22	Listening to information about climate change	33	67
23	Adjusting harvesting date	73.6	26.4
24	Out migration from climate risk area	28.3	71.7
25	Processing of crops to minimize post- harvest pest and disease attack	73	27
26	Indigenous adaptive measures	70	30
27	Inter cropping	63.3	36.7

Source: Field Survey, 2019
**Multiple responses:*

Note: Most of the responses depend greatly on types of crop the farmer plants.

Table 4.7 shows the percentage distribution of respondents adopted different strategies for climate variability adaptation in the study area to cushion the effects of climate on yam yield. For example, 63.1% planted now with early rainfall /onset, 83.1% planted mixed farming practices (possibly for economic purposes) 69.1% practice crop diversification, while 68.3% use early maturing crop variety, 73 process crops against post-harvest pest and moisture changes. 74.2% adjust land preparation based on prevailing condition and 83% adopted practice of planting cover crops to prevent soil erosion and inorganic fertilizer respectively. The practices of water harvesting in the area is low 14.4%. also use of information on climate change is low 33% among the framers. Similarly, use of minimum tillage or zero tillage to minimize GHG contribution is low 28.3%.

The result also indicates that farmers are adopting the "spiritual approach" or "prayers" to cushion the effect of climate change. They noted that, "the current changes in climate of the area are brought about by God and that they can only pray for mercies of God. This is more of the views of the older ones (39 years and above). Some of the widely adopted adaptive traditional measures in the area include:

i. Mulching used for organic manure
ii. On farm seed preservation and selection for coming season
iii. Mixed farming
iv. Mixed cropping
v. Use of wind breakers on the farm '
vi. Use of early maturing crop variety
vii. Use of recommended planting distance
viii. Inter cropping

ix. Planting before the rains

x. Staggered seed crop planting

xi. Crop diversification

The farmers indicated that while they noticed the manifestation of climate change in their environment, they adopted these measures and there has been improvement in their farming activities. When asked on the sources of these innovative strategies for climate change adaptation, about 73% of the respondents remarked that they did not copy or learn the practices from anywhere and that they are indigenous to them. Some of them opined that, these measures have helped them well in soil conservation and management. Although the farmers could not easily indicate a local term for climate change, they noted that the above measures and many others have been practiced for so many years because of the peculiarity of their environment even before climate change became a major issue of discourse in recent times.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The rainfall trend of the study area for the past twenty (20) years shows that rainfall amount has been very variable (fluctuating). The lowest rain fall occurred in 2004 which was 473.7mm in total and 1.3mm in average, while the highest rain fall was recorded in 2001 which was 1789.4mm in total and 4.9mm in average. Indeed 4.9mm (the total of 1789.4mm) as the highest average of rain fall is still very low in agricultural yield even with the short time crops. Most of the respondents are aware of climate change. The farmers got the knowledge of climate change through the knowledge of geography; through ordinary observation of the weather and climate; through media; and through agricultural extension officers. Rainfall of the study area for the period under study and as of these recent years has been inconsistence (fluctuating). The nature of climate in relation to Yam yield for the study period and as of recent years has been making the yields inconsistence (fluctuating).

5.2 Recommendations

Based on the major findings of this study the following recommendations are put forward toward the issue of rainfall variability on yam yield in Shiroro Local Government Area of Niger State.

1) There should be climate monitoring stations for every agricultural zones of Nigeria.
2) The government and the relevant agencies should not careless or use foolish political approach to the issues of climate change in the country.
3) There should be time to time awareness and enlightment campaign on the causes of climate change in various parts of the country.

4) This research recommends further studies on how to culture farmers on self-mitigation strategies to the occurrence and effects of climate variability for the farmers to be able to curb with drought occurrences.

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