



UNIVERSITI PUTRA MALAYSIA

***ECONOMIC IMPACT OF CLIMATE CHANGE ON MAIZE PRODUCTIVITY
IN NORTHERN NIGERIA***

KASIMU IBRAHIM

FPAS 2015 9



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By

KASIMU IBRAHIM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
Fulfillment of the Requirement for the Degree of Doctor of Philosophy**

May 2015

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Abstract of thesis presented to Senate of Universiti Putra Malaysia in Fulfillment of the requirement for the degree of Doctor of Philosophy

ECONOMIC IMPACT OF CLIMATE CHANGE ON MAIZE PRODUCTIVITY IN NORTHERN NIGERIA

By

KASIMU IBRAHIM

May, 2015

Chairman: Professor Mad Nasir Shamsudin, PhD

Faculty: Environmental Studies

In recent years, climate change has become a more serious issue than any other environmental problem. One of the main concerns is the risk it poses to food production, especially in developing countries, where a large percentage of the population relied heavily on agriculture for survival. Irrational allocation of resources also contributed to the decline of agricultural productivity in Africa. In Nigeria, few researches focused on assessing the economic impact of climate change and ways of improving productive efficiency of maize. Having established these problems, the main goals of this study are to estimate the economic impact of climate change on net revenue from maize in northern Nigeria and also to identify the role of socioeconomic factors in cushioning the impact. Furthermore, this research aimed to measure the technical efficiency of maize production and identify its determinants.

As part of solution to the problems results of the study are intended to inform farmers, researchers and policy makers, on the economic impact of climate change on net revenue and technical efficiency of the respondents in the study area. Climate data for the study mainly includes temperature and rainfall. Data on net revenue, input use, cost of production, yield and farm specific factors were collected through respondent's survey. The main methodologies used in the analysis of the study are the Ricardian and the stochastic frontier approaches. Results of the study obtained through Mann-Kendall, Ricardian, stochastic frontier and Tobit analyses revealed evidence of climate change. Although the impact was mixed, temperature played a more important role in determining farm net revenue, as against rainfall during the crop growing season. Furthermore, market distance, farm size and farm power were the factors that significantly determined net revenue. On the technical efficiency of farms, the inputs tested were found to significantly increase maize productivity. Findings showed that education, credit, household size, age and gender contributed significantly in reducing technical inefficiency of the respondents.

The conclusion of the study was that climate change had a mix impact on revenue from maize production. In addition, certain socioeconomic factors could be used by farms to adapt to climate change. Projections based on the analyses of the study showed that future climate change will be harmful to net revenue. Although the respondents achieved high

level of technical efficiency findings of the study revealed that technical inefficiency exist among maize farms. All inputs tested could be used to increase productivity, but increase in the supply of labor may lead to a more significant rise in productivity. Similarly, factors such as education, credit, age, household size and gender could be explored to improve technical efficiency. To comprehensively address the problems of climate change and inefficient resource use, there is the need to focus attention on assessing the impacts of climate change and technical efficiency, two problems that previous studies have not addressed properly. The policy implications of these results, if carefully evaluated are expected to serve as a framework for developing climate change adaptation and efficient resource utilization options in the study area.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memunuhi keperluan untuk ijazah Doctor Falsafah

KESAN EKONOMI PERUBAHAN IKLIM TERHADAP PRODUKTIVITI JAGONG DI NIGERIA UTARA

Oleh

KASIMU IBRAHIM

May 2015

Pengurus: Professor Mad Nasir Shamsudin, PhD

Faculti: Pengajian Alam Sekitar

Dalam tahun-tahun kebelakangan ini, perubahan iklim telah menjadi isu yang lebih serius daripada apa masalah alam sekitar yang lain. Salah satu kebimbangan utama adalah risiko yang ditimbulkan olehnya kepada pengeluaran makanan terutamanya di negara membangun, di mana sebahagian besar daripada penduduk amat bergantung kepada pertanian untuk kelangsungan hidup. Isu pengagihan sumber yang tidak rasional secara negatif mempengaruhi kecekapan teknikal pengeluaran pertanian juga dikenal pasti sebagai salah satu faktor utama yang menyumbang kepada penurunan produktiviti pertanian di Afrika. Di Nigeria, beberapa kajian memberi tumpuan kepada penilaian kesan ekonomi perubahan iklim dan juga bagaimana untuk meningkatkan kecekapan pengeluaran jagong. Melihat kepada permasalahan ini, matlamat utama kajian ini adalah untuk menentukan kesan ekonomi perubahan iklim ke atas hasil bersih daripada jagong di Utara Nigeria dan untuk menentukan peranan faktor sosio-ekonomi dalam menampai impak yang terhasil. Di samping itu, kajian ini juga bertujuan untuk mengukur kecekapan teknikal pengeluaran jagong dan penenturannya.

Hasil kajian adalah bertujuan untuk memaklumkan kepada petani, penyelidik dan pembuat dasar, mengenai kesan ekonomi perubahan iklim ke atas pendapatan bersih dan kecekapan teknikal daripada responden di kawasan kajian. Data untuk kajian ini dikumpulkan melalui kaji selidik responden di mana maklumat mengenai pendapatan bersih, penggunaan input, kos pengeluaran hasil ladang dan faktor-faktor khusus telah diperolehi. Model Ricardian, *stochastic frontier* dan model Tobit telah digunakan untuk penganalisaan data. Hasil kajian menunjukkan bahawa walaupun perubahan iklim mempunyai kesan yang pelbagai kepada hasil bersih, suhu memainkan peranan yang lebih penting sebagai penentu pendapatan bersih ladang, berbanding hujan, terutamanya semasa musim penanaman. Tambahan pula, pasaran, saiz ladang dan tenaga ladang merupakan faktor yang signifikandalam menentukan pendapatan bersih. Dari segi kecekapan teknikal ladang, semua input yang diuji didapati meningkatkan produktiviti jagong dengan signifikan. Pendidikan, kredit, saiz isi rumah, umur dan jantina telah didapati boleh mengurangkan ketidakcekapan teknikal di kalangan responden.

Kesimpulan daripada kajian ini adalah perubahan iklim mempunyai kesan yang pelbagai kepada hasil bersih pengeluaran jagung di kawasan itu dan beberapa faktor sosioekonomi boleh digunakan sebagai pilihan penyesuaian ladang untuk mengurangkan impak yang terhasil. Unjuran analisis menunjukkan bahawa perubahan iklim masa depan akan menjadi ancaman kepada pendapatan bersih. Walaupun responden berjaya mencapai tahap tinggi kecekapan teknikal, kajian menunjukkan bahawa ketidakcekapan teknikal wujud di kalangan ladang jagung. Kesemua input boleh berupaya meningkatkan produktiviti tetapi peningkatan tenaga kerja akan memberikan peningkatan yang lebih ketara dalam produktiviti. Faktor-faktor seperti pendidikan, kredit, umur, saiz isi rumah dan jantina boleh diterokai untuk meningkatkan kecekapan teknikal. Untuk menangani masalah perubahan iklim dan penggunaan sumber yang tidak cekap secara komprehensif, adalah perlu untuk menumpukan perhatian jangkaan kesan perubahan iklim dan kecekapan teknikal, dua ancaman yang tidak ditangani dalam kajian-kajian sebelum ini.



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I certify that a Thesis Examination Committee has met on 18 May 2015 to conduct the final examination of Kasimu Ibrahim on his thesis entitled "Economic Impact of Climate Change on Maize Productivity in Northern Nigeria" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Ahmad Makmom bin Abdullah, PhD

Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Ramdzani bin Abdullah, PhD

Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Ismail bin Abd Latif, PhD

Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Muhammad Firdaus, PhD

Professor
Bogor Agricultural University
Indonesia
(External Examiner)



ZULKARNAIN ZAINAL, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 June 2015

This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Mad Nasir Shamsudin, PhD

Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Alias b. Radam, PhD

Associate Professor
Faculty of Economics and Management
Universiti Putra Malaysia
(Member)

Rusli Yacob, PhD

Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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Signature: _____ Date: _____

Name and Matric. No.: Kasimu Ibrahim GS30995

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Signature: _____

Name of _____
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Committee:

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Member
Supervisory
Committee:

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LIST OF ABBREVIATIONS

AE	Allocative Efficiency
BNRCC	Building Nigeria Response to Climate Change
CERES	Crop Environment Resource Synthesis
CGE	Computable General Equilibrium
CO ₂	Carbon dioxide
COLS	Corrected Ordinary Least Square
CROPWAT	Crop Water Requirements
DEA	Data Envelopment Analysis
DFI	Debreu-Ferrell Input
DFO	Debreu-Ferrell Output
DMU's	Decision Making Units
DSSAT	The decision Support System for Agro technology Transfer
EE	Economic Efficiency
EPIC	Erosion Productivity Impact Calculator
EU	European Union
FAO	Food and Agricultural Organization
FARM	Future Agricultural Resource Model
FGN	Federal Government of Nigeria
FME	Federal Ministry for Environment
GCM's	Global Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information System
IBSNAT	International Benchmark Sites Network for Agro technology Transfer
ICASA	International Consortium for Agricultural Systems Applications
IPCC	Intergovernmental Panel on Climate Change
LGA's	Local governments Areas
MLE	Maximum Likelihood Estimate
MOLS	Modified Ordinary Least Squares
NBS	National Bureau for Statistics
NIMET	Nigeria Meteorological Agency
SDEA	Stochastic Data Envelopment Analysis
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
UNDP	United Nations Development Program

UNFCC
USDA
USD

United Nations Framework Convention on Climate Change
United States Department for Agriculture
United States Dollar

CHAPTER 1

INTRODUCTION

1.1 Background

Historically, science has shown that the world climate has been dynamic for millions of years. However, climate change in the past two centuries was unprecedented. The current changes in climate coupled with low farm output were identified as the major impediments to agriculture in Nigeria. This research was conducted to study the economic impact of climate change on net revenue and technical efficiency of maize productivity in northern Nigeria. The analysis was intended to improve on the existing literature, with regards to these two issues, in the context of northern Nigeria. Climate change is recognized by today's world as the most important environmental problem affecting humanity. It refers to a serious and continuous change in weather pattern. It is largely attributed to the emission of greenhouse gases such as carbon dioxide, methane, nitrous oxide and water vapor by humans. These gases are mainly produced by the transport, agriculture, manufacturing and energy sectors of the economy.

The scientific community largely believed that the earth climate continuously changed for millions of years. However, evidence has shown that anthropogenic activities from industrial revolution in the past two centuries were largely responsible for the recent rise in the concentration of greenhouse gases above usual limits. This, according to the fourth assessment report of the Intergovernmental Panel on Climate Change IPCC (2007) led to changes in the frequency and intensity of climate; resulting in extreme and violent weather events. The extreme weather manifested as warmer temperatures, heavy rainfall, drought, floods and cyclones. The aggregate shift in weather pattern is known as the climate change; the impact of which together with rising world population poses a serious threat to the vital sectors of the world economy. The economic sectors most vulnerable to climate change are mainly water supply, ecosystems, coastal habitats, industries, health and agriculture.

With the hindsight that climate change phenomenon is global in nature and its impact economy wide; it should be understood that agricultural sector in all countries of the world are exceptionally vulnerable, due to their dependence on natural climate. Agriculture is the world's oldest economic activity. It refers to the production, processing, promotion and the distribution of agricultural products, including forestry, fruit and vegetable cultivation, poultry and beekeeping. Agriculture provides food and raw materials to the entire world population. It is the backbone of the economy of a given country. The sector serves as the major source of employment to over 70% of the economically active world rural populace. Furthermore, it accounts for 3% of World GDP (World Bank 2012). Similarly, agriculture provides food security and a source of foreign exchange and savings. It is also the main supplier of industrial raw materials and source economic development in many countries.

Having established the importance of agriculture to the world; it is pertinent to discuss the role of agriculture to the Nigeria's economy. In Nigeria, despite the rapid growth of oil industry, agriculture still remained one of the most viable sectors of the economy.

The agricultural sector contributed 33% to GDP in 2013 based on the rebased GDP figures (NBS 2014). About 80% of the domestic food in the country, especially from crops and forestry is produced by small scale farmers. The fishery and livestock products are supplemented by imports. Agriculture, in addition to providing raw materials to the manufacturing industries, also serves as a source of foreign exchange earnings as well as economic development. It provide employment for about 80% of the Nigeria's rural poor population (NBS 2014). Despite the economic importance of agriculture in Nigeria, agricultural practices are still carried out using low level technology. Inputs use is inefficient and average production per hectare is 1.4 tons, much lower than world average (4 tons/ha). Currently, two important factors were identified as threats to agricultural growth and development in Nigeria; these are climate change and poor farm output due to inefficient resource use (Ajobefun, 2002; Aye & Mungatana 2010; Bosello et al., 2013; Hassan et al., 2012; Ogundele & Okoruwa 2006; Placid, 2000). Figure 1.1 below represents Nigeria's sectoral contribution to GDP in 2013.

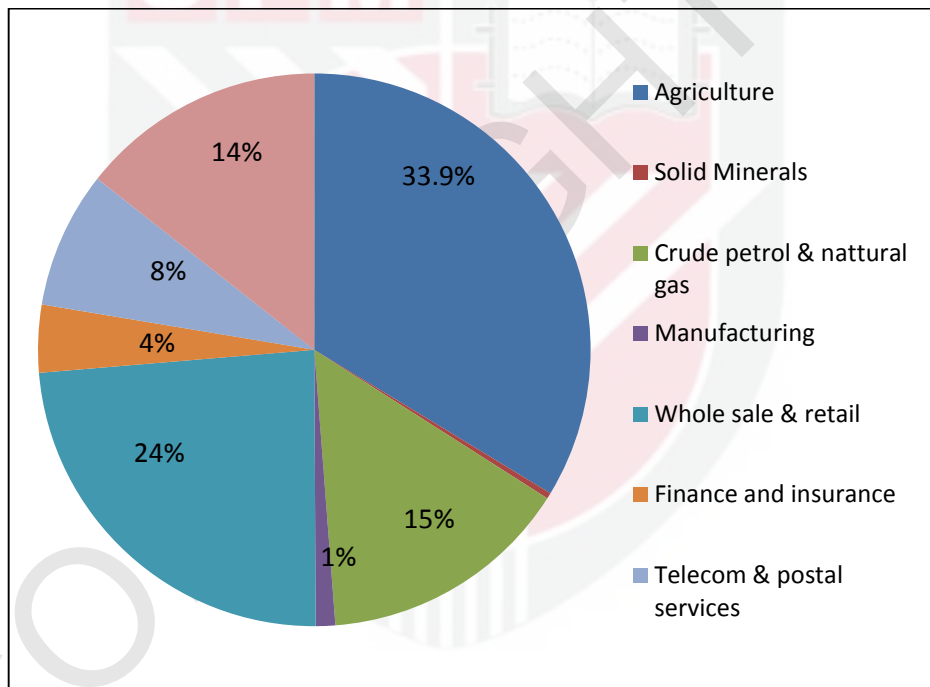


Figure 1.1: Nigeria's Percentage Share of GDP 2013 (NBS 2014)

In the last paragraph, the importance of agriculture to the Nigerian economy was highlighted; in this part global impact of climate change will be outlined. Despite uncertainties on the total economic impact of climate change on the world economy, several bodies such as IPCC showed that by the end of the 21st century, huge economic losses will be incurred due to climate change across the globe. Similarly, facts from scientific studies showed impact on agriculture in many regions of the world. Worldwide impact was forecasted to reduce grain production by 20% to 30% (Darwin et al., 1995). Global welfare changes in agriculture will result to a loss of sixty one

billion USD (Reilly et al., 1996). Significant negative impacts were also predicted across the globe (Fischer & Van Velthuizen 1996; Rosenzweig and Parry 1994; Tsigas et al., 1997; Reilly 1999; Kurukulasuriya et al., 2006; Mendelsohn et al., 1994; Kurukulasuriya & Rosenthal 2003). A common prediction of the impact of climate change across the globe made by several studies is the reduction in the magnitude of future food production (IPCC 1996; Bindi and Olesen 2011; Kurukulasuriya & Rosenthal 2003). The warming scenario predicted by scientist will lead to variation of agricultural impacts across regional and local divides. However, emerging facts predicted worst impact for tropical regions (Mendelsohn, 2000; Kurakulasuriya & Rosenthal 2003). One estimate put losses in agricultural production from developed countries at 2% - 4% and developing countries will lose an estimated 14% -16% of their total production. Table 1.1 shows the regional impact of climate change on agriculture.

Table 1.1: Regional impact of climate change on agriculture

Region	Impact (% of GDP)	Yield reduction (%)
World	10	-
Developed countries	2 - 4	-
Developing countries	14-16	-
Africa	10	50
Asia	9	30
Australia New Zealand	-	30
Europe	4	10
United States	3.6	-

Source; IPCC 2007

In addition, more evidence of the impacts of climate change on world agriculture is emerging from growing body of literature. It was predicted that a 2.5 °C (36.5 °F) rise in temperature will hamper crop yields (Amiraslany, 2010). This coupled with growing human population will result in higher food prices. Although, this trend will have small impact on global revenue; more impact is forecasted for developing countries. A considerable reduction in rainfall was also forecasted in many parts of the world. This will make crop yields even more vulnerable. Impact of climate change will not only affect agricultural productivity, but also worldwide supply and demand of agricultural produce, as well as farm prices and revenue. The climate in Africa is mostly dry, characterized by short rainy season. Like other parts of the world the trend of temperature is increasing and there is uncertainty on the future trend of rainfall. However, high population pressure on natural resources, extreme poverty, heavy reliance on agriculture exacerbated by marginal climate makes African region the most vulnerable to climate change (Kurukulasuriya et al., 2006; Matthews et al., 2007). In West African Sahel alone an estimated 80% of the population is involved in agriculture and livestock farming; these sectors contributed about 35% to GDP in these countries. The total economic impact of climate change on agriculture in these countries is put at 10% of their GDP (Kurukulasuriya & Rosenthal 2013). The crucial role played by agriculture in the socio economic development of many developing countries including Nigeria justifies the concern on the negative impact of climate change.

The points above strive to establish evidence of negative impact of climate change on the global economy; the situation is not different in Nigeria. Findings from many

studies showed evidence of rise in temperature and changes in the intensity of rainfall across all regions (Aaron, 2011; BNRCC 2011; FME 2003; 2012; Hassan et al., 2012; Kalmalkar et al., 2010; NIMET 2014). It was forecasted that temperature will rise by 1.5 °C to 2.5 °C (34.7 °F – 36.5 °F) in the 21st century; and there will be a general slight increase in rainfall across different parts of the country. Projection from these studies showed that like in many other countries of Africa, the agricultural sector in Nigeria will also be susceptible to the impact of climate change. Estimate of damage in Nigeria is projected to reach up to 1.5% to 3% of GDP each year by 2030; it will also lower crop yield by 5% to 25% by 2050 (Hassan et al., 2012; Bello et al., 2012). Massive reliance on agriculture by the citizens, lack of institutional capacity to adapt and the geographical location of Nigeria makes it more vulnerable to climate change. Despite these harsh forecasts on the most important sector of the Nigerian economy; there is still lack of sufficient empirical studies that assessed economic impact of climate change on agriculture.

To provide a clear picture of the situation, it is to be noted that researches that conducted the assessment of the economic impact of climate change on agriculture in Nigeria using various approaches are quiet few. Ricardian method was however used by Ajetomobi et al., (2010); Odozi et al., (2013); Bosello et al., (2013); Fonta et al., (2011) to analyze economic impact of climate change on agriculture. A common finding of these studies revealed that climate change will be harmful to agriculture in Nigeria. The two most important elements of climate that were observed to affect agriculture in Nigeria are temperature and rainfall. The vulnerability of impact is contingent on wide range of local environmental and management factors in various agro ecological zones. However, the few studies conducted mainly, concentrated on the southern part of the country and their focus was not on cereal crops. Generally, under the current situation, literature on the impact of climate change on farm revenue is scanty. Specifically, little is known about how maize farms behaved under changing climate in northern Nigeria. It is therefore difficult to trace a study that measures the impact across northern Nigeria. The few studies conducted were limited to small areas with no variation in climate; as a result a clear picture of the impact cannot be obtained. This justified that measuring the impact of climate change on agriculture over wide range of climate is becoming an increasingly important aspect of assessing climate change impact in Nigeria.

Having enunciated the gap in knowledge on the impact of climate change in Nigeria, what follows next is a synopsis of the Ricardian method. Ricardian method is one of the potential techniques for measuring the economic impact of climate change on agriculture. It was based on the perceptions that land values match the output of land in a competitive environment. One of the major assumptions of the technique is the direct relationship between climate and farm values. Ricardian method is a recent technique that is widely applied to assess the impact of climate on land values or net farm revenue. The impact is measured by conducting a regression of farm revenue on climatic variables. The method assumes farmers change their use of inputs and outputs continuously, to suit the immediate environment and as a result adaptation options are implicitly taken. With this assumption, adaptation options are considered as a black box, because the modifications are not explicitly modeled (Mendelsohn & Dinar 2009). To use the Ricardian technique, inputs such as labor, capital and crop choices are not included in the regression because they are endogenous factors. Similarly, accurate measurement of variables, large sample size and wider variation in relevant variables

especially climate are important considerations for accuracy in the Ricardian technique. Mendelsohn et al., (1994) first applied the method to measure land values in US. Mendelsohn and Kurukulasuriya (2008) also used the technique as the methodology for the analysis of a multicounty study, which considered the impact of climate change on crops and livestock in Africa.

So far the description of the problem setting concentrated mainly on the issue of climate change. However, another important problem of agriculture in Nigeria as highlighted earlier is low resource use efficiency. Efficiency of a farm (production unit) can be measured either with respect to its normatively desired performance or with the performance of another farm. Thus, measures of efficiency are essentially computed by comparing observed performance with some specified standard notion of performance. The “production frontier” serves as one such standard in the case of technical efficiency. Technical efficiency can be defined as the ability and willingness of a production unit to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function), given the surrounding technology and environmental conditions. Farrell (1957) carried out the first empirical study to measure technical efficiency for a cross-section of production units by using a deterministic/non-parametric frontier approach.

The measure above assumes that the production function of the fully efficient unit is known in some manner. Since this bench mark of frontier production function is never known in practice, Farrell suggests that it can be estimated from sample data using either a non-parametric piecewise linear technology or by a parametric function such as the Cobb-Douglas form. A potential advantage of the stochastic production frontier approach is that random variations in catch can be accommodated, so that the measure is more consistent with the potential harvest under “normal” working conditions. A disadvantage of the technique is that although it can model multiple output technologies, doing so is somewhat more complicated; for it requires stochastic multiple output distance functions and raises problems for outputs that take zero values (Paul, Johnson & Frengley, 2000). An implicit assumption of production functions is that all firms are producing in a technically efficient manner, and the representative (average) firm therefore defines the frontier.

To address the concern for low agricultural output in Nigeria, the issue of resource use efficiency should be considered. At this point, it is important to note that although maize is important as a food and industrial crop in Nigeria and despite challenges posed by the threat of low output, few studies that analyzed technical efficiency of resource use examined maize in their assessments. Studies that estimated the technical efficiency of maize farms in Nigeria using the stochastic frontier model include (Aye & Mungatana 2010; Etim & Okon 2013; Ogunniyi 2011; Ogunniyi 2012; Oluwatayo & Adesoji 2008; Sadiq 2013). Findings of these studies revealed that substantial amount of yield and revenue from maize is lost due to inefficient utilization of farm inputs. Despite this gloomy picture, the focus was not on maize; the few studies that estimated the technical efficiency of maize based their assessments mostly in the southern part of the country mostly, within one agro ecological zone; this makes it difficult to generalize their conclusions to countrywide. Therefore, empirical findings of studies on economic impact of climate change as well as technical efficiency of maize in northern Nigeria is lacking and the scanty information cannot be generalized to countrywide level. This study is an attempt to provide a deep assessment of the economic impact of

climate change on maize revenue as well as the technical efficiency of maize farmers in northern Nigeria. This effort is aimed at providing a clear picture of the situation with respect to the maize industry.

Having provided basis for the current research in the preceding part, it should be clearly understood that the study is necessary in order to provide more insights on the magnitude of the impact of climate change on revenue. In addition, the study is vital for an in-depth assessment of the technical efficiency level of maize farmers in northern Nigeria with a view to improve the growth and productivity of the industry. This effort is essential for national planning and policy formulation to creating necessary measures that will lessen the impact of climate change and raise farm output. This study to date is among the few analyses that simultaneously evaluate economic impact of climate change and technical efficiency of maize productivity covering 3 out of the 4 agro ecological zones in northern Nigeria; it is an effort to fill the existing gaps in literature. Findings of the study are likely to be beneficial to farmers, researchers as well as the policy makers in improving their knowledge of climate change impact on revenue. It will also provide a picture of the technical efficiency of maize production. These efforts are important for developing climate change adaptation framework and resource use policy that will increase farm resilience and output; an indispensable pre-requisite for Nigeria's sustainable growth and development.

1.2 Problem Statement

To provide a clear understanding of the situation, before stating the main problem of the study, it is important to begin by highlighting the major constraints to maize production in northern Nigeria.

a) Soil Fertility

Maize production in the Savannas is faced with several constraints which limit its output. A combination of poor soil fertility, drought and *Striga hermonthica* infestation leads to an on-farm yield reduction by over 70% even with the use of high-yielding varieties. Land-use intensification resulting from high population pressure especially in the Northern Guinea Savanna has resulted in serious land degradation and nutrient depletion (Oikeh et al., 2003). Soils in the region are deficient in nitrogen; this most often affects maize yield (Carsky & Iwuafor, 1997). High cost of inputs, inappropriate application methods and low supply, limits the use of nitrogen fertilizers. The problem of poor soil fertility in the Guinea Savanna is exacerbated by occasional drought at various stages of crop growth. For maize, drought incidence at the flowering and grain-filling stages can lead to serious yield reduction.

b) Weeds

Findings of research studies and farmers experience in the Northern Guinea and Sudan Savannas of Nigeria revealed that *Striga* infestation has remained a serious pest affecting millet, sorghum, maize, and upland rice (Showemimo et al., 2002). In northern Nigeria, almost all farms grown with maize and sorghum were reported to be infested (Dugie et al., 2009). It was estimated that 10% to 100% of grain of these cereal

crops is lost to *Striga* infestation. In addition to damage due to this parasitic weed, substantial losses are incurred as a result of competition with other weeds.

c) Resource Use Efficiency

In view of the importance of maize as a major staple food in Nigeria, the current low level of maize output which at present stood at 8 million tons is a source of concern for policy makers and farmers. Under this situation, the demand for the commodity is always short of supply, resulting into shortages and price increase. The situation is more worrisome because of the fact that Nigeria's average yield which stood at 1.4 tons/ha is far lower than world average yield of 4.3 tons/ha. It is even lower than some African countries such as South Africa. Several efforts made by the government in Nigeria to tackle the problem of low output, such as the use of enhanced production technology like the use of fertilizer, improved seeds, chemicals and improved farm production practices failed to yield the desirable results. Findings from several studies began to point towards production inefficiency. Low input use efficiency was identified as one of the major constraint to maize output in Nigeria.

d) Climate Change

It is now widely agreed that climate change constitute one of the greatest threat to the world economy. The sub Saharan Africa was projected to be more vulnerable to climate change as a result of decline in rainfall, rise in temperature, extreme weather events and floods; this has serious negative implications for agriculture. In Nigeria and most especially northern Nigeria agriculture is heavily dependent on climate. Evidence of impact of climate change on agriculture in Nigeria showed that crop yield that is highly dependent on climate is declining leading to serious reduction in farm revenue (Bello et al., 2012; Farauta et al., 2011). Maize an important cereal crop grown in northern Nigeria and highly dependent on climate is one of the crops projected to be affected by climate change in Nigeria and all parts of Sub Saharan Africa (Cairns et al., 2013).

Having accentuated the current situation, with regards to maize production in northern Nigeria, the enormity of the problem could be appreciated considering the role of maize to Nigeria's economy. Maize contributed about 6.95 % to crop production GDP in 2012 (NBS 2012). Akimwumi (2014) reported that output from maize was 10.28 million metric tons and provided revenue of ₦259 billion (1.2 billion USD). In 2010 about 7003 tons were imported to supplement local demand. Problem of the study could therefore be stated as; decline in farm revenue as a result of climate change as well as low level of farm output due to inefficient use of inputs were among the major problems of maize production in northern Nigeria (Ajobefun, 2002; Aye & Mungatana 2010; Bosello et al., 2013; Hassan et al., 2012; Ogundele & Okoruwa 2006; Placid, 2000). Findings from several studies have consistently drawn the attention of the world on the impacts and consequences of the world climate. The susceptibility of maize crop to climate change heightens the concern for the impact in Nigeria. Rising average temperature, uncertainty in the trend of rainfall with mixed impact especially in northern Nigeria, increased incidence of drought and floods as well as desertification and reduction in the country's land under forest cover are few but strong evidences of climate change (Farauta, et al., 2011; Oluwunmi, 2009; Anuforom, 2010). Similarly a number of studies Ogunniyi (2011); Sadiq et al., (2013); Aye and Mungatana (2010); Olatomide and Omowumi (2010) and Etim and Okon (2013) linked the low output of maize farms in northern Nigeria to the inefficient use of inputs.

1.3 Research Question

The central question that guided this study is how the impact of climate change affects net revenue from maize production and the factors that contribute to technical efficiency of maize production in northern Nigeria?

1.3 Research Hypothesis

Based on the review of literature, five major hypotheses will guide the study

Null hypothesis H_0 :

- a) Revenue from maize do not exhibit high rate of decline as a result of climate change
- b) Revenue from maize does not decline as a result of marginal rise in temperature and precipitation
- c) Revenue from maize production does not vary as a result of change in climatic scenario
- d) Use of farm inputs does not contribute to technical inefficiency of maize production in northern Nigeria

Alternative Hypothesis H_1 :

- a) Revenue from maize exhibit high rate of decline as a result of climate change
- b) Revenue from maize declines as a result of marginal rise in temperature and precipitation
- c) Revenue from maize varies due to change in climatic scenario
- d) Use of farm inputs contribute to technical inefficiency of maize farms in northern Nigeria

1.4 Study Objectives

The general objective of this study is to analyze the relationship between climate change and net revenue and also to determine the technical efficiency of maize farms in northern Nigeria.

More specifically the study has the following objectives:

- a) To measure the impacts of climate change on revenue from maize production in northern Nigeria
- b) To estimate the impact of marginal change in climate on maize net revenue
- c) To estimate the impact on net revenue from maize under different climatic scenarios
- d) To evaluate the technical efficiency of maize farms
- e) To analyze the determinants of technical efficiency of maize farms

1.5 Significance of the Study

Picture of the emerging threat of climate change on agriculture makes it evident that the economic impact assessment will continue to be a critical component of climate change mitigation and adaptation policies. In Nigeria, although few studies considered the assessment of the economic impact of climate change on agriculture Ajetomobi et al.,

(2011); Odozi et al., (2013); Bosello et al., (2013); Fonta (2011) most of the studies did not focus on cereal crops, which provide the main sources of food in Nigeria. In addition the few studies concentrated only on the southern part of the country. Their assessments are therefore based on areas with uniform climates; this provides a sketchy picture of the impact. Similarly literature from previous studies is nearly silent on the vulnerability of farm revenue to climate change in Nigeria. To provide a comprehensive picture of the situation, an in depth assessment of the impact across northern Nigeria is vital. The current study, which is one the few regional scale studies that cut across agro ecological zones in northern Nigeria, attempted to bridge these gaps, by undertaking to assess the economic impact of climate change on maize revenue.

The study made at least four significant contributions through evaluating economic impact of climate change on maize. First the study contributed to the expanding body of knowledge by assessing the impact of climate change on revenue from maize production. Through deep assessment on how climate change impact affects farm revenue, it is possible to understand more clearly the relationship between farm revenue and climate change; this is expected to provide the best option to tackle the problem. Secondly, lack of sufficient information on the impact of climate change on maize in Nigeria showed that there is wide dearth of knowledge on the subject. The study contributed towards bridging this gap. Another contribution made by the study is providing a picture of how farm revenue from maize production will change with future climate. The ultimate issue underlying this research is how farm adaptation will reduce the impact of climate change. It is anticipated that the study may identify ways through which farm adaptations will contribute in reducing the impact of climate change on farm revenue in the study area. Lastly, the findings of the study are expected to provide adequate knowledge that will serve as a baseline as well as a guide to farmers and policy makers in the area of climate change impact on maize.

Similarly, one additional problem that affects agriculture in Nigeria as identified by previous research effort is low level of farm output. Substantial amount of produce and revenue are lost due to inefficient utilization of farm inputs. Research on technical efficiency of agricultural production in Nigeria is scanty; the few studies conducted do not cover the entire country and considered only few selected crops. As a result insufficient information on the technical efficiency of maize production existed. To raise output, it is necessary to close this knowledge dearth. This study provided a comprehensive assessment of the technical efficiency of maize farmers across many geographical areas in northern Nigeria; to date it is one of the few studies that conducted a regional scale analysis of the technical efficiency of maize production in northern Nigeria. The study is expected to be invaluable in raising the level of technical efficiency of farmers in northern Nigeria by making the following contributions. Findings of the study are anticipated to provide a clear image of the level of technical efficiency of the respondents engage in maize production in the area. Findings of the study are also hoped to provide insight on vital inputs to raise the level of maize output. In addition, socioeconomic factors that contributed to technical efficiency were determined with a view to making improvements. Lastly findings of the study analyzed the level of technical efficiency of the respondents from each agro ecological zone in the area. This is expected to assist the respondents from all the agro ecological zones in improving resource use efficiency.

1.6 Organization of the Thesis

This thesis consists of five chapters which were organized as follows. In chapter one, a brief background of the study was provided; in this part the main problem setting of the research which is climate change was exhaustively described. In the next part, attempt to link the problem with agriculture was made, the importance of agriculture to the world economy and Nigeria was also highlighted. Having done this, the study attempted to give an account of the world wide impact of climate change on agriculture. The focus was then narrowed to the impact of climate change on agriculture in Nigeria. In the section that follows, the problem of the study was identified and stated; this was followed by the identification of the research questions and the study hypothesis. Following the hypothesis is the study objectives; in this part the general and the specific objectives of the research were stated. Lastly, the chapter concluded by a brief description of the significance of the study.

Chapter two was arranged as follows; firstly, an account of the impact of climate change on agriculture was provided under this a brief outline of the Kyoto protocol was made. This was followed by description of the potential methods of measuring the economic impact of climate change on agriculture. Next, the theoretical framework of the study was laid. Under the theoretical framework a detailed analysis of structural Ricardian model was made and the strengths and weaknesses were exposed; this was followed by the specification of the Ricardian model. In the next section, a critical analysis of previous studies that considered the Ricardian methodology was made. In the second part of the chapter, theories of technical efficiency were treated, estimation techniques for both the efficiency and inefficiency effects model were reviewed. Under the same section; merits and demerits of the stochastic frontier approach were examined. Next, potential approaches to measuring technical efficiency were considered. An overview was made of previous studies that measures technical efficiency, this was followed by an overview of previous stochastic frontier analysis and lastly, studies that considered two-step analysis were reviewed.

Chapter three treated the methodology of the study and was structured as follows; in the first part, the area of study was described; this section focused on the description of the geography of the area, its climate and agriculture. Description of the models of study and justification for their application as tools of analysis was also considered in this part. A detailed description of the study variables follows in the next section; under this part both the dependent and independent variables were explained and their measurement briefly described. In the last section of the chapter, the study design and methods were considered under which the procedure for sampling, data collection and data analysis as well as estimation procedure and econometric estimation were discussed.

Presentation, interpretation and the implications of the results were treated in chapter four; the chapter was divided into two main sections. In section one results of the analyses for the study was presented; it began with the results of the descriptive statistics for the study, followed by the Mann-Kendall test. Result of the Ricardian analysis was later presented. It comprised of the result for the marginal impact analysis and analysis of future climate change scenario. Ricardian analysis for small and large farms was also treated. Next section considered the result of the stochastic frontier analysis; this was followed by the results of the Tobit analysis. The result presentation section limits itself to the introduction of the results. In the second part of the chapter

the results were thoroughly and critically discussed, providing detailed interpretation and the implications for the results. The chapter concluded by providing a general overview of the findings and implication for the study.

The last chapter of the study was chapter five. The main highlights of the chapter included a general summary of the major findings of the study, where a brief account of the problem of study, the objectives of the study, methodology and results of the study were made; in the same section the implication and major contribution of the study were elucidated. The general implication for the study was also presented in this part. The meaning, implications and the consequences of the result were also illustrated. Limitations of the study were later presented and expectations for future research were recommended based on the findings of the study. Lastly the chapter ended with a concise but comprehensive conclusion of the analyses for the study.



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