ECONOMIC IMPACT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION IN NIGERIA

BY

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BEING A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ECONOMICS, FACULTY OF SOCIAL SCIENCES, NNAMDI AZIKIWE UNIVERSITY, AWKA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D) DEGREE IN ECONOMICS.

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JULY, 2017

CERTIFICATION PAGE

This is to certify that this Ph.D Dissertation titled, "Economic Impact of Climate Change on Agricultural Production in Nigeria" was carried out by Anuforo, Cajetan Chima with registration number 2010117001P, is an original research carried out by me, except where references are made to published literature, and has not been submitted elsewhere for the award of any certificate, degree or diploma.

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APPROVAL PAGE

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DEDICATION

To my wife, the members of my family, my students at St Christopher's Junior Seminary 3-3 Onitsha and my students at Holy Innocents Juniorate Convent Nkpor.

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All that we know is a sum total of what we have learned from all who have taught us directly and indirectly. I am indebted to the countless outstanding men and women who by their commitment and dedication to becoming the best they could, have inspired me to do the same.

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ACRONYMS

BNRCC	Building Nigeria Response to Climate Change
CAADP	Comprehensive African Agriculture Development Program
CD	Cobb-Douglas
COP	Conference of parties
FAO	Food and agricultural organization
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHGs	Greenhouse Gases
GRP	Green Revolution Program
HDR	Human Development Report
IAMs	Integrated Assessment Model
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
NAFPP	National Accelerated Food Production Project
NAPA	National Adaptation Program of Africa
NASPA	National Adaptation Strategy and Plan of Africa
NBS	National Bureau of Statistics
NCRI	National Cereal Research Institute
NGOs	Non-governmental organizations
NPC	National Population Commission
NPFS	National Program on Food Security
NWP	Nairobi Work Program
OFN	Operation Feed the Nation
REDD	Reducing Emissions from Deforestation and Forest Degradation

SCCF	Special Climate Change Fund
SCCU	Special Climate Change Unit
SRES	Special Report on Emission Scenarios
TFP	Total Factor Productivity
UCS	Union of Concern Scientist
UNDP	United Nation Development Program
UNEP	United Nation Environmental Program
UNFCCC	United Nation Framework Conference on Climate
WDI	World Development Indicator

ABSTRACT

This study examined the economic impact of climate change on agricultural production in Nigeria. We estimated and simulated the impact of climate change on aggregate (sum total of crop production, livestock production, forestry production and fish production) agricultural output in Nigeria for the period 1970 – 2015. Since the impact of climate change on crop production, livestock production, forestry production and fish production is not the same, the study estimated disaggregated agricultural output model using cointegration analysis, error correction mechanism and impulse response functions (IRFs).The results indicate that climate factors have significant impact on both aggregate and specific agricultural outputs in both the short term and long term. In order to account for the asymmetric impact of climate change on different agricultural outputs in Nigeria, we assessed the elasticities of specific agricultural output to climate change in Nigeria. As expected, the impacts of climate change on agricultural output differ across output/product. Except forestry, variations in CO_2 emission has negative significant effect on both aggregate and other components of agricultural output. Rainfall variation has significant positive effect on both aggregate and all the components of agriculture. The effect of temperature was however found to be mild over the period. Based on the findings, the conclusion that climate changes are important factors emerges. The study therefore, recommends among other things that Nigerian government needs to give agriculture a serious priority, and that policy to minimize the effects of current climate change (especially, CO_2) should be pursued. Again, there is equally an urgent need to raise awareness of rural farmers about effective weather and climate risk management and the sustainable use of weather and climate information for agricultural production in Nigeria.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

The performance of the agricultural economy is central to the overall wellbeing of the populace. Not only does it serve as source of livelihood for approximately one-third of the world's population (FAO, 2013), it is key to ensuring sustainable food security, employment opportunities amongst others. This is why different countries place high premium on agriculture and strive to develop and protect the sector.

Agriculture has a rich history in Nigeria, and the progressive roles it had played in the past are well known. Its antecedents in the lives of what is today referred to as Nigeria and its people both in social, political and economic spheres are equally well documented, including that of its colonial masters abroad. Agricultural produce serving as raw materials fast-tracked the industrial revolution in Europe pioneered by the British, fuelling its engines with palm oil from the coaster states of the Bight of Benin, in today's South-South Nigeria. Our ancestors, though technologically backward as compared to what obtains in our time today, were almost farming with bare hands using crude implements. Yet, they produced enough food crops to feed themselves like most other Africans and also produced cash crops for export abroad. From their first contact with the outside world through Trans Saharan trade to the end of Atlantic trade, our forebears were never found wanting. They responded accordingly to the demands of their time, the limitations notwithstanding. The emerging British capitalist economy and other European countries no longer had needs for trading slaves, after decades of devastating havocs wrecked on the burgeoning ancient economy by the illegitimate trade on humans. The dawn of legitimate trade became the order, occasioned by the emerging industrial revolution in Europe that required agricultural raw materials to drive. According to Eko (2009), Our fathers braced the challenges and exported the needed materials like palm oil, timbers, elephant tusks and other products running into millions of tones, that ensured that the fledging European economy particularly England survived and laid the basis for her future growth, development and influence.

Today, Nigerian's overall performance in agricultural production is quite below expectations. Over 75% of the populations, mostly rural dwellers are involved in agricultural activities, yet the sector accounts for less than 5% of the foreign exchange earnings (Adesina, 2013).The sector is still witnessing serious problems that are posing threat to sustainable food security in the country. The country presently finds it difficult to produce basic food items to feed its teeming population despite being endowed with fertile and cultivable arable land running into millions of hectares across different regions for crop cultivations and livestock breeding; miles of flowing rivers and resourceful Atlantic Ocean with varieties of fishes and a vast rich forest belt. Evidently, food production index has not kept pace with the growing population. Despite successive government programs and policies on the sector, the performance rating of the sector has not kept pace with expectation especially in the area of providing food for the population. Nigeria is presently the world largest importer of rice, spending over 2.5 billion dollars, approximately N400 billion annually on importation of food items from less endowed countries like Thailand and Indonesia (Adesina, 2013).

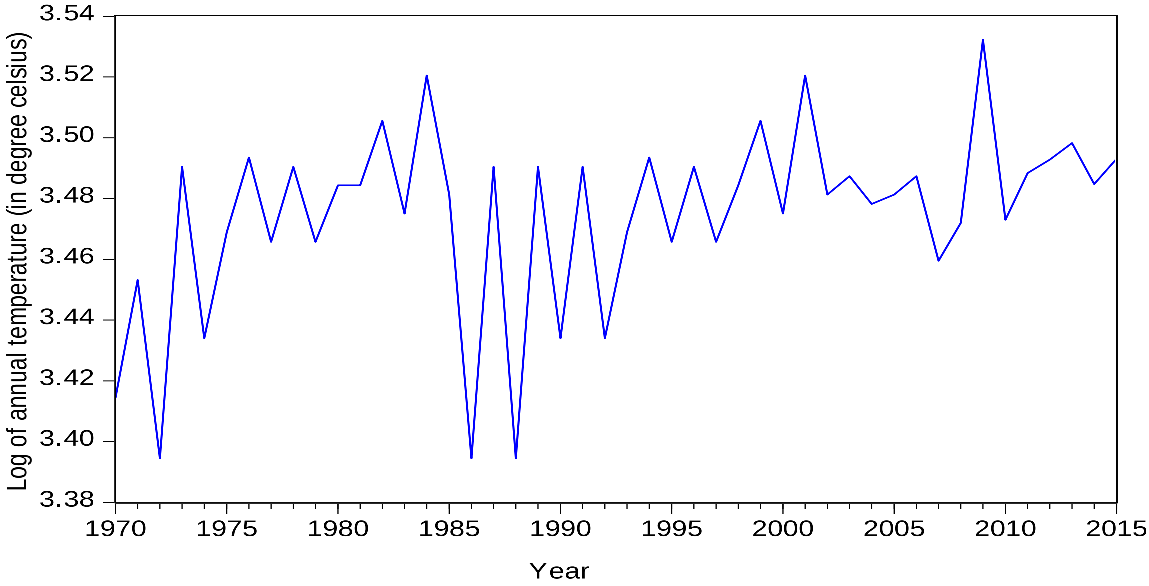
Many reasons for the poor performance of the agricultural sector in Nigeria have been adduced, such as negligence of the sector by the government following the discovery of oil, the use of crude farming system among others. In the final analysis, these reasons hinge on capital and labour shift. But besides these factors, factors that are supplied by nature also play important roles. Among the natural resources, climate is the predominant factor that influences food production.

Climate is the primary determinant of agricultural productivity. Those that are most essential for food crop production are land, water, sunshine, air, temperature soil conditions, carbon dioxide etc. Climate, as defined by Oyekale,Bolaji and Olowas(2009) is the state of atmosphere, which is created by weather events over a period of time. A slight change in the climate will affect agriculture. Climate change is an important environmental, social and economic issue. It threatens the achievement of Millennium Development Goals aimed at poverty and hunger reduction, health improvement and environmental sustainability (UNDP, 2010).The national survey conducted between 2003 and 2004 shows that slightly above half of the population (51.6 percent) live below US$1 dollar per day and the relative national poverty incidence was found to be 54.4 percent (NBS, 2005; 2008).

The recent Human Development Report by the United Nations Development Programme (UNDP, 2015) shows that about 64.4 and 83.7 percent of the population lives below $1.25 and $2 a day respectively. The Intergovernmental Panel on Climate Change (IPCC, 1995)defined climate change as internal changes within the climate system or in the interaction among its components, because of changes in external forces either for natural reasons or because of human activity. The dangers of climate change is neither limited to any continent or country nor is the study been restricted to any discipline. Due to the increasing global awareness on the subject, many experts (both economic and non-economic), have attempted to study the matter from diverse backgrounds.

The issues of climate change are important for Nigeria for several reasons, particularly, empirical evidences have shown that Nigeria's climate exhibits differing degree of temporal variability, particularly with regard to rainfall and temperature as shown in the figures below:

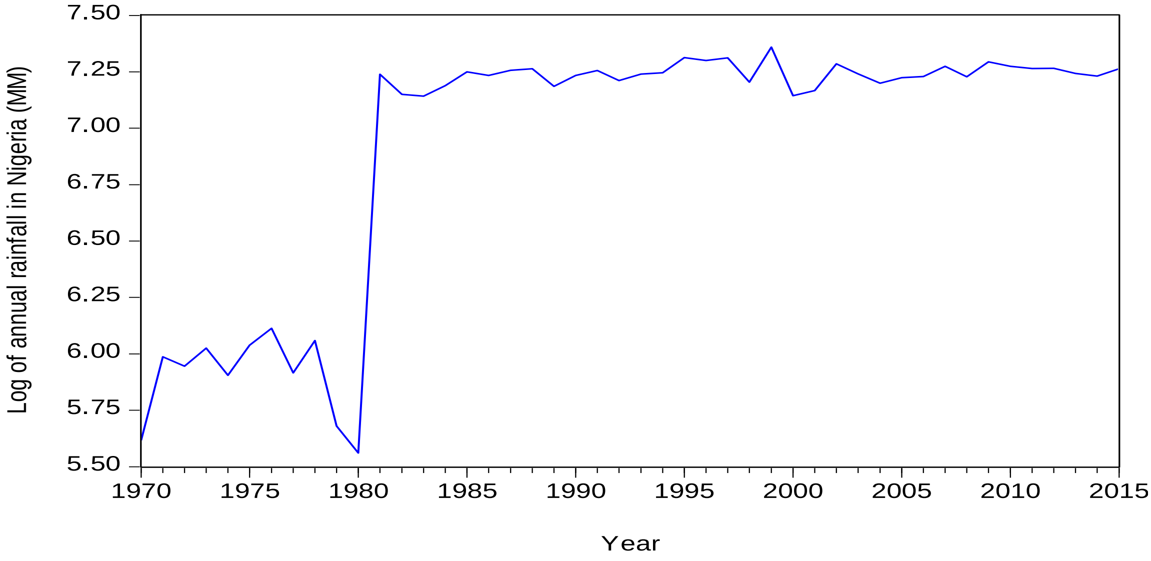
Figure 1.1: Annual temperature in Nigeria (^{0}C) 1970 - 2015



Source: *The researcher's contribution based on data from CBN Statistical Bulletin, (2015)*

In figure 1.1, we show in logarithmic value the trend of annual mean temperature in Nigeria between 1970 and 2015. We plotted the logarithmic value in order to have a clear picture of the behaviour of temperature in Nigeria over time. The results show a severe variability in temperature over the period. In real term, the mean temperature between 1970 and 1992 was 25^{o}C while the mean temperature between 1993 and 2015 was 27.1^{o}C. This reveals an overall mean increase of 1.9^{o}C.Again, in figure 1.2, we show the trend in annual rainfall in Nigeria.

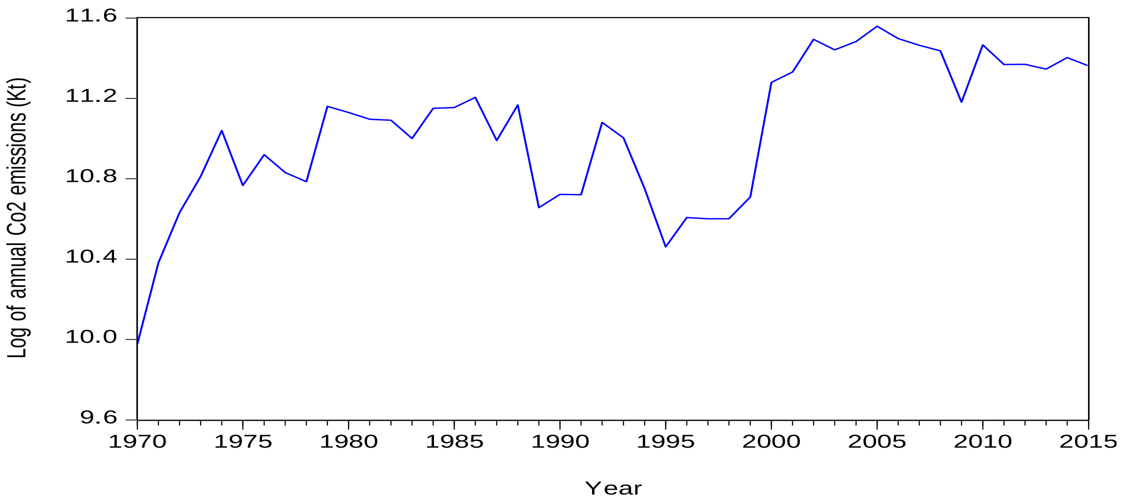
Figure 1.2: Annual rainfall in Nigeria (MM) 1970 – 2015.



Source: *The researcher's contribution based on data from CBN Statistical Bulletin, (2015)*

Figure 1.2 shows some irregularities in annual rainfall. The trend shows that beginning from 1980s, the annual rainfall in Nigeria has been on the increase. Another climate factor that has demonstrated high rate of variability is Nigeria is atmospheric CO2 concentrations as also shown below:

Figure 1.3: Annual CO2 emission in Nigeria (Kt) 1970 – 2015.



Source: *The researcher's contribution based on data from CBN Statistical Bulletin, (2015)*

Evidently, Nigeria has recorded cases of climate changes overtime and at the same time falling per capita food production. Understanding and predicting these variations in climate and their effects on agricultural production in Nigeria as a whole and specifically on various components of aggregate agricultural output which include: crop production, livestock production, forestry production and fish production is essential for socio-economic progress of Nigeria. Most conflicts in Nigeria today are environmental based. Take for example, the conflicts between farmers and herdsmen. With the painful realization of serious desert encroachment in some Northern part of the country, the herdsmen with a pressing duty to affirm the survival of their cattle, have continuously pushed their way down the Southern area in search of water and vegetation for their cattle. The fight for space and the limited arable land resources have left trails of sadness in the wake of herdsmen/farmers' conflict. Nigeria is today more than ever before faced with serious challenge of sustaining domestic food production in the face of challenging climate variability that has transcended and affected all facet of live, especially agricultural output. The grave danger this problem poses to the economic wellbeing of the people coupled with likely short and long term implications on national economic development is the driving force for carrying out this study as it is expected that the findings of this work will help to proffer possible solution on how to cushion the rate of damage.

1.2 Statement of the Problem

The National Population Commission (NPC, 2014) has projected that Nigeria population will reach two hundred and forty million by 2020. This implies that food demand will increase with this projected increase in population. The capacity of Nigeria to ensure adequate food supply for her growing and expectant population is a function of the efficiency and sustainability of food production capacity in the country especially in the wake of global climate change that is threatening food production. Nigeria is already experiencing serious food production challenges. These challenges manifest itself in the inability of the nation to produce enough food to feed its population. Available evidence shows that Nigeria is plagued with diverse ecological problems which have been directly linked to climate change. Farmers now face tragic crop failures, which reduce agricultural production in general, increase hunger, poverty, malnutrition and disease. Due to this threat, many farmers are abandoning farming for non-farming activities.

For more than a decade, it was thought in Nigeria that adopting food import as a policy would address the nation's food shortage problem. However, it has become obvious that such policy rather than bring solutions, has fuelled inflation, discouraged local production and created poverty among many farm households and helped to cause food insecurity. This therefore has left the government with no other better option than to seek possible means to improving domestic food production. Regrettably, improving domestic food supply in the country is faced with serious problem of climate change. Different sectors of agriculture in the country react differently to change in climate and unless the rates at which climate change impact on these sectors are investigated and curtailed, continuous government efforts to improving domestic food supply in the country will remain a mirage.

Admittedly, much efforts have been made towards increasing the availability and adoption of improved agricultural production in Nigeria both at the National and State levels. The Federal Government have initiated program aimed at improving agricultural production in Nigeria through promotion of improved production application such as fertilizer, hybrid seeds, pesticides, herbicides and better management practices. Several improved agricultural varieties that are drought-tolerant and low nitrogen-tolerant have equally been introduced to farmers. Despite these efforts, food production remained low thus raising question about the efficiency with which resources are used, and how they react to environmental changes.

Nigeria, in the recent times, has recorded serious flood disaster in the Southern part of the country that destroyed agricultural products worth billions of naira. In the Northern part of the country, serious desert encroachment is forcing herdsmen down the south to search for water and vegetation for their cattle and this is generating serious conflicts between the herders and local farmers. With little or no insurance coverage, many farmers are losing their fortune. The uncertainty of climate change impact is today creating fear, anxiety and gradual loss of confidence in the agricultural sector. If this is not properly handled, it might lead to wide spread food insecurity and defeat the government policy on domestic food production.

To avoid living in deliberate denial of the present reality facing the agricultural sector, there is a need to empirically examine the agricultural output-climate change nexus and the extent to which different agricultural outputs in Nigeria respond to abrupt climate change.

It is against this background that this study analyses the impact of climate change on aggregate agricultural production in Nigeria on one hand, and the impact of climate change on different components of agricultural outputs in Nigeria in both the short-run and long-run basis. To the best of my knowledge, no previous study has focused on disintegrating the impact of climate change in the different sectors of agriculture in the country as most research seems to approach the problem in aggregate standpoint. The study therefore, intends to resolve the following research questions.

1.3 Research Questions

This study revolves around the answering of the following research questions;

1. How does climate change affect different agricultural outputs in Nigeria in the short and long-run?
2. Is the impact of climate change on different agricultural outputs the same across products and which agricultural output is adversely affected by climate change in Nigeria?
3. How do different agricultural outputs in Nigeria respond to abrupt climate change in the long-run?

1.4 Objective of the Study

The main objective of this work is to assess the effect of climate change on aggregate agricultural output in Nigeria in the short- and long- run. Specifically, the study intends to:

1. Determine whether climate change affects different agricultural outputs in Nigeria in the short- and long-run.
2. Ascertain whether the impacts of climate change on different agricultural output in Nigeria are same across product. And examine which agricultural output is mostly affected.
3. Assess the how different agricultural outputs in Nigeria respond to abrupt climate change in the long-run.

1.5 Research Hypotheses

As a further guide to the conduct and advancement of this study, the following research pairs of hypotheses are tested:

Hypothesis one:

H0: Climate changes does not affect different agricultural outputs in Nigeria in the short and long-run.

H1: Climate changes affect different agricultural outputs in Nigeria in the short and long-run.

Hypothesis two

H0: The impacts of climate change on different agricultural output in Nigeria are symmetry across product.

H1: The impacts of climate change on different agricultural output in Nigeria are asymmetry across product.

Hypothesis three

H0: Different agricultural outputs in Nigeria do not respond differently to abrupt climate change in the long-run.

H: Different agricultural outputs in Nigeria respond differently to abrupt climate change in the long-run.

1.6 Significance of the Study

In making and implementing any reliable national or regional policy aimed at improving agricultural production, good understanding of the major factors affecting production as well as the magnitude of their effect is very important. This work will provide current empirical evidence that will broaden agricultural policy makers' understanding of the subject for effective policy formulation especially now that the Federal Government has established a fully-fledged department of climate change in the Ministry of Environment.

It will also contribute to the body of literature on the subject thereby stimulating interest for further studies on the area of study. Students of economics, researchers as well as the general public wishing to widen their knowledge in the area of study will find this work very useful. The outcome of this study will inform policy makers on whether or not there is an even effect of climate change on the component of agricultural output, thereby assisting them in devising appropriate and specific policies for each component of agricultural output rather than the usual studies on aggregate agricultural output in climate change estimates. Farmers and other stake holders in agricultural sector will equally benefit from the contributions from the findings and recommendations of this work as it will help them to understand proactive measures that will help in palliating the effect of climate change

1.7 Scope and Limitations of the Study

The study covers a period of 45 years ranging from 1970 to 2015. This period is considered appropriate for this study for the following reasons; first, it falls within the period of high climate anomalies in Nigeria (1970 – 2010)as observed by Odjugo (2010). Second, it covers up to 30 years which the World Meteorological Organization defines as classical period for climate change (WMO 2007). Third, it falls within the period of some major agricultural policies in Nigeria such as Green Revolution (1980), Root and Tuber Expansion (2003), and others till the present agricultural Transformation Agenda. This work is limited to Nigeria and the choice of agricultural sector is because of its sensitivity to climate variations.

The focus of this work is more economic than agricultural as interest is majorly on finding solution to the threat climate variability poses on a sector (agriculture) that contributes greatly to national development. Time series data is adopted and data are sourced from assessment reports and journals. Although rainfall, temperature and CO2 emissionsare not the only indicator for climate change, this study uses them based on the fact that they are principal indicators recognized by the Intergovernmental Panel on Climate Change (IPCC 2007). The major challenge in the execution of this work was the problem of accessing data on climate variables.

CHAPTER TWO*:* REVIEW OF RELATED LITERATURE

This chapter presents the review of relevant available literatures relating to the subject matter. Agricultural production and climate change interact in a mutually reinforcing process over the course of development. To fully understand the magnitude, nature and implication of this interaction, knowledge on the trend of climate change and agricultural production in Nigerian is imperative. Theoretical and empirical literature on this subject is reviewed as they are sourced from assessment reports and journals.

2.1 Theoretical literature Review

2.1.1 Conceptual Issues

(1) The Concept of Agriculture in the context of the Study

"FAO's vision of a world without hunger is one in which most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat." (FAO, 2007f)

The present study adopts the definition of agriculture (UNDP, as cited by Downes and Pemberton, 2009) to include; "crop production, livestock, forestry and fishery". In applying this definition to Nigeria, the agricultural sector is among the most important in terms of contribution to GDP, employment creation, export earnings, community development (especially in rural areas) and contribution to the country's food security requirements. Economic and social linkages among these subsectors of agricultureare particularly critical elements in terms of the overall macroeconomic impact of the sector.

Plantation agriculture, (mainly cocoa, oil palm, rubber) which historically was the main commodity during the colonial period, represents a total institution whose legacy still exists today. For many communities, agriculture remains the main source of community economic and social activity. In many geographical locations, agricultural enterprises provide a range of community services, including health, education, infrastructure and transport facilities. As such, any negative influence on the operations of these agricultural enterprises are likely to impact not only the enterprise itself, but also the human development of the communities in which these activities occur. Crop production, livestock, fishery and forestry subsectors are very relevant here, because of the multipliers effect resulting from their operations.

Agriculture is a very critical area of economic activity in Nigeria in terms of significance of the sector to food security, poverty reduction, employment generation and foreign exchange earnings. As such, any external shock to it may likely have a serious impact on the livelihoods of a large part of the population, as well as on the general economic well-being of the country. In this regard, there have already been various observations which articulate the likely impact of the progressive change in climate on the Nigeria landform, with serious implications for the viability of the continuation of existing agricultural practices in Nigeria

The flood experience of 2012 and 2013that destroyed plants and livestock provides an important example of the impact that climate event can have on Nigeria. According to IPCC (2007), global temperature has gradually increased by 0.3° C to 0.6° C over the past century, with most of this rise occurring in the past 40 years.

(2) The Concept of Climate Change

The alarm on the possibility of an enhanced or human induced greenhouse effect was first raised over 200 years ago by a Swedish scientist, Svante Arrhenius. He hypothesized that the increased burning of coal would lead to an increase concentration of carbon dioxide in the atmosphere, and would lead to global warning (Arrhenius 1896). Since Arrhenius time, greenhouse emissions have grown dramatically. Carbon-dioxide concentration in the atmosphere has increase by about 35 percent over pre-industrial levels. In addition to increased burning of fossil fuels such as coal, oil and natural gas, synthetic chemical substances such as chlorofluorocarbons (CFCs) as well as methane and nitrous oxide emissions from agriculture and industry contribute to the greenhouse effects.

Since the 1970s when the issue of climate change emerged to the front burner ininternational development dialogue, it has attracted various definitions from various quarters. According to the World Meteorological Organization (WMO), climate change encompasses all forms of climatic inconstancy or a significant change (i.e. a change with significant economic, environmental and social lives) in the mean values of a meteorological element, particularly temperature or amount of precipitation in the course of a certain period where the means are taken over periods of a decade or longer (WMO, 1992),.

The United Nation Framework Convention on Climate Change (UNFCCC,1992) defines climate change as the alteration of the global atmosphere and is in addition to the natural climate variability observed over comparable periods and can be attributed directly or indirectly to human activity (UNFCCC, 1992).

Climate change is precisely defined by the intergovernmental Panel on Climate change (IPCC, 1995), as internal changes within the climate system or in the interaction among its components, because of changes in external forces either for natural reasons or because of human activity.

2.1.2 Basic Theories

(1) Ricardian Theory of net land value

The Ricardian theory is founded on Ricardo's original observation that the value of land reflects its productivity. It is modeled in a cross-sectional fashion such that the technique enables the measurement of the determinant of farm revenue. Ricardian Method (RM), regress climatic variables such as temperature and precipitation on farm yields. As cited in Seo, Mendelsohn and Munflingho (2005), the RM accounts for the direct impact of climate on yields of different crops as well as the indirect substitution of different inputs, introduction of different activities, and other potential adaptation activities by farmers to different climates. Thus, the greatest strength of the model is its ability to incorporate the changes that farmers would make to fit their operations to climate change (Mendelsohn &Dinar, 1999). The major flaws are (i) crops are not subject to controlled experiments across farms (ii) it does not account for future change in technology, policies and institutions, (iii) assumes constant prices which is really not the case with agricultural commodities since other factors determine prices; and, (iv) fails to account for the effect of factors that do not vary across space such as C02 concentrations that can be beneficial to crops (Kaiser et al. 1993). This method has been extensively used in most studies in Africa to assess the economic impact of climate change on crop yields (Molua & Cornelius, 2007; Kabubo-Mariara & Karanja, 2007; Kurukulasuriya & Mendelsohn, 2007; De, 2009).

(2)The Growth Accounting model

The origin of the growth accounting framework can be traced back to the works of Solow (1957) and Kendrick (1961).More recently, the subject has been revisited and expanded by Elias (1992), Young (1995) and Dowling (1998).

The growth accounting framework involves the dichotomy of observed growth in a sector production output into its main components. This last component was first known as Solow's residual. It was originally viewed as growth in output attributable to technical progress. More recently, it has become generally known as total factor productivity (TFP). The name is quite functional because it encompasses all source of output growth apart from those attributable to capital and labor.

The growth accounting method has become very useful in analyzing the fundamental determinants of output growth. At a sector production level, the growth accounting exercise relates factor growth rates to relative factor shares and the TFP to such, contemporary issues as competitiveness and human capital development.

One sterling contribution of the growth accounting framework is in the determination whether the growth in a sector output has been generated by the growth in factor inputs or derived by productivity. The relevance of this distinction is that observed growth in a sector propelled by rapid increase in capital, labor or material inputs are not sustainable in the long run. Sustainable long run growth in output can only be guaranteed through productivity and the TFP provides an excellent index for its measurement (Iyoha, 2001).

The Growth Accounting Model

The production function of the ith production sector can be given as

$$Q = f_i(K_i L_i M_i\, t) \qquad 2.1$$

Where: Q_i = total output of the ith production sector

K_i = capital service

L_i = labor service

M_i = intermediate input

t = the level of technology

Expressing Eqn. 1 in logarithm form gives

$$\ln Q_i = \ln K_i + \ln L_i + \ln M_i + \ln t \qquad 2.2$$

When more aggregate productivity measures are derived, such as for all the sectors that make up the aggregate, intermediate input are assumed to net out, so that only labor and capital input are used.

Review of Determinant of Factor Shares with Cobb-Douglas Production Function

One of the important production functions based on empirical hypothesis is the Cobb-Douglas production function. Originally, it was applied to the whole manufacturing industry in America though it can be applied to the whole economy or to any of its sectors. Following Bernard (2007), the Cobb-Douglas (CD) production function is a substantial guidance for specifying supply-side agricultural potential output which is primarily determined by measurable factor input. This theory is to a large extent consistent with the theory of supply of production function that underlies specification of the supply-side of agricultural output. The Cobb-Douglas (CD) production function was derived from the observation by Cobb and Douglas that over the long run, the relative share of National Output earned by Labour (L) and Capital (K) tends to be increasing. The CD production is generally given by the following equation.

$$Q = AK^{\beta} L^{\alpha} \qquad 2.3$$

Where;

Q = Total output

K = Capital

L = Labor

A = Efficiency (level of technology)

β and α = Substitution parameter

$\beta = (1 - \alpha)$ and $\beta + \alpha = 1$

Linear Homogeneity of C-D Production Function

If we increase each factor in equation (2.3) by a constant λ we have

$$Q = A(\lambda K)^{\beta} (\lambda L)\alpha$$

$$Q = A(\lambda K)^{\beta} (K^{\beta})(\lambda\alpha)(L\alpha)$$

$$Q = A\lambda^{\beta+\alpha} K^{\beta} L^{\alpha}$$

Rewriting the above we have;

$$Q = \lambda^{\beta+\alpha} AK^{\beta} L^{\alpha}$$

From the above equation, we observe that the CD production is linearly homogenous of degree $^{\beta+\alpha}$in labor capital. The interesting property of Cobb-Douglas production is that parameter estimates are the partial elasticity of output with respect to factor input, holding other factors constant. The summation of the estimate gives information about the return to scale, that is, the response output to proportional change in input. However, in order to capture variable not captured in the traditional production function, this work will adopt the extended production function. This makes it possible for climatic variable to be capture into the model.

(3) Sustainable Livelihood Theory

Chambers and Conway (1991) defined sustainable livelihoods as "the capabilities, assets (including both capital and social resources) and other farming practices required for a means of living". This theory maintained that increase in production can only be achieved by ensuring control of factor that retards output, gaining access to capital resources and income-earning activities, ease shocks and meet contingencies as well as enhancement and maintenance of productive resources on a long term basis. Thus, increase in agricultural productions is not just mere meager crop production, but ensuring increase return to scale where doubling the inputs will more than double the output.

The concept of sustainability, has over the years gone through various transformations, just like development theory in general. In 1960, the United Nations Food and Agricultural Organization (FAO) launched the International Freedom from Hunger Campaign which mobilized government and non-government support. The goal was to end hunger by enabling people to grow enough food to feed themselves rather than through reliance on food aid. As Argenal (2010) observed, the theory was that if national government could produce enough to supply the demand in their countries, hunger will disappear.

Until the 1980s, the concept of food security was based on absolute food availability, meaning that an aggregate reduction in food commodities within a nation due to climate change or war could cause a famine. As at then, hunger in the world was a major policy issue by the principal international development institutions (Ihuoma, 2013).

From the early 1980s, theoretical emphasis on agricultural production shifted as policy makers began to explore individual and household agricultural production as opposed to agricultural production from a national perspective. It was gradually accepted that meager agricultural production alone could not guarantee food needs. The paradigm shift was necessitated by the seminal work of Sen (1981) on poverty and famines. Sen's work was based on a new analytical framework in which hunger is seen as a consequence of "entitlement failure" or the inability of people to access and command enough food through legal means and not necessarily as a result of food deficiency (low food output). Using the entitlement framework, Sen explained that a decline in food availability was neither necessary nor sufficient to create a situation of hunger. He showed that famine could occur in absence of any change in production, if the value of work activities declined relative to the cost of staple food. This analytical framework has serious practical implication considering the fact that large proportion of the population in a developing country like Nigeria depend in Agriculture for both food and income. Sen showed that famine occurs when food availability falls below required demand causing people not to meet their demand because of a spike in food prices or a fall in wage, or both.

This result has proved very important for hunger and famine prevention and relief, and has also provided a useful guide to study agricultural productivity. In many cases, people face hunger not because food is not available, but because they cannot afford it due to limited supply. They are therefore forced to reduce their demand for food. The policy implications of this theory are important: to enhance agricultural production, policies should be designed to boost food production and stimulate demand by guaranteeing the legal, social and economic entitlements of the people and reducing the external factors that retards production (Conceicao, Horn-Phathanothaoi &Ngoroano, 2001).

Between 1984 and I985, Africa witnessed a severe and prolonged famine that had profound impact on food security theory and practice. The famines in the continent revealed people intentionally suffering from hunger instead of losing their assets. It was observed that people assess their risk and have to take into account short and long-term survival options. This is especially true in populations that are frequently subject to crises. It was accepted that food is not always the first priority of people living through famine, but one objective out of many (Argenal, 2010).

This argument gave rise to the theory of "sustainable livelihood". Relying on the postulations of Chambers and Conway as stated above, a livelihood is sustainable where it can cope with and recover from stress and shocks. This theory maintains that enhanced domestic food production can only be achieved by ensuring secured ownership of, or access to resources and income-earning activities including reserves and assets to offset risk, ease shocks and meet contingencies as well as enhancement and maintenance of productive resources on a long term basis. Thus, food sustainability is not just food affordability, but ability to produce food and earn income permanently. Despite the theoretical appeal of this theory, sustainable agricultural production has continued to be the bane of developing countries, the causes of which vary across countries and regions. This work is anchored on this theory of sustainable livelihood.

2.1.3 Other Related Theoretical Issues

(a) Agriculture in Nigeria

Agriculture used to be the principal foreign exchange earner of Nigeria from independence in 1960 up to the mid-1970s; at that time, Nigeria was among the world's largest producer of groundnuts, cocoa and palm oil and a significant producer of cocoanuts, citrus fruits, maize, pearl millet, cassava, yam and sugar cane.

In Nigeria today, agriculture is the main source of food and employer of labour employing about 60 - 70 percent of the population. It is a significant sector of the economy and source of raw materials used in processing industries as well as source of foreign exchange earnings for the country (Ayinde et al., 2011).Agriculture in Nigeria is mostly rain fed. In the north where rainfall is seasonal, farmers clear their land and await the commencement of the rains mostly in May/June. Food crops produced are mainly grains and cereals such as millet, guinea-corn, maize, rice, wheat, beans and cash crops include cotton, groundnut and sugar cane. The occurrences of droughts since the 1970s have necessitated the building of dams to supply water for irrigation agriculture. Examples include Tiga and Kadawa dams in Kano and Jigawa States, Zobe and Jibia in Katsina State, Goronyo and Bakalori dams in Sokoto State.

In the Middle Belt, food crops produced are mainly root crops like yams, cassava, cocoyam, potatoes, and beniseed. There are also highland temperate mixed crops produced on the high Plateau of Jos and Adamawa and examples are Irish potatoes, tea, temperate fruits like apple etc.

In the southern part, the main crops are roots and tree crops such as yams, cocoa yams, plantations, cocoa, rubber, palm produce, kola nuts etc. There is double maxima rainfall in the south which favours the growth of these crops. Some of these crops are grown for commercial purposes in plantations. Shifting cultivation remains the major farming system among the peasant/ local farmers who produce a large percentage of the total food supplies in the country (Akor, 2012).

Forestry is another major activity in Nigeria. In 2005, forestry production shows that 86.7% of the wood is used as fuel while the remaining 18.3% of the wood is used for producing sawn wood, veneer, railways sleepers, pulp and other products. These are products mainly from the southern forest region and some from the Middle belt and the north where there are forest reserves, communal forest areas within the savannah vegetation zones. Deforestation is however severe in the northern and southern parts and moderate within the north central and middle belt areas of Nigeria. Desertification is severe along the extreme north and moderate in the surrounding areas.

Cattle rearing are predominantly practiced in the northern part by the Fulani herdsmen who are nomadic in nature. They move in search of pasture grass and water for their cattle from the north to the middle belt up to the southern parts of Nigeria. There are also mixed farmers who rear cattle and sedentary rearers found in different parts especially in the northern parts. The main livestock reared are sheep, goats, pigs, cattle and poultry and the products include lamb and mutton, goat meat, pork, beef, milk and eggs (Macmillan, 2006).

Fishing is carried out on inland rivers, fish farms lakes and dams and along coastal waters. Fish production for the year 2009 shows that fishing on fish farms account for 8.6%; inland rivers and lakes, 40.78%; coastal waters, 44.7%; shrimps, 2.8%; and fish, 3.2%. Fish production for the year 2006 was 620,000 tones. Fishing is a major source of income and occupation to many people along inland rivers, river line areas of the Niger Delta and the coastal areas of Nigeria.

(b) Policies and programmes aimed at enhancing agricultural production in Nigeria

(i)The National Accelerated Food Production Project (NAFPP)

The desire to induce the masses of smallholder and large-scale farmers to boost food production "within the shortest possible time", led to the establishment in 1973 of the NAFPP, a program based on the green revolution concepts and experiences of Mexico, India, Philippines and Pakistan. Its main objective is to accelerate the production of six major food crops namely, rice, millet, sorghum, maize, wheat and cassava.

(ii)Operation Feed the Nation (OFN)

The Obasanjo`s administration launched the Operation Feed the National (OFN) scheme in 1976. The objective was to increase food production and eventually attain self-sufficiency in food supply. Under the scheme, encouragement and material assistance were given to the people in the form of technical advice and the supply of essential farm aids such as improved seeds, fertilizer, pesticides, and farmimplements. The program only succeeded in making the nation aware of need to increase local food production. Increased food importation, the land use decree, inadequate human and material resources, faulty campaign strategy and corrupt administration led to the collapse of the scheme (Anyanwu et al, 1997).

(iii)Green Revolution Program (GRP)

The core objective of this program was focused on self-reliance in food production. To achieve this, all known constraints to increased food production were to be removed. Under the scheme, new input procurement and distribution system came into operation. The program substantially improved food security and productivity in Nigerian.

(iv)National Economic Empowerment and Development Strategy (NEEDS) (2004 – 2007)

The key element of this development strategy included poverty eradication, employment generation, wealth creation and value reorientation. NEEDS provided help to agriculture, industry, small and medium scale enterprises and oil and gas. It sets up a series of performance targets that government wanted to achieve by 2007. These include a 6 percent annual growth in agricultural GDP of US $3 billion per year on agricultural exports and 95 percent self-sufficiency in food. NEEDS offered farmers improve irrigation, machinery and crop varieties which would help to boost agricultural productivity and tackle poverty head on since half of Nigeria’s poor people are engaged in agriculture. NEEDS/SEEDS process have been commended for bringing about cordial relationship between federal and state level planning. The plans enumerate strategic roles for the private sector in agriculture.

(v)National, Special Program on Food Security (NSPFS)

This program was launched in January 2002 in all the thirty six states of the federation. The broad objective of the program were: assisting farmers in increasing their output, productivity and income; strengthening the effectiveness of research and extension service training and educating farmers on farm management for effective utilization of resources; supporting governments efforts in the promotion of simple technologies for self-sufficiency; consolidating initial efforts of the program on pilot areas for maximum output and ease of replication; consolidating gain from on-going for continuity of the program and consequent termination of external assisted programs and projects. Setbacks associated with the program were seen in the inability of majority of the beneficiaries to repay their loan on time, complexity and incompatibly of innovation and difficulty in integrating technology into existing production system.

(vi)Root and Tuber Expansion Program (RTEP)

RTEP was launched on 16th April 2003 under Olusegun Obasanjo's administration. It covers 26 states and was designed to address the problem of food production and rural poverty. At the local farmers' level, the program hopes to achieve economic growth, improve access of the poor to social services and carry out intervention measures to protect poor and vulnerable groups. At the national level the program is designed to achieve food security and stimulate demand for cheaper staple food such as cassava, yam, potato etc. as against more expensive carbohydrate such as rice. Small holder farmers with less than two hectares of land per household were the targets of the program while special attention is being paid to women who play a significant role in rural food production, processing and marketing. RTEP also targets at multiplying and introducing improved root and tuber verities to about 350,000 farmers in order to increase productivity and income.

(vii)The Seven Point Agenda 2007 – 2011

The agricultural productive and food security agenda emphasized the development of technologies, research, financial injection into agriculture, production and development of agricultural input to change the sector so that there could be massive domestic and commercial outputs as well as technological transfer to farmers. The weakness of this policy were non – affordability of modern equipment and other production inputs, low access to credit/finance, poor rural infrastructure, collapse of research and extension systems, ineffective regulatory framework for enforcing grades and standards. Supply side problems, demand – supply gaps etc. (Uyi, 2012).

(viii) Transformation Agenda (2011 – 2015)

Agriculture and food security; to secure food and feed needs of the nation; enhance generation of national and social wealth through greater export and import substitution; enhance capacity for value addition leading to industrialization and employment opportunities; efficient exploitation and utilization of available agricultural resources; and enhance the development and dissemination of appropriate and efficient technologies for rapid adoption. The challenge here is that climatic zones usually represented large temperature categories, so that, subtle shifts within a zone had no effect, whereas a small shift from one zone to another had dramatic consequences.

(d) *Climate trend in Nigeria*

Discussions on climate change attract scientists in recent years as a result of global warming experiences. The change has significantly contributed to the increase of global disasters caused by climate related hazards as both developed and developing countries of the world are bearing the burden of repeated floods, temperature extremes and storms in which Nigeria is not left out.

Nigeria experiences tropical wet and dry climate. The weather across the year is roughly divided into two: the wet or rainy season between April and October for the Southern part, and May to September for the Northern parts. The dry season for the Southern parts is between November and March, and October to April for the Northern parts of the country. Change in the anomalies as result of occurrence of droughts, dust storms and flooding have shortened the duration of the climate as against the normal cycles. Therefore, the inhabitants with the hostile climate wonder about the unpredictable weather. The persistence of drought in some parts of the country could equally be attributed to the anti-cyclonic circulation of air mass of the atmosphere over the area.

As Odjugo (2010) observed, the temperature trend in Nigeria since 1901 shows increasing pattern. The increasewas gradual until the late 1960s and this gave way to a sharp rise in air temperatures from the early 1970s, which continued till date. The mean air temperature in Nigeria between 1901 and 2005 was 26.6°C while the temperature increase for the 105 years was l.l°C(Odjugo, 2010).. This is obviously higher than the global mean temperature increase of 0.74°C recorded since 1860 when actual scientific temperature measurement started (Spore 2008; IPCC 2007). Should this trend continue unabated, Nigeria may experience between the middle (2.5°C) and high (4.5°C) risk temperature increase by the year 2100.

Rainfall trend in Nigeria between 1901 and 2005 shows a general decline 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. Although there is a general decrease in rainfall in Nigeria, the coastal areas of Nigeria like Warn, Brass and Calabar are observed to be experiencing slightly increasing rainfall in recent times (Odiugo, 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 (IPCC 1996). Odiugo (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.

(e)*Causes of Climate Change*

There is a strong consensus among scientists that the main cause of the current global warming trend is human expansion of the greenhouse effect-warning that result when the atmosphere traps heat radiating from earth toward space. Gases that contribute to the greenhouse effect include:

Water Vapor:The most abundant greenhouse gas, but importantly, it acts as a feedback to the climate. Water vapor increases as the earth's atmosphere warms. But so does the possibility of clouds and precipitation, making these some of the most important feedback mechanisms to the greenhouse effect.

Methane:A hydrocarbon gas produced both through natural sources and human activities, including the decomposition of wastes in landfills, agriculture, especially rice cultivation, as well as ruminant digestion and manure management associated with domestic livestock. On a molecule –for-molecule basis, methane is a far more active greenhouse gas than carbon dioxide, but also one which is much less abundant in the atmosphere.

Chlorofluorocarbons (CFC): Synthetic compounds entirely of industrial origin used in a number of applications, but now largely regulated in production and release to the atmosphere by international agreement for their ability to contribute to destruction of the ozone layer and consequently, contribute to the already-damaged natural climatic structure.

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

Carbon dioxide (CO_2):A small but important component of the atmosphere. Carbon dioxide is released through natural processes such as respiration and volcanic eruptions and through human activities such as deforestation, land use changes, and burning of fossil fuel. Humans have increased atmosphere CO_2 concentration by a third since the industrial revolution began. This is the most important longer-lived cause of climate change. Carbon dioxide is the most important anthropogenic greenhouse gas (GHG). Its annual global emissions have grown between 1970 and 2006 by about 80 percent from 21 to 38 gigatonnes (Gt), and represented 77 percent to total anthropogenic GHG emissions in 2006 (IPCC, 2007). In Nigeria, CO2 emissions have risen consistently since the year 1995, but started declining from 2005. This is attributable to industrial activities that our modern civilization depends upon. There is now clear evidence to suggest that human-produced greenhouse gas such as carbon dioxide has caused much of the observed increase in earth's temperature globally over the past 500 years.

Agricultural Production: Another human cause of climate change is the altering ofthe earth's land cover as a result of agricultural activities that can change its ability to absorb or reflect heat and light. Land use changes such as deforestation and desertification, together with use of fossil fuels are the major anthropogenic sources of carbon dioxide. Deforestation adds to climate change by depleting rainforest, which absorb 20 percent of man-made CO_2 annually. Cutting down rainforest faster than they can be replaced has devastating effect on the carbon emission cycle, producing extra 17 percent of greenhouse gases. More deforestation means more CO_2 build-up in the atmosphere.

(f) ***Effects of Climate Change***

Global climate change has already had observable effects on the environment. Glaciers have shrunk, ice on rivers and lakes is breaking up, plant and animal change have shifted and trees are flowering soon. Effects that scientists had predicted in the past would result from climate change are now occurring as we can witness through loss of sea ice, accelerated sea level rise and more intensive heat waves.

According to the IPCC (2007), the extent of climate change effects on individual regions will vary over time depending on the ability of different societal and total systems to mitigate or adapt to the change. Below are some of the of climate change as forecast by the Panel:

North America:It is forecast that this region will witness decrease in snowpack in the regions; yields from rain-fed agriculture will increase by 5-20 percent in some countries; there will be increased frequency, intensity and duration of heat waves in cities that currently experience them;

Latin America: This region is projected to experience gradual replacement of tropical forest savannah in eastern Amazonia; there will be high risk of significant extinction in many tropical areas; the region will equally witness significant change in water availability for human consumption generation;

European:Most European countries will witness increased risk of inland flash floods, more frequent coastal flooding and increased erosion from storms and sea level rise;

Asia:In Asia, freshwater availability is projected to decrease in Central, South, East and Southeast Asia by the 2050s; coastal areas will be at risk due to increased flooding; death rate due to disease associated with flooding and droughts is expected to rise in some regions;

Africa: Climate change effects in Africa will manifest mainly in water unavailability. By 2020, between 75 and 250 million people are projected to be exposed in increased water stress; yield from rain-fed agricultural could be reduced by up to 50 percent in some regions; agricultural production including access to food may be severely compromised.

In Nigeria, climate change is expected to produce adverse effects on food production. Increase temperature is expected to decrease agricultural production in all parts of Nigeria, but particularly in the Sahel and Savanna. Expected impacts of higher temperature include: high evaporation rate and reduced soil moisture, lowering of the groundwater, and shrinking of surface water, especially in the North; lower crop yield due to increase in the Sahel and the savanna.

Changes in the amount of rain, increase rainfall intensity and changes in the pattern of rainfall lead to decreased agricultural productivity in all parts of Nigeria. Expected impacts of rainfall variability include; lower rainfall in the Sahel and savanna leads to lack of water for livestock, less fodder, reduced ability to house livestock, and drought; increased rainfall intensity in the coastal areas can lead to flooding, erosion of farmland, inundation, leaching, decreased soil fertility, and lower agricultural productivity; changing and erratic rainfall patterns make it difficult for farmers to determine planting time and can reduce the cropping season, leading to low germination, reduced yield, and crop failure.

Other extreme climate change effects such as storms impact agriculture both directly and indirectly. Direct impacts include crop damage and loss of farmland. Indirect impacts include road washouts, which make it difficult to access farms and to market products.

(g)*World Response to Climate Change*

Climate change and its potential negative effects are now global realities and serious efforts are being made to ensure appropriate response to the phenomenon. Recognizing climate change as a potential global threat, the World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The panel comprises of over 1,300 scientists from the developed countries. The first IPCC Assessment Report was completed in 1990. Since then, the IPCC has issued three more reports each deepening on the scientific understanding of climate change processes and their implication for the earth system. The fourth IPCC Assessment Report which won the Nobel Peace Prize that same year generated much public interest and raised climate change issues to the top of the international political agenda. The report has stimulated pro-active policy measures towards adaptation and mitigation to climate change. All government that have signed it belongs to the Conference of the Parties (COP), which meets annually to review global climate policy and oversee implementation of agreed mitigation and adaptation measures.

Based mainly on the findings and recommendations of the first IPCC Report, the United Nations Framework Conference on Climate Change (UNFCCC) established in 1992 but came into full force in 1994, provides overall macroeconomic, social, environmental and political framework for addressing climate change issues.

The Kyotot Protocol, being an outcome of the UNFCCC, was adopted in 1997 as an international and legally binding agreement to reduce GHGs emissions worldwide, and entered into full force 2005 on ratification by the required members of parties to the UNFCCC. The most important component of the Kyoto Protocol is its legally binding commitments for 39 developed countries to reduce their GHGs emissions by an average of 5.2 percent relative to 1990 levels. These emissions reduction must be achieved between 2008 and 2012, the "first commitment period" (FAO, 2008a).

Review and enforcement of these commitments are carried out by United Nations-based bodies. The Protocol places a heavier burden on developed nations under the principles of `common but differentiated responsibilities`. The reasons for this burden are twofold; firstly, because developed countries can more easily pay for the cost of cutting emissions, and secondly, developed countries have historically contributed more to the problem by emitting larger amounts of GHGs per person than developing countries.

In 2001, the Conference of the Parties(COP), acknowledged that least developed countries (LDCs) do not have the capacity to deal with adaptation to climate change. It therefore established a work program for supporting LCDs in the preparation and implementation of National Adaptation Program of Action (NAPA). The NAPA takes into account existing coping strategies at the grassroots levels, and builds on these to identify priority activities that would benefit from further support, rather than focusing on scenario-based modeling to assess future vulnerability, and long-term policy at the national (UNFCCC, 2007).

In 2006, the COP adopted the Nairobi Work Program on Impacts, Vulnerability and Adaptation to Climate Change (NWP) as a basis for consolidating and intensifying adaptation efforts. The NWP was developed to enable countries improve their understanding of climate change impacts and their risk exposure, and to increase their appropriate adaptation measures. It is an international framework implemented by parties to the UNFCCC, intergovernmental organizations, Non-governmental Organizations (NGOs), the private sector, local communities and other stakeholders (UNFCCC, 2007).

The United Nations has been taking the lead in providing funds for climate change programs. Several funds within the United Nations system finance activities aimed at reducing greenhouse emissions and increasing resilience to the negative impacts of climate change. The Global Environment Facility (GEF) was established in 1991 as an independent financial organization providing grants to developing countries for projects that benefit the global environment and promote sustainable livelihoods in local communities.

In its role as a financing mechanism of the UNFCCC, the GEF supports mitigation and adaptation measures that generate global benefit through the GEF Trust Fund. GEF projects in climate change help developing countries and economies in transition to contribute to the overall objective of the UNFCCC by reducing or avoiding GHG emissions in the areas of renewable energy efficiency and sustainable transport, and by supporting interventions that increase resilience to the adverse impacts of climate change in vulnerable countries, sectors and communities (GEF, 2007).

The GEF has three main funding components that focus on development namely; Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF) and the Adaptation Fund.

The SCCF provides finances for adaptation activities, especially projects on water resources management, land management, agriculture, health, infrastructure development, fragile ecosystems such as mountain ecosystems, and coastal areas integrated management. The current total fund for the Fund is US $62 million.

UNEP

The United Nations Environment Program (UNEP) works with countries to strengthen their ability to adapt to climate change, move towards low-carbon societies, improve understanding of climate science, and raise public awareness of the earth's changing climate. These sub-programs are closely aligned with Green Economy Initiative, which promotes cleaner investments and technologies as opportunities to reduce emission, protect our planet's biodiversity and ecosystems, and alleviate poverty through green job creation.

All of UNEP's works on climate change are shaped by the negotiation process of the UNFCCC. While negotiations continue towards reaching a more robust legally binding agreement, the UNFCCC meeting in Copenhagen, Denmark, in 2009 highlighted the importance of immediate actions and the need to support developing countries in their mitigation and adaptation efforts.

In line with these actions, UNEP is scaling up its role and response to climate change under a new action plan that complements the Program of Work for 2010 - 2011. Four priorities areas have been identified as lead areas that match calls for international guidance, urgent need for action at a national level on climate change and the organization's skill set, experience and mandates, namely:

Adaptation to Climate Change:UNEP helps countries reduce their vulnerability and use ecosystem services to build natural resilience against the impact of climate change.\\

Mitigating Climate Change: UNEP supports countries in making sound policy, technology and investment choices that lead to GHG emission reductions, with focus on scaling-up clean and renewable energy conservation.

Reducing Emissions from Deforestation and Forest Degradation(REDD):This is an effort to create financial value for the carbons store in forest, offering incentives for developing countries to reduce emissions from forest lands and invest in low-carbon paths to sustainable development. `REDD+` goes beyond that to include the role of conservation, sustainable management of forest and enhancement of forest carbon stocks.

Enhancing Knowledge and Communication: UNEP works to improve understanding of climate change science and raise awareness of climate change impacts among decision-makers and other target audiences (UNEP, 2010).

(i)Nigeria's Response to Climate Change

When the reality of climate change became glaring to the international community, Nigeria was among 154 countries that initialed the UNFCCC in 1994 and has ratified the Kyoto Protocol.The government and people of Nigeria acknowledge the importance of developing a national response to climate change and are taking appropriate steps to build a governance structure to managing the phenomenon. The Federal Government first created a national focal point, the Special Climate Change Unit (SCCU) within the Federal Ministry of Environment. It also mobilized the Inter-ministerial Coordinating Committee on Climate Change. In 2010, the National Assembly passed a bill for the establishment of a National Climate Change Commission, which, once established, will facilitate coordination and support for the multi-level and cross-sectional adaptation responses. In addition, development of a National Climate Change Response Strategy and Policy is on-going. In 2003, the federal government established a department of climate change in the federal ministry of environment.

Internationally, Nigeria has participated actively at meeting on climate change, including the annual Conference of Parties to the UNFCCC. Nigeria has also adopted the Economic

Commission for West Africa (ECOWAS) sub-regional action plan to reduce vulnerability to climate change.

In addition to the climate change activities of the Federal Government, other stakeholders in the country have begun to respond to the current and expected impacts of climate change. Some state governments, NGOs and other civil society groups, private sector organizations, communities, and individual Nigerians have begun to respond to the impacts of climate change (IINRCC, 2011).

To build on and consolidate on these initial climate change adaptation actions, and to ensure a truly national response to the significant and multi-dimensional impact of climate change, Nigeria needs an aggressive and widely supported strategy and action plan. This strategy and plan must be integrated, comprehensive in scope and inclusive of all stakeholders. This imperative has led to the development of Nigeria's National Adaptation Strategy and Plan of Action (NASPA). The vision, goal and objectives of NASPA include:
Vision: The strategy envisions Nigeria in which climate change adaptation is an integral component of sustainable development, reducing the vulnerability and enhancing the resilience of and the adaptive capacity for all economic sectors and all people - particularly women, children, and resource-poor men -- to the Adverse impacts of climate change, while also capturing (the opportunities presented by climate change).

Goal: To take action to adapt to climate change by reducing vulnerability to climate change impacts and increasing the resilience and sustainable wellbeing of fall Nigerians; and to minimize risk by improving adaptive capacity, leveraging opportunities, and facilitating collaboration inside Nigeria and with the community.

Objectives:To reduce the impact of climate change through adaptation measures; it can be undertaken by the federal, state, local governments, civil society, private sector, and communities and individuals, including measures that will: (1) Improve awareness and preparedness for climate change impacts; (2) reduce the impact of climate change on key sectors and vulnerable communities; (3) integrate climate change adaptation into national, state and local government planning and the plans of universities, research and educational organizations, civil society organizations, the private sector and the media.

The recommended policies, programs, and measures contained in the NASPA have been developed with a long term vision, but are based on a 5-year implementation timeframe. This means that the full strategy should be reviewed in detail every 5 years. At each review point, the plan should be reviewed in light of new knowledge and experience gained, and then formally renewed for another 5 years (BNRCC, 2011).

In 2001, the COP acknowledged that least developed countries (LDC) do not have the capacity to deal with adaptation to climate change. It therefore established a work program for supporting LCDs in the preparation and implementation of National Adaptation Program of Action (S'APA). The N'APA takes into account existing coping strategies

(j)Climate change and agriculture in Nigeria

The effects of climate change have already been felt in many parts of the country with the modification of intensity and seasonal nature of the rains, elevation of average annual temperatures, and intense frequency of widespread, high impact weather phenomena including drought and flooding. These effects of climate change directly have an impact on agriculture in Nigeria. Agricultural activities in Nigeria such as rain fed agriculture, livestock rearing, fisheries and forest products extraction are sensitive to climate change (FAO 2008).

***Climate change has impact on agriculture in Nigeria in the following ways*.**

Increase in temperature

Increase in temperature especially in the semi-arid region has resulted in the less farm work as farmers and other farm workers get tired easily due to dehydration constant sweating. This was supported by Bello et al (2012) who indicate that sudden increase in air temperature in Nigeria was observed as from the early 1970s until 2005 which is linked to the effect of climate change and its associated global warming which was previously reported by several studies. The mean temperature from 1901-1970 was 26.3°C and increases to 27.8°C from 1971-2005 (Bello et al., 2012). Also farmers continue to complain that agricultural produce has been very poor these days as they are facing declining crop yields due to weather fluctuations and other environmental threats. The result is that some farmers in Nigeria are abandoning farming for non-farming activities.

Drought

Due to drought in the north east, the Lake Chad is receding at a very fast rate so much so that the quantity of water is one third of its original volume. This has affected farming activities around the lake particularly dry season farming. According to Dami (2011), the reduction in the size of the lake is associated with two main factors: climate change and human demand for water. The climate factors include declining frequency and volume of rainfall received within and outside the basin from Rivers that drain into the Lake Chad such as Hadejia-Jamaare and Chari. The human factors are mainly related to land use and the increasing demand for water even as the supply is decreasing from the lake due to the climatic factors. The problem of drought had remarkably impacted the socio-economic life of the people in the region as the major activities in the basin are fisheries, rain-fed and irrigated farming which solely depend on the prevailing climatic conditions (Dami, 2011).A study by Joshua and Ekwe (2013) state that field interaction and discussion with the farmers on the farm reveal that many farmers are willing to do dry season farming but the available water is not enough for any meaningful production.

Serious and severe floods

In 2010, there was serious flooding due to heavy rains in different parts of the country which destroyed vast fertile farmlands at that time and subsequently resulted in higher food prices, increasing the fear of food insecurity and aggravating rural poverty. The problem of incessant floods and erosion continue to expose peasant farmers to the hazards of climate change. In 2011, there were severe floods in different parts of the country which directly affected agriculture. For example a heavy down pour that lasted six hours on 26th August, 2011 in Ibadan, Oyo state swept away poultry farms and fish ponds filled with chicken and fishes worth millions of Naira (Sunday, Tribune (2011). Again in 2012, the worst floods in over five decades submerged and destroyed farmlands of rice, yams cassava, maize, melon as well as plantain and banana in the State around River Niger, Benue and Cross River as the rivers were filled to capacity by heavy rains and thus over flow from their banks. This has also occurred in the far northern states of Katsina, Jigawa and Kano where farmlands of millet, guinea corn, maize etc were destroyed by the floods (Ibekwe, 2012).

Global climate change has brought heavy rainfall where rains that are to fall in different days in one month fall within one or two days leading to massive flooding as witnessed presently in 2014 in parts of India, Pakistan, USA, United Kingdom and Japan. The average temperature in regions across the globe goes up, as more rain falls. This happens because warm air holds more moisture and when warm air holding moisture meets cooler air, the moisture condenses into tiny droplets that float in the air. If the droplets get bigger and become heavy enough, they fall as rain (UCS, 2010). In Nigeria, this is the case where heavy seasonal rains fall particularly in the month of July to September were experienced in 2010, 2011, 2012 and 2013 which causes massive flooding that results in the bursting of rivers, Elapse of earth dams, release of water from large dams which displace people especially farmers in rural areas, submerging of farmlands and destroying crops, poultry and fish farms, contaminating water sources and sanitation facilities (IFRC, 2013).

Weather fluctuations

Fluctuation of the weather arising from climate change causes insurgence of infectious diseases such as malaria, cholera and meningitis particularly among rural dwellers thereby affecting their output in farming activities. This affects the health of farmers and market transactions, reducing their quality of life and agricultural output. Indeed, many prevalent infections including malaria, fever and cholera are climate sensitive as they are transmitted by mosquitoes which cannot survive if temperatures are too low and thus thrive when the weather conditions are warmer with global warming. According to Akingbade (2010), investigations revealed that in the year 2009, over 200 people were killed by meningitis in Nigeria and Niger Republic in one week. There were 25,000 suspected cases and 1,500 deaths in the first quarter of 2009.Experts have found a correlation between weather and meningitis which affects people in periods of erratic and unpredictable weather (Akingbade, 2010). In many areas in northern Nigeria fluctuating weather does not only cause diseases which affect the health of the farmers, but also confuse farmers about the start of the planting season.

Extreme weather events

Besides floods and drought, there is another extreme weather event as hailstones that accompanied heavy rains caused widespread destruction of houses of rural farmers, farmlands and agricultural products in some local government areas of Jigawa and Katsina States in September 2012.According to the residents of the areas the hailstorms and the destructions they cause were not seen by the people in their entire life time (Ibrahim, 2012). In June 2013, a late night heavy downpour showered large ice pellets on maturing plants destroying most of the crops which include okra, maize, vegetables and sugar cane on some irrigated farms in Mairuwa near Funtua in Katsina State. Most of the farmers have to bear the loss as the okra and the maize were not ready for harvest and cannot be sold. Also in the same State, Katsina and in the same month of June 2013, hailstorm consisting of ice pellets destroyed okra, maize and other vegetables in farmland whose cost is worth N10 million in villages of Faskari Local Government area. About 2,000 farmers were affected as most of their crops planted were completely damaged by the hailstorm which occurred when the crops were not ready for harvesting. Some of the farmers interviewed said that unless the Government helps the affected farmers, most of them will not be able to farm in the next planting season because they have lost all they have in the disaster (Ibrahim, 2013). In Nigeria's tropical weather, hailstorm was not normal but presently has being occurring frequently and in different locations in the country due to climate change.

Drought Conditions

Drought condition created by climate change especially in the north eastern part leads to decrease in pasture grass and water availability in the region. This leads to decrease in livestock production resulting in an impaired availability of milk, meat, egg and animal products such as hides and skin. The decrease in pasture grass can causes migration of herdsmen further down South and can increase the rate of Farmers-Fulani clashes as was recently witnessed in May 2013 near Abuja, the federal capital territory. The persistent drought conditions and desertification in the North East have been identified as the primary cause of reduction of the inflow of water into the Lake Chad, causing shrinking of the lake and resulting in conflicts between farmers, fishermen and pastoralists living along the border of the lake. The shrinking of the lake led to a reduction of land for cultivation and grazing (Fagbohun, 2010). According to Akingbade (2010), agriculture in northern Nigeria in general has being affected by drought as the dryness has led to dry farmlands, water beds and movement of people and their livestock to the southern region thus causing tension and conflict between the original inhabitants and the newcomers.

Increasing number of environmental refugees

Increase in the number of environmental refugees has drastically increased as people were forced to leave their homes in search of relief from harsh environmental conditions. These include floods, drought, oil spillage/ crude oil pollution, hailstorm/windstorm, pest incidence etc (Gwaram et al, 2004). For example many victims of 2012 devastating floods who were farmers were still living in displacement camps as at January 2013 which is bound to affect food security as many farmlands are idle and unprepared for the coming planting season. Drought conditions in the North east has led to the reduction in the size of the lake Chad apart from intensifying the conflict between pastoralists, farmers and fishermen, had also led to the emergence of environmental refugees (Fagbohun, 2010). Oil spillage and crude oil pollution has created climate refugees as flare motivates change in climatic conditions making large part of the Niger Delta land uncultivable and water resources economically unviable which has pushed people to migrate in order to seek alternative source of livelihood (Alaba et al, 2013).

Furthermore on the occasion of World Environment Day 2014 with the theme :"Raise Your Voice not the SeaLevel", the Minister of Environment warned that about 32 million Nigerians living along the coastlines of the Niger Delta might be displaced by rise in the sea level and thus become environmental refugees. An accelerated sea level rise of 0.5 meters, 35 per cent of the Niger Delta land mass would be lost, with an accelerated rise of 1.0 meters, 7.5 per cent of the Niger Delta gone under the sea (Blueprint,2014).

2.2 Empirical Literature

The subject of climate change is a broad one that goes across different discipline. Due to the increasing global awareness on the subject, many experts (both economic and non-economic), have attempted to study the matter from diverse backgrounds. Here, a review of some of the related empirical literatures is carried out.

Most available data on climate change are mainly global whereas the effects are more at regional levels. Mendelsohn and Dinar (1999) examined the impacts of climate change on agriculture in India and Brazil. They employed three different methods for the analysis namely; the Ricardian method, agro-economic model, and agro-ecological zone analysis. Environmental factors such as farm performance, land value or net income and traditional economic inputs which are land and labour, and support systems such as infrastructure were used as explanatory variables in the models. Unlike most studies, this analysis pointed out the significance of the adaptation. They argue that farmers will adapt to new condition due to climate change by making production decisions which are in their own best interests. Crop choice is one of the examples of farmers' adaptation to warmer weather in the paper. Wheat, corn, and rice are three crops as examples since the regions in which they grow depend on the temperature. As temperature gets warmer wheat farmers switch wheat to corn for making profits. Later, if temperature gets warmer again enough to lose profits, farmers adapt to warmer weather thus switch to rice from corn. The results of the Ricardian method, agro-economic model, and agro-ecological zone analysis showed that increase in temperature will decrease the crop production especially the crops grown in cool areas such as wheat. However, the authors argue that the result of the Ricardian method suggests that farmers' ability to adapt to new condition will mitigate the impacts of climate change in the long run while the agro-economic model and agro-ecological zone analysis would be more suitable for short run analysis since the adaptation is not included in the models.

Mathauda, Mavi, Bhangoo, and Dhaliwal (2000) investigated the effects of temperature change on rice yield in the Punjab region in India by using the simulation model between 1970 and 1990. They stratified the weather scenario by 5 different conditions which are normal weather, slight warm (0.5°C increase in temperature), moderate warm (1°C increase), greater warm (1.5°C increase), and extreme warm (2°C increase) in the simulation model. The model predicted that temperature increase decreases rice yield by 3.2% in slight warm, 4.9% in moderate warm, 8.2% in greater warm, and 8.4 % in extreme warm condition compared to normal condition scenario. The result also showed that an increase in temperature negatively affects not only rice production but also other rice attributions such as biomass, crop duration, and straw yield.

Torvanger, Twena and Romstad (2004) analyzed climate change impacts on agricultural production in Norway for the period 1958-2001. The study employed time series data with a biophysical statistical model to examine the dynamic linkages between yields of potatoes, barley, oats, wheat and climate change variables such as temperature and precipitation. The study found that there is a positive impact on yields from temperature in 18% of the crops. The effect is found to be strongest for potatoes.

Deschenes and Greenstone (2004) investigated the economic impact of climate change-on the US agricultural land. They replicated the previous literature's implementation of the hedonic approach and found that it produces estimates of the effect of climate change that are very sensitive to decisions about the appropriate control variables, sample and weighting. They found estimates of the benchmark doubling of greenhouse gases on agricultural land values that range from a decline of $420 billion (1997$) to an increase of $265 billion, or 30 percent to 19 percent. Despite its theoretical appeal, the wide variability of these estimates suggests that the hedonic method may be unreliable in this setting. In light of the potential importance of climate change, their work proposed a new strategy to determine its economic impact. They estimated the effect of weather on farm profits, conditional on county and state by year fixed effects, so the weather parameters were identified from the presumably random variation in weather across counties within states. The results suggest that the benchmark change in climate would reduce the value of agricultural land by $40 to $80 billion, or 3 percent to 6 percent, but the null of zero effect cannot be rejected. In contrast to the hedonic approach, these results are robust to changes in specification. Since farmers can engage in a more extensive set of adaptations in response to permanent climate changes, this estimate is likely biased downwards, relative to the preferred long run collect. Together the point estimates and sign of the likely bias contradict the popular view that climate change will have substantial negative welfare consequences for the US agricultural sector.

Faisal and Parveen (2004) examined the nature and magnitude of these threats forth benchmark years of 2030 and 2050. It has been shown that the overall impact of climate change on the production of food grains in Bangladesh would probably be small in 2030. This is due to the strong positive impact of CO_2 fertilization that would compensate for the negative impacts of higher temperature and sea level rise. In 2050, the negative impacts of climate change might become noticeable: production of rice and wheat might drop by 8 percent and 32 percent, respectively. However, rice was more sensitive to a change in temperature. Based on thepopulation projections and analysis of future agronomic innovations, this studyfurther showed that the availability of cultivable land alone would not be aconstraint for achieving food self-sufficiency, provided that the productivity of riceand wheat grows at a rate of 10 percent or more per decade. However, the situation would be more critical in terms of water availability. If the dry season water availability does not decline from (the 1990 level of about 100 billion mm^3, there would be just enough water in 2030 for meeting both the agricultural andnon-agricultural needs. In 2050, the demand for irrigation water to maintain foodself-sufficiency would be about 40 percent to 50 percent of the dry season wateravailability. Meeting such a high agricultural water demand might cause significant negative impacts on the domestic and commercial water supply, fisheries, ecosystems, navigation, and salinity management.

Measurement of the likely magnitude of the economic impact of climate change on African agriculture has been a challenge. The question is: will African agriculture survive climate change? Using data from a survey of more than 9,000 farmers across 11 African countries.

Seo, Mendelsohn and Munasinghe (2005) analyzed the climate change impacts on Sri Lankan agriculture using the Ricardian method and five AOGCM experimental models. The model analyzed the net revenue per hectare of the four most important crops (rice, coconut, rubber, and tea) in the country. This paper focused more on the precipitation effect on crop production while most literatures usually analyze the temperature effect. It is mainly due to the greater range of precipitation across the country although the limited range of temperature variation allows only a simple test of temperature impacts in the study. Both the Ricardian method and five AOGCM experimental models revealed that the effects of increase in precipitation are predicted to be beneficial to all crops tested and the benefit ranges from 11 % to 122 % of the current net revenue of the crops in the model. On the other hand, the impacts of increase in temperature are predicted to be harmful to the nation and the loss ranges from−18 % to−50 % of the current agricultural productivity

In his study, Benhin (2006) on the impacts of climate change on crop farming in South Africa using a cross-sectional Ricardian approach to measure relationship between net revenue from growing crops and climate. The study explored two specification of the Ricardian model. The first included only climate, soil and hydrology variables and is referred to as the 'without adaptation' model. The second included the relevant socioeconomic variables and is referred to as the 'with adaptation' model. This was to assess the extent to which these additional variables increase or decrease the effect of climate on crop sector. Climate impacts were also found to have, to a large extent, a non-linear relationship with net revenue. That is, increase in temperature and precipitation will be beneficial to crop farming but beyond a certain limit the impacts will be negative. In addition to irrigation and farm type, other socio-economic variables tested in the 'with adaptation' models included the area of cropland, a dummy for livestock ownership, access to electricity, access to public extension services and other sources of extension services, distance to crop market, farming experience and household size. The size of crop land area was found to be important, especially for dry land farmers, since a larger area enables them to spread their risk from adverse climate effects. Ownership of livestock was also found to be possible adaptation option; small-scale farmers and dry land farmers.

The study of Sene, Diop and Dieng (2006) on impacts of climate change on revenue and adaptation of farmers in Senegal used the Ricardian method to measure how climate affects net revenue. It was suggested that small farmers in Senegal have low net revenue and that small rain-fed farms were highly vulnerable to climate change. The model showed that net revenue depends on crop harvest, humidity and temperature. The study also revealed that farmers have several ways of adapting to climate change: diversify crops, choosing crops with a short growing cycle, weeding early in the north and late in the south, praying and so on.

Kabubo-Maria and Karanja (2006) observed in their study that climate affects Agricultural productivity and increased winter temperatures are associated with higher crop revenue, but increased summer temperatures have a negative impact. Increased precipitation is positively correlated with net crop yield. The results further showed that there is a non-linear relationship between temperature and revenue on the one hand and between precipitation and revenue on the other hand. And sols, irrigation and household size are positively correlated

Eid, El-Marsafawy and Ouda (2006) in their study, “The economic impacts of climate change on agriculture in Egypt using a Ricardian approach,” showed that a rise in temperature would have negative effects on net farm revenue in Egypt. Marginal analysis indicated that the harmful effect of temperature was reduced by adding the hydrology term and heavy machinery to the analysis. The results also showed that raising livestock on the farm to cope with climate change was not effective, probably as a result of small farm ownerships. The results also indicated that irrigation could defeat the adverse effect of higher temperatures and increase net revenue. Again it was also showed that using irrigation and investing in heavy machinery could reduce the harmful effects of global warming and improve the revenue. Irrigation and technology among other things are therefore the recommended adaptation options. The coping policy strategy should focus on crop management, water and land management.

In Nigeria, Agboola and Ojeleye (2007) examined the impact of climate change on food crop production in Ibadan. The study adopted both primary and secondary data collection procedures. For the secondary source of data, time series data covering 30 years were collected on climate variables and the analysis was done with bivariate Chi-square and ANOVA supported by graphical illustrations. The study revealed that farmers have noted various changes in climate conditions over the last two to three decades. It was further shown that there has been decline in crop yields on food crop production due to reduction in rainfall and relative humidity and as well as increase temperature.

Fleisher, Lichtrnan and Mendelsohn (2007) adopted a Ricardian model to test the relationship between annual net revenues and climate across Israeli farms. Net annual income is regressed on climate and other control variables across farms. The researchers found that farm net revenue is expected to increase by 16 percent in 2020, while by 2100, farm revenue is expected to drop by 60 - 390 percent, depending on different scenarios. Further analysis revealed that it is important to include the amount of irrigation water available to each farm in order to measure the response of farms to climate. With irrigation water omitted, the model predicted that climate change is strictly beneficial. But with the inclusion of water, the model predicted that only modest climate changes are beneficial, while drastic climate change in the long run will be harmful. The findings led to the conclusion that securing water rights to the farmers and international trade agreement can be important policy measures to help farmers adapt to climate change.

Kurukulasuriya and Mendelsohn (2007a) argued that previous analyses of climate change impact on agriculture have either omitted irrigation or treated it as though it is exogenous. In practice, it is a choice by farmers that is sensitive to climate. To determine the contribution of irrigation to food production, the authors developed a choice model of irrigation of cropland estimated across 8,400 farmers in Africa. The results indicated that the choice of irrigation in African is sensitive to both temperature and precipitation. The results also showed that African agriculture is sensitive to climate change. Many farmers will experience net revenue losses from warming. Elasticity of net revenue with respect to temperature was found to be -0.82 for dry land farms. That is, a 10 percent increase in temperature will lead to a loss in net revenues per hectare, on average, of 8.2 percent. Irrigated farms, on the other hand, arc more resilient to temperature change and, on the margin, are likely to realize slight gains in productivity. However, any reduction in precipitation will be especially deleterious to dry land fanners, generally the poorest segment of the agriculture community. Dry land farms are sensitive to precipitation (elasticity of 0.28) whereas precipitation has virtually no effect on the net revenues of irrigated farms. The results indicate that irrigation is an effective adaptation against, loss of rainfall and higher temperatures provided there is sufficient water available. This will be an effective remedy in select regions of Africa with water.

The objective of the study by Lotsch (2007) was to establish a quantitative relationship between land use in Africa and transient climate projections in the 21st century. The analysis revealed significant climate sensitivities of cropland density and distribution across a variety of agro-ecosystems. Based on the climate-cropland relationships, cropland density responds positively to increase in precipitation in semi-arid and arid ones of the sub-tropics and warmer temperature in arid elevations. Further analysis suggested that cropland area in Africa is likely to decrease significantly in response to changes in climate. The continent is expected to have lost on average 4.1 percent of its cropland by 2039, and 18.4 percent is likely to have disappeared by the end of the century. In some regions of Africa, the losses in cropland area are likely to occur at much a faster rate, with northern and eastern Africa loosing up to 15 percent of their current cropland area within the next 30 years. Gains in western and southern Africa due to projected increase in precipitation during the earlier portions of the century will be offset by losses later on. Recommendation is that sound policies to manage existing agricultural lands and the productivity of cropping systems should be pursued.

The study by Mendelsohn and Seo (2007a) has one salient purpose: to quantify some of the adaptations that farmers make to adjust to climate change. Using a sample of 2000 farmers across seven Latin American countries, the study modeled how Latin American farmers have adapted to the range of climates across the continent with respect to crops, livestock, and irrigation choice. The results showed that the choices of farm type arid irrigation are very sensitive to climate. Farmers are more likely to pick crops only in cooler temperature whereas they will choose livestock in dryer locations. Farmers are more likely to choose a crop-livestock combination in hot locations. Farmers will intend to irrigate in locations that are both cool and dry. The conclusion from the overall results suggested that farmers will do a great deal of adaptation in response to climate change.

In another study by Mendelsohn and Seo (2007b) the structural Ricardian method, an approach to modeling agricultural profitability was employed to understand how farmers change their behavior in response to climate change. A survey of 5,000 livestock farmers in 10 African countries revealed that the selection of species, the net income per animal, and the number of animals are highly dependent on climate. As the climate warms, net income across all animals will fall, especially across beef cattle. The fall in net income causes African farmers to reduce the number of animals on their farm, and to shift away from belt cattle toward goats and sheep. Small livestock and large livestock farms respond to climates differently. Small farms are diversified, relying on dairy cattle, goats, sheep, and chickens. Large farms specialize in dairy and beef cattle. Estimating a separate multinomial legit selection model for small and large farms, it was found that the two types of farm choose species differently and specifically have different climate response functions. The regression of the number of animals showed that large farms are more responsive to climate change. The results indicated that climate change will be harmful to commercial livestock owners, especially cattle owners. Owners of commercial livestock farms have few alternatives either in crops or other animal species. In contrast, small livestock farms are better able to adapt to warming or precipitation increases by switching to heat-tolerant animals or crops. They therefore recommended that African policy makers should pursue policies that encourage private adaptation to climate change.

Deressa and Hassan (2009) adopted the Ricardian approach that captures farmer adaptations to varying environmental factors to analyze the impact of climate change on crop farming in Ethiopia. By collecting data from farm households in different agro-ecological zones of the country, net crop revenue per hectare was regressed on climate, household and soil variables.

The results show that these variables have a significant impact on the net crop revenue per hectare of farmers under Ethiopian conditions. The seasonal marginal impact analysis indicates that marginally increasing temperature during summer arid winter would significantly reduce crop net revenue per hectare whereas marginally increasing precipitation during spring would significantly increase net crop revenue per hectare. Moreover, the net crop revenue impact of predicted climate scenarios for the years 2050 and 2100 indicated that there would be a reduction in crop net revenue per hectare by the years 2050 and 2100. Moreover, the reduction in net revenue per hectare by the year 2100 would be more than the reduction by the year 2050 indicating the damage that climate change would pose increases with time unless this negative impact is abated through adaptation. Additionally, results indicate that the net revenue impact of climate change is not uniformly distributed across the different ag1t)-ecological zones of Ethiopia.

Climate changes, associated with accumulation of greenhouse gases, are expected to have a profound influence on agricultural sustainability in Israel, a semi-arid area characterized by a cold wet winter and a dry warm summer. In realization of this, Haim, Shecter and Berliner (2009) explored the economic aspects of agricultural production under projected climate change scenarios using the "production function" approach, as applied to Iwo representative crops: wheat, as the major crop grown in Israel's dry southern region, and cotton, representing the more humid climate in the north. Adjusting outputs of the global climate-model to the specific research locations, they generated projections for 2070-2100 temperatures and precipitations for two climate change scenarios. Results for wheat vary among climate scenarios; net revenues become negative under the severe scenario (change from - 145 to 273 percent), but may increase under the moderate one (-43 to +35 percent), depending on nitrogen applied to the crop. Distribution of rain events was found to play a major role in determining yields. By contrast, under both scenarios cotton experiences a considerable decrease in yield with significant economic losses (-240 and -173 percent). Additional irrigation and nitrogen may reduce farming losses, unlike changes in seeding dates.

Kassahun (2009) examined the impacts of climate change on crop agriculture in Nile Basin of Ethiopia using the Ricardian model. Annual crop net revenue was regressed on climate and other variables. The results indicated that an annual increase of 1^0C in temperature would have a positive impact on annual crop net revenue for irrigated farms, but a negative impact for dry land farms and farms that represent Nile basin of Ethiopia. However, marginal impact of increasing precipitation would increase crop net revenue for both irrigated and dry land farms.

The results suggested that farmers are aware of climate change. In addition, the study examined the impact of uniform climate scenarios on the crop net revenue per hectare of farmers. These are increasing temperature by 2.5^0C and 5^0C; and decreasing precipitation by 7% and 14%. Based on the results of these simulations, the study predicted that crop net revenues would fall.

To understand the climate variability, environmental change and food security nexus in Nigeria, Obioha (2009) investigated the chain of interaction between climate change, drought condition and food production. The study employed secondary data gathered from government and non-governmental organizations. Using these data, the researcher made quantitative and qualitative analysis of drought condition, the nature of food production activities and the extent to which continuous climate change has affected the state of food production in the savannah region of Nigeria. Findings showed that desertification has impacted negatively on food production activities in the region, which has necessitated the intervention of the government to combat the problem through the assistance of international development agencies. Ensuring food security has been one of the major national priorities of Bangladesh since its independence in 1971. Now, this national priority is facing new challenges from the possible impacts of climate change in addition to the already existing threats from rapid population growth, declining availability of cultivable land, and inadequate access to water in the dry season.

Sowunmi and Akinola (2010) empirically examined the effect of climate variability on maize production in Nigeria. The study specifically analyzed the dynamic link between changes in climate elements and agronomic parameters for maize production in different ecological zones of Nigeria for the period 1980-2002. They employed the two-way analysis of variance and the coefficient of variation techniques of analyses. It was revealed that there exists a significant difference of annual rainfall, temperature and output of maize in the seven identified ecological zones.

Hassan (2010) analyzed how climate change has shaped African agriculture in the past and how it might impact on African farm economies in the future and what adaptation strategies African farmers have adopted to cope with these changes. The analyses covered all key farming systems and agro-climates of Africa in 11 countries in which data were collected from over 10,000 farm household surveys. Results provided evidence that African agriculture and the welfare of its rural population are vulnerable to climate change. The highest risk of future climate change damages is associated with specialized crop and livestock farming (mono systems) particularly under dry land conditions in arid and semi-arid regions. This indicates how difficult it is to achieve an African green revolution under the current high reliance on dry land systems (more than 95% of the land) given predicted harsh future climates (warmer and dryer projections) for most of the dry land areas in Africa. It will require substantial public and private investments in expanding irrigation and development of crop varieties and animal breeds that are tolerant to heat, water and low fertility stresses, and in building roads and marketing infrastructures that will improve access to critical inputs (e.g., fertilizer) and output trade. This essentially requires mainstreaming climate sensitivity as an integral component of all agricultural and broader economic development planning and policy design.

Sridhar and Ganesh (2010) applied Ricardian approach to measure the effect of climate change on net farm revenue in Nepal using cross-section data of Nepal Living Standard Survey 2003/04 and climate data from Department of Hydrology arid Meteorology, Nepal. The study examines the relationship between net farm revenue and climate variables using 656 households of 14 districts covering all climatic zones of Nepal. Net farm revenue is regressed on climate and socio-economic variables. The findings show that these variables have significant impact on the net farm value per hectare. More specifically, relatively low precipitation and high temperature seem to have positive impact on net farm income during the fall and spring seasons. Net farm income is likely to be increased by summer precipitation, but not by temperature. Marginal impacts are mostly in line with the Ricardian model, showing marginally increasing precipitation during summer and winter would increase net farm income, but reduce by the quarter terms and temperature of these seasons. Moreover, marginally increasing precipitation would increase farm income in the hilly region, but reduce it in Terai region. Other variables such as ratio of irrigated farm land and obtaining credit are found to have positive impact on net farm value but not by farm size. Conclusively, the impact of climate change on agriculture seems to be varied with the temperature and precipitation in different climatic zones

Kurukulasuriya and Ajwad (2010) applied the Ricardian technique to estimate the effect of climate change on the smallholder agriculture sector in Sri Lanka. The main contribution of the paper is the use of household-level data to analyze long-term climate interacts on farm profitability. Household-level data allows us to control for a host of factors such as human and physical capital available to fanners as well as adaptation mechanisms at the farm level. They found that non-climate variables explain about half the variation in net revenues. However, their results suggested that climate change will have a significant impact on smallholder profitability. In particular, reductions in precipitation during key agricultural months can be devastating. At the national level, a change in net revenues of between -23 percent and 22 per cent is likely depending on the climate change scenario simulated. These impacts will vary considerably across geographic areas from losses of 67 percent to gains that more than double current net revenues. The largest adverse impacts are anticipated in the dry zones of the North Central region and the dry zones of the South Eastern regions of Sri Lanka. On the other hand,-the intermediate and wet zones are likely to benefit, mostly due to the predicted increase in rainfall.

Nhemachena, Hassan and Kurukulasuriya (2010) measured the economic impacts of climate change on crop and livestock farming in Africa based on a cross-sectional survey of over 8000 farming households from 11 countries in east, west, north and southern Africa. The response of net revenue from crop and livestock agriculture across various farm types and systems in Africa to changes in climate normal's (i.e. mean rainfall and temperature) is analyzed. The analyses controlled for effects of key socioeconomic, technology, soil and hydrological factors influencing agricultural production. Results show that net farm revenues are in general negatively affected by warmer and drier climates. The small-scale mixed crop and livestock system predominantly typical in Africa is the most tolerant whereas specialized crop production is the most vulnerable to warming and lower rainfall. These results have important policy implications, especially for the suitability of the increasing tendency toward large-scale mono-cropping strategies for agricultural development in Africa and other parts of the developing world in light of expected climate changes. Mixed crop and livestock farming and irrigation offered better adaptation options for farmers against further warming and drying predicted under various future climate scenarios.

Odjugo (2010) investigated the regional evidences of climate change using Nigeria as a case study. Mean annual air temperature from 30 synoptic stations between 1901 and 2005 were collected from the Nigerian Meteorological Agency, Lagos and, Meteorological Departments in some airports. The data were divided into three climatic periods, namely, 1901-1935, 1936-1970 and 1971-2005 for the purpose of comparison. Time series, correlation, least square range test, ANOVA and isotherm maps were the statistical tools used to analyze the data. Results showed that air temperature is steadily increasing especially from the 1970s. Between 1901-1935 and

1936-1970 climate periods, temperature anomalies were below the 1970-2005 normal, but 22 years out of the 35 years were above the normal between 1971and 2005. The temperature anomalies showed that climate change signal is stronger as from the 1970s; the rate of temperature increase is higher in the semi-arid region than the coastal areas of Nigeria. The current available pieces of evidence show that Nigeria, like most parts of the world, is experiencing the basic features of climate change. Ayinde et al. (2011) examined the effect of climate change on agricultural production in Nigeria and the study covered the period 1980-2002 and adopted time series data. They analyzed their study with the recent cointegration technique of analysis and revealed that temperature had negative effect on agricultural productivity while rainfall was found to exert positive effect on agricultural productivity.

Adesina and Odekunle (2011) ascribed the climate change impact to the variability in rainfall and temperature regimes. They further identified a weak resilience to climate change in the Sudan-Sahel zone of the country declaring the North-East and the North-West zones as the most vulnerable zone, while South-West and South-East zones are the least vulnerable. It was concluded that climate change is real and happening in Nigeria from their findings.

Tunde, Usman, and Olawepo (2011) analyzed the effect of climate variables on crop production in Patigi, Kwara State, Nigeria and the study used time series data covering 1999-2008. The analysis was done by correlation and Ordinary Least Square (OLS) methods without examining the time series properties of the data. The study revealed that rainfall highly correlated with maize production but weakly correlated with Millet production and Sorghum. Temperature however was found to correlate with rice and groundnut production negative.

Ayinde, Muchie and Olatunji (2011) used a Co-integration model approach on time-series data from 1980 to 2000 to the effect of climate change on agricultural productivity in Nigeria, The study shows the climate change trends and also have negative effects on Nigerian agriculture. It revealed that heavy rainfall of the previous year could lead to erosion and leaching, while rainfall variability Sects agaric production, temperature variability seems not to have important effects on agricultural productivity in Nigeria economy.

Jiduana, Dab and Dia (2012), investigated empirically the effect of climate change on agricultural activities in selected settlements in Nigeria specifically, the Sudano-Sahelian Region. The study used a structured questionnaire and focus group approaches for data collection procedures and employed inferential statistical technique for the analysis. The study found that rainfall and temperature have been on a decline and increase respectively. The effects are decline in crop yield that has attracted the application of fertilizers and abandonment of farmlands.

Agricultural impact of climate change in Nigeria is uncertain (Apata, 2012). The paper is however very quick to observe a positive impact in the south but negative impact in the north. At aggregate level, he found a reduction of 178.37 percent in food production in the country with the North-West as the highest danger zone, while the south experiences marginal positive contribution except South-East that experienced a reduction of about 9.09 percent in food production.

Madu (2012) found that northern states are more vulnerable because of greater exposure to climate induced environmental hazards and low adaptive capacity (inadequate health-care, educational status, poor infrastructure and local economies), Using Principal Component Analysis, he identified states with low vulnerability (Lagos, Imo, Anambra, Abuja and FCT) and those states that are most vulnerable (Jigawa, Bauchi, Adamawa, Sokoto and Gombe). He summed up that infrastructure; technology adoption and diversification of economic activities are keys to reducing climate change vulnerability.

Using annual data for 34 countries from 1961 to 2009, Odusola and Abidoye (2012) found a negative impact of climate change on economic growth in Africa. Their results show that a 1 degree Celsius increase in temperature reduces GDP growth by 0.27 percentage point for the region. A higher impact of 0.41 percentage point was however observed when the sample period was reduced to 1961 to 2000 indicating a reduction in the influence possibly given increase in efforts towards adapting to climate change. The two largest economies in the Sub-Saharan Africa (South Africa and Nigeria) played some significant role in ameliorating the negative economic impact of climate change in the region.

Eregba, Babatolu and Akinnubi (2014) analyzed impact of climate change on crop production in Nigeria and the study used time series data covering 1970 to 2009. Cointegration analysis was used to estimate impact of climate change on crop production in Nigeria. The study reveals that climate change has a significant influence on crop production in Nigeria. The study equally revealed that impact of climate change varies across crops.

Onoja and Achike estimated the economic effect of climate change on arable crop production in Nigeria. The study adopted both primary and secondary data collection procedure. Econometric technique was used to estimate result and findings show that variation in rainfall, temperature, household size, labour and material exert statistical significant effect on level of agricultural output.

A cursory look at the empirical literatures shows some studies have measured impact of climate change on agricultural production in African countries and some other countries of the world. The studies in Nigeria however, concentrated at either state or regional levels. Few studies that consider climate impact on agricultural production in Nigeria adopted complete aggregate approach. The studies failed to identify how changes in climate specifically influence the different agricultural sectors like crop production, livestock, fishery, and forestry. The minimum time for research work on climate change as recommended by World Meteorological Organization is thirty years and some of the works did not meet this requirement. In this study the aggregate and disaggregate approach is adopted to estimate the general and specific impact of climate change in overall agriculture and the sectors that make up the agricultural sectors respectively.

Table 2.1 Summary of Empirical Literature Reviewed

Author / Year	**Location of Study**	**Topic**	**Variables**	**Method Of Analysis**	**Findings**
Mathauda et al (2000)	Punjab in India	Effect of Temperature Change on Rice Yield	Mean Temperature, mean rainfall	ANOVA	Increase in temperature negatively affect not only rice production but also other rice attribution as crop duration and straw yield.
Torvanger, Twena & Romstad (2004)	Norway	Analysis of Climate Change Impact on Agricultural Production in Norway .	Annual Mean Temperature and Precipitation.	Biophysical Statistical method	
Deschenes & Green (2004)	United State of America	Impact of Climate Change on USA Land	Mean Temperature, Rainfall, Relative Humidity and Sunshine	Sampling and weighing	Bench mark change in climate would reduce the value of agricultural land from 6 % to 3%
Faisal & Parveen (2004)	Bangladesh	Nature and Magnitude of Climate Effect for the Bench mark Years of 2030 and 2050	Carbon dioxide, Annual Mean Temperature, Arable Land	OLS	Strong positive co2,Fertilization would compensate for negative impacts of higher temperature as projected
Seo et al (2005)	Sri Lankan	Analysis of Climate Change Impact on Sri Lankan Agriculture	Mean Temperature, Precipitation	Experimental method and graphical illustration	Increase in precipitation are predicted to be beneficial to crop tested while increase in temperature are predicted harmful

Table 2.1 Summary of Empirical Literature Reviewed continued

Author / Year	Location of Study	Topic	Variables	Method of Analysis	Findings
Sowunmi & Akinola (2010)	Nigeria	The Effect of Climate Variability on Maize Production in Nigeria	Annual rainfall, Annual Temperature	ANOVA	Findings reveal that there is a significant difference of climatic variable and output of maize in the identifies ecological zones
Hassan (2010)	11 African countries	Implications of Climate Change for Agricultural Sector Performance in Africa: Policy Challenges and Research Agencies	Mean Temperature, Rainfall and socio-economic variables	OLS	Result provided evidence that African agriculture and the welfare of its rural population are vulnerable to climate change
Sridhar & Ganesh(2010)	Nepal	A Richardian Analysis of Climate Change Impact on Nepalese Agriculture	Mean Temperature, Precipitation, loan and socio-economic variables	OLS	Findings show that climate and socio-economic variables have significant impact on net farm value per hectare
Kurukulasuriya & Ajwad (2010)	Sri Lanka	Application of the Richardian Technique to Estimate the Impact Climate Change on Small Holder Farming in Sri Lanka		OLS	Findings show that non- climate variables explain about half the variable in net revenues. Result also suggest that climate change will have a significant impact on small holder profitability
Nhemachena et al (2010)	11 Countries in Africa	Economic Impacts of Climate Change on Crop and livestock Farming in Africa	Mean Temperature, Mean Rainfall, Irrigated land and socio-economic factors	Graphical illustration	Result shows that net farm revenues are in general negatively affected by warmer and drier climate
Tundeusman & Olawepo (2011)	Kwara state Nigeria	Effects of Climate Variables on Crop Production in Patigi, Kwara State	Mean Temperature, Mean Rainfall	OLS	Findings show that Rainfall highly correlated with maize production but weakly correlate with millet and sorghum production

Table 2.1 Summary of Empirical Literature Reviewed continued

Author / Year	**Location of Study**	**Topic**	**Variables**	**Method of Analysis**	**Findings**
Ayinde et al(2011)	Nigeria	The Effect of Climate Change on Agricultural Productivity in Nigeria: A Co-integration Model Approach	Annual mean temperature, annual mean rainfall	OLS	Temperature variability seems to have no effect in agricultural productivity.
Jiduana et al (2012)	Nigeria	Effect of Climate Change on Agricultural Activities in Settlements in Nigeria		ANOVA	Findings show that rainfall and Temperature have been on the decline and increase respectively. This has result in decline in crop yield that has attracted the application.
Eregba, Babatolu,& Akinnubi (2014)	Nigeria	Climate change and crop production in Nigeria: An Error Correction Modelling Approach	mean Rainfall, mean temperature, Fertilize utilization	OLS	Findings reveal that climate change affect crop production and the effect varies across crops.
Onoja & Achike (2014)	Nigeria	Economic analysis of climate change effect on arable crop production in Nigeria.	Mean rainfall, mean temperature, household size, labour and materials.	OLS	Result shows that variation in climatic variables exert significant effect on crop yield level.

Source: Compiled by the researcher, (2016)

2.2.1 Summary of Literature Review

From the review of available and related literature, it is obvious that the issue "climate change and agricultural production has evolved over the years and various theories have emerged to 'explain it. From Sen's "entitlement failure "which postulates that enhanced agricultural production can only be guaranteed by perfect functioning of the prevailing factor. The theory of "sustainable livelihood" improves on 'Sen's work and adds that improved agricultural productivity can be achieved by ensuring unlimited access to resources, control of external factors influencing agriculture and income-earning activities. Various factors have been identified as responsible for retarding agricultural production in Africa, ranging from use of local farm implements, diseases, and environmental degradation to climate change, and underinvestment in agriculture sector.

A common consensus among experts is that climate change is a reality and will affect the overall human existence by altering the natural ecosystem and activities relating to it, including agricultural production. Various empirical studies so far conducted on the impact of climate change on agricultural production in some countries yield quite different results. Some studies have shown that developing countries are most vulnerable to climate change while developed countries appear to be immune to the phenomenon despite contributing largely to it. Quite a number of other studies have equally shown that while agriculture in some countries will be adversely affected by rainfall alone, others have shown that temperature alone will impair agricultural activities, whereas in some other studies, both temperature and rainfall have been found to have significant Influence on agricultural income.

Much of the empirical studies on this study concentrated on the impact of climate change on aggregate agricultural output, rather than the composition of agricultural output. Analysing the effect of climate change on composition of agricultural output is important because the effect of change in the aggregate output may ignore the individual response of each component of aggregate output to climate change.

2.3 Justification of the Study

This study is not entirely new. Some studies have been carried out in this area as indicated in the extensive review of literature. However, there are still some gaps to be filled. Few studies that are available adopted the aggregate approach that makes it difficult for one to access specifically, how changes in climate affect the different sector of agriculture like crop production, livestock, fishery and forestry.

Intuitively, the impact of climate change on crop production, livestock production, forestry production and fish production is not the same. For instance, while rainfall may be good for crop yield, its effect of on livestock may assume different proportion. Also, the effect of CO2 on forestry production may not be adverse, while fish production may be hampered by CO2. Therefore, the use of aggregate agricultural output will yield biased and misleading results as it will hide some important information. To guard against this, the study disaggregated agricultural outputs into components (crop, livestock, forestry and fishery) and then examined the impact of climate change on each component.

Again, the time coverage in most of the earlier studies is equally small. Besides, there is exclusion of basic atmospheric factor that affect agricultural production like Co_2 in the studies. Thus, this study tends to bridge the gap by adopting a disaggregated approach that creates access for sector by sector analysis of climate change impact on agricultural production in Nigeria. This study also captures important variables like $C0_2$, adopt and apply a coherent and consistent model that explains the magnitude and nature of relationship that exist between climate variables and variance in agricultural production in Nigeria.

The study also explored some methodological issues. For instance, the use of Zivot-Andrews unit roots test to test for stationarity of the series and the possibility of structural changes in the series under study. Earlier studies on the impact of climate change on agricultural production in Nigeria, such as Ayinde et al (2011), Tundeusman and Olawepo (2011), Obioha (2009) etc. fail to take cognizance of possible structural breaks in the time series.

Finally, the current study satisfied the condition set by World Meteorological Organization (WMO) for research on climate change.WMO requires the use of Annual Mean data for at least a period of thirty years for successful estimate of climate impact in any sector. The current study span from 1970 to 2015 which covers a scope of forty five year.

CHAPTER THREE: RESEARCH METHODS

Methodology has to do with the principles that determine how methods or tools are developed and interpreted in any scientific investigation or disciplines. This conception suggests that in addition to specifying the methods of the research, the basis for choosing such methods as tool of analysis must also be established. On this note, this chapter spells out the various methods and procedures undertaken in order to arrive at the research findings as well as justification for using such methods. The chapter begins with a discussion on the theoretical framework, the model specification, estimation technique and data source and scope

3.1 Theoretical Framework

The empirical model specification for this study is anchored on the level of product aggregation and functional form frameworks. The sustainable livelihood theory, which links sustainable agricultural output to access to production resources is adopted. A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is therefore, sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Chambers and Conway 1992). Relying on this postulation of the sustainable livelihood theory which links food production to availability and utilization of production resources, this work adopt an extended production function that expresses agricultural production as a function of climate and other input factors.

The primal form of the production function can be estimated using econometric technique at different levels of aggregation. The most general production function specification is given by the aggregate production function. Such a function considers the aggregated production of multiple outputs at the macro level, e.g. sector or country. Much attention in the literature has been given to numerous problems plaguing aggregate productivity analyses and various solutions have been proposed (Jensen, 1977). Despite these advances, aggregation implies that it is not possible to determine the specific effect of one input (in this case climate factor) on one particular output (Just, Zilberman & Hochman, 1983). The response of outputs to changes in inputs, and especially weather, may vary considerably from product to product because of biological differences across agricultural products. Because of the asymmetry in the responses of agricultural outputs to input changes (especially climate), the current study toes the line of aggregate and disaggregate analysis.

The production function can also be estimated for multiple outputs. According to Just et al. (1983) a multiple-output production function is a technical relationship that specifies possible output mixes that can be produced from each mix of inputs. Huffman (1988) reviews studies using multiple-output, multiple-input functions. A multiple output production function is appropriate when one farmer produces several products and/or raises livestock within a farm. Mixed-cropping systems are common phenomenon in Nigeria. In such a system, it is difficult to identify input use for each agricultural product as these products are produced jointly. In this case, a system of single production functions has to be estimated jointly for all the mixed crops. But such an estimation technique is computationally demanding (Barrett & Hogset, 2003).

Alternatively, single output production functions focus on a single agricultural produce produced by the farmer. This approach estimates a production function independently for each produce. However, single production function estimation assumes reparability of inputs, which is not possible in the mixed cropped context of Nigeria. In this case, separate crop production function equations can be estimated jointly using Zellner's (1962) method for seemingly unrelated regressions (SUR). However, this method is not applicable when the set of explanatory variables differs across products and Zellner's cross-equations-correlations are not relevant in a context of wide agro-climatic conditions across groups (Narayana & Shah, 1984). Moreover, several technical limitations arise because of the limited development of the SUR estimator.Consequently, single production functions are estimated for aggregate agricultural product, and specifically for crop production, livestock, forestry and fishery.

On the question of the appropriate functional form, several functional forms exist to model production functions. The most common functional form is the constant elasticity of substitution (CES) function and its special cases given by Leontief and Cobb-Douglas functions. The CES function introduced by Arrow, Chenery, Minhas and Solow (1961) specifies production as:

$$Q = A[\gamma K^{-\rho} + (1-\gamma)L^{-\rho}]^{-1/\rho} \qquad 3.1$$

Where Q is output, K is capital and L labour, *A is* an efficiency parameter, $\gamma$is a share parameter and ρ is a substitution parameter. The CES function incorporates Leontief and Cobb-Douglas functions as special cases. The Leontief function occurs when ρ = 0 and implies that the production factors are used in fixed proportion (i.e. there are no substitution possibilities). This function is easy to specify but can be unrealistic. The Cobb Douglas function, achieved by setting $\rho = 1$, implies constant factor shares. Although the general form of the CES function does not restrict the elasticity of substitution, it assumes that the elasticity of substitution is constant.

Furthermore, the elasticity can be difficult to estimate when there are more than two inputs. According to Mundlak (2001), the CES function is rarely used in agricultural contexts and the agricultural production functions estimated closely resemble Cobb-Douglas functions. The analyses in this thesis are based on the Cobb-Douglas functional form.

The importance of using the production function to examine the effect of climatic change on agricultural production as noted by Deschenes and Greenstone (2004) derives from the fact that it controls explicitly for other inputs. However, its disadvantage lies in the fact that it does not take account of the full range of compensatory responses to changes in climate made by farmers. More specifically, a profit maximizing farmer is likely to make some adaption in his manner of producing, choice of products, etc, if the farmer feels that climatic change is relatively permanent. This will tend to bias the coefficient on the impact on the agricultural sector in our production function framework downwards (Mendelssohn, 1994). But since adaption to climatic changes is relatively low in Nigeria, this would produce relatively little bias. Hence, the choice of production function as the empirical model is justified.

3.2 Model Specification

Based on the foregoing discussion and building on other empirical studies, we develop a crop production function in the specific context of Nigeria and data availability. Traditionally, empirical studies have estimated the relationship between agricultural output and land, labour and capital inputs. However, several other factors also affect agricultural products, such as weather, agronomic constraints, agricultural practices and farm characteristics. Following Blanc (2011) and in line with Frisvod and Ingram (1995), we specify anempirical agricultural output function of the form:

$$AGQ_t = f\,(LAB_t, IRGA_t, FIMV_t\ ARDL_t, CO2_t\ AMTP_t, AMRF_t,) \qquad 3.2$$

Where AGQ_t is the aggregate agricultural output time *t* and the inputs LAB_t, IRGA, FIMV and $ARLD_t$, are labor, irrigation,value of food importation and arable land respectively. More importantly we includecarbon emission (C02), annual temperature (AMTP) and annual rainfall (AMRF) as climatic factors that may affect agricultural production. Few empirical analyses onagricultural production functions consider acreage as an explanatory variable (e.g. Chen et al., 2004). Most empirical studies on crop yield analyses consider experimental data where land expansion is not applicable, this does not pose an omitted variable bias in this studies. However, as this study employs national data reflecting actual cropping decisions, decreasing marginal productivity of land needs to be considered.

The Model in its stochastic form is expressed in the form:

$$AGQ_t = LAB^{\beta}{}_1 IRGA^{\beta}{}_2 FIMV^{\beta}{}_3 ARLD^{\beta}{}_4 CO2^{\beta}{}_5 AMTP^{\beta}{}_6 AMRF^{\beta}{}_7 U \qquad 3.3$$

Taking the log of equation (3.3) transforms the equation into linear form.

$$LAGQ_t = \beta_0 + \beta_1 LLAB_t + \beta_2 LIRGA_t + \beta_3 LFIMV + \beta_4 LARDL_t$$

$$+ \beta_5 CO2_t + \beta_6 LAMTP_t + \beta_7 LAMRF_t + U_t \qquad 3.4$$

The log transformation of the equation is taken in order to standardize the value of the variables, achieve linearity as well as allow for the easy interpretation of their coefficients as elasticity.

The sum of exponents β_1………………β_7, represents the return to scale. Each of the parameters β_1…………β_7 can be interpreted as a partial elasticity of the output with respect to the input in the production function. The U is the error term.

The above model is specified on the assumption that the impact of climate change on agricultural output is the same across products. But in reality, different agricultural outputs respond to climate change differently. This suggests that the responses of crop, livestock, fish and forestry to climate change in Nigeria may not be symmetry. To account for this, we specify alternative models for crop production, livestock, fishery and forestry. Specifically, we look at these variables as solely dependent on climate change. Two things informed our approach here: (1) we want to explicitly assess the impact of climate change on different agricultural outputs in Nigeria (2) and also investigate the agricultural output that is more prone to climate change. Thus from the baseline model specified in equation (3.4) we derive our agricultural product – specific model as follows:

$$LAGQ_{it} = \beta_0 + X\Pi + \beta_1 LCO2_{it} + \beta_2 LAMTP_{it} + \beta_3 LAMRF_{it} + \mathcal{E}_t \qquad 3.5$$

Where $LAGQ_{it}$ is (n x 1) vector of explained variable i at time t., specifically, $LAGQ_{it}$ includes: crop production (LAQCY), livestock production (LAQLV), fishery (LAQFH) and forestry

(LAQFS). X is the matrix of other important explanatory variables in a particular function, and Π is the matrix of coefficients and ε is the error term. Thus, the following equations:

$$LAQCY_t = \beta_{10} + \beta_{11}ARLD_t + \beta_{12}LIRG_t + \beta_{13}LCO2_t + \beta_4 LAMTP_t + \beta_{14}LAMRF_t + \varepsilon_{1t} \quad 3.5a$$

$$LAQLV_t = \beta_{20} + \beta_{21}LCO2_t + \beta_{22}LAMTP_t + \beta_{23}LAMRF_t + \varepsilon_{2t} \quad 3.5b$$

$$LAQFH_t = \beta_{30} + \beta_{31}LCO2_t + \beta_{32}LAMTP_t + \beta_{33}LAMRF_t + \varepsilon_{3t} \quad 3.5c$$

$$LAQFR_t = \beta_{40} + \beta_{41}LCO2_t + \beta_{42}LAMTP_t + \beta_{43}LAMRF_t + \varepsilon_{4t} \quad 3.5d$$

Where the β's are the parameters and ε_{1t}, ε_{2t}, ε_{3t} and $\varepsilon_4$tare uncorrelated error terms. We added arable land and irrigation as explanatory variables in crop production equation because they are important explanatory variables in crop production. Other functions are expressed only in terms of climate change.

A priori expectation

Variable	Equ (3.4)	Equ (3.5a)	Equ (3.5b)	Equ (3.5c)	Equ (3.5d)
LLAB	> 0 (+)				
LIRGA	> 0 (+)	> 0 (+)			
LFIMV	< 0 (-)				
LARLD	> 0 (+)	> 0 (+)			
LCo2	< 0 (-)	< 0 (-)	< 0 (-)	< 0 (-)	> 0 (+)
LAMTP	> 0 (+)	> 0 (+)	> 0 (+)	> 0 (+)	> 0 (+)
LAMRF	> 0 (+)	> 0 (+)	> 0 (+)	> 0 (+)	> 0 (+)

Source: researcher's compilation

Model Justification

Our models are estimated in both static and dynamic forms. For instance, in examining the long run impact of climate change on agricultural output, we estimated a static OLS model, while a dynamic OLS model estimated in fixed effect is used to assess the short run impact of climate change on agricultural output. The static OLS approach is necessary on the assumption that the effect of climate change on agricultural products at farm level is instantaneous. On the other hand, when we relax the above assumption, we estimated dynamic models in VAR framework. The choice of dynamic Models is based on the fact that they portray the time path of the dependent variable in relation to the current and past values of the independent variables. This is necessary if we characterise the responses of agricultural products to climate change over time. We also derive and estimate impulse response models of equations (3.4); (3.5a); (3.5b); (3.5c) and (3.5d). The impulse response functions(IRFs) follow the vector autoregressive (VAR) framework and have been variously used to characterise the response of one variable to an unexpected shock in another variable.Nordhaus and David (1997) is of the opinion that climate change is abrupt or unexpected, thus occasions shock. IRFs have been efficient in capturing the response of one variable to a unit shock in another variable. For instance, Bayoumi and Eichengreen (1994) use a VAR modelto analyse nominal and real shocks under different exchange rate regimes, also Hoffmann (2003) opines thatvector autoregression (VAR) approach can be utilised to test whether economies respond differently to shocks.

Variable Identification/Measurement

Aggregate agricultural output (AGQ) is measured as the total value of all agricultural product produced in a given year measured in constant market price in billions of naira.

Crop production (AQCY) is measured as the total value of all food crop produced in a year measured in constant market price in billions of naira.

Livestock production (AQLV) is the market value (in constant price) of all livestock produced in a given year measured in billions of naira.

Fishery (AQFH) is defined in similar manner as livestock production.

Forestry (AQFR) is the market value of all timbers produced in a given year measured in billions of naira

Arable land (ARLD) is defined as land under temporary crops (double – cropped are counted once), temporary meadows for moving or for pasture, land under market or kitchen gardens, and land temporary fallowed. It is measured in hectares.

Irrigation (IRGA) is a measure as the proportion of total arable land artificially provided with water for agricultural purposes. It is percentage of total arable land purposely provided with water, including land irrigated by controlled flooding.

Labour (LAB) is made up of employees who offer their services to the employers in the agricultural sector for the purpose of earning wages or other sources of income as their reward.

Annual temperature (AMTP) is measured as the degree of hotness or coldness. It can equally be seen as the intensity of heat present in a substance or object especially as expressed according to a comparative scale. Based on the subject on examination, the researcher will adopt the annual mean temperature (^{0}C) which implies change in the state of the climate that can be identified by changes in the mean temperature that persists for an extended period, typically decades or longer (IPCC, 2007).

Annual rainfall (AMRF) is a measured as the quantity of rain fall within a given area at a given time. It provides suitable condition for much type of agricultural products. Based on the subject on examination, the researcher will adopt the annual mean rainfall (mm) which implies change in the state of the climate that can be identified by changes in the mean rainfall that persists for an extended period, typically decades or longer (IPCC, 2007).

Value of food importation (FIMV) is the total value of food imported into the country from overseas measured in billions of naira.

Carbon emission (CO_2) is measured in mole fraction scale.

3.3 Estimation Technique and Procedure

Before estimation, each of the series is tested for the presence of unit roots, since a necessity for calculating means and variances is the data's Stationarity.The study employs the modified Ng-Perron unit root test procedure developed by Ng and Perron (2001). Ng and Peron (2001) propose some modifications to the Phillips (1987) test (MZa), Phillips and Perron (1988) (MZt), Bhargava (1986) (MSB), and the Point Optimal Test by Elliot, Rothenberg and Stock (1996) (MPT). This is done by combining a Modified Information Criterion for the lag length and a Generalised Least Squares method for detrending the data. The choice of this test over the traditional unit root tests (ADF, PP and KPSS) is based on the fact that they are more suitable for small sample and efficient in presence of structural breaks. Again, the Johansen (1991; 1995) Maximum likelihood method is employed and vector error correction mechanism is estimated to account for short-run dynamics in the models.

We further estimated an impulse response function (IRF) using vector autoregressive (VAR) framework to characterize the responses of an explained variable to changes in one explanatory variable, keeping other innovations constant.

Stationarity test (Unit root test)

This involves scrutinizing the time series property of the data to identify whether there is presence of unit root, i.e., non-stationary. There are several reasons why the concept of non-stationarity is importantand why it is essential that variables that are non-stationary be treateddifferentlyfrom those that are stationary. First, the stationary or otherwise of a series can strongly influence its behavior and properties. Second, the use of non-stationarity data can lead to spurious regressions. Third, if the variables employed in a regression model are not stationary, thenit can be proved that the standard assumptions for asymptotic analysiswill not be valid. In other words, the usual t-ratios and F - statistics will not be normally distributed. Fourth, if the variables employed in a regression model are not stationary, then the standard assumptions for asymptotic analysiswill not be valid.

Two models that have been frequently used to characterize thenon-stationarity, the random walk model with drift, otherwise called as stochastic non-stationarity:

$Y_t = \mu + y_{t-1} + u_t$3.6

And the trend-stationary process, otherwise called deterministic non-stationarity – so-called because it is stationary around a linear trend:

$Y_t = \alpha + \beta_t + u_t$3.7

Where u_t is a white noise disturbance term in both cases.

However, the stochastic stationarity model is the model that has been found to best describe most non-stationary financial and economic time series. So we take it that the series in this study follow this model of non-stationarity. This form of non-stationarity is easily removed through differencing. But first the stationarity or otherwise of the data has to be first ascertained. This study employed theZivot–Andrews unit root test. This test is preferred because it is efficient in the presence of structural breaks. If there is no structural break in the series, we apply any of the conventional unit root procedure (such as ADF, PP KPSS etc); otherwise, we apply the Ng-Perron unit root approach to confirm the result of Zivot-Andrew test.

Cointegration test

OLS regression estimates with non-stationary time series data often produce unacceptable results, even though the overall results may indicate a high degree of fit as measured by coefficient of multiple correlation, R^2 or adjusted coefficient of R^2, high auto correlated residuals and low standard significance as measured by the usual t-statistics (Gujarati, 1995).

Moreover, many economic variables have a strong tendency to trend over time, such that the levels of these variables can be characterize as non-stationary, since they do not have a constant mean over time. Given two completely unrelated but integrated series, regression of one on the other will tend to produce an apparently significant relationship when, in fact, they are not related.

This study therefore, adopts the cointegration/ error correction (EC) techniques to estimate the base equation (3.4). This selection is based on the premise that if the variables are non-stationary, the desirable properties of consistency, efficiency, and unbiasedness will be lost if Ordinary

Least Squares (OLS) technique is used to estimate the equation, which could lead to spurious results and inference, hence, inaccurate predictions. Cointegration and error correction is used because it adds richness, flexibility and versatility to the econometric modelling and integrates short-run dynamics with long equilibrium. Hence accurate predictions can be more confidently made on the economic relationship between the variables.

To test for cointegration, the researcher adopted the Johansen (1991; 1995) Maximum likelihood method, considering that the model in this study is multivariate and may contain more than one cointegrating relationship. The Johansen approach is able to identify all the cointegrating vectors within a given set of variables and therefore has advantage over the Engel-Granger and Engel and Yoo approaches (Brooks, 2002). The researcher can test the null hypothesis using the following two likelihood ratio tests statistics:

Trace Test:

$\lambda_{trace}(r) = t(1\text{-}\lambda_1)$, r = 0, 1, 2,………., n-1 3.8

Where n is the total number of observations, the λ_{trace} tests the null hypothesis that the number of distinct cointegrating vector is less than or equal to r against a general alternative. T trace has a chi square distribution with M-r degrees of freedom. The big values of T trace provide evidence which is against the hypothesis of r or lesser cointegrating vectors.

Maximal Eigenvalue Test:

This is for estimating r cointegrating vectors against the alternative of r+1 cointegrating vectors. This test evaluates the null hypothesis:

H_0: r = r0 (cointegration)

H_1: r = r0 + 1 (no cointegration)

$\lambda_{max\,=}$ -Tlog $(1 - \lambda_{T+1})$, r = 0, 1, 2,…….n-1 3.9

Where λ_i is the estimated values of the characteristic roots (Eigenvalue) obtained from the estimated matrix, r is the number of cointegrating vectors and T is the number of usable observations. The λ_{max} statistics uses the null hypothesis that there are less than or equal to r versus exactly r+1 cointegrating vectors.

Error Correction Model (ECM)

Given that the variables, we proceed to estimate the vector error correction model (ECM). This model is developed to account for short run dynamics between the dependent and the explanatory variables. If there is a long run equilibrium relationship between the dependent and explanatory variables, there may be short run disequilibrium. We can treat the error term in our VEC model as the "equilibrium error" and we can use this error term to tie the short-run behaviour of agricultural product (AGQ) to its long-run value. Therefore, if the diagnostic test (cointegration test) indicates any evidence of cointegration, then EC model of the following form is estimated to account for short run dynamics between the dependent and explanatory variables:

$$\Delta LAGQ_t = a_0 + \Delta LAGQ_{t-1} + \Delta X_{t-1} + a3EC_{t-1} + \varepsilon_t \qquad 3.10$$

Where X is the matrix of explanatory variables (labour, irrigation, value of food importation, arable land, carbon emission, annual temperature, annual rainfall), ECt_{-1} is the error correction mechanism with one period lag, ε_t is the white noise and a's are the coefficients. The lag length is determined using lag selection criteria.

Vector Auto-Regressive (VAR) Model

In solving the third research objective, we test for shocks using the impulse-response function (IRF) and variance decomposition of the Vector Auto Regressive (VAR) model. In applied study of this nature, it is often of interest to know the response of one variable to an impulse in another variable in a system that involves a number of further variables as well.

Impulse Response Function (IRF)

IRF is an essential tool in causal analyses. We used IRF to capture the responses of agricultural products to changes in climate per time. The impulse response analysis provides extremely useful information with which to characterize the dynamics of a model by illustrating the evolution over time of the effects of shocks on variables and, importantly, on the persistence of the shocks over a long period. Thus, we would like to investigate the impulse response relationship between the variables in a higher dimensional system. Of course, if there is a reaction of one variable to an impulse in another variable we may call the latter causal for the former. This type of causality will be studied by tracing out the effect of an exogenous shock or innovation in one of the variables on some or all of the other variables.

Recall that $\Phi_1^{i} = \Psi_i$ just the $i-th$ coefficient matrix of the MA representation of a VAR (1) process. The MA coefficient matrices contain the impulse responses of the system. This result holds more generally for higher order VAR (p) processes as well. VMA (∞) representation:

$$y_t = \sum_{i=0}^{\infty} \Psi_{i\varepsilon t-i} \Psi_0 = I_n$$

Impulse-response function is the presented thus;

$$y_t = \sum_{i=0}^{\infty} \Psi_{i\varepsilon t-i}$$

$$\{\Psi_n\}_{i,j} = \frac{\partial y_{it+n}}{\partial \varepsilon\, jt}$$

The response of $y_{i,t+n}$ to a one-time impulse in $y_{j,t}$ with all other variables dated t or earlier held constant. The response of variable i to a unit shock in variable j will as well be depicted graphically to get a visual impression of the dynamic interrelationships within the system.

3.4 Evaluation of Estimates

The parameter estimates of the model is evaluated under three sub-headings:

Economic "A priori" criteria:

This refers to the expected signs and magnitude of the parameters of economic relationships and is determined by the principles of economic theory. It is one of the criteria used in determining whether the estimates are theoretically meaningful and statistically (Koutsoyiannis, 1973).

Therefore based on economic theory, the independent variables are expected to take the signs discussed earlier in relation to the dependent variables in their respective function.

Statistical criteria: first order test:

The adjusted R-squared (R^{-2}), the coefficient of determination is used to measure the goodness of fit of the regression line. It also measured the variation in the dependent variable that is induced by the explanatory variable. The t-statistics is used to test for individual significance of the parameter estimates and the f-statistics is used to test for the overall significance of the parameter estimates.

Econometric Criterion: 2^nd^ Order Test

This aims at investigating whether the assumptions of the OLS are met. They determine the reliability of the statistical criteria and establish whether the estimates have the desirable properties of unbiasedness and consistency. The econometric criteria are;

Test for stationarity: stationarity is said to exist if the mean and variance of a variable are constant overtime. In short, if a time series is stationary its mean variance and auto covariance (at various lags) remain the same no matter at what point we measure them, that is they are time invariant (Gujarati, 2009).

Test for normality: This shows whether the model is normally distributed.

Test for Multicollinearity: This is a situation where the explanatory variables are rightly inter-connected and is referred to as Multicollinearity, when the explanatory variables are rightly correlated; it becomes difficult to disentangle the separate effect of each of them on the dependent variable. Hence, this test enables us to test for linear collinearity among the explanatory variables.

Test for Autocorrelation: autocorrelation refers to a correlation between members of series of observation ordered in time (as in time series data). The classical linear regression model assumes that such autocorrelation does not exist in the disturbance U_i. Symbolically, $E(U_i, U_j = 0_i = J)$ (Gujarati, 2009).

Test for Heteroscedascity: An important assumption of the classical linear regression model is that the disturbance U_i appearing in the population regression function are homoscedastic, that is they all have the same variance (Gujarati 2009).

3.5 Re-statement/test of Research Hypotheses

The hypotheses are re-stated here as follow:

H_1^1: Climate changes affect different agricultural outputs in Nigeria in the short- and long-run.

H_1^2: The impacts of climate change on different agricultural output in Nigeria are the same across product. And no particular output is mostly affected.

H_1^3:Different agricultural outputs in Nigeria respond differently to abrupt climate change in the long-run.

The research hypotheses re-stated above are tested at 0.05 level of significant. We test for both individual and general significance of the parameters using t-test and the probability test of significance approach, and then, the F-test approach.

***Individual parameter test of significance*:**

Under the hypothesis:

H0: Bj = 0: the parameter estimate is not statistically significant at 5% level of significance

H1: Bj ≠ 0: the parameter estimate is statistically significant at 5% level of significance

Decision rule:

Reject H0, if the t-calculated > the t-critical, otherwise don't.

Alternatively, reject H0, if the probability value < 0.05. , otherwise don't.

***Overall significance*:**

Under the hypothesis:

H0: B0 = B1 = B2 = … = Bj = 0: the parameter estimates are simultaneously equal to zero at 5% level of significance

H1: B0 ≠ B1≠ B2 ≠ …….≠ Bj ≠ 0: the parameter estimates are not simultaneously equal to zero at 5% level of significance

Decision rule:

Reject H0, if the F-calculated > the F-critical, otherwise don't.

3.6 Source of Data

The models were estimated using annual time series data spanning from 1970 to 2015. The data set was sourced from the CBN Annual Report and Statement of Accounts, CBN Statistical Bulletin and the National Bureau of Statistics Annual Abstract of Statistics World Economic Outlook (WEO).

CHAPTER FOUR: DATA PRESENTATION, ANALYSES AND DISCUSSION OF FINDINGS

In this chapter, we present and analyze the data using the techniques discussed in chapter three, and then, we test the hypotheses, make simulations and discuss the findings vis-à-vis other similar studies.

4.1 Data Presentation

The raw data used in this study is presented in the appendix. We also present the summary statistics of these variables, to have a glimpse of the nature of the data. The results are shown in the table below:

Table 4.1: Summary statistics

Variables	Mean	Max.	Min.	Std. Dev.	Obs.
LAGQ	5.79	9.60	2.35	2.63	
LAQCY	5.65	9.48	2.22	2.66	
LAQLV	3.24	6.89	0.02	2.46	
LAQFR	1.81	5.17	-1.56	2.14	
LAQFH	2.19	6.19	-2.21	2.75	
LIRGA	-0.34	-0.11	-0.47	0.09	
LARLD	17.25	17.49	17.12	0.12	46
LLAB	16.60	16.72	16.55	0.02	
LAMTP	3.47	3.53	3.39	0.03	
LAMRF	9.92	7.36	5.56	0.59	
LCO2	11.04	11.56	9.98	0.36	
LFIMV	9.28	12.69	4.06	2.82	

Source: The researchers' computation

Table 4.1 shows the summary statistics of the variables used including the mean, minimum and maximum values and the standard deviation etc. The standard deviation is a widely used measure of the variability or dispersion, being algebraically more tractable though practically less robust than the expected deviation or average absolute deviation. A low standard deviation indicates that the data points tend to be very close to the mean, and vice versa.

4.2 Data Analyses

4.2.1 Stationarity test

We begin the data analysis by looking at the time series behaviour of our variables of interest. This is necessary in order to forestall the incidence of spurious regression. The stationarity test is first conducted using the Zivot-Andrew unit root test. The essence of this test is to investigate whether there are structural changes in the series. If this ascertained, the modified Ng-Perron test statistics is then applied, otherwise any of the conventional unit root test procedures is used. The results are shown below:

Table 4.2: Summary of Zivot-Andrew unit root test

Variable	t-Statistics	Breakpoint	I(d)	Lag Length
LAGQ	-3.018	1992	I(1)	1
LAQCY	-2.966	1992	I(1)	1
LAQLV	-3.469	1993	I(1)	0
LAQFR	-2.714	1981	I(1)	1
LAQFH	-2.597	1994	I(1)	1
LIRGA	-3.697	1990	I(1)	1
LARLD	-4.036	2005	I(1)	0
LLAB	-3.120	2008	I(1)	2
LAMTP	-2.140	1986	I(1)	1
LAMRF	-4.281	1981	I(1)	0
LCO2	-4.472	2000	I(1)	0
LFIM	-4.643	1995	I(1)	0

******, ** and * denote statistical significance at 1%, 5% and 10% level respectively***.

The critical values for Zivot and Andrews test are -5.57, -5.08 and -4.82 at 1 %, 5 % and10% levels of significance respectively.

Source: the researchers' computation

In table 4.2, we present the summary of Zivot-Andrews unit root test. The result reveals that there are structural breaks in all the series. Again all the series are difference stationary at different lag lengths. This result implies that all the variables have gone through structural changes over time. Given this conclusion, the application of any conventional unit root approaches (such as ADF, PP, ERS or KPSS) may not be appropriate, since these tests have shown not to be efficient if the series has gone through structural changes. Hence, the Ng-Perron modified approach is used to validate the Zivot-Andrews result. The result of modified Ng-Perron unit root test is presented in the following table.

Table 4.3: Summary of Ng-Perron modified unit root test

Variable	@level				@difference				
	MZa	MZt	MSB	MPT	MZa	MZt	MSB	MPT	
LAGQ	0.39	0.26	0.66	30.77	-14.18***	-2.66***	0.19**	1.73***	*I(1)*
LAQCY	0.37	0.24	0.66	30.39	-13.95***	-2.64***	0.19***	1.76***	*I(1)*
LAQLV	0.58	0.41	0.71	35.20	-21.30***	-3.26***	0.15***	1.15***	*I(1)*
LAQFR	0.15	0.08	0.56	22.71	-14.02***	-2.62***	0.19**	1.85**	*I(1)*
LAQFH	1.0	1.09	1.01	71.70	-19.66***	-3.12***	0.16***	1.30***	*I(1)*
LIRGA	-3.63	-1.24	0.34	6.77	-16.99***	-2.90***	0.17***	1.49***	*I(1)*
LARLD	0.78	0.59	0.76	41.13	-19.62***	-3.12***	0.16***	4.74***	*I(1)*
LLAB	0.44	0.24	0.55	23.46	-19.09***	-3.08***	0.16***	1.30***	*I(1)*
LAMTP	-3.75	-1.27	0.34	6.58	-8.66**	-2.08**	0.24**	2.82**	*I(1)*
LAMRF	-2.08	-0.90	0.43	10.65	-21.67***	-3.28***	0.15***	1.16***	*I(1)*
LCO2	-5.34	-1.60	0.30	4.68	-16.70***	-2.89***	0.17***	1.47***	*I(1)*
LFIMV	-2.24	-0.90	0.40	9.76	-16.05***	-2.83***	0.18***	1.55***	*I(1)*
asymptotic critical value									
1%	*-13.80*	*-2.58*	*0.17*	*1.78*					
5%	*-8.10*	*-1.98*	*0.23*	*3.17*					
10%	*-5.70*	*-1.62*	*0.28*	*4.45*					

Note: *** and ** denote significant at 1% and 5% significance level respectively

Source: the researchers' computation

The result of the stationarity test using the Ng-Perron modified unit root approach suggests that all the variables under review are difference stationary at 1% and 5% significant level. This implies that they are all I(1) process which corroborates the Zivot – Andrew results .

This evidence that all the variables are integrated at the same order 1(1) provides us the basis for co-integration test, on the event that the variables are cointegrated, we estimate two types of model for each of our equations: (1) An OLS model using the levels of the data. This provides the long-run equilibrating relationship among the variables. (ii) An error correction model (ECM). This represents the short-run dynamics of the relationship between the variables. In testing the possibility of cointegration among the variables,we make use of the aggregate agricultural output (AGQ) which is universal set for crop yield (AQCY), livestock (AQLV), fishery (AQFH) and forestry (AQFR). Before testing for the possibility of long run equilibrium among the variables is conducted, we performed a lag order selection test to decide the optimal lag to be included in the Johansen Co-integration test. The result of this test is reported in the table below:

Table 4.4: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	213.6500	NA	9.69e-15	-9.565115	-9.237450	-9.444282
1	487.2393	432.6529*	5.95e-19*	-19.31346	-16.36447*	-18.22596*
2	547.6468	73.05088	9.62e-19	-19.14636	-13.57605	-17.09220
3	626.3708	65.90847	1.28e-18	-19.83120*	-11.63957	-16.81038

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The optimal lag selected by all the information criteria, except the log likelihood and Akaike Information criteria, for the cointegration analysis is lag one (1).Hence, we choose lag one (1) for the co-integration analysis. Next, we test for the existence of cointegration among the variables of the model. The co-integration result is reported in table below.

4.2.2. Co-Integration Test

The result of multivariate Johansen cointegration test is shown below:

Table 4.5: The summary of Johansen cointegration test

		Trace Test			Maximum Eigenvalue Test		
Ho	**H1**	**Trace stat**	**5% critical Value**	**P-value**	$\lambda - Max$	**5% critical value**	**P-value**
$r \le 0$	$r = 1$	283.54***	159.53	0.0000	94.05***	52.36	0.0000
$r \le 0$	$r = 2$	189.49***	125.62	0.0000	68.33***	46.23	0.0001
$r \le 2$	$r = 3$	121.16***	95.75	0.0003	52.01***	40.08	0.0015
$r \le 3$	$r = 4$	69.15	69.81	0.0565	27.61	33.88	0.2319
$r \le 4$	$r = 5$	41.53	47.86	0.1722	16.42	27.58	0.6296
$r \le 5$	$r = 6$	25.11	29.80	0.1575	13.10	21.13	0.4435
$r \le 6$	$r = 7$	12.02	15.49	0.1562	8.02	14.26	0.3767

Note: ** indicates significant at 5% level of significance

The cointegration test using the Trace Statistics and Maximum Eigen values indicate three co-integrating equation at 5% significant level. This finding implies that the null hypothesis of no co-integrating equation is rejected at 5 percent significant level. Hence, we conclude that there is a long-run relationship between the aggregate agricultural output (AGQ) and it drivers, which in this case include: rainfall (AMRF), temperature (AMTP), carbon emission (CO2), value of food imported (FIMV), irrigation (IRGA), labour (LAB) and arable land (ARLD) 1970 to 2015. This result implies that these variables have been moving together over time; hence they have long-run relationship.

Having established the existence of long run relationship among the variables, we estimate two types of models: (1) An OLS model at level to obtain the long run equilibrating relationship between the variables and (2) Avector error correction model to account for short run dynamics of the relationship between the variables. In each case, we estimate five different models: (1) Aggregate agricultural output function (2) crop production function (3) livestock production function (4) fish production function and (5) forestry production function.

4.2.3 Long-Run Coefficients

Table 4.6: The summary of long run elasticities

	LAGQ (1)	LAQCY (2)	LAQLV (3)	LAQFR (4)	LAQFH (5)
Constant	19.44	205.33***	73.92***	76.98***	92.98***
	(52.27)	(26.79)	(27.59)	(23.06)	(30.08)
LLAB	8.56***				
	(3.46)				
LIRGA	3.74***	10.75***			
	(1.13)	(1.71)			
LFIMV	0.61***				
	(0.05)				
LARLD	8.17***	12.51***			
	(0.83)	(1.43)			
LCO2	-0.53***	-0.22	-2.24***	2.61***	-2.72***
	(0.19)	(0.41)	(0.74)	(0.62)	(0.81)
LAMTP	-3.59	-1.95	10.77	11.27	14.09
	(1.99)	(4.07)	(8.23)	(6.87)	(8.97)
LAMRF	0.28***	1.15***	2.17***	1.56***	2.34***
	(0.07)	(0.23)	(0.46)	(0.38)	(0.50)
Observation	*46*	*46*	*46*	*46*	*46*
Adj. R^2	*0.98*	*0.92*	*0. 57*	*0.61*	*0.62*
F-stat	*363.93*	*103.08*	*20.99*	*24.16*	*23.01*
DW	*2.01*	*1.56*	*1.51*	*1.55*	*1.55*

****** denotes significant at 5% level of significance and standard error in brackets ( )**

In the above table, we present the long run estimate of both the aggregated and disaggregated agricultural output in Nigeria for the period 1970 to 2015. The short-run version of the model is shown below:

4.2.4: Error correction model (Short-Run Coefficients)

Table 4.7: The summary of short run elasticities

	Δ(LAGQ)(1)	Δ(LAQCY)(2)	ΔLAQLV(3)	Δ(LAQFR)(4)	Δ(LAQFH)(5)
Constant	-6.73	26.25***	0.79	0.62	19.63***
	(12.87)	12.08)	(0.58)	(1.79)	(5.53)
ΔLAGQ(-1)	0.64***				
(0.15)					
ΔLAQCY(-1)		0.64***			
(0.13)					
ΔLAQLV(-1)			0.34***		
(0.12)					
ΔLAQFR(-1)				0.45***	
(0.14)					
ΔLAQFH(-1)					-0.16
(0.16)					
ΔLLAB	1.54***				
	(0.62)				
ΔLIRGA	0.63	-0.06			
	(0.54)	(0.34)			
ΔLFIMV	-0.01				
	(0.05)				
ΔLARLD	1.47***	0.31***			
	(0.15)	(0.10)			
ΔLCO2	-0.09	0.06	-0.36***	0.16***	-0.20
	(0.12)	(0.12)	(0.12)	(0.05)	(0.18)
ΔLAMTP	-0.46	-0.54	-0.86	0.11	0.04
	(0.50)	(0.48)	(0.57)	(0.36)	(0.75)
ΔLAMRF	0.08***	-1.12***	0.24***	-0.27***	-0.61***
	(0.02)	(0.07)	(0.12)	(0.05)	(0.11)
ECT(-1)	-0.18***	-0.08***	-0.06***	-0.04**	-0.12***
(0.03)	(0.03)	(0.01)	(0.01)	(0.05)	
Observation	*44*	*44*	*44*	*44*	*44*
$R^2$0.40 0.430.16	*0.26*	*0.10*			
F-stat28.08	*38.23*	*21.09*	*13.11*	*11.01*	
DW	*1.82.012.02*	*2.07*	*2.04*		

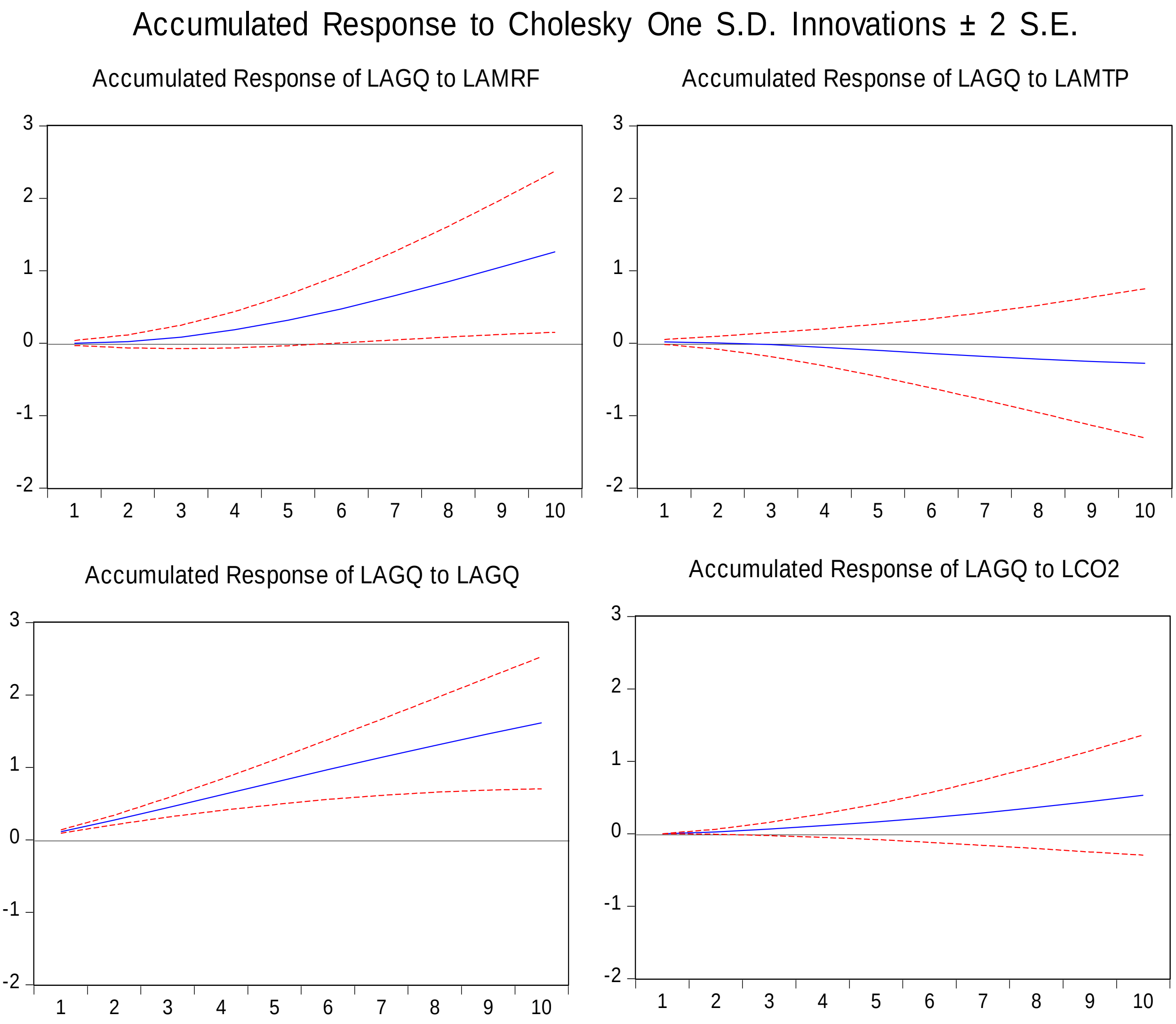
****** denotes significant at 5% level of significance and standard error in brackets ( )**

4.2.5 Impulse Response Function

But before returning to the evaluation of these estimates, we simulate and characterise the responses of different agricultural outputs to climate change keeping other innovation constant. The impulse response function is used to capture the responses of aggregate agricultural output (AGQ), crop production (AQCY), livestock production (AQLV), fish production (AQFH) and forestry production (AQFR) to shock in climate change in Nigeria.

The responses of aggregate agricultural output to climate change in Nigeria (1970 – 2015)

Figure 4.1: Impulse response of AGQ to AGQ, rainfall, temperature and carbon emission

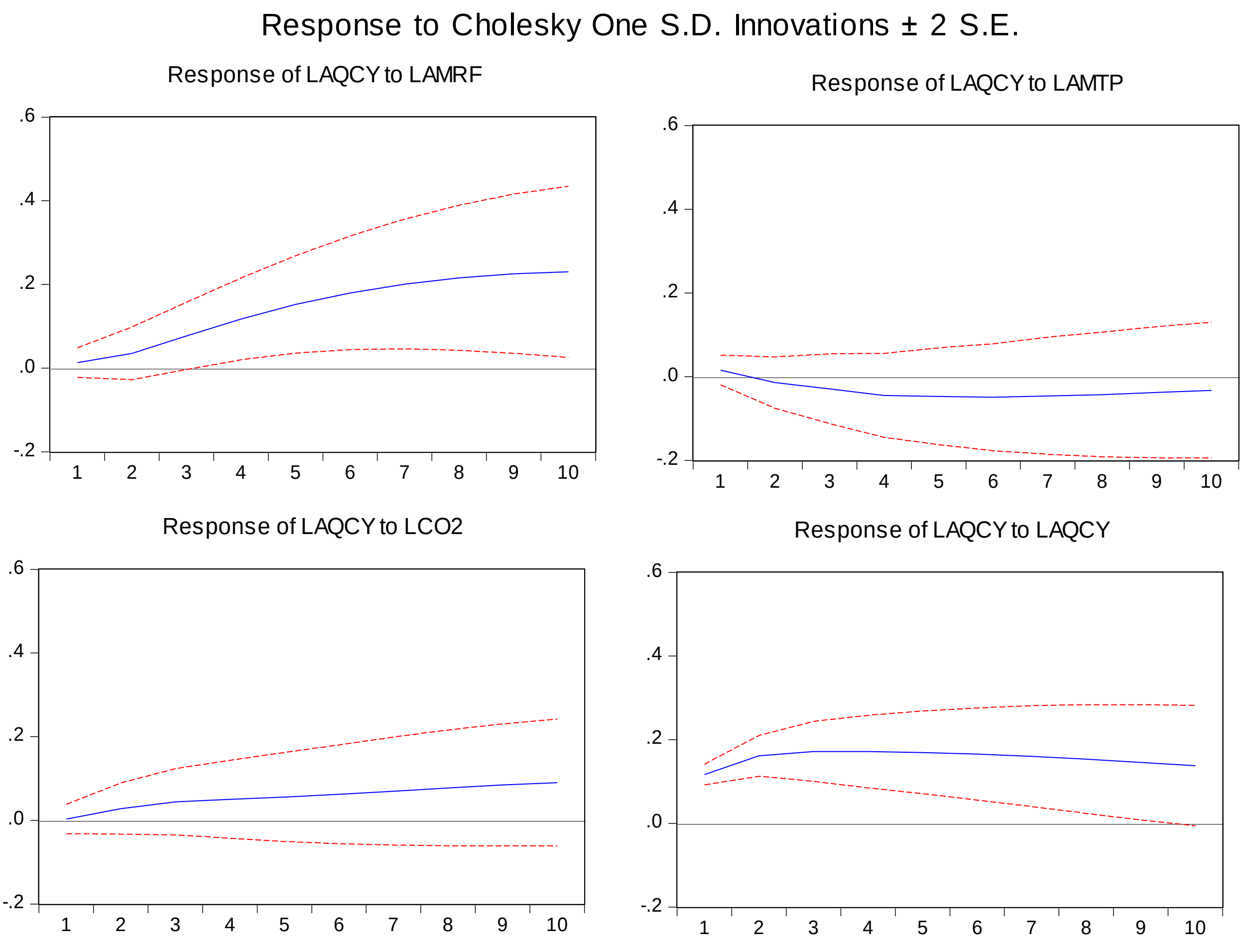


Source: The researcher's computation using Eviews, (2016)

In figure 4.1, we present the results of the responses of aggregate agricultural output (AGQ) to its own shock and to shocks in climate factors (rainfall, temperature and carbon emission) over a period of ten years. The results show the impulse response function of AGQ to its own shock and to shocks in rainfall, temperature and carbon emission. The results suggest that the impact of one unit shock from carbon emission on AGQ is not felt in the first period, however, in the second up to the tenth period, the effects is felt and positive. AlsoAGQ responds positively to its own shock and rainfall in first period up to the tenth period. On the other hand, the effect of temperature on aggregate agricultural output is positive only in the first period and becomes negative from the second period to the last period.

The responses of crop production to climate change in Nigeria (1970 – 2015)

Figure 4.2: Impulse response of AQCY to AQCY, rainfall, temperature and carbon emission

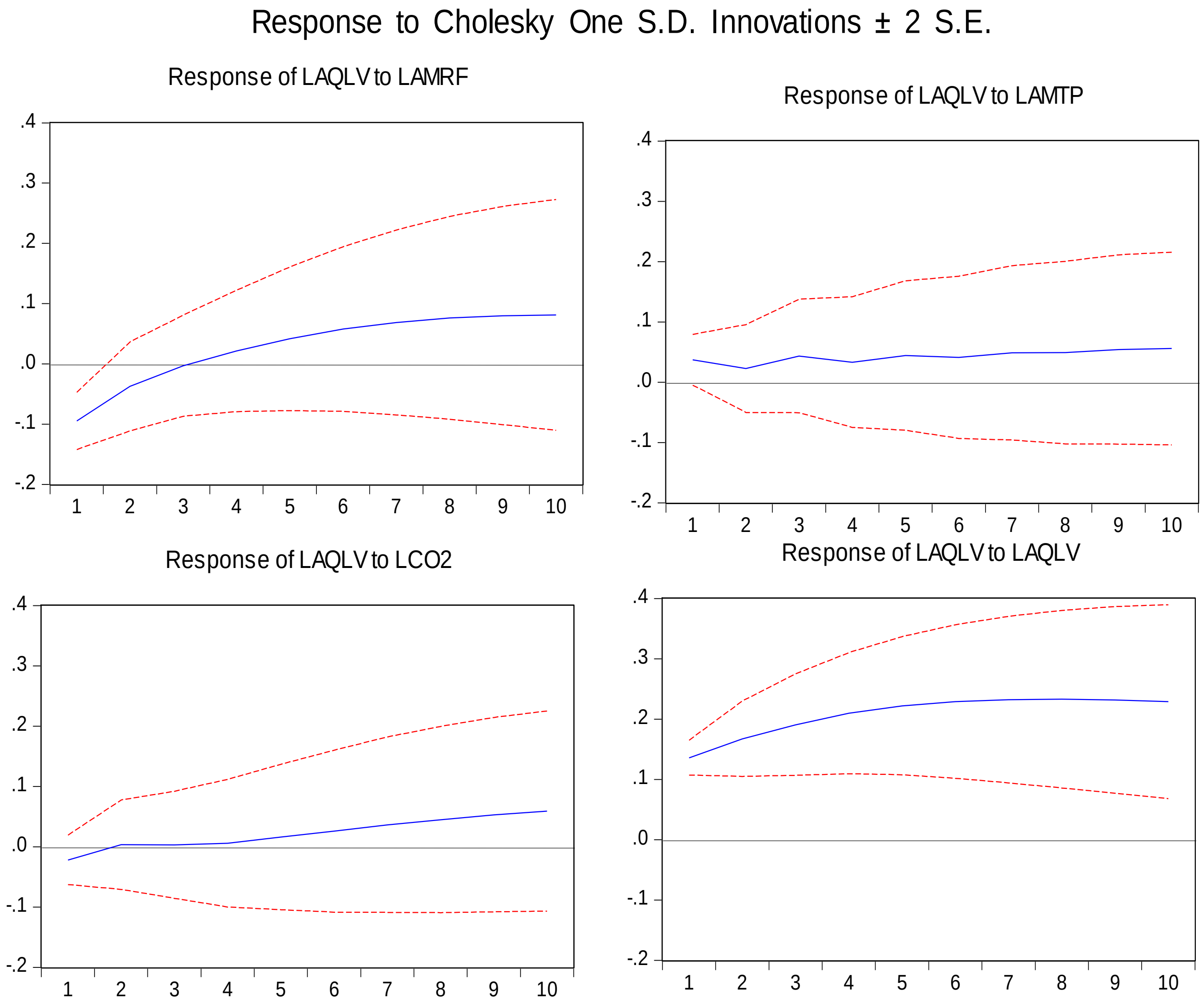


Source: The researcher's computation using Eviews, (2016)

Figure 4.2 shows the responses of crop production (AQCY) to its own shock and to shock in climate factors (rainfall, temperature and carbon emission) over a period of ten years. As the figure shows, except to shock in temperature, crop production responds positively to its own shock, to shock in rainfall and shock in carbon emission, beginning from the first period to the tenth period.

The responses of livestock production to climate change in Nigeria (1970 – 2015)

Figure 4.3: Impulse response of AQLV to AQLV, rainfall, temperature and carbon emission

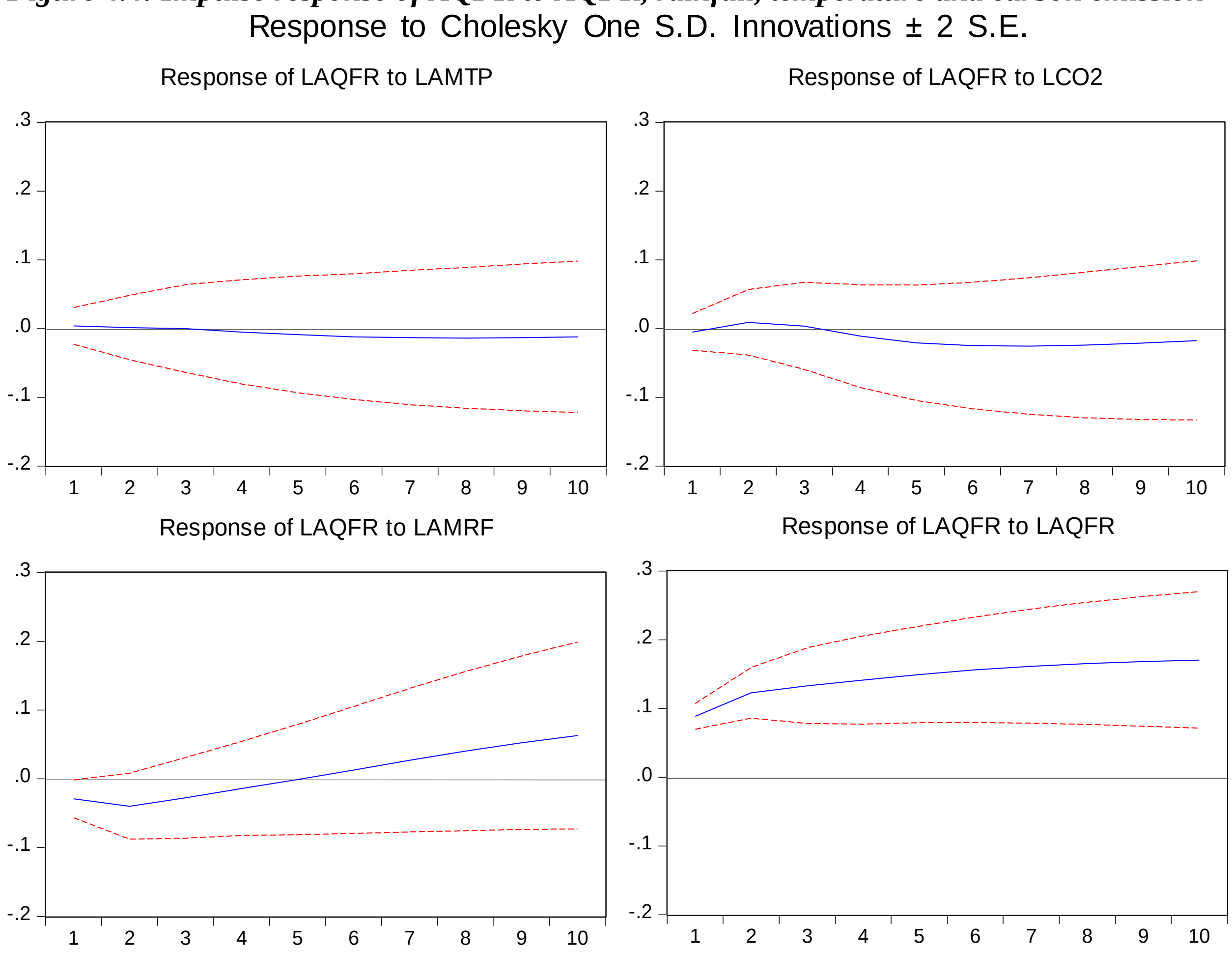


Source: The researcher's computation using Eviews, (2016)

Figure 4.3 shows the responses of livestock production (AQLV) to its own shock and to shock in climate factors (rainfall, temperature and carbon emission) over a period of ten years. The results suggest that livestock production responds negatively to shock in rainfall and carbon emission in the initial periods. The responses to temperature and its own shock are positive all through the period of ten years.

The responses of forestry production to climate change in Nigeria (1970 – 2015)

Figure 4.4: Impulse response of AQFR to AQFR, rainfall, temperature and carbon emission

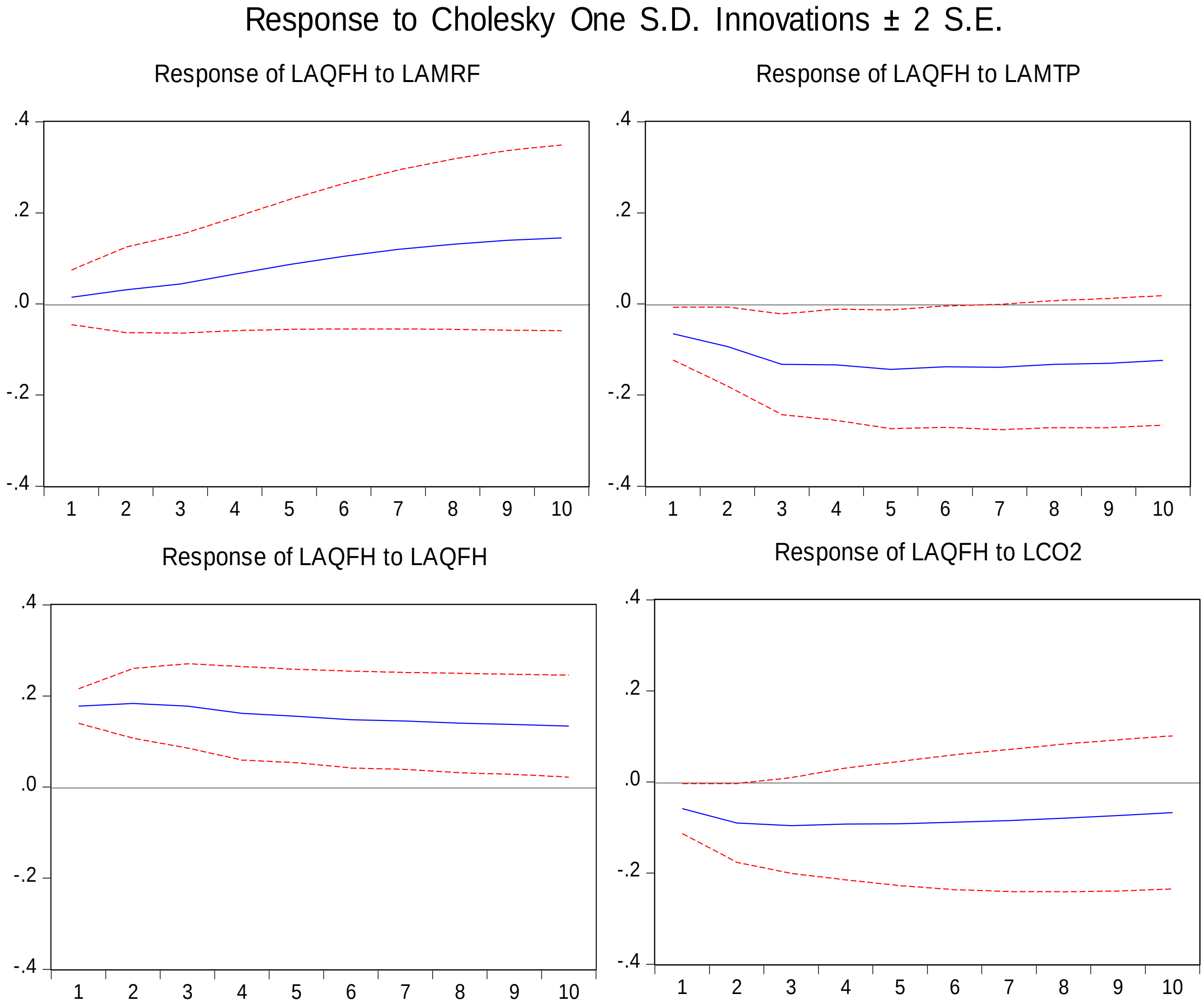


Source: The researcher's computation using Eviews, (2016)

Figure 4.4 shows the responses of forestry production (AQFR) to its own shock and to shock in climate factors (rainfall, temperature and carbon emission) over a period of ten years. The results suggest that forestry production responds negatively and positively to shock in rainfall, temperature and carbon emission. However, the responses of AQFR to its own shock are positive all through the period of ten years.

The responses of fish production to climate change in Nigeria (1970 – 2015)

Figure 4.5: Impulse response of AQFH to AQFH, rainfall, temperature and carbon emission



Source: The researcher's computation using Eviews, (2016)

Figure 4.5 shows the responses of fish production (AQFH) to its own shock and to shock in climate factors (rainfall, temperature and carbon emission) over a period of ten years. The results suggest that fish production responds negatively to shock in temperature and carbon emission. However, the responses of AQFH to its own shock and rainfall are positive all through the period of ten years.

4.3 Evaluation of Estimate/ test of Research Hypotheses

We evaluate the above long – run and short – run estimates based on the following criteria:

4.3.1 Economic Criterion

Climate change and Aggregate Agricultural output in Nigeria (1970 – 2015)

The result in table 4:6 (column 1) shows that except temperature, all the variables have statistically impact on aggregate agricultural output in Nigeria. While Labour, arable land, value of imported food, irrigation and rainfall exert positive and significant effect on aggregate agricultural output, carbon emission has significant and negative effect on aggregate agricultural output. A unit increase in labour, irrigation, value of imported food, arable land and rainfall will cause total agricultural output to expand by about 8.56 units, 3.74 units, 0.61 units, 8.17 units and 0.28 units in the long run respectively. On the other hand, a unit rise in carbon emission and temperature will cause total agricultural output to fall by 0.53 units and 3.59 units in the long run respectively.

The autonomous component of the model (AGQ) is positive and statistically insignificant at 5% significant level. Though, it does not make much sense in economics, technically speaking, it captures the impact of the "other things" on the dependent variable.

Expected and Obtained Signs of the Variables

Variable	expected sign	obtained sign	remark
LLAB	> 0	> 0	conforms
IRGA	> 0	> 0	conforms
ARLD	> 0	> 0	conforms
FIMV	< 0	>0	does not conform
CO2	< 0	<0	conforms
AMTP	> 0	< 0	does not conform
AMRF	> 0	> 0	conforms

All the variables, except temperature and value of food import conform to the a priori expectation.

Climate change and Crop production in Nigeria (1970 – 2015)

In table 4.6 (column 2), we present the long run estimates of our crop production function modeled as a function of irrigation, arable land, carbon emission, temperature and rainfall. The result shows that, while the effects of carbon emission and temperature on crop production are not significant, other variables have statistically significant effect on crop production. Evidently, arable land, irrigation and rainfall exert positive and significant effect on crop production, while carbon emission has significant and negative effect on crop production. A unit increase in arable land, irrigation and rainfall will push crop production up by about 12.51 units, 10.75 units and 1.15 units in the long run respectively. On the other hand, a unit rise in carbon emission and temperature will cause crop production to fall by 0.22 units and 1.95 units in the long run respectively. The autonomous component of the model (AQCY) is also positive and statistically significant at 5% significant level.

Expected and Obtained Signs of the Variables

Variable	expected sign	obtained sign	remark
IRGA	> 0	> 0	conforms
ARLD	> 0	> 0	conforms
CO2	< 0	< 0	conforms
AMTP	> 0	< 0	does not conform
AMRF	> 0	> 0	conforms

All the variables, except temperature conform to the a priori expectation.

Climate change and Livestock production in Nigeria (1970 – 2015)

To make explicit allowance for the effect of climate change in Nigeria, we estimated a livestock production function that is exclusively dependent on climate factors such as rainfall, temperature and carbon emission. The result is as shown on table 4.6 (column 3), indicates that only the effects of carbon emission and rainfall on livestock production are significant, while the effect of temperature is not significant. If rainfall and temperature increase by an average of 1 unit, livestock production will record an average increase of about 2.17 units and 10.77 units respectively. On the other hand, a unit rise in carbon emission will depress livestock production by 2.24 units. Again, the autonomous component of the model (AQLV) came out positive and statistically significant at 5% significant level.

Expected and Obtained Signs of the Variables

Variable	expected sign	obtained sign	remark
CO2	< 0	< 0	conforms
AMTP	> 0	> 0	conform
AMRF	> 0	> 0	conforms

All the variables, (carbon emission, temperature and rainfall) conform to the a priori expectation.

Climate change and Forestry production in Nigeria (1970 – 2015)

The result is as shown on table 4.6 (column 4), reveals that the effects of all the variables on forestry production are positive, however, only the effects of carbon emission and rainfall are statistically significant. A unit increase in carbon emission, temperature and rainfall will lead to about 2.61 units, 11.27 units and 1.56 units rise in forestry production in the long run respectively. Again, the autonomous component of the model (AQFR) came out positive and statistically significant at 5% significant level.

Expected and Obtained Signs of the Variables

Variable	expected sign	obtained sign	remark
CO2	> 0	> 0	conforms
AMTP	> 0	> 0	conform
AMRF	> 0	> 0	conforms

All the variables, (carbon emission, temperature and rainfall) conform to the a priori expectation.

Climate change and Fish production in Nigeria (1970 – 2015)

The result is as shown on table 4.6 (column 5), indicates that all the variables except carbon emission have positive impact on fish production in the long run. If rainfall and temperature increase by an average of 1 unit, fish production will record an average increase of about 2.34 units and 14.09 units respectively. On the other hand, a unit rise in carbon emission will depress fish production by 2.72 units. Again, the autonomous component of the model (AQFH) came out positive and statistically significant at 5% significant level.

Expected and Obtained Signs of the Variables

Variable	expected sign	obtained sign	remark
CO2	< 0	< 0	conforms
AMTP	> 0	> 0	conform
AMRF	> 0	> 0	conforms

All the variables, (carbon emission, temperature and rainfall) conform to the a priori expectation.

4.3.2 Econometric/Statistical criteria: 1st order test

Climate change and Aggregate Agricultural output in Nigeria (1970 – 2015)

The adjusted R^2 indicates that that the explanatory variables account for about 98% changes in aggregate agricultural output in Nigeria for period 1970-2015. The general F-value suggests that all the partial coefficients are not simultaneously equal to zero and hence statistically significant at 5% critical value.

Climate change and Crop production in Nigeria (1970 – 2015)

The adjusted R^2 indicates that that the explanatory variables account for about 92% changes in crop production in Nigeria for period 1970-2015. The general F-value suggests that all the partial coefficients are not simultaneously equal to zero and hence statistically significant at 5% critical value.

Climate change and Livestock production in Nigeria (1970 – 2015)

The adjusted R^2 indicates that that the explanatory variables account for about 57% changes in crop production in Nigeria for period 1970-2015. This is as expected, given that the traditional determinants of production are excluded from the regression. The general F-value suggests that all the partial coefficients are not simultaneously equal to zero and hence statistically significant at 5% critical value.

Climate change and Forestry production in Nigeria (1970 – 2015)

The adjusted R^2 indicates that that the explanatory variables account for about 61% changes in forestry production in Nigeria for period 1970-2015. This is as expected, given that the traditional determinants of production are excluded from the regression. The general F-value suggests that all the partial coefficients are not simultaneously equal to zero and hence statistically significant at 5% critical value.

Climate change and Fish production in Nigeria (1970 – 2015)

The adjusted R^2 indicates that that the explanatory variables account for about 62% changes in crop production in Nigeria for period 1970-2015. This is also as expected, given that the traditional determinants of production are excluded from the regression. The general F-value suggests that all the partial coefficients are not simultaneously equal to zero and hence statistically significant at 5% critical value.

4.3.3 Econometric criteria: 2ndorder test

We further evaluate the estimated long – run coefficients for each model using different econometric criteria namely, stationarity test, LM serial correlation test and Heteroskedasticity test.

Climate change and Aggregate Agricultural output in Nigeria (1970 – 2015)

Test for serial correlation

The Durbin-Watson test for serial correlation shows that the error terms are not serially correlated. The values of the R-Square and Durbin-Watson also indicates that the OLS result is not spurious, since the value of Durbin-Watson is grater that the R-Square.

More formally, we apply the Breusch-Godfrey Serial Correlation LM Test to validate the DW test. The result is shown below:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.155274	Prob. F(2,36)	0.1306
Obs*R-squared	4.918941	Prob. Chi-Square(2)	0.0855

The Breusch-Godfrey Serial Correlation LM Test indicates that there is no serial correlation in our estimated aggregate agricultural output model, since the probability of the F-statistic for the test is 0.1306 – greater than the 5 percent significance level. This implies the acceptance of the null hypothesis of no serial correlation in the estimated model. This result corroborates the Durbin-Watson serial correlation test.

Test for heteroscedasticity

Heteroskedasticity Test: Glejser

F-statistic	1.848118	Prob. F(7,38)	0.1061
Obs*R-squared	11.68298	Prob. Chi-Square(7)	0.1115
Scaled explained SS	8.950594	Prob. Chi-Square(7)	0.2562

The result of the heteroskedasticity test using the Glejser approach. The result suggests that there is no heteroskedasticity in the estimated model. This follows from the fact that the probability value of the F-statistic for the test is 0.106, being greater than 0.05, leading to the conclusion that the residuals are homoscedastic.

Climate change and Crop production in Nigeria (1970 – 2015)

Test for serial correlation

The Durbin-Watson test for serial correlation shows that the error terms are not serially correlated. The values of the R-Square and Durbin-Watson also indicates that the OLS result is not spurious, since the value of Durbin-Watson is grater that the R-Square.

More formally, we apply the Breusch-Godfrey Serial Correlation LM Test to validate the DW test. The result is shown below:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.895676	Prob. F(2,38)	0.0675
Obs*R-squared	6.083443	Prob. Chi-Square(2)	0.0478

The Breusch-Godfrey Serial Correlation LM Test indicates that there is no serial correlation in our estimated aggregate agricultural output model, since the probability of the F-statistic for the test is 0.068 – greater than the 5 percent significance level. This implies the acceptance of the null hypothesis of no serial correlation in the estimated model. This result corroborates the Durbin-Watson serial correlation test.

Test for heteroscedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.253242	Prob. F(5,40)	0.0675
Obs*R-squared	10.10891	Prob. Chi-Square(5)	0.0722
Scaled explained SS	13.45793	Prob. Chi-Square(5)	0.0194

The result of the heteroskedasticity test using the Glejser approach. The result suggests that there is no heteroskedasticity in the estimated model. This follows from the fact that the probability value of the F-statistic for the test is 0.08, being greater than 0.05, leading to the conclusion that the residuals are homoscedastic.

Climate change and Livestock production in Nigeria (1970 – 2015)

Test for serial correlation

The Durbin-Watson test for serial correlation shows that the error terms are not serially correlated. The values of the R-Square and Durbin-Watson also indicates that the OLS result is not spurious, since the value of Durbin-Watson is grater that the R-Square.

More formally, we apply the Breusch-Godfrey Serial Correlation LM Test to validate the DW test. The result is shown below:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	47.64442	Prob. F(2,40)	0.063
Obs*R-squared	32.39947	Prob. Chi-Square(2)	0.0430

The Breusch-Godfrey Serial Correlation LM Test indicates that there is no serial correlation in our estimated aggregate agricultural output model, since the probability of the F-statistic for the test is 0.063 – greater than the 5 percent significance level. This implies the acceptance of the null hypothesis of no serial correlation in the estimated model. This result corroborates the Durbin-Watson serial correlation test.

Test for heteroscedasticity

Heteroskedasticity Test: Glejser

F-statistic	1.714611	Prob. F(3,42)	0.1786
Obs*R-squared	5.019031	Prob. Chi-Square(3)	0.1704
Scaled explained SS	4.077815	Prob. Chi-Square(3)	0.2532

The result of the heteroskedasticity test using the Glejser approach. The result suggests that there is no heteroskedasticity in the estimated model. This follows from the fact that the probability value of the F-statistic for the test is 0.18, being greater than 0.05, leading to the conclusion that the residuals are homoscedastic.

Climate change and Forestry production in Nigeria (1970 – 2015)

Test for serial correlation

The Durbin-Watson test for serial correlation shows that the error terms are not serially correlated. The values of the R-Square and Durbin-Watson also indicates that the OLS result is not spurious, since the value of Durbin-Watson is grater that the R-Square.

More formally, we apply the Breusch-Godfrey Serial Correlation LM Test to validate the DW test. The result is shown below:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	55.75982	Prob. F(2,40)	0.110
Obs*R-squared	33.85636	Prob. Chi-Square(2)	0.060

The Breusch-Godfrey Serial Correlation LM Test indicates that there is no serial correlation in our estimated aggregate agricultural output model, since the probability of the F-statistic for the test is 0.110 – greater than the 5 percent significance level. This implies the acceptance of the null hypothesis of no serial correlation in the estimated model. This result corroborates the Durbin-Watson serial correlation test.

Test for heteroscedasticity

Heteroskedasticity Test: Glejser

F-statistic	2.204945	Prob. F(3,42)	0.1016
Obs*R-squared	6.259045	Prob. Chi-Square(3)	0.0997
Scaled explained SS	5.226350	Prob. Chi-Square(3)	0.1560

The result of the heteroskedasticity test using the Glejser approach. The result suggests that there is no heteroskedasticity in the estimated model. This follows from the fact that the probability value of the F-statistic for the test is 0.102, being greater than 0.05, leading to the conclusion that the residuals are homoscedastic.

Climate change and Fish production in Nigeria (1970 – 2015)

Test for serial correlation

The Durbin-Watson test for serial correlation shows that the error terms are not serially correlated. The values of the R-Square and Durbin-Watson also indicates that the OLS result is not spurious, since the value of Durbin-Watson is grater that the R-Square.

More formally, we apply the Breusch-Godfrey Serial Correlation LM Test to validate the DW test. The result is shown below:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	60.29765	Prob. F(2,40)	0.123
Obs*R-squared	34.54263	Prob. Chi-Square(2)	0.050

The Breusch-Godfrey Serial Correlation LM Test indicates that there is no serial correlation in our estimated aggregate agricultural output model, since the probability of the F-statistic for the test is 0.123 – greater than the 5 percent significance level. This implies the acceptance of the null hypothesis of no serial correlation in the estimated model. This result corroborates the Durbin-Watson serial correlation test.

Test for heteroscedasticity

Heteroskedasticity Test: Glejser

F-statistic	2.446034	Prob. F(3,42)	0.0771
Obs*R-squared	6.841622	Prob. Chi-Square(3)	0.0771
Scaled explained SS	6.359155	Prob. Chi-Square(3)	0.0954

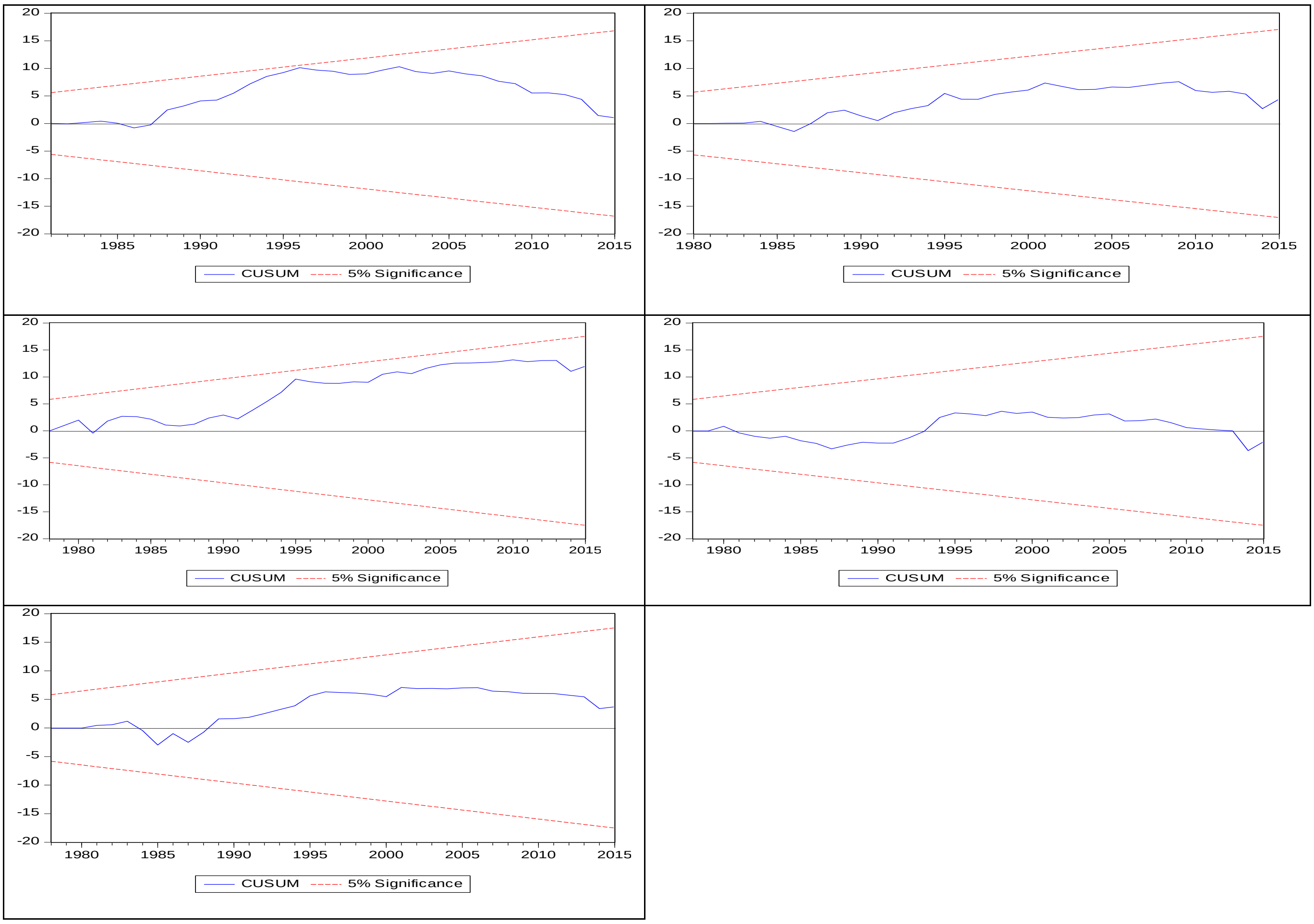
The result of the heteroskedasticity test using the Glejser approach. The result suggests that there is no heteroskedasticity in the estimated model. This follows from the fact that the probability value of the F-statistic for the test is 0.08, being greater than 0.05, leading to the conclusion that the residuals are homoscedastic.

Evaluation of the Error Correction Model

In table 4.7, we report the ECM results for both the aggregated and disaggregated agricultural output in Nigeria for the period under review. The result shows that the error correction term in each of the models is correctly signed with a values -0.18, -0.08, -0.06, -0.04 and -0.12 for aggregate agricultural output, crop production, livestock production, forestry production and fish production functions respectively and is statistically significant at the 5 percent significance level, this further confirm the existence of long run relationship among the variables of the model. This suggests that about 18%, 8%, 6%, 4% and 12% disequilibrium in each of the model is corrected within one year.

Next, we test for the dynamic stability of the ECMs, the result is shown below:

Figure 4.6: Result of CUSUM Test.



Source: The researcher's computation using Eviews, (2016)

The CUSUM test for stability shows that the recursive residuals are within the critical 5% significant lines. The results indicate the absence of structural change and the stability of the parameter estimates is verified.

Hypotheses Testing and Inferences

The hypotheses are tested using the conventional t-test approach and inferences based the impulse response function. The hypotheses are re-stated here as follow:

H_1^1: Climate changes affect different agricultural outputs in Nigeria in the short- and long-run.

H_1^2: The impacts of climate change on different agricultural output in Nigeria are the same across product. And no particular output is mostly affected.

H_1^3: Different agricultural outputs in Nigeria respond differently to climate change in the long-run.

Hypothesis one: Climate changes affect different agricultural outputs in Nigeria in the short- and long-run.

This hypothesis is verified using the long- and short-run estimates in sections 4.3.4 and 4.3.5 respectively.

Given the null hypothesis; H_0:B's= 0: the parameter estimates are not statistically significant at 5% level (Climate changes do not affect different agricultural outputs in Nigeria in the short- and long-run).

We reject the null hypothesis if the probability value is < 0.05(or alternatively, if the calculated t-value is greater than the critical t-value).

Using tables 4.5 and 4.6 as presented in sections 4.3.4 and 4.3.5, the null hypothesis is rejected and alternative hypothesis accepted. Hence we conclude that climate changes affect different agricultural outputs in Nigeria in the short- and long-run.

Hypothesis two

The impacts of climate change on different agricultural output in Nigeria are the same across product. And no particular output is mostly affected.

This hypothesis is tested based on inference, the estimates on tables 4.5 and 4.6 shows that the impact of climate change on different agricultural outputs are not the same across product. While some climate factor impacts have positive impact on agricultural outputs, some impact negatively. Also, the magnitude of impact differs across products. For instance, CO2 emission has much negative impact on fish production in the long run, while rainfall on the other hand has greater positive impact on fish production in the same long term. However, in the short run Co2 emission exerts much negative effect on livestock production while rainfall affects crop production adversely in the same short period.

Hypothesis three

Different agricultural outputs in Nigeria respond differently to climate change in the long-run.

Again this hypothesis is inferred from the estimated impulse response function (IRF). The IRF (as discussed above) indicates that the null hypothesis isrejected. Hence, we conclude that different agricultural outputs in Nigeria respond differently to climate change in the long-run.

4.4 Discussion of Findings

The main objective of this work is to assess the effect of climate change on aggregate agricultural output in Nigeria in the short- and long- run. From this broad objective, three other specific objectives emerge: (1) to determine the extent to which climate change affects different agricultural outputs in Nigeria in the short- and long-run. (2) To ascertain whether the impacts of climate change on different agricultural output in Nigeria are same across product. And examine which output is mostly affected, and (3) to assess the how different agricultural outputs in Nigeria respond to climate change in the long-run. In pursuance of these objectives, the following findings were made.

First, subjecting the aggregate agricultural output function and its fundamentals to cointegration test reveals clear evidence of long run relationship. This result implies that over the period, agricultural outputs have been moving closely with climate factor. This is a new insight into the Agricultural output-climate change nexus and corroborates the finding of Ayinde, Muchie and Olatunji (2011) that long run relationship between climate change and agricultural productivity in Nigeria. Most studies on this issue in Nigeria have used data at either state or regional levels.

The long run estimates show that CO_2 emission has significant adverse effect on aggregate agricultural output, livestock production and fish production, while its effect on forestry in the long run is positive and significant. The impact of CO_2 emission on food production, though negative is mild in the long run. The short run estimates also indicate that CO_2 has significant negative and positive impact on livestock production and forestry production respectively. The impact of CO_2 on aggregate agricultural output and fish production is negative and insignificant. This result suggests that the nature of the effect of CO_2 on any agricultural output depends on time. Some products are better-off in the long run and/or long run while some products are not.

The impact of temperature on aggregate agricultural output and crop production are negative, though not significant in both the long and short run. On the contrary, forestry and fish product are positively affected by temperature in both the long and short run. Livestock production is affected positively by temperature in the long run but negatively in the short run respectively. It is instructive to note that these effects of temperature on different output are mild over the period. These findings also lend credence to earlier findings by Ayinde, Muchie and Olatunji (2011) that the impact of temperature on agricultural output is not significant.

Further, the long run estimates show that annual rainfall has significant positive effect on aggregate agricultural output, crop yield, livestock production, forestry and fish production. The short run estimates show that aggregate agricultural output and livestock production are the only output that are positively affected by annual rainfall, the other outputs are negatively affected by annual rainfall. These are agree with that of Agboola and Ojeleye (2007) who claim that decline in crop yield on food crop production is due to reduction in rainfall.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary of the study, conclusions drawn from the findings of the study, recommendations suggested, contributions of the study to knowledge and agenda for further studies.

5.1 Summary of Findings

Climate change concerns are re-shaping policy debate, reflected in the increased numberof conferences, research and development programmes for climate change adaptation and mitigation. Climate change has become a headline issue in policy statements from donors, governments and civilsociety actors. In the agricultural sector, most agencies have started re-thinking their agricultural portfolios inrelation to the projected climate change impacts. New funding streams are providing new opportunities as wellas challenges for the agricultural sector in Nigeria and elsewhere. It is against this background that this study assessed the impact of climate change on different agricultural outputs in Nigeria. This study adds to the growing body of Literature on the impact of climate change on agriculture using data set spanning from 1970 – 2015.The study combined error correction techniques and vector autoregression framework.

The preliminary test of stationarity was conducted using the modified Ng-Perron framework. The results reveal that all the variables except fertilizer utilization are level stationary i.e. I (0) process at 5%. This result suggests the possibility of long run equilibrium between aggregate agricultural output and climate elements (rainfall, temperature and $C0_2$ emissions), hence, the need for cointegration analysis. The Johansen Co-integration analysis indicates the presence of long run relationship amongst the aggregate agricultural output and modeled economic fundamentals, including climate factors.

Given this result, we estimated – (1) a static OLS model to assess the long run impact of climate change on aggregate agricultural output in Nigeria, on one hand, and specific impact of climate change on different agricultural outputs in Nigeria. (2) An error correction model that accounts for short run impact of climate change on agricultural outputs at both aggregated and disaggregated forms.

We further characterize the responses of aggregate and disaggregate agricultural outputs to climate change and other fundamentals over a period of ten years using impulse response function (IRF). The results were presented and discussed in the preceding chapter.

5.2 Conclusion

Two top objectives of the Sustainable Development Goals (SDGs) are: to end poverty in all its forms everywhere and to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. The issue of food security has dominated contemporary development debate. And achieving food security will not be possible without improved agricultural productivity.

In Nigeria, as well as elsewhere, promoting sustainable agriculture demands an-all inclusive effort. To this end, this study examined the impact of climate change on agricultural output in Nigeria. The study adopted econometric analysis approach. We estimated and simulated the impact of climate change on aggregate agricultural output in Nigeria for the period 1970 – 2015. From the result, we conclude that CO2 emission has had some adverse effects on aggregate agricultural output in Nigeria; while on the average rainfall has led to increase in agricultural outputs. However, one major shortfall of aggregation is its treatment of cases as if they are symmetric (homogenous). In order to account for the asymmetric impact of climate change on different agricultural outputs in Nigeria, we assess the elasticities of specific agricultural output to climate change in Nigeria. As expected, the impacts of climate change on agricultural output differ across output/product. From the agricultural output-specific results, we conclude that, while CO2 emission has adverse impact on crop yield, livestock production and fishery production, its effect on forestry production is positive. Again, weconclude, that on the average, the effect of rainfall on different agricultural output in Nigeria is positive and the same across output.

5.3 Policy Recommendations

The results of this work have highlighted the need for investment in the adaptive capacity of farmers, especially small-scale farmers who are severely restricted by their heavy reliance on natural climate factors whilst also lacking necessary complementary inputs and institutional supports systems. The existence of institutional support systems will assist farmers in further understanding anticipated climate changes and available conservation agricultural practices that will help in cushioning the effect of climate change. There is need for putting in place policies and programmes that will make the food crop farmers to be proactive in the use of resources and at the same time adapting to climate change. Particularly, the following policy recommendations are proffered:

- Study reveals that rainfall has significant positive influence on domestic food production in Nigeria. The viable policy option to achieving sustainable food production is to design and implement small and large scale irrigation projects in agro based rural areas. This will enhance local food production by reducing the vulnerability of agricultural output to climate change through provision of alternative water supply for agricultural needs.
- Find also shows that increase in carbon emission is a serious threat to domestic food production in Nigeria. This fact highlights the importance of putting adequate policy measures in place to drastically reduce the rate of carbon emission especially those emanating from gas flaring, bush burning, deforestation and fossil fuel consumption. Strict legislation to this effect by the legislative arm of the government should be seen a matter of national interest.
- Different zones in Nigeria are faced with different climate induced challenges as our study reveals. There is need to critically investigate the best adaptation strategy that is required in each zone. For instance, the Northern zone is often faced with drought problems while the Southern often face flooding problems. Adaptation policies by government should target different agro ecological zones based on the constraints and potentials of each agro ecological zones rather than uniform approach to the problems. Irrigation facilities should be built especially in the North while drainage system should be built and maintained in the Southern zone.
- There is an urgent need to raise awareness of rural farmers about effective weather and climate risk management and the sustainable use of weather and climate information for agricultural production. This could be achieved by application of Government proposed implementation of E-SRP (Seasonal Rainfall Prediction), that will give rural farmers access to rainfall gauge and educate them how to read the trend of weather.
- There is a need to make the food farmers participate in programmes that address climate change policies in the country. To achieve this, agro meteorological centers should be established in agricultural based local government areas in the country.
- Agricultural production can beincreased and sustained by developing agricultural technologies that are environmentally sensitive.

- Further, agricultural innovation that increasessoil nutrient and do not contribute to change inclimate should be encouraged. This calls for improve funding and monitoring of agricultural research institute in the country for effective performance.
- Government should provide functional credit facilities to help the farmers in the area of climate change adaptation especially the inputbased like fertilizer.
- Government should set up modern ranches for raising livestock and stop herdsmen from infringing on the property rights of land owners and users because of desert encroachment caused by climate change in a given land location.

5.4 Contributions of the Study to Knowledge

Though substantial research has been carried out in this area, to the best of the researcher's knowledge, no studies have jointly analyzed the impact of climate change on agricultural output at both aggregated and disaggregated form; this study fills this gap. Again, estimating the impact of climate change on agricultural output using data at farm level may be overestimating the contribution of agriculture to the national economy, since some of the outputs are consumed at farm level and never included in GDP, this study also fills part of this gap by using data on Agriculture share to GDP.

5.5 Agenda for Further Studies

Despite the proliferation of research in this area, some gaps are yet to be filled. We therefore, suggest that further studies be carried out on the effects of climate change on agricultural produce export in Nigeria;effects of climate change adaptation strategies on each food crop (yam, cassava, maize) production efficiency;among others.

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APPENDICES

Data Set

Year	AQCY	IRGA	FEUT	ARLD	LAB	AMTP	AMRF	CO2	FIMV
1970	9.18	0.668164	311847	29330000	15455000	30.4	275	21539.96	57.7
1971	9.8	0.668477	324469	27350000	15682000	31.6	398	32280.6	88.8
1972	10.42	0.668896	326543	27400000	15966000	29.8	382	41426.1	95.8
1973	11.04	0.668896	356785	27450000	15888000	32.8	414	49577.84	126.8
1974	11.66	0.668896	376587	27500000	15929000	31	367	62291.33	154.8
1975	12.28	0.6667	400674	27690000	15950000	32.1	419	47395.98	298.8
1976	12.9	0.6645	378654	27630000	15958000	32.9	452	55247.02	441.7
1977	13.52	0.6612	453645	27730000	15963000	32	371	50567.93	780.7
1978	14.14	0.6612	432890	27780000	15971000	32.8	428	48294.39	1027.6
1979	14.76	0.6582	346578	27870000	15984000	32	293	70289.06	1254.5
1980	15.39	0.6582	514670	27890000	15997000	32.6	260	68154.86	1437.3
1981	16.02	0.6582	423560	28013000	16218000	32.6	1392.1	65958.33	1819.6
1982	17.90	0.6547	396756	28175000	16163000	33.3	1274.6	65602.63	1642.3
1983	20.44	0.6513	356479	28338000	16163000	32.3	1264.8	59929.78	1761.1
1984	26.87	0.6478	353780	28500000	16079000	33.8	1324.3	69625.33	1349.7
1985	31.33	0.6444	312786	28825000	16056000	32.5	1408.4	69893.02	1199
1986	32.46	0.6378	256700	28825000	16038000	29.8	1386.1	73505.02	801.9
1987	49.57	0.6553	235100	28947000	16013000	32.8	1417.9	59343.06	1873.3
1988	77.30	0.6307	325200	29177000	16006000	29.8	1427.6	70747.43	1891.6
1989	106.35	0.6272	363900	29353000	16007000	32.8	1320.2	42441.86	2108.9
1990	106.64	0.7071	400380	29539000	15995000	31	1386.2	45375.46	3474.5
1991	127.13	0.7206	429200	29800000	16080000	32.8	1415.7	45247.11	3045.7
1992	192.77	0.7179	440000	29922000	16156000	31	1354.7	64883.9	12840.2
1993	314.18	0.7152	461000	30044000	16222000	32.1	1394.2	60061.79	13953.4
1994	476.45	0.7125	296000	30165000	16277000	32.9	1402.4	46658.91	13837
1995	847.56	0.7141	183000	30371000	16321000	32	1499.9	34917.17	88349.9
1996	1,147.43	0.7459	173500	28700000	16354000	32.8	1480.6	40421.34	75392
1997	1,298.58	0.7581	137700	28200000	16373000	32	1498.6	40190.32	100728
1998	1,434.10	0.7582	163200	30000000	16381000	32.6	1346	40182.99	102165.1
1999	1,524.23	0.7565	167700	30520000	16376000	33.3	1571.6	44788.74	103489.9
2000	1,607.49	0.7942	187500	30610000	16359000	32.3	1267.2	79181.53	113630.5
2001	2,151.33	0.8237	221000	30660000	16369000	33.8	1296.1	83350.91	160209.1
2002	2,538.63	0.8182	166200	32000000	16367000	32.5	1458.8	98125.25	144297.6
2003	2,880.54	0.8443	229748	32000000	16352000	32.7	1395.6	93138.13	201648.3
2004	3,478.10	0.8001	152170	33000000	16324000	32.4	1338.3	97047.16	178747.4
2005	4,218.33	0.8001	215171	35000000	16282000	32.5	1372	104696.5	171817.1
2006	5,291.62	0.7001	227619	37000000	16227000	32.7	1378.6	98513.96	174229
2007	6,024.38	0.7001	88334	37500000	16227000	31.8	1443.4	95250.33	178561
2008	7,114.79	0.7001	497697	37550000	16348000	32.2	1378.1	92683.43	278561.9
2009	8,200.92	0.8921	502455	39572000	18264000	34.2	1472.5	71788.86	324567.7
2010	9,196.00	0.7001	271216.7	37350000	16277667	32.23333	1443.6	95482.57	210450.6
2011	10,323.65	0.7641	362828.7	38207333	16245333	32.73333	1429.2	86574.2	260563.5

2012	11,965.51	0.7641	423789.6	38157333	16267333	32.87778	1430.5	86651.62	271193.4
2013	13,069.15	0.785433	378833.4	38376444	16946333	33.05556	1398.7	84615.21	265194
2014	10495.056	0.742767	352611.6	37904889	16963222	32.61481	1381.4	89569.46	247402.5
2015	11786.105	0.771211	388483.9	38247037	16929000	32.88889	1428.2	85947.01	265650.3

LAQFH	LAQCY	LAQFR	LAQLV
-2.207274913	2.217027205	-1.560647748	0.019802627
-1.832581464	2.282382386	-1.272965676	0.048790164
-1.560647748	2.343727036	-1.049822124	0.076961041
-1.347073648	2.401525041	-0.867500568	0.104360015
-1.171182982	2.456164181	-0.713349888	0.131028262
-1.021651248	2.507971923	-0.579818495	0.157003749
-0.891598119	2.557227311	-0.46203546	0.182321557
-0.776528789	2.604170071	-0.356674944	0.207014169
-0.673344553	2.64900766	-0.261364764	0.231111721
-0.579818495	2.691920819	-0.174353387	0.53462645
-0.494296322	2.733717948	0.092013511	0.967715187
-0.299825144	2.773829897	0.060332466	0.53462645
-0.097888602	2.88497542	0.065628206	0.985298304
0.284899326	3.017384396	0.14766079	1.255716043
0.156469415	3.2909803	0.234249382	1.498441849
-0.316509273	3.444575226	0.295843232	1.577249676
0.035561803	3.480075774	0.36447603	1.608423714
-0.111792988	3.903360824	0.37584364	1.7334825
0.450102058	4.347734897999999	0.532842968	1.793290272
1.012244016	4.666699293	0.689168805	2.19390936
1.405834771	4.669460625	0.700927653	2.250853019
1.571106153	4.845216367	0.802902038	2.354109925
1.847034671	5.261513289	1.007983154	2.74506364
2.016016898000001	5.749971145	1.290149351	3.20776742
2.333790634	6.166357418	1.701077596	3.602980807
2.96955555	6.742357523	2.02294121	4.185169642
3.423295404	7.04528295	2.251070674000001	4.479042195
3.611870288	7.169025275	2.442352224	4.585312764
3.804721935	7.268294121	2.677428777	4.672957387
3.947421463	7.329242841	2.872675556	4.710521484
4.010372012000001	7.382426255	3.110707402	4.756975903
4.340729775	7.673841096	3.312825488	5.040164887000001
4.522874614	7.839378411	3.502132062	5.210590538
4.684119968	7.965734575	3.699352218	5.309569369
4.868430208999999	8.154240414	3.944649958	5.496707172
5.09134176	8.347193611	4.185961861	5.724526972
5.280429376	8.573879542	4.296755605999999	5.936751227
5.373067772	8.703570014	4.428576673	6.07339392
5.539839666	8.869931551	4.595348564	6.240165798
5.672255242	9.012001828000001	4.710174323999999	6.369256033
5.793575726	9.126524377999999	4.822881937	6.49548278

5.923105919	9.242192532000002	4.942958716	6.628082182
6.059658122	9.389783931	5.053398058	6.761047443
6.187705712	9.478009878	5.167617025	6.885232793
5.931346135	9.258659533	4.944164971	6.634072931
6.062642954	9.374676538999998	5.058862502	6.763617875

Summary Statistics (a)

	LAGQ	LAQCY	LAQLV	LAQFR	LAQFH	LIRGA	LFEUT	LARLD
Mean	5.791188	5.649853	3.238274	1.806639	2.191944	-0.341182	12.60869	17.24788
Median	5.619949	5.505742	2.976416	1.149066	1.931526	-0.356532	12.76449	17.20562
Maximum	9.596222	9.478010	6.885233	5.167617	6.187706	-0.114177	13.15128	17.49363
Minimum	2.353278	2.217027	0.019803	-1.560648	-2.207275	-0.466490	11.38888	17.12423
Std. Dev.	2.626907	2.655299	2.455212	2.142456	2.752878	0.087480	0.404130	0.120414
Skewness	0.069470	0.063981	0.073030	0.229334	0.051031	0.613905	-0.926406	0.888915
Kurtosis	1.402663	1.393326	1.463827	1.597011	1.480296	2.467839	3.236014	2.251711
Jarque-Bera	4.927345	4.979069	4.563894	4.175945	4.446506	3.432194	6.686505	7.131178
Probability	0.085122	0.082949	0.102085	0.123938	0.108256	0.179766	0.035322	0.028280
Sum	266.3946	259.8932	148.9606	83.10540	100.8294	-15.69436	579.9996	793.4023
Sum Sq. Dev.	310.5289	317.2776	271.2631	206.5554	341.0252	0.344371	7.349446	0.652474
Obs	46	46	46	46	46	46	46	46

Summary Statistics (b)

	LLAB	LAMTP	LAMRF	LCO2	LFIMV
Mean	16.60232	3.474542	6.918868	11.03671	9.276235
Median	16.60176	3.482776	7.229838	11.09407	9.497719
Maximum	16.72044	3.532226	7.359849	11.55882	12.69025
Minimum	16.55344	3.394508	5.560682	9.977665	4.055257
Std. Dev.	0.024823	0.030850	0.588570	0.359099	2.816041
Skewness	2.465805	-1.110422	-1.289957	-0.605740	-0.240739
Kurtosis	12.76531	4.204744	2.835976	2.945579	1.595144
Jarque-Bera	229.3907	12.23515	12.80882	2.818742	4.227094
Probability	0.000000	0.002204	0.001654	0.244297	0.120809
Sum	763.7066	159.8289	318.2679	507.6887	426.7068
Sum Sq. Dev.	0.027727	0.042829	15.58863	5.802837	356.8538
Observations	46	46	46	46	46

Long run estimation: AGQ function

Dependent Variable: LAGQ
Included observations: 46

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAMRF	0.280989	0.070693	3.974778	0.0316
LAMTP	-3.588856	1.988551	-1.804759	0.0790
LARLD	8.165772	0.834640	9.783589	0.0000
LCO2	-0.529133	0.189951	-2.785630	0.0083
LFIMV	0.607661	0.053662	11.32378	0.0000
LIRGA	3.742815	1.127285	3.320205	0.0020
LLAB	8.561601	3.457146	2.476494	0.0178
C	19.44290	52.26560	0.372002	0.7120

R-squared	0.985303	Mean dependent var	5.791188
Adjusted R-squared	0.982596	S.D. dependent var	2.626907
S.E. of regression	0.346557	Akaike info criterion	0.875234
Sum squared resid	4.563877	Schwarz criterion	1.193259
Log likelihood	-12.13039	Hannan-Quinn criter.	0.994368
F-statistic	363.9347	Durbin-Watson stat	2.009952
Prob(F-statistic)	0.000000		

Long run estimation: AQCY function

Dependent Variable: LAQCY
Included observations: 46

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAMRF	0.235037	0.143523	1.637629	0.1098
LAMTP	-3.914714	2.072745	-1.888662	0.0666
LARLD	8.307533	0.869978	9.549135	0.0000
LCO2	-0.585471	0.197993	-2.957028	0.0053
LFIMV	0.613865	0.055934	10.97473	0.0000
LIRGA	3.740054	1.175013	3.378733	0.0017
LLAB	8.563069	3.463519	2.473986	0.0168
C	205.6786	26.78848	7.677118	0.0056

R-squared	0.924372	Mean dependent var	5.649853
Adjusted R-squared	0.981493	S.D. dependent var	2.655299
S.E. of regression	0.361230	Akaike info criterion	0.958169
Sum squared resid	4.958518	Schwarz criterion	1.276193
Log likelihood	-14.03788	Hannan-Quinn criter.	1.077303
F-statistic	341.9260	Durbin-Watson stat	1.390693
Prob(F-statistic)	0.000000		

Long run estimation: AQFH function

Dependent Variable: LAQFH
Included observations: 46

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCO2	2.720663	0.808423	3.365397	0.0016
LAMRF	2.340061	0.497409	4.704503	0.0000
LAMTP	14.08936	8.967363	1.571183	0.1236
C	-92.97989	30.08080	-3.091004	0.0035

R-squared	0.621760	Mean dependent var	2.191944
Adjusted R-squared	0.594743	S.D. dependent var	2.752878
S.E. of regression	1.752477	Akaike info criterion	4.042879
Sum squared resid	128.9894	Schwarz criterion	4.201891
Log likelihood	-88.98622	Hannan-Quinn criter.	4.102446
F-statistic	23.01352	Durbin-Watson stat	1.55454
Prob(F-statistic)	0.000000		

Long run estimation: AQFR function

Dependent Variable: LAQFR
Included observations: 46

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAMTP	11.26946	6.873012	1.639668	0.1085
LAMRF	1.559785	0.381238	4.091372	0.0002
LCO2	2.613727	0.619613	4.218319	0.0001
C	76.98846	23.05535	3.339288	0.0018

R-squared	0.612155	Mean dependent var	1.806639
Adjusted R-squared	0.606952	S.D. dependent var	2.142456
S.E. of regression	1.343182	Akaike info criterion	3.510901
Sum squared resid	75.77375	Schwarz criterion	3.669913
Log likelihood	-76.75072	Hannan-Quinn criter.	3.570468
F-statistic	24.16329	Durbin-Watson stat	1.549843
Prob(F-statistic)	0.000000		

Long run estimation: AQLV function

Dependent Variable: LAQLV
Included observations: 46

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAMTP	10.76914	8.226193	1.309128	0.1976
LAMRF	2.169750	0.456297	4.755128	0.0000
LCO2	2.240263	0.741605	3.020831	0.0043
C	73.91690	27.59456	2.678676	0.0105

R-squared	0.565842	Mean dependent var	3.238274
Adjusted R-squared	0.571259	S.D. dependent var	2.455212
S.E. of regression	1.607632	Akaike info criterion	3.870342
Sum squared resid	108.5481	Schwarz criterion	4.029355
Log likelihood	-85.01787	Hannan-Quinn criter.	3.929909
F-statistic	20.98617	Durbin-Watson stat	1.556173
Prob(F-statistic)	0.000000		