IMPACT OF WEATHER ON GUINEA CORN PRODUCTION IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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ABSTRACT

Guinea corn is one of the major cereal crops widely grown in Nigeria, and a very important staple food for the populace particularly in the northern part of the country. Excessive increases in temperature results in low agricultural productivity and this may lead to depletion of soil nutrients and destruction of soil structure and organisms which contribute to the fertility of the soil. The study examines the impact of weather on guinea corn production in Igabi Local Government Area of Kaduna State, Nigeria. Qualitative and quantitative research techniques was adopted. Standardized Precipitation Index (SPI) and Diurnal Temperature Range (DTR) was used. The findings show temperature of 0.74 which signifies strong positive relationship between temperature and Guinea corn yield and Rainfall 0.117 which also signifies strong positive relationship between rainfall and Guinea corn yield. The mean maximum temperature trend of the study area for the period under study has been very variable (fluctuating). The lowest temperature was recorded in 2011 which was 11804.0^{0}C (in total) and 32.3^{0}C in average, while the highest temperature was recorded in the years of 2009 and 2013 which was 12488.9 ^{0}C in total and 34.4^{0}C in average. The study concludes that rainfall and the temperature of the study area for the period under study and as of these recent years has been inconsistence (fluctuating). The nature of weather in relation to Guinea corn production for the study period and as of recent years has been making the yields inconsistence (fluctuating). The study 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

1.0 INTRODUCTION

1.1 Background to the Study

Guinea corn is one of the major cereal crops widely grown in Nigeria, and a very important staple food for the populace particularly in the northern part of the country (Tashikalma *et al.*, 2012). The Nigerian guinea corn production was 11.5 tons in 2010 and forecast was 11.7 tons in 2011 (United States Department of Agriculture, 2010). The crop yield has increased because of the acceptance by farmers of improved varieties developed by local research institutes. Climate is a long-term average weather conditions that directly or indirectly affects agricultural production. Weather determines the choice of what plant to cultivate, how to cultivate it, the yields of crops and nature of livestock to keep. Ajadi (2011) reported that solar radiation, temperature, moisture and other climatic parameters determine the global distribution of crops and livestock as well as crop yield and livestock productivity. Reuben and Barau (2012) observed that rainfall distribution and the occurrence of moisture stress condition during the vegetative period are critical for the yield formation of the guinea corn. In view of the foregoing, Odjugo (2010) opined that weather is unequivocal and its impacts are here with us.

Year-to-year variations in crop yields pose a significant risk to subsistence farmers or people depending on local supply (Headey, 2011; Schewe *et al.*, 2017). Annual crop yields depend on several factors. In addition to weather conditions, the occurrence of weeds, diseases, and pests can result in yield fluctuations (Gregory *et al.*, 2009). Weather has emerged as a global concern in the past 20 years. One particular worry is the potentially disastrous consequence for agriculture and food security in many parts of the world, particularly developing countries (FAO 2007; IPCC 2007; Kotir 2011). Crop farming is extremely vulnerable to climate change and it has been predicted that weather will impact negatively on agricultural yield in the 21st century through higher temperatures, and rainfall variable (WB 2010). This susceptibility of agriculture to weather has led to the scientific and policy communities questioning the capacity of farmers to adapt (Mertz *et al.* 2009). Weather impacts are already being experienced through increasing temperatures, variable rainfall and climate related extreme events.

Available pieces of evidence show that each day brings fresh proofs of weather impacts and these impacts include increasing temperatures, decreasing rainfall. Excessive increases in temperature results in low agricultural productivity and this may lead to depletion of soil nutrients and destruction of soil structure and organisms which contribute to the fertility of the soil. Ordinarily, rainfall can be considered to have positive impact on agricultural productivity except where it leads to flooding, erosion and leaching. Rainfall amount and high temperatures are the most important elements of weather variation in Nigeria as a result the north region of Nigeria is increasingly becoming an arid environment at a very fast rate occasioned by the fast reduction in the amount of surface water, flora and fauna resources on land. Consistent reduction in rainfall leads to a reduction in the regeneration rate of land resources. The northern zone particular Kaduna therefore faces the threat of desert encroachment (Adejumo, 2014)

Impacts of weather on the socio-economic sector guinea corn production are projected to include; decline in yield and production, reduced marginal GDP from agriculture, fluctuation in local market price, change in geographical distribution of trade regimes, increased number of people at risk of hunger and food security and migration and civil unrest (Khanal, 2014). Increase in temperature, at the same time, might affect both the physical and chemical properties in the soil. Increased temperature may accelerate the rate of releasing CO_2 resulting in less than optimal conditions for plant growth. When temperatures exceed the optimal level for biological processes, guinea corn often respond negatively with a steep drop in net growth and yield. Heat stress might affect the whole physiological development, maturation and finally yield of cultivated crops like guinea corn (Khanal, 2014; Rosegrant *et al.*, 2013).

The impact of weather on crop production in Kaduna State has received limited attention despite the fact that over 60% of the active populations are farmers. Studies on weather variations have revealed that the potential impacts of weather will include every aspect of the four dimensions of food security; food availability (production and trade), food accessibility, food stable supplies, and food utilization (Nwafor, 2007). Olarenwaju (2012) reported that many of the problems facing agricultural production are weather related. It is against this background that this study is put forward to ascertain the impact of weather on guinea corn yield in Igabi Local Government Area of Kaduna State.

1.2 Statement of the Problem

Yamusa, *et al.*, (2013) opined that the amount of rainfall is increasing above normal, the onset dates are always varying with backward shift in planting dates of up to 10 days in the ecological zone, Igabi in Kaduna state belong to and unpredictable incidence of early season dry spells thus affecting the length of growing season. If the present trend should continue, there will be greater negative effects of this variability on agricultural production since pest and plant disease vectors are often arthropod and their geographical distribution is determining by rainfall, temperature, relative humidity and availability of host plants.

Excessive increases in temperature results in low agricultural productivity and this may lead to depletion of soil nutrients and destruction of soil structure and organisms which contribute to the fertility of the soil. Ordinarily, rainfall can be considered to have positive effect on agricultural productivity except where it leads to flooding, erosion and leaching. Rainfall amount and high temperatures are the most important elements of weather that affect crop yield in Nigeria as a result the northern region of Nigeria is increasingly becoming an arid environment at a very fast rate occasioned by the fast reduction in the amount of surface water, flora and fauna resources on land.

Consistent reduction in rainfall leads to a reduction in the regeneration rate of land resources. The northern zone therefore faces the threat of desert encroachment. The southern area of Nigeria, which was largely known for high rainfall, is currently confronted by irregular rainfall and high temperatures (Adejumo, 2014; Obioha, 2008; FME, 2004). The impact of weather on agricultural production in Nigeria has received limited attention despite the fact that over 60% of the active populations of Nigerians are farmers. Studies on impact of weather globally and in Nigeria have revealed that the potential impacts of weather will include every aspect of the four dimensions of food security; food availability (production and trade), food accessibility, food stable supplies, and food utilization (Nwafor, 2014). Olarenwaju (2012) reported that many of the problems facing agricultural production are weather related. Based on this paucity of knowledge on the impact of weather on guinea corn production in Kaduna State, particularly Igabi Local Government Area. Hence, this study will attempt to fill the existing gap created by those identified researches which will make this thesis worthy to be carried out by the researcher to provide answer to the listed research questions.

1.3 Research Questions

The study sought to find answers to the following questions:

i. What has been the trend of weather variations (Rainfall and temperature) over the past 20 years (1999-2018) in Igabi Local Government Area of Kaduna State?

ii. How does weather variations impact guinea corn production in the area?

iii. How do the farmers perceive the impact of weather variations on guinea corn production?

iv. What are the adaptation strategies of the farmers in response to the impacts of weather variations?

1.4 Research Aim and Objectives

The aim of this study is to examine the impact of weather on guinea corn production in Igabi Local Government Area of Kaduna State, Nigeria. Specifically, the study sought to:

i. Examination of Rainfall and Temperature Variations across the study area for over the past 20 years

ii. Examine the impacts of weather on Guinea Corn production;

iii. Examine the farmer's perception on the impacts of weather variations on Guinea Corn production; and

iv. Assess the current adaptation strategies of the farmers in response to the impacts of weather variations.

1.5 Justification for the Study

Weather plays a significant role in shaping natural ecosystems, human economies, and cultures in many ways. In developing countries, a greater proportion of people engage in livelihood activities pertaining to primary production, making the impact of weather more intense than in developed areas where secondary activities dominate.

The study will go a long way to improve the methodological strand of previous studies. The quantitative approach has been adopted by previous researchers in finding out the effects of climate variability on crop production (Traore *et al.,* 2013; Awotoye and Matthew, 2010 and Tshiala and Olwoch, 2010). However, the deficiency associated with this particular approach is that, it emphasises the breadth of the study rather than the depth (Creswell, 2010). It is in the light of this that this research employs the mixed methodology to add a qualitative dimension to the already used quantitative approach to help address the problem holistically.

The study will provide information on the perceived extent to which weather variation has impacted on Guinea corn production and the farming families. The information will help government to encourage and support farmers in production activities. The knowledge of the findings would help the government to make policies on how to check the effects of climate change on agriculture in the area and Nigeria in general. The study will provide information to agricultural extension workers on adaptation strategies, which they could teach the farmers to adapt to in such situations. One of the purposes of the study is to discover the suitable strategies for alleviating the impact of weather variations. The information would serve as a body of knowledge for the agricultural extension workers who teach the farmers on improved farming practices.

The findings of the study would help farmers to reduce the impact of climate change on agricultural production. The study will suggest to the farmers' suitable adaptation options in coping with weather variations effects on agriculture. An understanding of the impacts of weather would help the framers to mount appropriate strategies to keep agricultural production profitable to matching the varying trend in farming activities. The study could be used as a resource material on weather variations and its impact on agriculture for researchers who may be interested in researching on related topics. The research is equipped with the findings on the impacts of weather guinea corn production and farming families as well as strategies for coping with the change which could beef up the literature in their studies.

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 weather 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.

1.6 Scope of the Study

The geographical scope of this study will cover four communities (Amaza, Audi, Burgu and Yalwa) in Igabi Local Government Area of Kaduna State. Contextually, the study will analysed the trend of climate variability over the past twenty years (1999-2018) as well as how weather variations impacts Guinea Corn production in Igabi Local Government Area. The study will also be investigated how the farmers perceive the impacts of weather variations on their crop production and finally assesses the current adaptation strategies of the farmers in response to the impacts of weather variations.

1.7 The Study Area

1.7.1 Location of the Study Area

Igabi Local Governmnet Area lies within latitudes 10^0 25′ 28″ N and 11^0 35′ 53″ N and Longitudes 7^0 21′ 49″ E and 7^0 50′ 00″ E (Figure 1.1). The area covers an area approximately 3,727 square kilometers and shares boundaries with Kaduna North, Kaduna South, Zaria, Kajuru, Kauru, Igabi and Birnin-Gwari Local Government Councils. Turunku is the headquarters of Igabi LGA which was the seat of power of the famous Queen Amina of Zazzau. The seat of Queen Amina and many historical evidences are still located on Turunku Hill as well as tomb of Bakwa Turunku the father of Queen Amina andher sister Zaria where Zazzau Emirate derived its name.

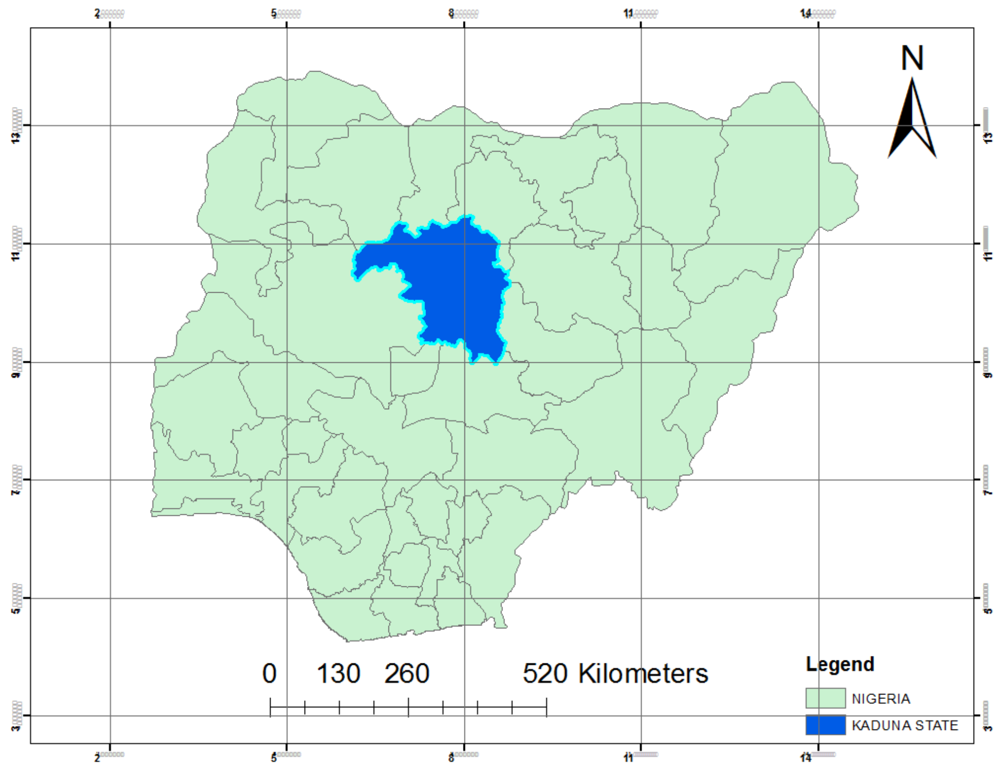

Figure 1.1: Location of Kaduna State
Source: Kaduna State Ministry of Land and Geoinformatics, 2018

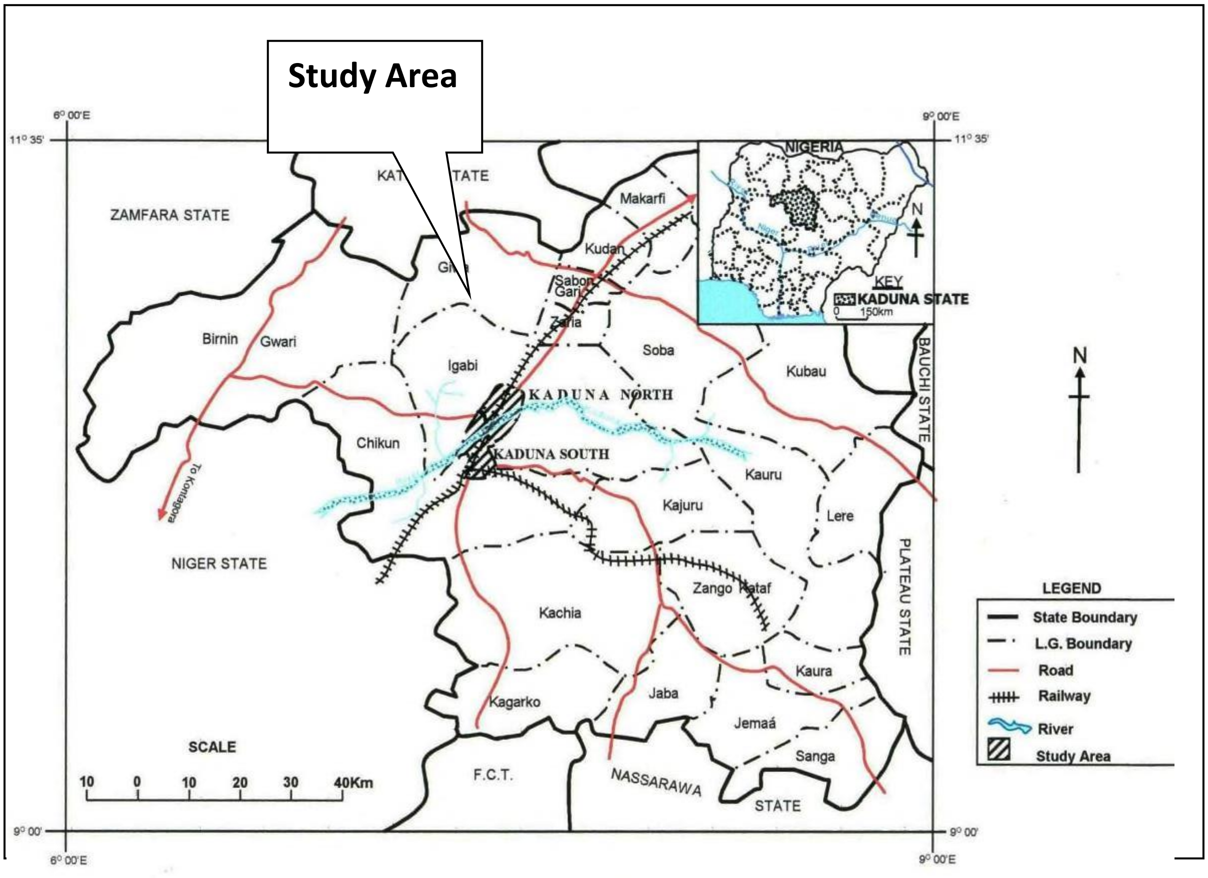

Figure 1.2: Kaduna Map showing Igabi

Source: Kaduna State Ministry of Land and Geoinformatics, 2018

1.7.2 Climate of the Study Area

1.7.2.1 Rainfall of the Study Area

The study area has an average annual rainfall of 1250mm. The rains occurs between months of April – October when the South Westerly humid winds brings in rain. The dry seasons last between November and March when the prevailing North Easterly winds

(Harmattan) brings with it dusty, dry and cool air of the Sahara desert ushering in the dry season. The mean annual rainfall in the study area ranged from 1000mm to 1500mm. The month of August-September recording highest rains of 300mm (Yamusa, *et al.*, 2015). The rainy season starts between 10^{th} of April to 20^{th} of May and extends to October.

1.7.2.2 Temperature of the Study Area

The temperature of the study area resembles that of the North Central Zone of the country. Temperature ranges between 25^0 C – 35^0C during the dry season. The temperature may rise to about 42^0C in March/April which is the hottest period. The coldest month is December/January. During the harmattan popularly referred to as the West Africa Doctor, temperature sometimes reaches freezing point (Record from the nearest meteorological station over a period of 15years) (Yamusa *et al.*, 2015).

1.7.3 Vegetation and Soils of the Study Area

The vegetation cover of the study area is uniform and monotonous typical of the Northern Guinea Savanna Zone. Green (2007) further described the vegetation as containing three vegetation sub-types viz:

1. Isoberlinia doka woodland grassland
2. Gallery or riparian vegetation
3. Shrub land composed of trees – shrub association.

Other areas of the forest are covered by Uapacamonotes Afornosia association, V-togoensis, M. Kekrstingi afzelia Africana, etc. In the low ground near Numanshi stream which stretches into the park serving as a source of water for animals during the dry season, one finds a terminalia Pseudocederela Mitrogya association with; Terminallia macrotera, Mitragyna inermis, philiostigma inermis. The presence of these vegetation types signifies clay composition in the soil.

The soil types of the study area corresponds fairly closely with the vegetation belts of the guinea savanna which extends from east to west of Kaduna metropolis. Excepts for highland areas, Kaduna metropolis has high temperature which promotes active chemical and biological changes in the soil. There are few outcrops and some fossilized literate hills in the study area. Soil types includes; sandy loams and a little clay in valleys (Oyedele, 2011). The climate, soil and hydrology supports the cultivation of most of the study area staple crops and still leaves ample scope for grazing, fresh water, fishing and forestry. Rich fertile alluvial soils are visible around the stream banks. Estimate shows that 80% of the people in the local government area engage directly or indirectly in agricultural activities (Oyedele, 2011). Oyedele (2011) opined that the soils are yellowish to reddish, deep, well drained and fine or medium textured. Bleached layers of ferruginous tropical soils associated with ferralitic soils are also found along the River Kaduna flood plain.

1.7.4 Topography of the Study Area

Geologically the study area is covered by sedimentary rock formation consisting of sand stones and alluvial deposited especially around the site of the park. The area lies on a flat gently rolling land with few hills. In and around the Park, there are important land marks which are of potential interest to tourist. Some of the exquisite barren rocks make the landscape alluring and this create attractive scenery. Some of these lands are Tsunin Buffa, Kashiga Mountains, Marmara Hills, etc. the beauty of the under field land marks inhabited by both animals and birds sharing the luxury of tropical sunshine alongside meandering rivers makes the park attractive and beautiful. Most of the hills are rounded granite domes and flat topped mensas or residual hills with reddish-brown sand stones are characteristics relief features of the study area (Jatau *et al.,* 2013).

Generally the topography of the study area is that of an undulating Plateau that forms part of the rich tourist attractions in areas like Kufena in Zaria, Kagoro, Kwoi, Gwantu etc. These areas have protruding hard resistant granite rocks that are so attractive for sightseeing. Variable elevations of land topography ranging from the lowest height of 380m above sea level in river valleys and as high as 450m occurring mostly in upland areas leads to the spring up of streams arounds the study area. The Ukinkina, Kuzomani and Kuwaimbana rivers are some of the major streams that drain around the study area. Other streams include the Dagara stream, Bogoma stream and Numashi stream. Kwiambana Rivers forms quite an extensive length of the northern boundary of the study area, draining from west to east. The two streams Kuzomani and Ukinkina both drains from the centre parts of the park. Kuzomani drains to the west into the Kuwaimbana while the Ukinkina drains out from the park in the South West (Shehu, 2011). Its main rivers are River Kaduna, River Gurara, River Kogum and River Kubani (Shehu, 2011).

1.7.5 Geology of the Study Area

The area understudy is underlain by Precambrain rocks of the Nigerian Basement Complex. The weathering of the crystalline Basement Complex rocks under tropical condition is well known to produce a sequence of unconsolidated material whose thickness and lateral extent vary extensively. Groundwater localization within the Basement Complex occurs either in the weathered mantle or in the fracturing, fissuring and jointing systems of the bedrock (Ako and Olorunfemi, 1999; Olayinka and Olorunfemi, 1992). These unconsolidated materials are known to reflect some dominant hydrologic properties, and the highest groundwater yield in Basement Complex area are found in areas of thick overburden overlying fractured zones and are characterized by relatively low resistivity. The Basement Complex rocks in the areas are mostly migmatite, granite gneiss, undifferentiated schists and porphyritic biotite grantite.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual Framework

Weather plays an important role in agricultural production (Stern, 2011). It has a profound influence on crop growth, development and yields; on the incidence of pests and diseases; on water needs; and on fertilizer requirements (Tenge, 2011). This is due to differences in nutrient mobilization as a result of water stresses, as well as the timeliness and effectiveness of preventive measures and cultural operations with crops (Timofeev, 2012). Weather aberrations may cause physical damage to crops and soil erosion (Stern, 2011). The quality of crop produce during movement from field to storage and transport to market depends on weather. Bad weather may affect the quality of produce during transport, and the viability and vigour of seeds and planting material during storage (Selvaraju *et al.*, 2015). Thus, there is no aspect of crop culture that is immune to the impact of weather.

Weather factors contribute to optimal crop growth, development and yield (Bradshaw, 2013). They also play a role in the incidence and spread of pests and diseases. Susceptibility to weather-induced stresses and affliction by pests and diseases varies among crops, among different varieties within the same crop, and among different growth stages within the same crop variety (Selvaraju *et al.*, 2015). Even on a climatological basis, weather factors show spatial variations in an area at a given time, temporal variations at a given place, and year-to-year variations for a given place and time. For cropping purposes, weather over short periods and year-to-year fluctuations at a particular place over the selected time interval have to be considered. For any given time unit, the percentage departures of extreme values from a mean or median value, called the coefficient of variability, are a measure of variability of the parameter.

The shorter the time unit, the greater the degree of variability of a given weather parameter (Bartlett, 2011). The intensity of the above three variations differs among the range of weather factors. Over short periods, rainfall is the most variable of all parameters, both in time and space. In fact, for rainfall the short-period interannual variability is large, which means that variability needs to be expressed in terms of the percentage probability of realizing a given amount of rain, or that the minimum assured rainfall amounts at a given level of probability need to be specified (Bartlett, 2011). For optimal productivity at a given location, crops and cropping practices must be such that while their cardinal phased weather requirements match the temporal march of the relevant weather element(s), endemic periods of pests, diseases and hazardous weather are avoided. In such strategic planning of crops and cropping practices, short-period climatic data, both routine and processed (such as initial and conditional probabilities), have a vital role to play (Bradshaw, 2013).

2.1.1 Weather and Guinea Corn production

Greenhouse gases emissions from human activities are responsible for weather variation (*et al.,* 2011). Weather variations leads to increased temperatures, changing rainfall patterns and amounts, and a higher frequency and intensity of extreme climate events such as floods, cyclone, droughts, and heatwave (Roudier et al. 2011). Temperature increases and erratic rainfall patterns affect crop agriculture most directly and adversely (Lansigan et al. 2013;4 Almaraz et al. 2016). Variation in weather over time affects guinea corn production adversely (Behnassi 2011). The channels of the impacts are depicted in Figure 1.1. Variations in weather generally involve changes in two major climate variables: temperature and rainfall. The increase in temperature shortens the phenological phases of crops (such as planting, flowering and harvesting) (Liu *et al.,* 2010; Teixeira *et al.* 2011) and affects plant growth and development. The fluctuations and occurrence of extreme weather events reduce guinea corn yields significantly, particularly at critical crop growth stages (Lansigan *et al.,* 2000; Teixeira *et al.,* 2011).

Rainfall extremes, through droughts and floods are very detrimental to guinea corn productivity. Higher and/or heavy rainfall results in higher yield losses through flooding (Roudier et al. 2011). In contrast, insufficient rainfall leads to greater drought frequency and intensity, while increased evaporation leads to complete crop failure (Liu *et al.,* 2010). Overall, temperature and rainfall changes reduce the cropped area, production level and yield. This reduction or fluctuation in guinea corn yield warrant farmers' adaptability to minimise these adverse effects. However, adaptation strategies at the farm level vary from area to area and from farm to farm. Farmers' adaptive capacity is determined by their socio-demographic characteristics, farm characteristics and accessibility to institutional factors

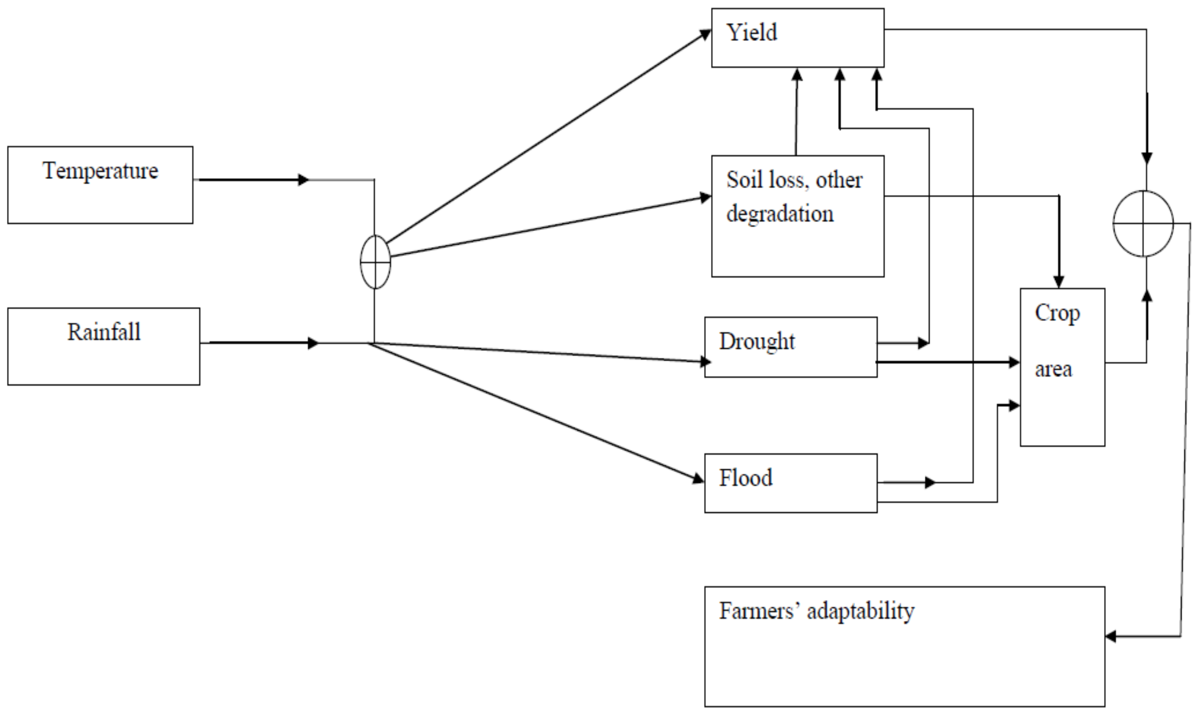

Figure 2.1: Conceptual framework of weather impacts on guinea corn production

2.1.2 Weather

Weather is the state of the atmosphere, describing for example the degree to which it is hot or cold, wet or dry, calm or stormy, clear or cloudy (Crate and Nuttall, 2009). Most weather phenomena occur in the lowest level of the atmosphere, the troposphere, just below the stratosphere. Weather refers to day-to-day temperature and precipitation activity, whereas climate is the term for the averaging of atmospheric conditions over longer periods of time. When used without qualification, "weather" is generally understood to mean the weather of Earth (Crate and Nuttall, 2009).

Weather is driven by air pressure, temperature and moisture differences between one place and another. These differences can occur due to the sun's angle at any particular spot, which varies with latitude. The strong temperature contrast between polar and tropical air gives rise to the largest scale atmospheric circulations: the Hadley Cell, the Ferrel Cell, the Polar Cell, and the jet stream. Weather systems in the mid-latitudes, such as extratropical cyclones, are caused by instabilities of the jet stream flow. Because the Earth's axis is tilted relative to its orbital plane, sunlight is incident at different angles at different times of the year. On Earth's surface, temperatures usually range ±40°C (−40 °F to 100 °F) annually. Over thousands of years, changes in Earth's orbit can affect the amount and distribution of solar energy received by the Earth, thus influencing long-term climate and global climate change (Roberts *et al.*, 2012). On Earth, the common weather phenomena include wind, cloud, rain, snow, fog and dust storms. Less common events include natural disasters such as tornadoes, hurricanes, typhoons and ice storms. Almost all familiar weather phenomena occur in the troposphere (the lower part of the atmosphere). Weather does occur in the stratosphere and can affect weather lower down in the troposphere, but the exact mechanisms are poorly understood (Roberts *et al.*, 2012).

Weather occurs primarily due to air pressure, temperature and moisture differences between one place to another (Ajetomobi, 2016). These differences can occur due to the sun angle at any particular spot, which varies by latitude from the tropics. In other words, the farther from the tropics one lies, the lower the sun angle is, which causes those locations to be cooler due the spread of the sunlight over a greater surface. The strong temperature contrast between polar and tropical air gives rise to the large scale atmospheric circulation cells and the jet stream. Weather systems in the mid-latitudes, such as extratropical cyclones, are caused by instabilities of the jet stream flow. Weather systems in the tropics, such as monsoons or organized thunderstorm systems, are caused by different processes (Ajetomobi, 2016).

2.1.3 Weather Monitoring

Agriculture represents 32.3% of GDP value in low income countries and 16.7% in lower middle income countries. In the developing world, agriculture depends largely on rain precipitations. Rain-fed agriculture represents the quasitotality of agricultural land in Sub-Saharan Africa, and the largest proportion of agricultural land in South America and South Asia. Rain-fed agriculture is also considerably less productive than irrigated agriculture. The dependency of the agriculture sector on rain means accurate weather forecasts are in high demand (World Bank, 2015).

This need is made greater by the global impact of climate change, which has resulted in weather patterns becoming more unpredictable. In Sub-Saharan Africa, for example, Malawi has faced multiple weather shocks in the last twenty years, with shifts in rainfall patterns and severe storms, with increased instance of severe flooding and droughts. Such events have undermined the agricultural economy on which the majority of the population depends upon. In 2015, the extended dry spell followed by severe flooding in the South of the country wiped out 90,000 hectares of cropped land. After declaring a state of national emergency, the government reported that 2.8 million people, equivalent to 17% of the total population, will require food assistance. Overall, the impact of climate change will be most felt in the developing world. According to the World Bank, in Africa the effects of climate change could cause food prices to increase by as much as 12% by 2030, and by up to 70% by 2080 (World Bank, 2015).

Smallholder farmers in the developing world need to adapt to changing climate conditions. For the provision of weather forecasts, however, farmers rely on national meteorological agencies with low capacity and obsolete technologies. Over 60% of national meteorological agencies, the vast majority in emerging markets, are significantly challenged with respect to their core infrastructure (observational networks, forecasting systems and telecommunications). To improve weather services, there is a need for greater engagement and collaboration of different stakeholders, including government and transnational organisations with global weather data (e.g. the European Centre for Medium-Range Weather Forecasts, and the US National Center for Environmental Prediction), commercial weather forecasting companies (e.g. MeteoGroup, StormGeo, Foreca, Ignitia), and international research institutions and NGOs with open data (Ajetomobi, 2016).

2.1.4 Rainfall

Rain is liquid water in the form of droplets that have condensed from atmospheric water vapor and then become heavy enough to fall under gravity (Alistair, 2003). Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation.

The major cause of rain production is moisture moving along three-dimensional zones of temperature and moisture contrasts known as weather fronts. If enough moisture and upward motion is present, precipitation falls from convective clouds (those with strong upward vertical motion) such as cumulonimbus (thunder clouds) which can organize into narrow rainbands. In mountainous areas, heavy precipitation is possible where upslope flow is maximized within windward sides of the terrain at elevation which forces moist air to condense and fall out as rainfall along the sides of mountains. On the leeward side of mountains, desert climates can exist due to the dry air caused by downslope flow which causes heating and drying of the air mass. The movement of the monsoon trough, or intertropical convergence zone, brings rainy seasons to savannah climes (Alistair, 2003).

The urban heat island effect leads to increased rainfall, both in amounts and intensity, downwind of cities. Global warming is also causing changes in the precipitation pattern globally, including wetter conditions across eastern North America and drier conditions in the tropics. Antarctica is the driest continent. The globally averaged annual precipitation over land is 715 mm (28.1 in), but over the whole Earth it is much higher at 990 mm (39 in). Climate classification systems such as the Köppen classification system use average annual rainfall to help differentiate between differing climate regimes. Rainfall is measured using rain gauges. Rainfall amounts can be estimated by weather radar (Ajetomobi, 2016).

Precipitation, especially rain, has a dramatic effect on agriculture. All plants need at least some water to survive, therefore rain (being the most effective means of watering) is important to agriculture. While a regular rain pattern is usually vital to healthy plants, too much or too little rainfall can be harmful, even devastating to crops. Drought can kill crops and increase erosion, while overly wet weather can cause harmful fungus growth. Plants need varying amounts of rainfall to survive. For example, certain cacti require small amounts of water, while tropical plants may need up to hundreds of inches of rain per year to survive (Ajetomobi, 2016).

2.1.5 Crop Production

Crop production is a branch of agriculture that deals with growing crops for use as food and fiber. It depends on the availability of arable land and is affected in particular by yields, macroeconomic uncertainties, as well as consumption patterns; it also has a great incidence on agricultural commodity prices. The importance of crop production is related to harvested areas, returns per hectare (yields) and quantities produced. Crop yields are the harvested production per unit of harvested area for crop products. In most of the cases yield data are not recorded, but are obtained by dividing the production data by the data on area harvested. The actual yield that is captured on farm depends on several factors such as the crop's genetic potential, the amount of sunlight, water and nutrients absorbed by the crop, the presence of weeds and pests. Crop production is measured in tonnes per hectare, in thousand hectares and thousand tonnes (Ajetomobi, 2016).

2.1.6 Guinea corn

Guinea corn also known as sorghum, is a cereal grain that originated in Africa and is eaten throughout the world, especially valuable terrain because of its resistance to drought (Odunfa, 2012). Guinea corn is a nutrient rich grain that is often ground into flour to make bread, porridge, pancakes and Kunun drink. This product offers a number of nutritional and therapeutic benefits. Guinea corn contain about the same and some times more protein than many other grains. It is use for food, fodder, and the production of alcoholic beverages. It is drought tolerant and heat tolerant, and is especially important in arid regions. It is an important food crop in Africa, Central America, and South Asia, and is the fifth most important cereal crop grown in the world (Akinsoyinu and Mba, 1978; Odunfa, 2012; Amusa and Odumbuka 2009). Guinea corn is one of the nutritional high light, its mineral content in ¼ cup serving contains 13mg calcium 2.1mg iron 13.8mg phosphorus, these are essential minerals needed for bone health and strength (Van der walt, 2010)

Guinea corn has been, for centuries, one of the most important staple foods for millions of poor rural people in the semiarid tropics of Asia and Africa. For some impoverished regions of the world, Guinea corn remains a principal source of energy, protein, vitamins and minerals. Guinea corn grows in harsh environments where other crops do not grow well, just like other staple foods that are common in impoverished regions of the world. It is usually grown without application of any fertilizers or other inputs by a multitude of small-holder farmers in many countries (FAO, 2005).

Guinea corn is the third most important cereal crop grown in the United States and the fifth most important cereal crop grown in the world. In 2010, Nigeria was the world's largest producer of Guinea corn, followed by the United States and India. In developed countries, and increasingly in developing countries such as India, the predominant use of guinea corn is as fodder for poultry and cattle *(*Rajulapudi, 2015*).* Leading exporters in 2010 were the United States, Australia and Argentina; Mexico was the largest importer of guinea corn.

An international effort is under way to improve guinea corn farming. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has improved guinea corn using traditional genetic improvement and integrated genetic and natural resources management practices. New varieties of guinea corn from ICRISAT has now resulted in India producing 7 tons per hectare (Rajulapudi, 2015). Some 194 improved cultivars are now planted worldwide. In India, increases in guinea corn productivity resulting from improved cultivars have freed up six million hectares of land, enabling farmers to diversify into high-income cash crops and boost their livelihoods. Guinea corn is used primarily as poultry feed, and secondarily as cattle feed and in brewing applications (Daniel, 2013).

2.1.7 Weather trend in Nigeria

The temperature trend in Nigeria since 1901 shows increasing pattern (see Figure 2.1). The increase was gradual until the late 1960s and this gave way to a sharp rise in air temperatures from the early 1970s, which continued till 2005. The mean air temperature in Nigeria between 1901 and 2005 was 26.6^0C while the temperature increase for the 105 years was 1.1^0C. This is obviously higher than the global mean temperature increase of 0.74oC recorded since 1860 when actual scientific temperature measurement started (Spore 2011; IPCC 2012). Should this trend continue unabated, Nigeria may experience between the middle (2.5^0C) and high (4.5^0C) risk temperature increase by the year 2100 (Odjugo, 2010). Rainfall trend in Nigeria between 1901 and 2005 shows a general decline (see Figure 2.2). Within the 105 years, rainfall amount in Nigeria dropped by 81mm. The declining rainfall became worst from the early 1970s, and the pattern has continued till date. This period of drastic rainfall decline corresponds with the period of sharp temperature rise (see Figure 2.2). Although there is a general decrease in rainfall in Nigeria, the coastal areas of Nigeria like Warri, Brass and Calabar are observed to be experiencing slightly increasing rainfall in recent times (Odjugo, 2010).

This is a clear evidence of climate change because a notable impact of climate change is, increasing rainfall in most coastal areas and decreasing rains in the continental interiors

(NEST 2013). Odjugo (2010) observed that the number of rain days dropped by 53% in the north-eastern Nigeria and 14% in the Niger-Delta Coastal areas. These studies also showed that while the areas experiencing double rainfall maximal is shifting southward, the short dry season (August Break) is being experienced more in July as against its normal occurrence in the month of August prior to the 1970s. These are major disruptions in climatic patterns of Nigeria showing evidences of a changing climate. The computed R^2=0.82 and R^2=0.18 in temperature (see Figure 2.2) and rainfall (see Figure 2.3) respectively shows that within the past 105 years the temperature increase (warming) in Nigeria is statistically significant while the rainfall decline is not. This is a pointer that Nigeria is going to be hardly hit by global warming in the nearest future while the declining and shifts in rainfall pattern are becoming a worrisome development (Odujgo, 2012).

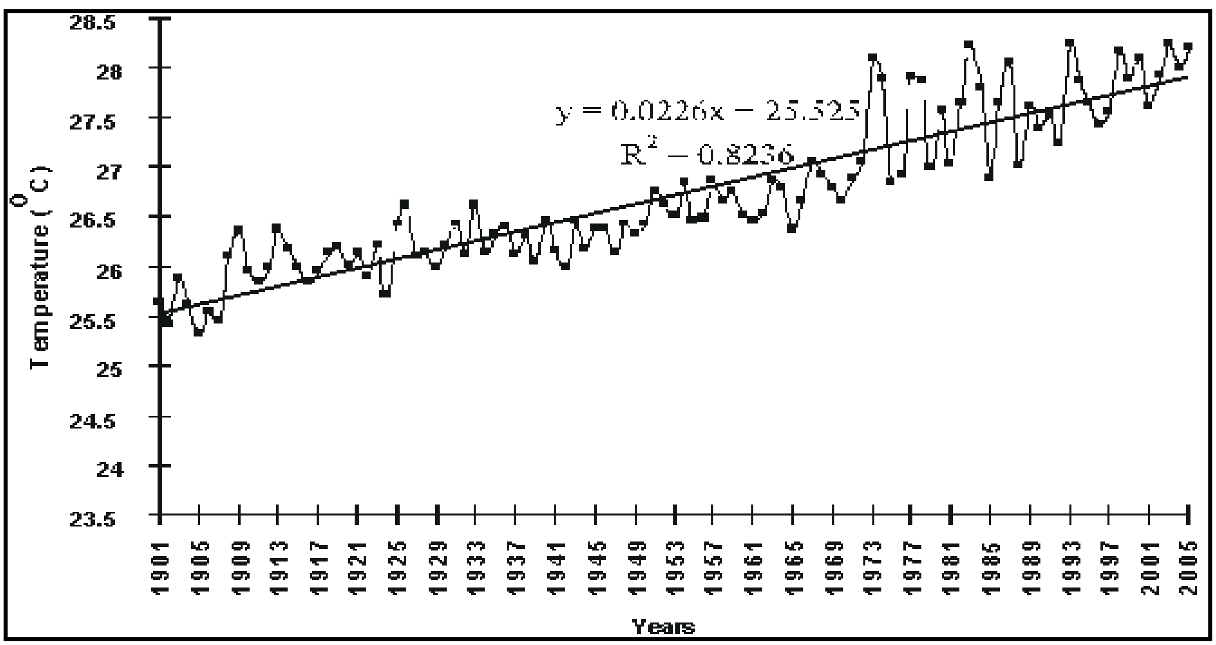

Figure 2.2: Air temperature distribution in Nigeria between 1901 and 2005
Source: Odjugo, 2012

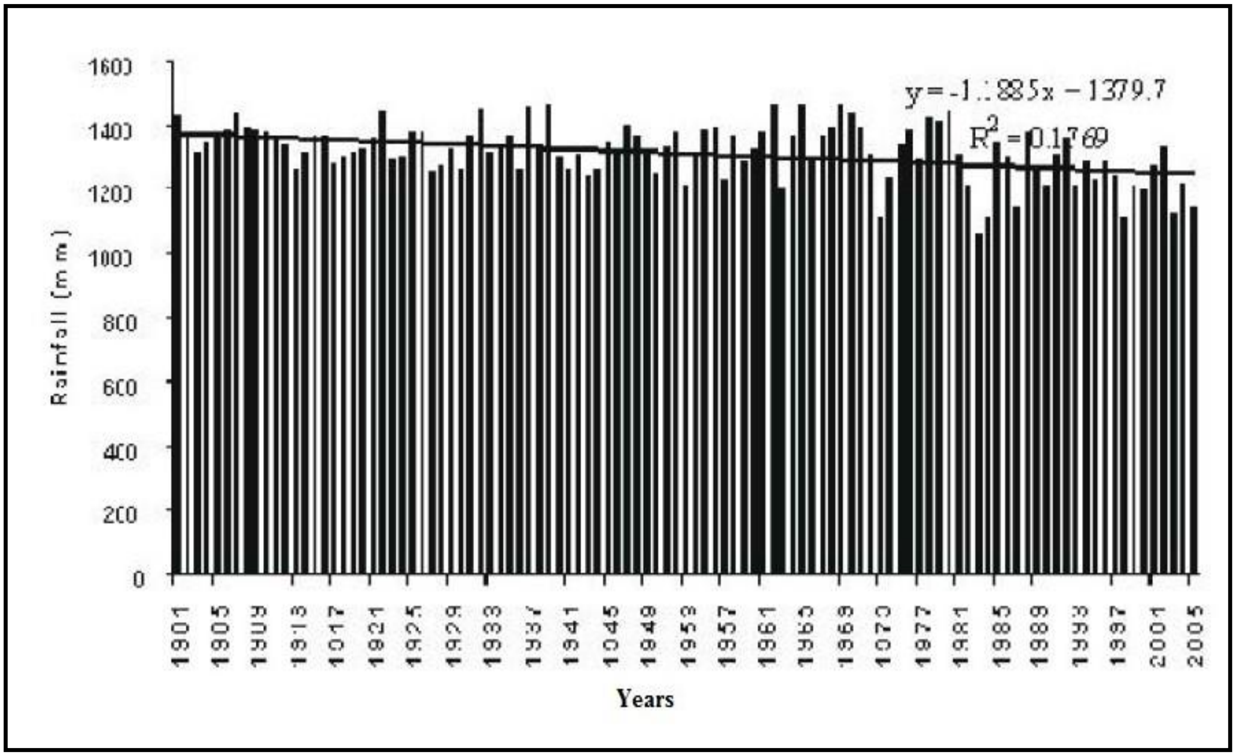

Figure 2.3: Rainfall distribution in Nigeria between 1901 and 2005
Source: Odjugo, 2012

2.1.8 Temperature

Temperature is a physical quantity expressing hot and cold. It is measured with a thermometer calibrated in one or more temperature scales (Moran and Shapiro, 2006). The most commonly used scales are the Celsius scale (formerly called *centigrade*) (denoted °C), Fahrenheit scale (denoted °F), and Kelvin scale (denoted K). The kelvin (spelled with a lower case k) is the unit of temperature in the International System of Units (abbreviated SI), in which temperature is one of the seven fundamental base quantities. The Kelvin scale is widely used in science and technology (Moran and Shapiro, 2006).

Theoretically, the coldest a system can be is when its temperature is absolute zero, at which point the thermal motion in matter would be zero. However, an actual physical system or object can never attain a temperature of absolute zero. Absolute zero is denoted as 0 K on the Kelvin scale, −273.15 °C on the Celsius scale, and −459.67 °F on the Fahrenheit scale (Moran and Shapiro, 2006). The effects of increased temperature exhibit a larger impact on grain yield than on vegetative growth because of the increased minimum temperatures. These effects are evident in an increased rate of senescence which reduces the ability of the crop to efficiently fill the grain or fruit.

2.2 Theoretical Framework

There are many theories of weather in relation to climate change. The first theory of weather in relation to climate change reviewed in this study is known as Anthropogenic Global Warming, or AGW, (IPCC, 2013) contends that human emissions of green-house gases, principally carbon-dioxide (CO_2), methane, and nitrous oxide, are causing a catastrophic rise in global temperature. The mechanism whereby this happens is called the enhanced greenhouse effect. Another theory of climate change is called Global Bio-thermostat which holds that negative feedbacks from biological and chemical processes entirely or almost entirely offset whatever positive feedbacks might be caused by rising CO_2. These processes act as a “Global Bio-thermostat” keeping temperatures in equilibrium. The scientific literature contains evidence of at least eight such feedbacks which includes Carbon Sequestration, Carbonyl Sulfide, Diffuse Light, Iodocompounds, not counting cloud formation, dimethyl sulfide and other Aerosols.

Another theory of climate change is called Human Forcings spearheaded by Omojolaibi, (2014), it holds that mankind’s greatest influence on climate is not its greenhouse gas emissions, but its transformation of Earth’s surface by clearing forests, irrigating deserts, and building cities. According to Pielki (2009), although the natural causes of climate variations and changes are undoubtedly important, the human influences are significant and involve a diverse range of first-order climate forcings, including but not limited to, the human input of carbon dioxide (CO_2). Short descriptions of some of these "human forcings" other than green-house gases follow.

According to Gray (2009) the lead proponent of "Ocean Currents Theory" which contends that global temperature variations over the past century and a half, and particularly the past 30 years, were due to the slow-down of the ocean's Thermohaline Circulation (THC).Ocean water is constantly transferred from the surface mixed layer to the interior ocean through a process called ventilation. The ocean fully ventilates itself every 1000 to 2000 years through a polar region (Atlantic and Antarctic) deep ocean subsidence of cold-saline water and a compensating upwelling of warmer less saline water in the tropics. This deep ocean circulation, called the Meridional Overturning Circulation (MOC), has two parts, the primary Atlantic Thermohaline Circulation (THC) and the secondary Surrounding Antarctica Subsidence (SAS). Paleo-proxy data and meteorological observations show there have been decadal to multi-century scale variations in the strength of the THC over the past thousand years, when the THC circulation is stronger than normal the earth-system experiences a slightly higher level of evaporation-precipitation (~2 percent). When the THC is weaker than normal, as it is about half the time, global rainfall and surface evaporation are reduced about 2 percent (Gray, 2009).

Bast (2010) presented a theory of climate change as propounded in 1600s by Johannes Kepler[1] called the theory of Planetary Motion. The theory states that most or all of the warming of the latter part of the twentieth century can be explained by natural gravitational and magnetic oscillations of the solar system induced by the planet's movement through space. These oscillations modulate solar variations and/or other extraterrestrial influences of Earth, which then drive climate change. An extraterrestrial influence on climate on a multi-millennial time-scale associated with planetary motion was first suggested by a Serbian astrophysicist, Milutin Milankovitch, and published in 1941. More recent discoveries have enabled scientists to accurately measure these effects on climate. Earth's orbit around the sun takes the form of an ellipse, not a circle, with the planet passing farther away from the sun at one end of the orbit than at the other end. The closest approach of the planet to the sun is called "perihelion" and the farthest is called "aphelion". Perihelion now occurs in January, making northern hemisphere winters slightly milder. The change in timing of perihelion is known as the precession of the equinoxes, and it occurs every 22,000 years (Bast, 2010).

2.2.1 Different theories for estimating weather impacts on crop yield

Different methods and approaches for estimating the impact of weather on the agriculture sector are found in the literature. They are grouped into two broad categories: partial economic models and economy-wide models. Partial equilibrium models analyse a single market or commodity or subsets of markets or sectors whilst general equilibrium models observe the economy as a complete system of co-dependent elements (such as industries, factors of production, institutions and the rest of the world) (Sadoulet & De Janvry 1995). The most common economy-wide general equilibrium model is the computable general equilibrium (CGE) model. Partial equilibrium models encompass four approaches: crop modelling/agro-economic, Ricardian/cross-sectional, panel data (Deressa & Hassan 2009) and agro-ecological zone (AEZ).

2.2.1.1 Computable general equilibrium approach

The CGE model estimates the economy-wide effects of weather (Deressa & Hassan 2009). CGE methods are based on a system of linear and non-linear equations that can be solved to simulate equilibrium. As weather affects different sectors of an economy directly or indirectly, CGE models are required for weather impact assessment (Winters *et al.,* 1996). The main advantage of applying CGE models is that they take into account the economy-wide effects of weather. However, the major disadvantages of the model are difficulties with model selection; functional forms and parameter specification; data consistency or calibration problems; the absence of statistical tests for the model specification; and the complexity of the CGE models and the high level skills required to develop and utilise them (Gilling & McCarl 2002).

2.2.1.2 Crop modelling or production function approach

Based on the weather-yield relationship, the crop modelling approach estimates the effects of weather on agricultural production. Survey or experimental data are used to measure this relationship. This agronomic-economic method commences with a crop model that is calibrated from carefully controlled agronomic experiments (Adams *et al.,* 2008). The agronomic modelling evaluates how a crop reacts to the changing environmental conditions. In this initial stage, environmental variables are employed to measure crop yields and output variations in laboratory type settings. The changes in yields are then entered into the economic model as inputs to predict the aggregate impact on crop yields and prices under various settings. Models have been developed and calibrated through repeated experiments by agronomists to forecast yield changes of specific crops under different weather settings (Adams *et al.,* 2008). Crop simulation models developed worldwide include CERES (Hawaii), CROPSYST (Washington), CROPWAT and CROP Yield Forecasting (FAO), APSIM (Australia) and SWB (Pretoria). These models have been successfully employed in many studies (Easterling *et al.,* 1993; Rosenzweig et al. 1995; Makadho 1996; Iglesias *et al.,* 2000; Tubiello et al. 2000; Du Toit *et al.,* 2002).

While this approach offers a carefully controlled and randomised application of environmental conditions, the laboratory style outcomes might not incorporate the adaptive behaviour of optimising farmers. Though some adaptation is modelled, it is not clear how well this corresponds to the actual behaviour of farmers (Guiteras 2009). This approach is expected to produce estimates with a negative bias when farmers' actual practices are more adaptive. Furthermore, if the presumed adaptation does not take adjustment mechanisms into consideration, these estimates could be over optimistic (Guiteras 2009). In developing countries, most agronomic models perform an unsatisfactory job of incorporating adaptation. Incorporating new technologies has also traditionally been overlooked in agronomic models (Mendelsohn & Tiwari 2000).

2.2.1.3 Ricardian/cross-sectional approach

The cross-sectional approach examines farm performance in different climate zones. This has been named the Ricardian approach as it is based on the theoretical work of the classical economist David Ricardo. His Rent Theory states that land values or net revenue from land uses reflect land productivity at a particular site under conditions of perfect competition (Ricardo 1817, 1822). The approach explores a cross-section of farmers in various climatic settings and looks at the relationship between the land value or net revenue1 and agro-climate factors (Mendelsohn *et al.* 1994; Kumar & Parikh 1998). That is, it specifies land value as a function of weather, economic, demographic and physical variables (Mendelsohn *et al.*, 1994). The marginal contribution of each input variable to farm income is measured by regressing land value on a set of environmental input variables. The main strength of this approach is that it captures farmers' adaptations that affect the net revenue or farm income. The approach has been successfully applied in many countries: the USA (Mendelsohn *et al.*, 1994; Mendelsohn & Dinar 2003), England and Wales (Maddison 2000), Kenya (Mariara & Karanja 2007), Taiwan (Chang 2002), South Africa (Gbetibouo & Hassan 2005), Cameroon (Moula 2009), China (Wang *et al.*, 2009), and India and Brazil (Sanghi & Mendelsohn 2008).

All these theories has direct link with the impact of weather on crop production since changes in weather over longer period of time result to climate change which in turn impact on crop production precisely guinea corn production in the study area.

2.3 Empirical Studies

Ofor *et al.* (2009) studied crop protection problems in production of maize and guinea corn in Northern Guinea Savanna of Nigeria and control measures. The cultivation of Maize and Guinea corn in the northern Guinea Savanna of Nigeria is faced with lots of Crop protection problems which hinder full scale production of these crops in that ecological zone. Structured questionnaire was used to collect data during the 2008 farming season from three hundred and five farmers across the Northern Guinea Savanna of Nigeria. The finding of the study revealed problems range from biotic factors like vertebrate and invertebrate pests, disease pathogens, nematode and weeds, to abiotic factors such as nutrient deficiencies, environmental conditions (climatic, edaphic), and agronomic, logistic or social problems. Addressing the various problems militating against the production of maize and Guinea corn in this zone will further help strengthen the national food reserve base and alleviate the devastating effects of the global food crisis particularly in Nigeria. The study conclude that plant protection is currently considered as being synonymous with the use of pesticides whose utilization is the only barometer for ascertaining achievement in this respect. Other control methods which are relatively easy to adopt should be explored and exploited. A number of pests can effectively be checked by manipulation of cultural practices, for example, depth of planting, soil and water management, soil amendments (for nematodes), and dry season deep plowing for killing insects and pathogens in the soil. Growing maize and sorghum in areas where the environment is unsuitable for pests and diseases attack and where the crops have relative advantage for high yield potential is essential for good economic returns from the farm.

Bello *et al.,* (2012) examined evidence of climate change impacts on agriculture and food security in Nigeria. 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. The spatiotemporal pattern of temperature and rainfall of Nigeria between 1901 and 2005 (105 years), using temperature and rainfall data to support the concept of regional climate change and its impact on Agriculture and food security was in-vestigated. Also assessed was the level of agriculture funding and output in Nigeria. Mean annual air temperature and rain-fall data between 1901- 2005 (105 years) were obtained from Food and Agricultural Organization publications, National Bureau of Statistics, Central Bank of Nigeria bulletin and National Meteorological Agency. Descriptive statistics were used to analyze the data. The results showed that within the period of 105 years, rainfall decreased by 81 mm with increasing temperature of 1.1℃. The unpredictability of rainfall and steadily increasing air temperature were observed from 1971-2005. The total federal budget between 2001 and 2005 averaged 824 billion Naira per year of which very small amount (14.7 billion (1.8%)) went to agricultural sector. The actual spending was 681 billion naira per year with 11.4 billion naira for agriculture. Over 25 years, there were low and dramatic walloping of public spending in agriculture relative to large size and importance of agricultural sector in the economy. There is a continuous rise in output from 1987 to 2000 before it dropped in 2001. Land degradation, desert encroachment, drying up of surface waters, coastal inundations, and shift in cultivated crops over time affected the food security in Nigeria. The current available data showed that Nigeria, like most parts of the world is experiencing the basic features of climate change. Therefore, Nigerian government/ private sector partnership should encourage agricultural, industrial and domestic practices which will not contribute to the emission of greenhouse gasses.

Labaris *et al.* (2014) evaluated problems of guinea corn marketing in Nasarawa State, Nigeria. The study examines the problems of sorghum marketing in Nasarawa State. Structured questionnaire was used to collect data during the 2013 farming season from two hundred and forty food marketers across six Local Government areas of the State. The descriptive statistics were used to analyze and describe the data collected while the Kohls (1985) formula was used to determine the estimates of market margins and marketing efficiency was calculated using Olukosi and Isitor (1990) formulae. The results indicate that the average farm gate price of guinea corn was ₦10 000 per 100 kg bag. The average marketing cost was ₦1, 100 per bag and average net marketing margin was ₦1, 233.3 per bag. The average marketing efficiency was 106.5 .The major problems confronting guinea corn marketing; transportation problem, inadequate market infrastructure, inadequate funding, and shortage of processing facilities, seasonality and perishability of food produce and ethnic crisis. To improve guinea corn marketing in the study area it is recommended that adequate transportation facilities should be provided by government, private individuals and corporate groups; research into post-harvest storage and processing techniques should be intensified; and funds should be made available to food marketers so that they can take advantage of bulk purchasing, market expansion and post-harvest processing.

Aondoakaa (2012) studied effects of climate change on agricultural productivity in the Federal Capital Territory (FCT), Abuja, Nigeria. The effects of the dynamics of climate on agricultural production are the thrust of this paper. Temperature, rainfall and crops (rice, maize, cassava, groundnut and garden eggs) data were collected for a period of 10 years from the meteorological and agricultural department of the Agricultural development programme (ADP) Gwagwalada. The work assembled and analysed all available data which are needed for evaluating the implication of climate change on agricultural production in the FCT. Some measure of central tendencies were used to critically analyse the parameters such as arithmetic mean, standard deviation, coefficient of variance, simple regression, correlation and multiple regression model to correlate the relationship among rainfall, temperature and crop yield. The paper concludes there exists positive relationship between each climatic element and crop yield but on a very weak significance; there has been constant increase in temperature over the years with 2009 having the highest of 35^{0}C; there is decline in rainfall over the years, and subsequent decline in the productivity of the crops from the correlation carried out in the study. These recommendations were forwarded: Crop yield should be regressed on other environmental factors such as soil fertility. A longer period of data could be collected for better analysis; and data on rainfall, temperature and other crops could be collected and investigated upon to correlate the result with this finding.

Ammani *et al.,* (2012) evaluated climate change and maize production: empirical evidence from Kaduna State, Nigeria. An estimated 80% of the maize crop suffers periodic yield reduction due to drought stress. Drought at flowering and grain filling period may cause losses of 40-90%. Predicated on the argument that climate change resulted from changes in climatic elements such as rainfall, this study aimed at investigating the relationship between rainfall, among other factors, and maize crop production in Kaduna state over a period of 15 years. Time series data on aggregate maize production, fertilizer use, total area under cultivation with the maize crop and annual rainfall in Kaduna State for the period 1990-2005 were collected and analysed using multiple regression technique. Findings of the study showed that annual rainfall contributes significantly and positively to maize production in the study area inspite of climate change, indicating that climate change has not significantly altered the pattern of rainfall in the study area in such a way as to affect maize production negatively.

Moses (2016) assessed drought in Kaduna State, Nigeria between 2000 and 2014. Kaduna state is located within the Guinea Savannah of the African Continent. As a result, it is susceptible to desertification and the risks of drought abound. This study examined the three most important ways of monitoring drought in any locality: people‘s perception, precipitation data and satellite remote sensing. Simple statistical tables were used to present and analyse the data. Equally, Microsoft Office Excel, Statistical Package for Social Science (SPSS), and Idrisi software were used to analyse the data. The study revealed that there have been episodes of drought in Kaduna state within the period under review. The study also revealed that there is a positive relationship (0.72) between rainfall and vegetation vigour/biomas in the state. Similarly, vegetation condition index (VCI) revealed a value 10.2% indicating a severe drought in the state. Therefore, the study concluded that both rainfall and vegetation vigour/biomas are generally decreasing; indicating a strong positive correlation value of 0.71 (71%). The study therefore recommends that there should be public enlightenment campaign on drought as it is a very complex phenomenon and its effects very devastating. The study recommends that individuals be encouraged to develop the habit of tree planting to curtail the dilapidating vegetation in the state. Government should provide an effective municipal supply of water across the state for both domestic and industrial usage in a bid to protect underground water resources. In addition, research and extension services should be carried out in order to develop particular breeds of seeds that can survive the drought.

Kondwani (2013) examined climate change impact on rainfed corn production in Malawi. Agriculture is the mainstay of the economy in Malawi and accounts for 40% of the Gross Domestic Product (GDP) and 90% of the export revenues. Corn (maize) is the major cereal crop grown as staple food under rainfed conditions, covers over 92% of the total agricultural area, and contributes 54% of the caloric intake. Corn production is the principle occupation and major source of income for over 85% of the total population in Malawi. Issues of hunger and food insecurity for the entire nation are associated with corn scarcity and low production. Global warming is expected to cause climate change in Malawi, including changes in temperature and precipitation amounts and patterns. These climate changes are expected to affect corn production in Malawi. This study evaluates the impacts of climate change on rainfed corn production in Malawi. Lilongwe District, with about 1,045 square miles of agriculture area, has been selected as a representative area. First, outputs of 15 General Circulation Models (GCMs) under different emission scenarios are statistically downscaled. For this purpose, a weather generator (LARSWG) is calibrated and validated for the study area and daily precipitation as well as minimum and maximum temperature are projected for 15 GCMs for three time horizons of 2020s, 2050s and 2090s. Probability assessment of bounded range with known distributions is used to deal with the uncertainties of GCMs' outputs. These GCMs outputs are weighted by considering the ability of each model to simulate historical records. AquaCrop, a new model developed by FAO that simulates the crop yield response to water deficit conditions, is employed to assess potential rainfed corn production in the study area with and without climate change. Study results indicate an average temperature increase of 0.52 to 0.94^{0}C, 1.26 to 2.20^{0}C and 1.78 to 3.58^{0}C in the nearterm (2020s), mid-term (2050s) and long-term (2090s) future, respectively. The expected changes in precipitation during these periods are -17 to 11%, -26 to 0%, and -29 to -3%. Corn yields are expected to change by -8.11 to 0.53%, -7.25 to -14.33%, and -13.19 to -31.86%, during the same time periods. The study concludes with suggestion of some adaptation strategies that the Government of Malawi could consider to improve national food security under climate change.

Igwe *et al.,* (2014) studied climate change and growth rate of food grain output in Nigeria (1970-2010). The study examined climate change and growth rate of food grain output in Nigeria from 1970-2010. Time series data of maize, rice, millet, sorghum, wheat, temperature and rainfall were used for the study. Data analysis involved the use of Descriptive Statistics and the annual additive series (Trend) Analysis measured in years by getting the annual average of parameters which depict the factual position of climate change by variations of the weather parameters over time. Findings showed that the preferred weather parameters (rainfall and temperature), and the food grain (maize, rice, millet, sorghum, guinea corn, wheat) exhibited significant changes in trend of growth during the 1970-2010 period. Rainfall grew at the compound growth rate of 5.3 % more than temperature per annum. The compound growth rate of maize, millet, sorghum, and wheat output were less than the compound growth rate of rice by 0.9%, 6.5%, 5.9% and 6.4% respectively, and the compound growth rate of maize, rice, sorghum, and wheat outputs were more than the compound growth rate of millet output by 5.6%, 6.5%, 0.6% and 0.1% respectively. Acceleration was witnessed in the growth rate of temperature, rainfall, sorghum, guinea corn and millet; deceleration for wheat, while stagnation was witnessed in the growth rate of rice and maize over the 1970-2010 periods. There was significant difference in the average growth rate of rainfall and each of maize, millet, sorghum and wheat yield; and no significant difference between rainfall and rice. There was no significant difference also in the average growth rate of temperature and each of maize, millet, sorghum and wheat yield; but there was significant difference between temperature and rice. The conclusion of the study is that food grain yield was influenced by rainfall and temperature. It is therefore recommended that if increase in food grain production is to be sustained, proper irrigation and drainage should be applied.

Baiyegunhi and Fraser (2009) assessed the profitability of sorghum production in three Villages of Kaduna State, Nigeria. Poverty in Nigeria is overwhelmingly a rural problem. In 1985, 86.6 percent of those living below poverty line of US $1 per day were in the agricultural sector. This figure dropped to 66 per cent in 1992. However, of the total population of poor people in 1992, 10 million were living in the rural areas and are engaged in farming. Nigerian small-scale farmers are characterized by the use of unimproved inputs and traditional production tools that are capable of generating only very small incomes. This low income of the farmers leads to vicious cycle of poverty with low levels of savings and investments, which in turn leads to low productivity and low income. In explaining the poverty status of farmers, it is necessary to look into the profitability of their farm enterprise to show the close links existing between productivity and farm income. This study attempts to estimate the profitability of sole sorghum production on small and large scale farms, it uses the gross margin analysis to determine the farm income on small and large scale farms. Empirical results indicate that the farmers are making profits, given the benefits relative to costs involved in sorghum production on both the small and large scale farms. To fully tap the potential of increase productivity and farm income, the study surmises that expanded access to improved technologies on sorghum production should be extended to the farmers through extension services.

Rosemary (2012) examined the impacts of climate change on crop production practices among small holder farmers in Guruve District, Zimbabwe. This research was carried out in Guruve district with the aim of documenting local people's experiences and perceptions towards climate change impacts on crop production and their responses. Qualitative and quantitative methodologies were used in an attempt to analyze the impact of climate change on crop production practices and the strategies that people invent to ensure improved crop productivity. The Sustainable Livelihoods Framework, Structure-Agency and the Actor-oriented perspective (AOP) were the chief analytical tools employed to explore the phenomenon under study. Primary data was collected from small scale crop producers using semi-structured questionnaires with farmers, interviews with farmers and key informants as well as observations. Published and unpublished data were also consulted. The study revealed that climate change affects crop productivity due to insufficient rains and sometimes too much rain which results in various crop diseases and failure in Guruve. The farmers have however not been passive victims as they have adapted in several ways mainly through conservation farming thereby managing to sustain their livelihoods. The study concludes that the wealth of knowledge on coping and adaptation that farmers have should form the foundation for designing crop production innovation systems to deal with impacts of climate change on crop production practices.

Ajetomobi (2016) assessed the effects of weather extremes on crop yields in Nigeria. This study seeks to analyze how extreme weather conditions affect crop yield and risk in Nigeria and to assess the potential implications of weather extremes on the nation's crop insurance portfolio. A panel of Nigerian state-level crop yields was paired with a fine-scale weather data set that included distribution of temperature and precipitation between the minimum and maximum across all days of the growing season for selected crops. Weather data were examined from January 1, 1991 to December 31, 2012. The analysis was started with the traditional approach of estimating climate change impact by a quadratic regression model of weather and Growing Degree Days (GDD) on crop yields using panel data estimation. Later, Harmful Degree Days (HDD) and Vapour Pressure Deficit (VPD) were step-wisely included. Interactions of rainfall, GDD and VPD were also explored. In the production approach, crop yield was specified as a function of weather inputs (temperature and precipitation). The results showed that the time when the lowest and highest yields were obtained differed by crops. The highest (43.50 kg/ha) and lowest (1.085kg/ha) yields for cassava were observed in 1999 and 2001, respectively, while both highest and lowest yields for sorghum were recorded in 2012. Daily maximum temperature between 30 and 35 °C occurred more than a 1000 times over all the days covered in this study (January 1, 1991 to December 31, 2012). The regression results showed that high damage to cassava, cotton and maize was evident by the strong and negative coefficient of Harmful Degree Days (HDD). For sorghum and rice, an exposure to heat range showed a negative influence on the yield. In order to address the negative weather effects and other problems associated with the National Agricultural Insurance Corporation (NAIC) such as little access by farmers, high information asymmetric and transaction costs, crop insurance based on indices from Nigeria Meteorological Agency (NIMET) could be adopted to compensate part of the damage caused to the farm products.

Akullo (2014) examined the effect of weather on crop yields: A case study of the maize crop in Masindi District Western Uganda. Weather and crop yield is a crucial consideration for food security in Uganda. This study considered a relationship between weather and maize yield as an aid to emphasize the significance and need for weather information and monitoring for enhancing food security and sustainable livelihoods in Masindi District. The study used questionnaires and observations from the field, climate data (mean monthly rainfall and mean monthly maximum and minimum temperatures) from the Uganda Meteorology Authority as well as maize crop yields over season 1 (March to May) and season 2 (August to November) in the study region to establish the relationship between maize yield and climate parameters. Results concerning perceptions of the Masindi farmers obtained from structured questionnaires indicate rainfall and temperature are crucial for crop growth in the two cropping seasons. These observations were in agreement with climate (mean monthly rainfall and mean monthly maximum and minimum temperatures) data for Masindi station from 1961 to 2012 inclusive. Analysis of the climate data showed that cropping seasons are punctuated by rainfall peaks in April and October, lower mean seasonal maximum temperatures and higher mean seasonal minimum temperatures over the growing seasons. The study also found that the major food crops planted in Masindi District included cassava and maize. However, since cassava is an annual crop, maize was the crop chosen to investigate the relationship between maize yield and climate parameters. The coefficients of determination R2 = 0.55 and R2 = 0.47 for season 1 and 2 respectively indicate that the weather elements (rainfall and maximum and minimum temperature) affect crop yields in the region. Hence maize yields in Masindi District are vulnerable to weather and climate variability which have a great impact as crops are rain fed. The implications of findings of this study for the respective stakeholders such as government and local authorities is to improve the early warning weather and climate information systems for Masindi farmers. Further study should consider the development of crop weather models that can be used to forecast seasonal yield or expected yield for any given phenological stage of the crop. This can aid government and local authorities in the placement of contingency plans for Masindi District communities' food security.

2.3.1 Summary of Reviewed Literature

This review of the existing literature has outlined some gaps or weaknesses. Earlier studies on the impact of weather on agriculture emphasised developed countries' agriculture which indicated they are not affected adversely. The very few studies of developing countries' agriculture have increased recently. The results, however, are not homogeneous because of different agricultural systems, geographical characteristics and technological states. Moreover, most of these early studies have assumed little or no adaptation and focused merely on the likely impact of weather on guinea corn yield. Most of the past cross-sectional studies used county or district level data. But these studies do not allow for the detailed socio-economic and demographic characteristics of farmers that are likely to affect their choice of adaptation and, thereby, farm productivity. A few recent studies have used farm level data. Impact and adaptation studies that use detailed farm level data are scant. Previous studies using time series data have not focused on guinea corn. Moreover, the results from those studies were not robust because of insufficient statistical and diagnostic tests. However, none of these studies looked at the impact of weather on guinea corn production in Kaduna State, Nigeria. There is paucity of information on the impact of weather on guinea corn production in Kaduna State, Nigeria especially in Igabi Local Government Area as indicated in some of the review literatures of this study. Hence, this study will attempt to look at the impact of weather on guinea corn production in Igabi Local Government Area of Kaduna State, Nigeria to fill these existing knowledge gaps.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Types of Data

The types of data used for this study include both quantitative and qualitative. The quantitative type of data used include collecting rainfall and temperature data from Nigeria Meteorological Agency (NIMET) of the Nigerian College of Aviation Technology (NCAT) Zaria and Guinea corn yield will also be obtain from Kaduna State Agricultural Development Agency for a period of 20 years (1999 – 2018). The qualitative types include questionnaire and oral interview.

3.2 Sources of Data

3.2.1 Primary data

The primary sources of data include questionnaire, oral interview and field survey. The purpose of selecting these sources of data include sourcing information on socio-economic challenges attributed to variation in guinea corn production in the study area; and adaptation strategies put in place to reduce the impact of weather on guinea corn production in the study area.

3.2.2 Secondary data

Based on World Meteorological Organsation (WMO) standard, a weather station covers a radius of 100 kilometers; therefore, monthly rainfall and temperature data of 1999-2018 (20 years) was obtained from the Nigerian Meteorological Agency (NIMET) of the Nigerian College of Aviation Technology (NCAT) Zaria and Guinea corn yield will also be obtain from Kaduna State Agricultural Development Agency for a period of 20 years (1999 –

2018). This provide a reliable representation of the study area rainfall and temperature. This complemented by texts, journals, thesis and dissertations from published and unpublished authors, also, internet materials on impact of weather on guinea corn production will be utilized so as to widen the scope of literature review.

3.3 Instrument for Data Collection

Quantitative and qualitative data were collected using a structured questionnaire, field survey and oral interview.

3.3.1 Questionnaire administration

Part of the instruments used for data collection were structured questionnaire. The questionnaire was collected information on the socio-economic challenges attributed to variation in guinea corn production in the study area and the adaptation strategies put in place to reduce the impact of weather on guinea corn production in the study area. The questionnaire was translated into local languages by interviewer for the farmers that could neither read nor write. The purpose of visiting the respondents in their farms is to get firsthand information about the socio-economic challenges attributed to variation in guinea corn production as well as the adaptation strategies put in place to reduce the impact of weather on guinea corn production in the study area. The questionnaires was be distributed by hand by the researcher on the days of visits to the respondents and later retrieved on completion for those farmers that are literate while those that are not literate, the interviewer was translate the questions in the questionnaire into the local language of the farmers.

3.3.2 Oral Interview

Oral interviews was also conducted by the researcher on some of the management and staff of the various associations of guinea corn farmers which also help in X-raying some vital information needed for the study.

3.3.3 Field Survey

Reconnaissance survey was also be conducted to see clearly how weather has impacted on guinea corn production in the study area and how they are coping with the variation. Useful information was derived from this field survey which was integrated to those qualitative information generated from questionnaire and oral interview.

3.4 Sampling and Sample Size

Sample size can be defined as part of the population chosen for a survey. Sample size of this study will be generated using Cochran's formula. This formula is concerned with applying a normal approximation with a confidence level of 95% and a limit of tolerance level (error level) of 5%.

To this extent the sample size is determined by no =

$$n_o = \frac{Z^2pq}{e^2} \quad 3.1$$

Where: n_o = the sample size

e = is the desired level of precision (i.e. the margin of error),

p = is the (estimated) proportion of the population which has the attribute in question,

q = 1 – p,

z-value is found in Z table which is located in appendix I of this study.

p = 0.5. Now we will be using 95% confidence, and at least 5 percent—plus or minus—precision. A 95% confidence level gives us Z values of 1.96, per the normal tables, so we get

$((1.96)^2 (0.5) (0.5)) / (0.05)^2 = 385.$

Therefore, n = 385 respondents

The study respondents was 385 and simple random sampling was used to distribute the questionnaires among the respondents.

3.5 Methods of Data Analysis

3.5.1 Examination of Rainfall and Temperature Variations across the study area for over the past 20 years

To achieve objective one which is to examine rainfall and temperature variations in the study area. Rainfall and maximum temperature to be obtained was on daily and monthly basis for a period of 20 years (1999 to 2018) and this was converted into mean annual value using the statistical technique below.

$$\bar{x} = \frac{\sum x}{n} \qquad 3.2$$

Where x is the rainfall occurrence in the study area and n = number of months' occurrence.

The same was applied for maximum temperature to obtain the monthly and annual mean value for the period of twenty years under study.

Simple linear (least square) analysis was used.

The equation:

$$\{[(at + b) - Yt]\}^2 \text{ where } at + b = \text{time line.} \qquad 3.3$$

Computation of Standardized Precipitation Index (SPI)

SPI, developed by McKee *et al*. (1993), an index that quantify the degree of wetness and dryness of an area on various timescales (say 1, 3, 6, 12 and 24 months) over the time (Khan, Gabriel and Rana 2008) was used. The SPI analysis for this research was computed using 20 years' time series rainfall data. Positive SPI values indicate greater than median precipitation, while negative values indicate less than median precipitation.

3.5.2 Examination of effect of Rainfall and Temperature on Guinea Corn production

Multiple linear regression was used to test the relationship between rainfall, temperature and guinea corn production.

$$Y = \pm a_1 \pm b_{\underline{1}} x_1 \pm b_2 x_{\underline{2}} + b_3 \underline{x}_3 \dots \dots \dots \dots \dots \dots \pm b_n x_{\underline{n}}$$

3.4

Where: Y = Guinea corn production yield;

x_1, x_2, x_3= rainfall and temperature

$a_1, b_1, b_2, b_3 \ldots\ldots\ldots b_n$ = are constant

X will be for rainfall and temperature values and Y will be for guinea corn yield values. This will be used to achieve objective two of the study.

3.5.3 Examination of the farmers perception on the impact of weather on guinea corn production

To achieve objective three of this study which is to investigate how farmers perceive the impact of weather on guinea corn production in the study area, descriptive statistics (frequency-percentage) will be used as a method of data analysis. Frequency percentage equation is given below.

$$\text{Frequency-percentage} = \frac{\text{Number of}}{\text{Total}} \times \frac{100}{1} \qquad 3.5$$

The frequency-percentage procedure is highly instrumental and effective in analysis of data obtained from the questionnaire. This is so because of its suitability, relative ease of interpretation and presentation.

3.5.4 Assessment of the current adaptation strategies of the farmers in response to the impact of weather variation.

To achieve objective four which is to assess the adaptation strategies put in place to reduce the impact of weather on guinea corn production, probit model was used to examine these strategies already adopted in the study.

Therefore, the selection equation analyzing the probability that the farmer adapts to weather variability is specified by following a probit model. This follows the assumption that the cumulative distribution of εi is normal (Wooldridge, 2001):

$$P(y = 1|\boldsymbol{x}) = G(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k)$$

$$G(z) = \Phi(z) \equiv \int_{-\infty}^{+\infty} \phi(v) dv$$

$$\phi(z) = (2\pi)^{-1/2} \exp\left(-\frac{z^2}{2}\right)$$

(3.6)

Where Φ is the normally cumulative distribution function. It is assumed that the probability of a farmer undertaking any adaptation at all (Y=1) depends on a vector of independent variables (X), unknown parameters (α), and the stochastic error term (ε) (Gujarati, 2003). The probability of a farmer undertaking any adaptation at all P(Y=1|X)) has been modeled empirically as a function of independent variables such as experience, gender, education, and household income; whether a farmer has observed decadal changes in rainfall and temperature and general availability of information about impact of weather on guinea corn production. This model implies a diminishing magnitude of marginal effects for the independent variables; the coefficients give the signs of the marginal effects of each of the independent variables on the probability that the farmer undertakes any adaptation at all.

Table 3.1: Summary of Methods and Materials

S/NO	Objectives	Source of Data	Data to be used	Statistical method
1	To analyse the trend of weather variation over the past 20 years (1999-2018) in Igabi Local Government Area of Kaduna State	NIMET, Nigeria College of Aviation Technology, Zaria	Daily / Annual rainfall and temperature for 20 years (1999-2018)	Standardized Precipitation Index (SPI) and Diurnal Temperature Range (DTR) will be used
2	To examine how Rainfall and Temperature impact on Guinea Corn production;	NIMET, Nigeria College of Aviation Technology, Zaria. Kaduna State Agricultural Development Project, Kaduna	Rainfall; Temperature and Guinea Corn yields	Multiple linear regression will be used.
3	To investigate how farmers perceive the impact of weather variations on Guinea Corn production;	Field Survey	Structural Questionnaire and Oral Interview	Descriptive statistics which will involve frequency and percentage will be used.
4	To assess the current adaptation strategies of the farmers in response to the impact of weather variations	Field Survey	Structural Questionnaire and Oral Interview	Descriptive statistics and probit model will be used.

Source: Authors, 2019

CHAPTER FOUR

4.0 DISCUSSION AND RESULTS

4.1 Rainfall and Temperature Variations in the study area

The relationship of crop and rainfall gave a negative relationship and others positive relationship. The relationship of both rainfall and temperature on Guinea corn showed a strong negative relationship. From 4.1, it can be deduced that there is a constant increase in temperature. This shows that there is yearly change in temperature that can alter the yield of Guinea corn yield in the study area. The coefficient of variation as seen above of maximum temperature 34.2 and minimum temperature 32.3 shows that there is a consistency in the variation although not too strong.

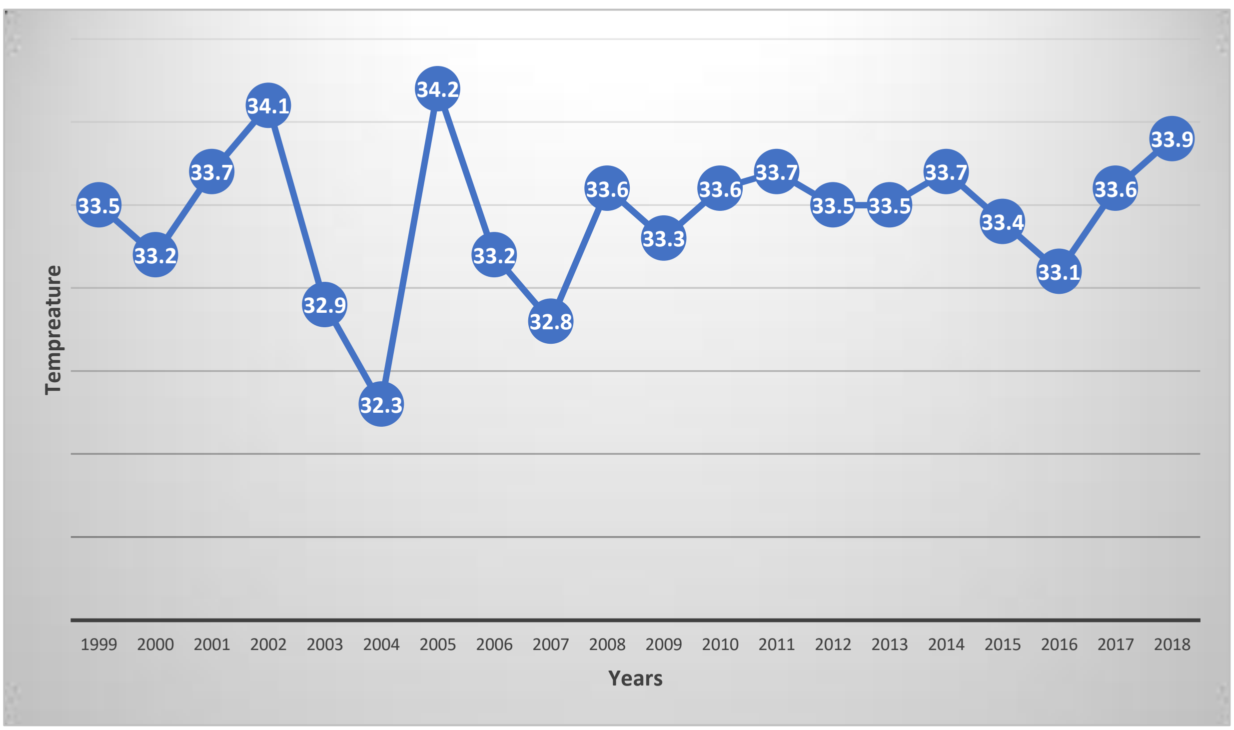

Figure 4.1: Pattern of Maximum Temperature in the study area

The figure showed the trend of temperature over the years in the study area, a close look at the graph reveals that the temperature from 2010 was constantly increasing except for the fall in 2016, but they never went below 32°C in 2004. The year 2005 experienced the highest temperature of 35°C. Figure 4.2 shows the annual total rainfall in the study area from 1999-2018.

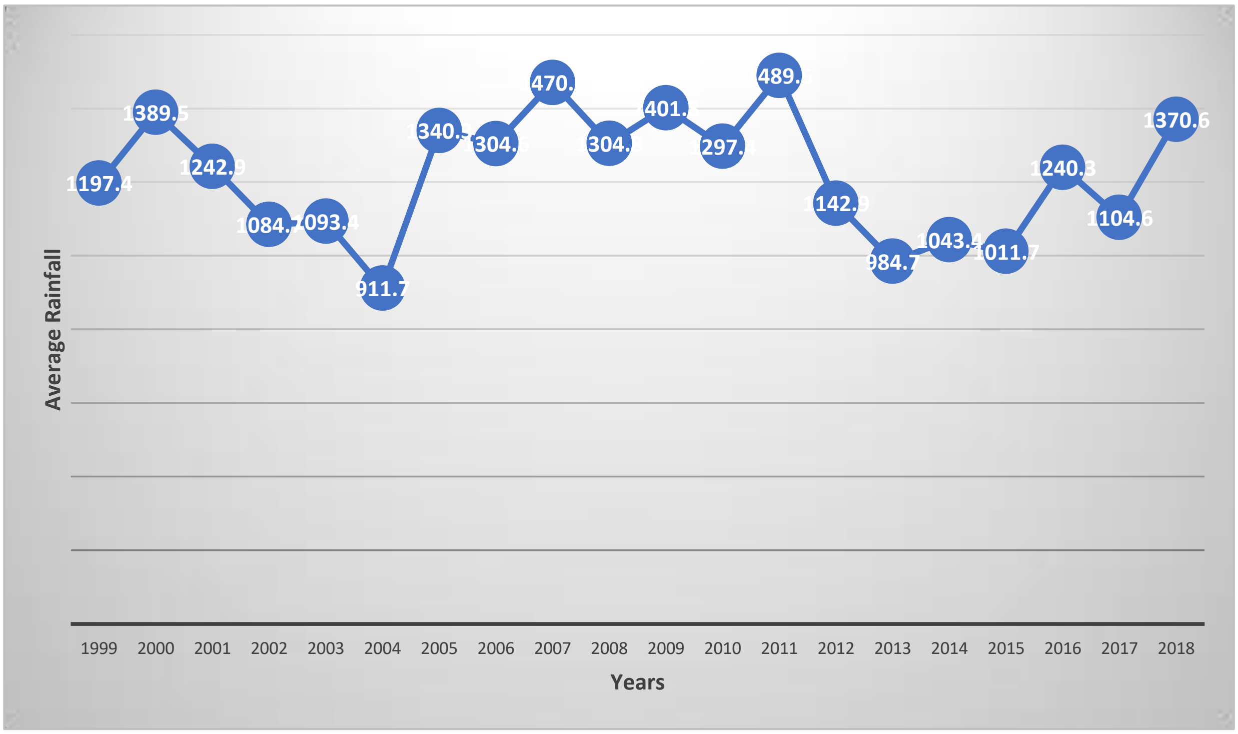

Figure 4.2: Rainfall pattern in the study area

The graph in figure 4.2 displays the pattern of rainfall in the study area. A look at the graph shows that there has not been constant rainfall pattern in the study area. But the graph has it that 2012 recorded the highest rain fall followed by 2007. From the graph it is observed that the rainfall pattern fluctuates. this is to show that the rainfall pattern was not stable throughout the decade. The data on Guinea corn yield per tones covers a period of (20) twenty years, the area cultivated in hectare is presented in figure 4.3

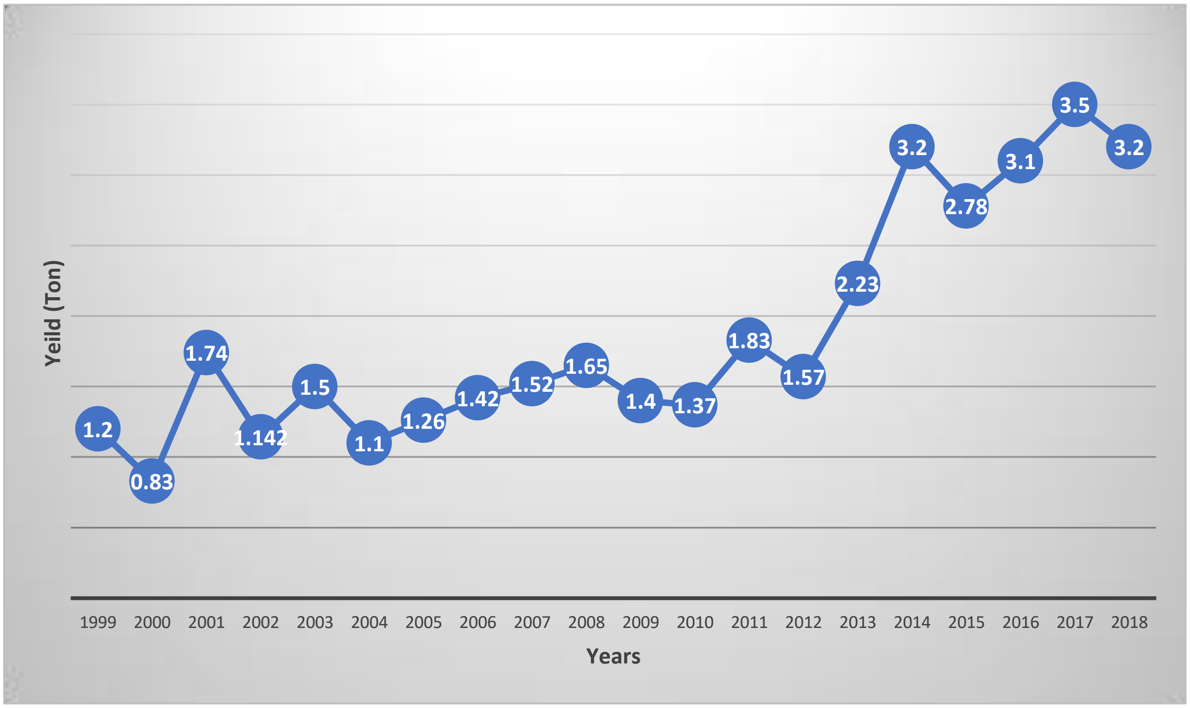

Figure 4.3: Guinea Corn yield in the study area

4.2 Examine the Impacts of weather on Guinea Corn production

Figure 4.4 showed the rainfall pattern over the years between 1999-2018. This shows that there is uneven pattern of rainfall implying that crop yield differs from year to year. This is as a result of the relationship between rainfall and Guinea corn in this investigation.

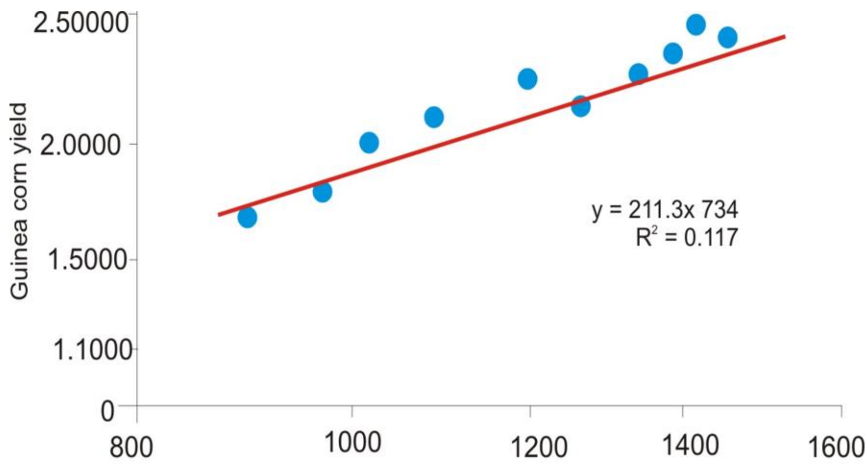

Figure 4.4: Line graph showing the relationship between annual rainfall and Guinea corn yield

It is also noted that Guinea corn yield in the study area is uneven; this is as a result of the area coverage which differ from year to year. This goes a long way to affect the amount of Guinea corn and the coefficient of variation in the study area. The relationship between temperature and guinea corn yields in the area using the Pearson correlation technique where Guinea corn is dependent variables and temperature, the independent variable. The mean value of crops against the numbers of hectare of land cultivated and the mean value of temperature were used to determine their relationship.

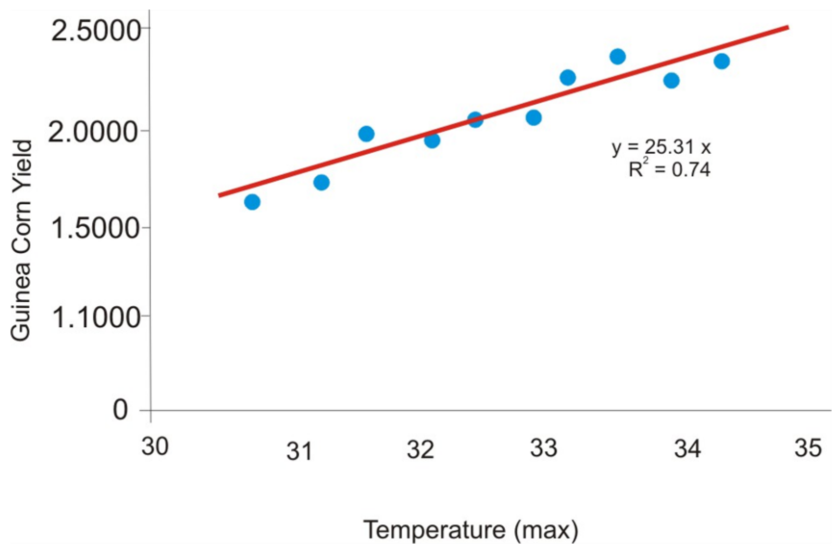

Figure 4.5: Line graph showing the relationship between temperature and Guinea corn yield

In line with the aim of this study which is to examine the relationship between rainfall and temperature variability on Guinea corn production, multiple regression was applied. The annual yield was regressed against rainfall and temperature to established the relationship that exist between them. Thus, these results were obtained from the regression, as shown in the table below:

Table 4.1. Summary of the analysis

Table 4.1: Summary of relationship between rainfall, temperature and Guinea corn production

Variables	Regression value	Remarks
Temperature	0.74	There exists a strong positive relationship between temperature and Guinea corn yield
Rainfall	0.117	There exists a strong positive relationship between rainfall and Guinea corn yield

4.3 Farmers Perception on Impact of weather variations on Guinea Corn production

Farmers perception on the effect of climate variability on rice and Guinea Corn production in the study area was analysis, 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 that they are aware of climate change.

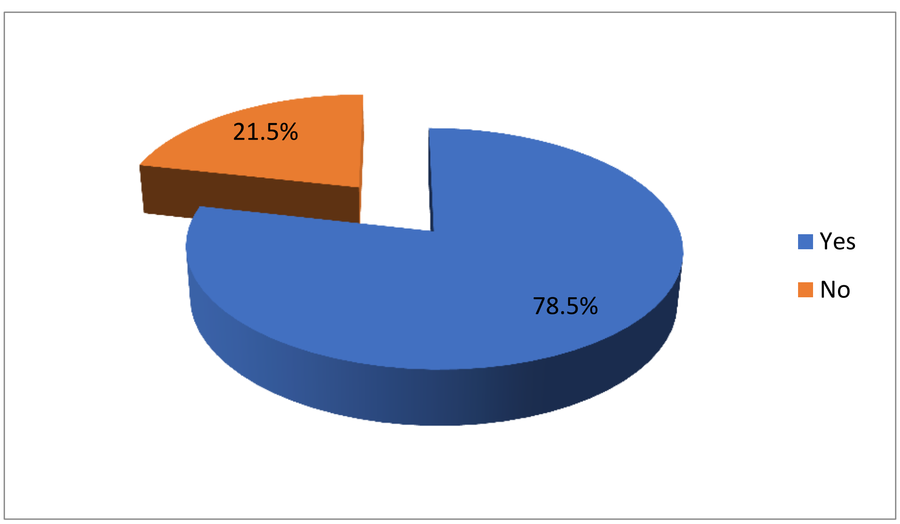

Figure 4.6: Been aware of change in weather

Figure 4.6 reveal the means by which farmers in the study area got the knowledge of change in weather; 26.6% of the residents have knowledge of change in weather through their knowledge of geography; 50.1% of the residents got the knowledge of change in weather through ordinary observation of the weather and climate; 19.7% of the residents have knowledge of change in weather through media; and 3.6% of the residents got the knowledge of change in weather through agricultural extension officers.

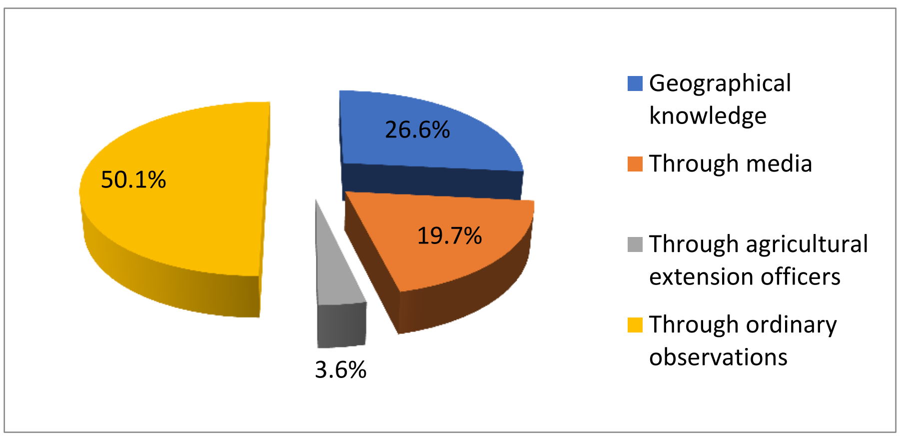

Figure 4.7: Means of been aware of change in weather

From figure 4.8, 58.4% of the respondents stated that the rainfall in the study area for about twenty (20) years was inconsistence (fluctuating). 41.6% of the residents stated that the rainfall in Igabi as about thirty (20) years back was normal. None of the residents stated that the rain fall was intensive.

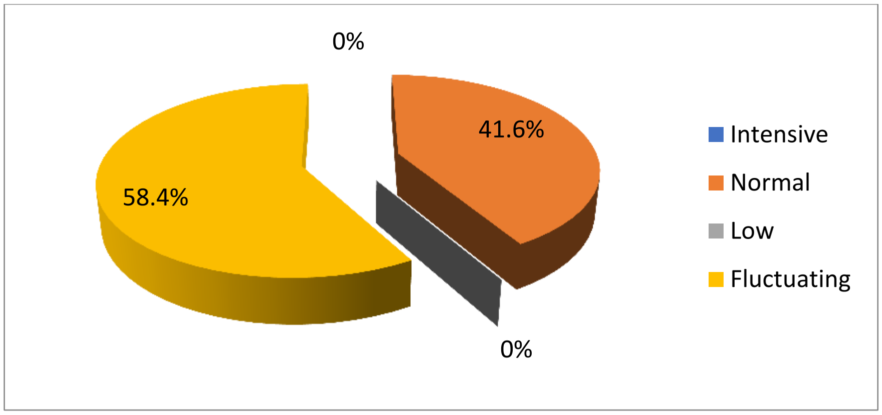

Figure 4.8: Nature of rainfall for twenty (20) years back

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

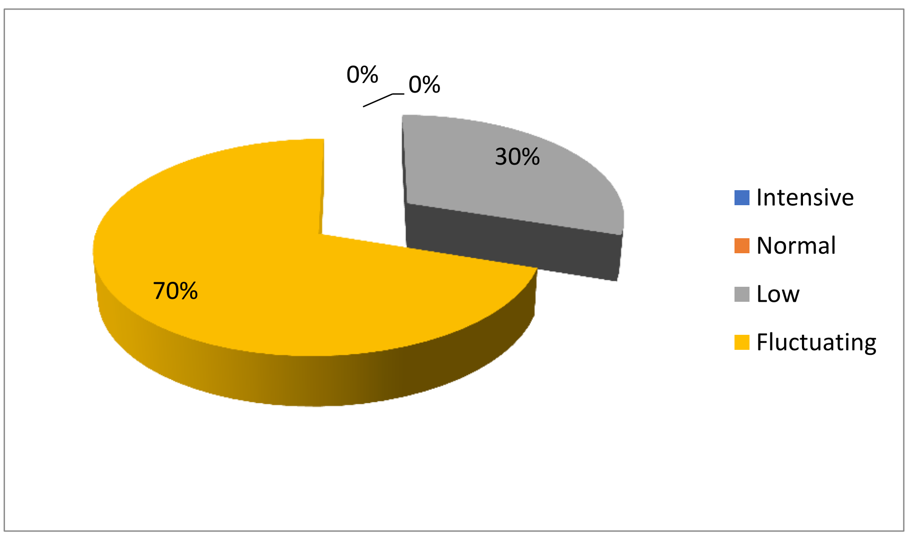

Figure 4.9: The nature of rain fall at present

Figure 4.10 shows the nature of the temperature of the study area for twenty (20) years back. More than half (50.5%) of the respondents stated that the temperature of the study area for twenty (20) years back was inconsistence (fluctuating). 29.7% of the respondents stated that the temperature of the study area for twenty (20) years back was hot. 13.7% of the respondents stated that the temperature of the study area as for twenty (20) years back was very hot. It was only 6.1% of the respondents stated that the temperature of the study area for twenty (20) years back was normal; these are among the very old men.

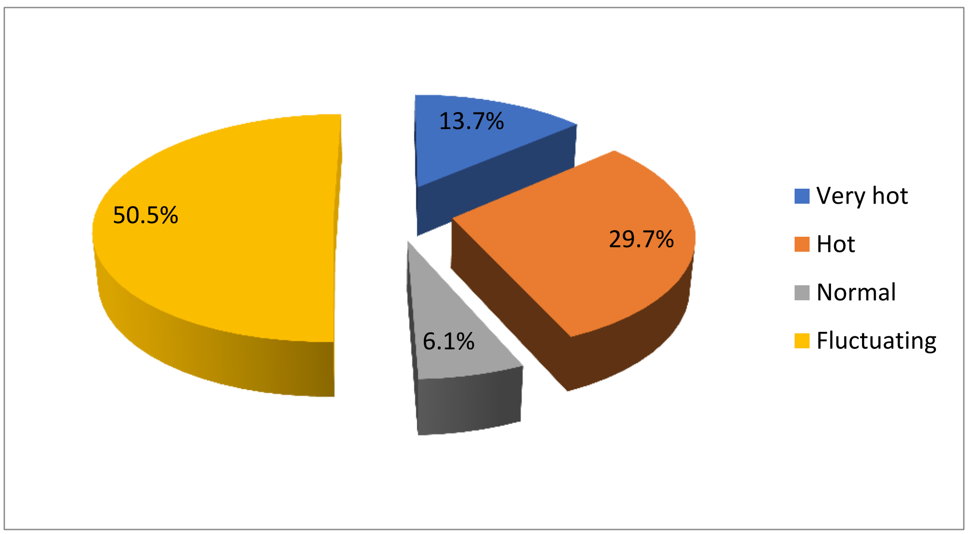

Figure 4.10: The nature of the temperature as for twenty (20) years back

Figure 4.11 shows the nature of the temperature of the study area of these recent years. More than half (56.6%) of the respondents stated that the temperature of the study area as of these recent years is inconsistence (fluctuating). 29.7% of the respondents stated that the temperature of the study area as of these recent years is hot. 13.7% of the respondents stated that the temperature of the study area as of these recent years is very hot. None of the respondents stated that the temperature of the study area as of these recent years is normal.

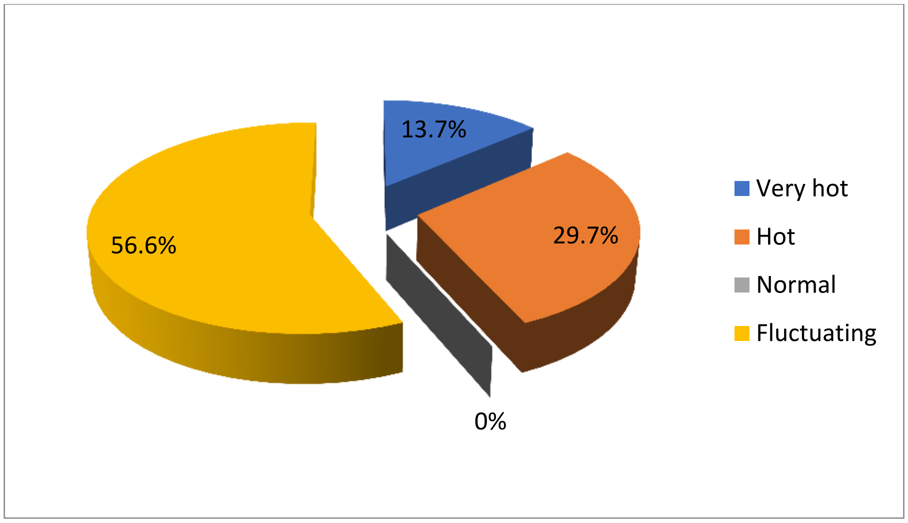

Figure 4.11: The nature of the temperature as of these recent years

Figure 4.12 shows the nature of weather in relation to crop production as about thirty (20) years back in the study area. More than half (53.6%) of the respondents stated that the nature of climate in relation to rice and Guinea corn production as about thirty (20) years back in the study area was making the yields inconsistence (fluctuating). 34.6% of the respondents stated that the nature of climate in relation to rice and Guinea corn production as about thirty (20) years back in the study area was not encouraging good yield. 12% of the respondents stated that the nature of climate in relation to crop production as about thirty (20) years back in the study area was encouraging good yield; these are very old aged men that experienced the good years of Guinea corn cultivation in the study area.

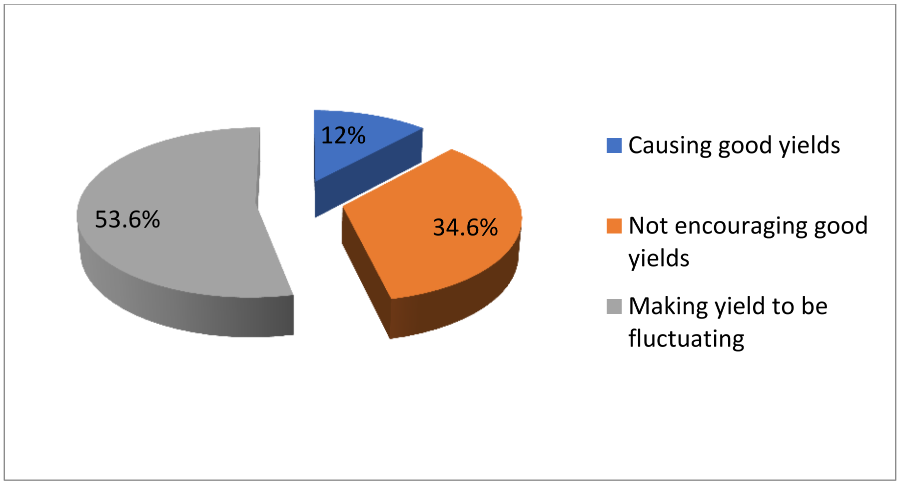

Figure 4.12: The nature of weather in relation to crop production

Figure 4.13 shows the nature of climate in relation to crop production as of these recent years in the study area. More than half (59.4%) of the respondents stated that the nature of climate in relation to crop production as of these recent years in the study area is making the yields inconsistence (fluctuating). 34.6% of the respondents stated that the nature of climate in relation to crop production as of these recent years in the study area is not encouraging good yield. Only 6% of the respondents stated that the nature of weather in relation to crop production as of these recent years in the study area is encouraging good yield.

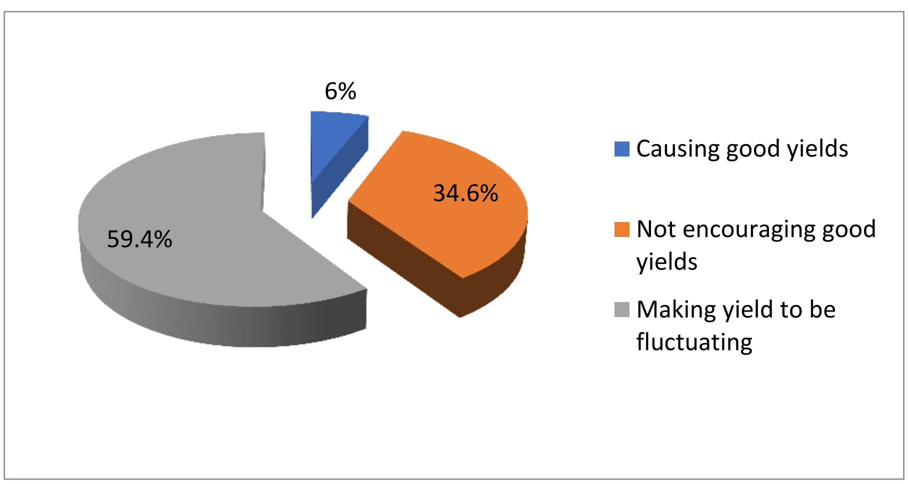

Figure 4.13: The nature of weather in relation to crop production

4.4 Adaptation strategies of the farmers in response to the effects of climate variability

Figure 4.14 show that there are no any mitigation or any adaptive measure(s) put in place to curb with effects of weather on Guinea corn in the study area.

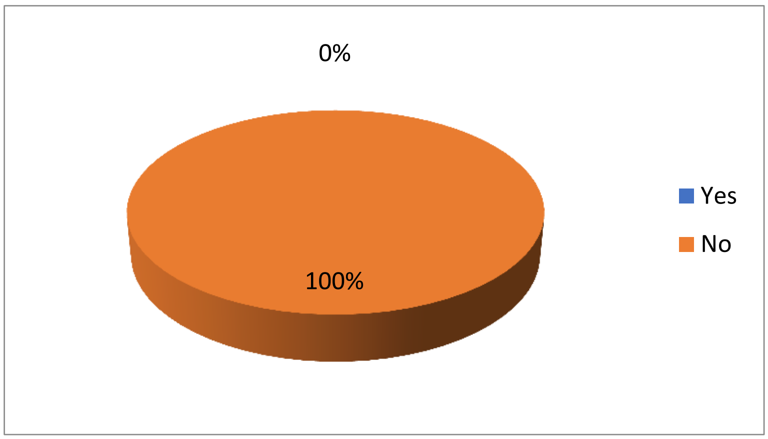

Figure 4.14: Mitigation and adaptive measures been put in place to curb with effects on weather Guinea corn in the study area

Figure 4.15 show that there are no any kind of mitigation or any adaptive measure(s) put in place to curb with effects on weather on Guinea corn in the study area.

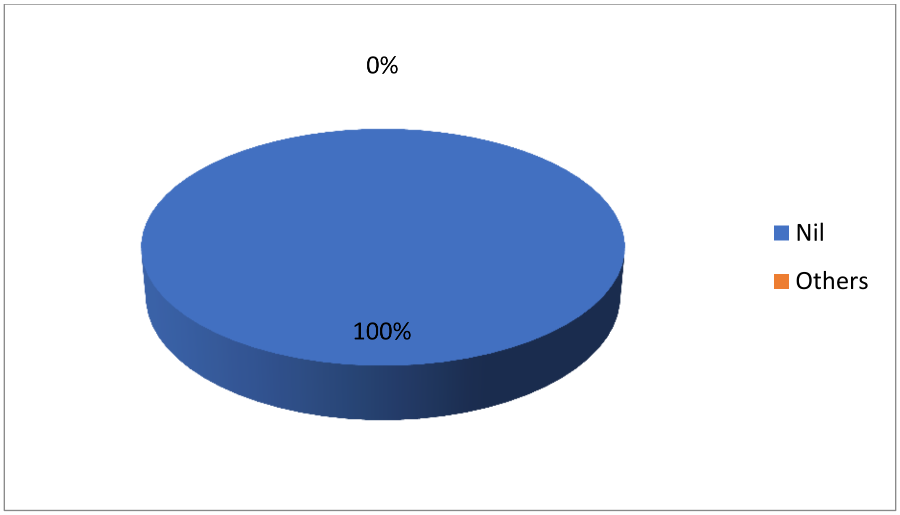

Figure 4.15: Kinds of adaptive measures

4.5 Summary of Findings

The relationship of crop and rainfall gave a negative relationship and others positive relationship. The relationship of both rainfall and temperature on Guinea corn showed a strong negative relationship. This shows that there is yearly change in temperature that can alter the yield of Guinea corn yield in the study area. The coefficient of variation as seen above of maximum temperature 34.2 and minimum temperature 32.3 shows that there is a consistency in the variation although not too strong.

The findings show trend of temperature over the years in the study area, a close look at the graph reveals that the temperature from 2010 was constantly increasing except for the fall in 2016, but they never went below 32^{o}C in 2004. The year 2005 experienced the highest temperature of 35^{o}C. it also shows that there has not been constant rainfall pattern in the study area. But the graph has it that 2012 recorded the highest rain fall followed by 2007. From the graph it is observed that the rainfall pattern fluctuates. this is to show that the rainfall pattern was not stable throughout the decade. It also shows that there is uneven pattern of rainfall implying that crop yield differs from year to year. This is as a result of the relationship between rainfall and Guinea corn in this investigation.

It is also noted that Guinea corn yield in the study area is uneven; this is as a result of the area coverage which differ from year to year. This goes a long way to affect the amount of Guinea corn and the coefficient of variation in the study area. The relationship between temperature and guinea corn yields in the area using the Pearson correlation technique where Guinea corn is dependent variables and temperature, the independent variable. The mean value of crops against the numbers of hectare of land cultivated and the mean value of temperature were used to determine their relationship. In line with the aim of this study which is to examine the relationship between rainfall and temperature variability on Guinea corn production, multiple regression was applied. The annual yield was regressed against rainfall and temperature to established the relationship that exist between them.

Farmers perception on the effect of climate variability on Guinea Corn production in the study area was analysis, it was discovered that 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 that they are aware of climate change. It also reveal the means by which farmers in the study area got the knowledge of change in weather; 26.6% of the residents have knowledge of change in weather through their knowledge of geography; 50.1% of the residents got the knowledge of change in weather through ordinary observation of the weather and climate; 19.7% of the residents have knowledge of change in weather through media; and 3.6% of the residents got the knowledge of change in weather through agricultural extension officers.

The findings also shows the nature of the temperature of the study area for twenty (20) years back. More than half (50.5%) of the respondents stated that the temperature of the study area for twenty (20) years back was inconsistence (fluctuating). 29.7% of the respondents stated that the temperature of the study area for twenty (20) years back was hot. 13.7% of the respondents stated that the temperature of the study area as for twenty (20) years back was very hot. It was only 6.1% of the respondents stated that the temperature of the study area for twenty (20) years back was normal; these are among the very old men. The finding also reveal that more than half (56.6%) of the respondents stated that the temperature of the study area as of these recent years is inconsistence (fluctuating). 29.7% of the respondents stated that the temperature of the study area as of these recent years is hot. 13.7% of the respondents stated that the temperature of the study area as of these recent years is very hot. None of the respondents stated that the temperature of the study area as of these recent years is normal.

It was also discovered that the nature of climate in relation to crop production as of these recent years in the study area. More than half (59.4%) of the respondents stated that the nature of climate in relation to crop production as of these recent years in the study area is making the yields inconsistence (fluctuating). 34.6% of the respondents stated that the nature of climate in relation to crop production as of these recent years in the study area is not encouraging good yield. Only 6% of the respondents stated that the nature of weather in relation to crop production as of these recent years in the study area is encouraging good yield.

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 production even with the short time crops. The mean maximum temperature trend of the study area for the period under study has been very variable (fluctuating). The lowest temperature was recorded in 2011 which was 11804.0^{0}C (in total) and 32.3^{0}C in average, while the highest temperature was recorded in the years of 2009 and 2013 which was 12488.9 ^{0}C in total and 34.4^{0}C in average. Truly even at this lowest average mean maximum temperature32.3^{0}C, is really high and uncomfortable for human being and for crop production also. This shows that the study area is a place of often.

Most of the respondents are aware of change in weather. The farmers got the knowledge of change in weather through the knowledge of geography; through ordinary observation of the weather and climate; through media; and through agricultural extension officers. Rainfall and the temperature of the study area for the period under study and as of these recent years has been inconsistence (fluctuating). The nature of weather in relation to

Guinea corn production 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 impacts of climate weather on crop production especially in Igabi Local Government Area of Kaduna State.

1. There should be climate monitoring stations for every agricultural zones of Nigeria.
2. There should be time to time awareness and enlightment campaign on the causes of climate change in various parts of the country.
3. 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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Appendix

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

SCHOOL OF POSTGRADUATE STUDIES

DEPARTMENT OF GEOGRAPHY

QUESTIONNAIRE

Topic:

IMPACT OF WEATHER ON GUINEA CORN PRODUCTION IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

A research work is proposed to be done on the above topic in pursuit of Degree of M.TECH. The aim of this survey is to obtain useful information needed for the success of the research. All information obtained would be treated with utmost confidentiality and respect for this research work only.

MOHAMMED, Usman Kawu
M.Tech/SPS/2016/6548

SECTION A: PERSONAL DATA

1. What is your sex? (A) MALE [ ] (B) FEMALE [ ]

2. What is your age? (A) 18-30 YEARS [ ] (B) 31-40 YEARS [ ] (C) 41-60 YEARS [ ] (D) 61 AND ABOVE
3. Are you educated? (A) YES [ ] (B) NO [ ]
4. What is your level of education? (A) SSCE/GRADE II [ ] (B) CERTIFICATE [ ] (C) NCE/DIPLOMA [ ] (D) FIRST DEGREE [ ] (E) MASTER'S DEGREE AND ABOVE
5. What is your Occupation? (A) CIVIL SERVANT [ ] (B)BUSINESS PERSON [ ] (C) FARMER [ ] (D) POLITICIAN [ ]
6. For how long have you being in this place? (A) 1-1O YEARS[ ] (B) 11-20 YEARS[ ] (C) 21-30 YEARS [ ] (D) 31YEARS AND ABOVE

SECTION B: ANALYSE THE CLIMATIC TRENDS (RAINFALL AND TEMPERATURE) IN THE STUDY AREA

1. Are you aware climate change? (A) Yes (B) No
2. If you are aware, through which means? (a) Geographical knowledge (b) Through media (c) Through agricultural extension officers (d) Through ordinary observations
3. How was the rainfall of this place about twenty (20) years back? (a) Intensive (b) Normal (c) Low (d) Fluctuating
4. How is the rain fall as of this recent years? (a) Intensive (b) Normal (c) Low (d) Fluctuating
5. How was the temperature of this place about twenty (20) years back? (a) Very hot (b) Hot (c) Normal (d) Fluctuating
6. How was the temperature of this place of this recent years? (a) Very hot (b) Hot (c) Normal (d) Fluctuating
7. How was the climate in relation to crop production as about twenty (20) years back? (a) Causing good yields (b) Not encouraging good yields (c) Making yield to be fluctuating

8. How is the climate in relation to crop production as of this recent years? (a) Causing good yields (b) Not encouraging good yields (c) Making yield to be fluctuating
9. Which crop(s) do you cultivate most? (a) Rice (b) Geunie corn How were the yields about thirty (30) years and above? (a) Very low (b) Low (c) Normal (fear) (d) High (e) Very high
10. How are the yields as of this recent years? a) Very low (b) Low (c) Normal (fear) (d) High (e) Very high
11. Are there adaptive measures put in place to curb with drought effects on agricultural production in your place? (A) Yes (B) No
12. If there are measure, mention them? ………………………………………………………..