UNIVERSITI PUTRA MALAYSIA

IMPACTS OF CLIMATE CHANGE ON CROP PRODUCTION AND FARMERS' ADAPTATION STRATEGY IN SEMI-ARID ZONE OF NORTH-EASTERN NIGERIA

MAHMUD MOHAMMED BOSE

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By

MAHMUD MOHAMMED BOSE

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

November 2014

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DEDICATION

This work is dedicated to my lovely parents and the entire family for their timeless effort and support in my academic pursuit. I remain highly indebted to you all.

Abstract of the thesis Submitted to the Senate of Universiti Putra Malaysia in fulfilment of the Requirement for the Degree of Master of Science

IMPACTS OF CLIMATE CHANGE ON CROP PRODUCTION AND FARMERS' ADAPTATION STRATEGY IN SEMI-ARID ZONE OF NORTH-EASTERN NIGERIA

By

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November, 2014

Chairman: **Associate Professor Ahmad Makmom Abdullah, PhD**

Faculty: **Environmental Studies**

Climate change and its projected impact on the environment and socio economic systems now constitute the most important environmental problem that faces the North-eastern Nigeria which has been classified as a draught prone zone of the country. As such, it becomes imperative to assess the trend of the climatic variability, as well as its effects on crop production and farmers' adaptation strategies in coping with the changing climate. Data applied in this study were collected from the relevant agencies of the Nigerian government, and a farm level survey data collected in 2012/2013 farming year in the North-eastern Nigeria. The climatic variability was evaluated using mean monthly temperature and rainfall data for the period 1971 – 2010 collected from Nigeria Meteorological Agency. The dataset was aggregated to obtain average yearly values and Mann Kendall test was carried out using XLSTAT software and MAKESENS Microsoft template to calculate the statistical significance of the tendencies at monthly and annual scale.

The findings revealed increase in annual temperature of +0.76 °C from 1971 to 2010 has been recorded in the entire North-eastern Nigeria, whereas annual rainfall has not exhibited any significant trend. In addition, the study detected the impact of climatic variability; changes in temperature, rainfall and relative humidity on the yield of four most commonly harvested crops in the area using Crop time series model. Consistent with the global scenario, it revealed that temperature changes were found to have a discernible negative impact on the yield of all the four crops. However, rainfall and relative humidity were found to have a positive impact on the yield of all the four crops i.e. Sorghum, Millet, Maize and Cowpea. Conclusively, the adaptation strategies used by farmers to cope with the climate change and its associated constraints was identified based on a surveyed data of 400 respondents. Farmers have adopted a variety of adaptation strategies including soil conservation, change in planting date, producing agro forestry product, use of improve crop seedlings, application of mix-cropping, moving to a different site and irrigation practices in other to cope with the changing climate. Also, farmers outlined are the most important barriers to adaptation as a lack of agricultural technology, shortage of farm labour, knowledge on appropriate adaptation strategies, and government support.

Lastly, a Multivariate Probit Model was used to analyse the determinants of farmer's choices of climate change adaptation strategies and there constraints. The results from the Multivariate model highlight that household characteristics such as education, farming experience, household size, farm ownership and size, information on climate change, access to extension services, and access to credit facility are having a significant impact on adaptation to climate change. Thus, the findings provide policy recommendations and action plans to cope with the changing nature of climate change factors.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PERUBAHAN IKLIM TERHADAP PENGELUARAN TANAMAN DAN STRATEGI PENYESUAIAN PETANI DALAM ZON SEPARA GERSANG DI TIMUR LAUT NIGERIA

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Perubahan iklim dan kesannya kepada alam sekitar serta sistem ekonomik sosial kini menjadi masalah utama dalam bidang alam sekitar yang dialami di Timur Laut Nigeria yakni telah dikelaskan sebagai kawasan cenderung kemarau. Tambahan, ianya menjadi keperluan untuk menafsir pola perubahan iklim serta kesannya terhadap pengeluaran pertanian dan strategi pengesuaian petani dalam menyesuaikan diri dengan perubahan iklim. Data yang digunakan dalam kajian ini telah dikumpulkan dari agensi dalam kerajaan Nigeria yang berkaitan serta data kaji selidik dikalangan petani dikumpulkan bagi dua tahun tempoh penanaman pada 2012 hingga 2013 di Timur Laut Nigeria.Perubahan iklim telah ditafsir mengunakan min suhu dan taburan hujan bulanan untuk tempoh 40 tahun (1971-2010) yakni telah dikumpulkan daripada Agensi Meteorologi Nigeria. Set data tersebut telah diagihkan untuk memperoleh nilai purata tahunan dan kemudian mengira kecenderungan kepentingan statistik untuk skala bulanan serta tahunan dengan penggunaan aplikasi ujian *Mann Kendall* daripada perisian *XLSTAT* dan contoh daripada *MAKESENS Microsoft*.

Keputusan yang diperoleh membuktikan bahawa peningkatan suhu tahunan adalah sebanyak +0.76 °C daripada tahun 1971 hingga 2010 yang telah direkodkan di seluruh Timur Laut Nigeria, manakala taburan hujan tahunan pula tidak menunjukkan sebarang pola yang ketara. Sebagai tambahan, kajian ini memerhatikan kesan perubahan iklim; perubahan suhu, taburan hujan dan kelembapan relatif pada pengeluaran 4 jenis tanaman utama yang dituai di sesuatu kawasan dengan menggunakan model siri masa penanaman. Selari dengan peristiwa global, didedahkan bahawa perubahan suhu didapati mempunyai kesan negatif kepada pengeluaran kesemua empat jenis tanaman utama tersebut. Walau bagaimanapun, taburan hujan dan kelembapan relatif didapati memberikan kesan positif terhadap pengeluaran keempat-empat tanaman iaitu *Sorghum, Millet,* jagung dan *Cowpea*.

Kesimpulannya, strategi penyesuaian yang digunakan oleh petani untuk menyesuaikan diri dengan perubahan iklim dan faktor-faktor penyekang telah dikenalpasti berdasarkan data kaji selidik daripada 400 orang responden. Para petani telah menyesuaikan diri dengan pelbagai jenis strategi penyesuaian termasuk pemuliharaan tanah, penukaran tarikh penanaman, penghasilan produk agro-perhutanan, penambahbaikan baka tanaman, penggunaan penanaman campuran, perpindahan ke tapak lain dan menjalankan pengairan tanaman sebagai usaha menyesuaikan diri dengan perubahan iklim. Selain itu, kefahaman para petani adalah penghalang utama dalam penyesuaian diri disebabkan oleh kurangnya teknologi agrikultur, tenaga petani, pemgetahuan dalam bidang strategi penyesuaian diri serta bantuan daripada kerajaan. Akhir sekali, Model *Multivariate Probit* telah digunakan untuk menganalisa faktor penentu pilihan petani dalam strategi penyesuaian perubahan iklim serta faktor penghalang. Keputusan yang diperoleh dari model *Multivariate* merumuskan bahawa ciri-ciri isi rumah seperti pelajaran, pengalaman bercucuk tanam, saiz isi rumah, saiz ladang dan hak milik, pengetahuan mengenai perubahan iklim, perlanjutan perkhidmatan dan kemudahan pinjaman untuk pertanian memberikan kesan yang penting terhadap penyesuaian kepada perubahan iklim. Oleh yang demikian, hasil yang diperoleh menyediakan cadangan polisi dan pelan tindakan dalam penyesuaian kepada perubahan alam sekitar ekoran daripada faktor-faktor perubahan iklim.

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I certify that a Thesis Examination Committee has met on 21 November 2014 to conduct the final examination of Mahmud Mohammed Bose on his thesis entitled "Impacts of Climate Change on Crop Production and Farmers' Adaptation Strategy in Semi-Arid Zone of North-Eastern 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 Master of Science.

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LIST OF ABBREVIATIONS

ADP	Agricultural Development programmes
CERES	Crop Environment Resource Synthesis
ECM	Error Correction Model
ECT	Error Correction Term
FAO	Food and Agriculture Organization
FMOE	Federal Ministry of Environment
GCM	General Circulation Model
GHG	Green House Gases
GLAM	General Large Area model
IIA	Independent of Irrelevant Alternative
IITA	International Institute for Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
NACB	Nigerian Agricultural Credit Bank
NALDA	National Agricultural Land Development Authority
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Statistics
NIMET	Nigeria Meteorological Agency
OFN	Operation Feed the Nation
SWAT	Soil and Water Assessment Tool
SSA	Sub-Sahara Africa
VECM	Vector Error Correction Model

CHAPTER 1

INTRODUCTION

1.1 Introduction

Climate change is one of the most serious environmental threats that have been facing mankind throughout the world. This has been a great challenge in sub-Saharan Africa and has been attributed to natural climate cycle and human activities. The region is characterised by frequent occurrence of rainfall patterns shift, planet warms, and extreme climatic shocks such as droughts, floods, and forest fire. The intensity of climate change is expected to have serious economic and social impacts on man and his environment particularly among the rural farmers, whose livelihood depends on rain fed farming. These tend to have an adverse effect on food production in the region (Nicholson, 2013).

The predominance of the poor population in Africa are farmers. They are naturally exposed to adverse effect of climate change. Zoellick (2009) reveals the farmers in the region are faced with decline in agricultural productivity, drastic crop failures, increased in hunger, malnutrition and various forms of contiguous diseases. The literature suggest that that crop yield in Africa may decrease by 10-20% by the year 2050 or even up to 50% due to overdependence of farmers in the region on subsistence rain-fed farming, which its productivity solely depends on climate change (Alexandratos & Bruinsma, 2012). This has been the cause of poor yields and low level of agricultural productivity in the region. Hence, the farmers become more vulnerable to poverty.

The climate change phenomenon in Africa threatens vulnerabilities, poverty and seriously undermine prospects for development (Vander et al., 2011). This aggravates the existing vulnerabilities of the poorest people who depend on subsistence rain fed agriculture for the sustenance of their livelihood. Hence, It is now well recognized that Agricultural production is very sensitive to climate change (Christensen et al., 2007; Nelson, et al., 2009). It is expected that the adverse effect of climate change on agricultural productivity will increase the incidence of rural poverty in many African countries as many rural people depend on agriculture as the means of sustaining their livelihood (Dinar et al. 2008). Hence, the African smallholder farmers have no alternative than to adapt to the climate change and its variability to maintain their wellbeing.

The farmers employ various forms of agricultural systems and practices to meet the changes in financial and physical conditions caused by the climate change. They adopts new innovations, changing yield mixtures and institutional courses of action to acclimatise with the situation (IPCC, 2007). Variations in temperatures and rainfall patterns as well as an increase in carbon dioxide (CO_2) levels are expected to affect agriculture, especially in tropical regions. Such changes may manifest in the reduction of land quality and low agricultural yields due to increasing temperature. This is likely to have substantial negative impacts on level of agricultural productivity in the region. The agricultural productivity will be affected by the changing climate due to its interlink with the climatic factors such as temperature,

solar radiation, and precipitation. This called for urgent need to educate farmers regarding the potential impacts that may arise as a result of the changes. It also requires an individual commitment, government assistance, increased in investments and financial resources, and enhancement of local and national capacity.

The extent to which climate change affects livelihood of the farmers depends to a large extent on the level of their awareness as well as intensity of their adaptation in response to climate change (Dinar et al. 2008). Awareness of farmers on the effects of climate helps in the proper understanding of farmers' attitude towards choosing adaptation strategy to cope with the adverse effect of climate change.

In the Nigerian context and most of the countries in the Sub-Saharan Africa, the agricultural sector is prone to climate change due to unpredictable changes in weather condition. The literature suggest that the smallholder farmers, livestock holders, , women, elderly, children, poor households, women headed households, illiterates, and those with low technological-know-how are more likely to be exposed to threat of climate change in the country (FMOE, 2010). This situation is further aggravated due to overdependence on rain-fed agriculture couple with lack of capacity to diversify into other activities in the country.

The adverse effects of climate change in Nigeria and other Sub-Sahara African countries could be in form of drought, environmental degradation, pest and diseases, rural-urban migration, depletion of household assets, decline in soil conditions increased in health risks, spread of infectious diseases, biodiversity loss, depletion of wildlife and other natural resource base and change in livelihood systems(Apata, 2010). This portrays that there is the need for concerted efforts toward tackling the menace of the adverse effect of climate change on livelihood of farmers in the country. On this basis, this study aimed at examining the impacts of climatic variability on crop production and farmer's adaptation in the Semi-arid zone of North-eastern Nigeria.

1.2 Problem Statement

The incidence of climate change in the country is increasingly observed with many farm lands becoming less fertile as a result of variations and instability of weather condition. This situation often worsens the wellbeing of farmers in the country, which are predominantly poor with limited information and resources for the adaptation to climate change. It is predicted that in some African countries which Nigeria is among climate change would decrease rain fed crop yields by about 50 percent. The impact of climate change on smallholders livelihood in the region is could be disastrous due to continue decline in the level of agricultural productivity coupled with the lack of effective insurance facilities in the region (Maddison, 2007; Nelson et al., 2009).

Although several studies have been undertaken to examine the impact of climate change on Agriculture and farmers wellbeing in Nigeria (Apata, 2009; Odjugo, 2010, 2011). However, the made mention studies failed to investigate the adaptation strategies opted by farmers in the country with their associated constraints. They focused more on the monetary impact of climate change and suggest adaptation strategies. Secondly, current studies have focused on aggregate national level data

while studies using disaggregate data are also important in understanding at regional and state level. Thus, this may lead to a biased estimate on the effect of climate change on agriculture due to differences in the climatic condition in the country. Thirdly, they overlooked the effect of climatic variability on the yield of agricultural product in the country.

Fourthly, there are studies in the literature that have attempts to analyse the impact of climate change on agricultural productivity and the factors affecting farmers decision in choosing adaptation strategies related to methods of crop production, livestock rearing and production systems in Nigeria and other African countries (Alexandratos & Bruinsma, 2012; Boko et al. 2007; Christensen et al., 2007; Dinar et al. 2008; Nelson et al., 2009; Nelson, et al., 2009b). However, results from these existing studies are obtained from aggregated countries data. As such their result is insignificant in identifying country specific effects. The partial assessment of the current studies also provides little insight into the level of awareness of the farmers on adaptation strategies and how do they use it to cope with the climatic change for improvement in their wellbeing. To better address the adverse effects of climate change on the wellbeing of the farmers in the country, it becomes imperative to address the existing gaps in the literature.

1.3 Research Questions

The research questions for this study were drawn after extensive literature review of related studies. The negative effect of climate on farmers' livelihood can be reduced through effective adaptation strategies. This requires involvement of the local community. In response to the climate change, the small scale farmers in farming communities of Northeastern Nigeria practice various adaptation methods to enable them cope with its adverse effect. Some of these adaptation methods are said to be perform efficiently, some moderate, while some fail along the line.Thus, there is need for an in-depth investigation so as to answer the question;

1. What is the trend of the climatic variability?
2. The effect of the climatic variability on crop production
3. What are the opted adaptation strategies and their associated constraints among the small scale farmers?

1.4 Objectives of the Study

The general objective of this study is to examine the impacts of climate change on crop production and farmers' adaptation in semiarid zone of North-eastern Nigeria

Specific Objectives

1. To assess the trend of the climatic variability
2. To evaluate the effects of climatic variability on crop productivity

3. To explore the adaptation strategies used and its associated constraints

1.5 Significance of the Study

This study will contribute to the growing literature on climate change. It will also provide empirical evidence on the effects of climate change on agricultural productivity and on choice of adaptation strategies in rural Nigeria, where about 85percent of the population are subsistence rains fed farmers. To improve on the existing studies this study uses the disaggregated data, while the current studies have given attention to only global and national scale. However, the disaggregated data can serve as a vital instrument in understanding adaptive capacity of farmers at the local level. This is particularly important in the Nigerian context giving the heterogeneity nature of its weather condition.

The rural communities which are largely inhabited by small scale farmers have also the largest stake in developing how they cope with climate change, and understanding how they are currently using adaptation strategies to cope with climate change should be the basis for future action. The findings will also be used as a tool for developing strategies for mitigating the menace of climate change in the study area. It will assist in creating awareness among the farmers. The conduct of the research work is by all standards timely and justifiable since this is the first time work of this nature will be carried out in the study area. Also, knowledge of the associated constraints will assist government in evolving policy that will strengthen adaptation through investing on these factors.

1.6 Scope of the Study

The scope of this study is to assess the adaptation strategies to climate change-among farmers in the North-eastern Nigeria. Specifically, the exact spatial scope of the study covers Ganjuwa in Bauchi state, Biu in Borno state, and Ganye in Adamawa state. The target population is the farmers with emphasis on assessing their awareness on climate change issues as it affects crop production, the adaptation strategies they use in coping to the changing climate and this could be verified via its effect specifically on farming activities in the study area. Methodologically, co-linearity between the major climate variables that are known to affect crops limits the application of the crop time series model in this study. Multi co-linearity is common problem in statistical analysis, and often makes it impossible to attribute yield changes to a single variable.

1.7 Organisation of the Thesis

This thesis is organized into five chapters. The first chapter discusses the global trend of climate change and its effect on the African continent and Nigeria. The implication of this on agriculture, need for farmers' adaptation to the changing climate, the objectives of the study and the limitations.

Chapter two elaborates the general theories on climate change, its effect on agricultural productivity, adaptations theories and strategies, methodologies and approaches used, the driving factors as well as the model that have been successfully used in the study of farmers adaptation in respond to the changing climate. The constraints to adaptation and the agricultural policies in Nigeria were also highlighted.

Chapter three focuses on the description of the study area, data acquisitions, sampling tools and the statistical analysis of the drivers of adaptation to the changing climate. Methodologies used for estimating the effects of climatic variables on crop production, and the climatic variability of the study area where also discussed in this chapter.

Chapter four describes the results obtained from this study. This chapter also presents the changes in climatic variability and its effects on the crop production, farmers' variability index, adaptations strategies and associated constraints to adaptation.

Chapter five elaborates on the major findings of the study, shortcomings in the study and also presents recommendations for future studies.

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