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New Technologies and Yam Production Efficiency in Nigeria: Potential for Improved Farm Household Wellbeing

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Abstract

Nigeria is an agrarian economy with over seventy percent of the population engaged in agriculture. However, the nation depends heavily on food imports. Nigerian food producers are predominantly resource-constrained poor farmers, who are the most food insecure. Nigerian agriculture is chiefly conducted to meet household food requirement but is gradually transitioning to semi-subsistence agriculture.

Agriculture was once the mainstay of Nigeria. The Nigerian agricultural sector was abandoned for the oil sector in the early 1970s. This neglect has negative consequences on the country's agriculture. Presently, Nigerian agriculture is characterized by low performance. Nigeria, once a net food exporter has become a net food importer.

With a view to enhancing the performance of Nigeria farmers, improved technologies have been developed and disseminated to farmers. In spite of this, there is food insecurity and poverty intensification in the country. This raises the questions whether or not farmers are adopting these technologies and the efficacy of these technologies in enhancing farmer performance and alleviating poverty in the country.

Yam is a significant crop in Nigeria. It is a highly prized crop in the country. It has sociocultural, medicinal, nutritional and economic value. It is nutritionally superior to comparable crops including sweet potato and taro. Notwithstanding, yam farmers in Nigeria are performing poorly. Yam production in Nigeria is mainly impeded by high cost, unavailability of planting material, and over reliance on labour-intensive traditional yam production methods which are expensive, encourage the use of low quality planting materials, and inhibit mechanization of yam production. Yam Minisett Technology (YMT) is an on-farm yam multiplication technique which enables development of high quality planting materials for yam production.

The aim of this project is to ascertain the potential of new technology and increased farmers efficiency for wellbeing improvement with reference to yam production and YMT in Nigeria. The specific objectives of this project are to: (i) describe yam production in Nigeria; (ii) compare farm activities and yam production systems in Nigeria; (iii) examine indicators and determinants of performance of yam producers (performance indicators being technical and

economic); (iv) examine the role of technology adoption on farmer performance and wellbeing; (v) assess the superiority of seed yam from YMT over other planting materials; and (vi) ascertain determinants of adoption of improved technology.

A multi-stage sampling technique was adopted to elicit cross-sectional data from three hundred and sixty yam farmers (120 respondents per State) in three yam-producing States of Nigeria. The States were Benue, Enugu and Ondo. The States are located in different agro-ecological zones of Nigeria and use different methods for yam production. Data were drawn from two Local Government Areas (LGAs) in each State. The LGAs were Katsina-Ala and Buruku in Benue State, Nkanu-east and Uzo-Uwani in Enugu State, and Ose and Owo in Ondo State.

Primary and secondary data were used in this investigation. Primary data were collected from the respondents by using a well-structured questionnaire, direct observation and by interviewing farmers. Secondary data were obtained from databases, websites and literature. Data collected include socioeconomic data, resource endowment and utilization data, input and output data, data on farming systems and techniques, attitudinal data, environmental data and health data.

Data were analyzed with descriptive statistics, econometrics and economic models. Descriptive statistics were used to describe yam production. An econometric model (stochastic frontier analysis) was used to evaluate the indicators of performance of yam farmers. Two functional forms, the Cobb-Douglas and the Translog production and cost functions, were used to investigate the production and cost of yam. The models were compared for goodness-of-fit. The best functional form was used to determine the technical and economic efficiency and factors influencing efficiency. Metafrontier analysis was used to test the presence of environment/technology gaps between States. The impact of YMT adoption on yam farmer performance was investigated using Propensity Score Matching. Factors influencing adoption were determined with Probit model. Gross Margin (GM) analysis was used to determine the profitability of yam with and without YMT. Partial budgeting was also performed to confirm the profitability of YMT. Net return was used to compare the yam cropping systems.

The stochastic frontier analysis showed that, on average, Nigerian yam farmers in those States were not fully efficient in yam production. Benue State was technically efficient in yam production. Both Benue and Enugu yam farmers were relatively economically efficient. The performance (technical and economic efficiency) of Nigerian yam farmers is influenced by farmer's socioeconomic profile, decisions, and access to inputs and facilities. Yam production is affected by farm size, quantity of planting material, labour and capital input. Cost of yam is determined by output, capital input, rent on land, planting material, wage rate and price of fertilizer.

The result of the metafrontier analysis revealed that the production environment and technology for yam differ between States in Nigeria. Benue and Ondo States have more favourable environments for yam production. Enugu yam farmers are operating in a more restrictive environment.

GM analysis established that yam production is relatively profitable. Yam had a higher GM than other root and tuber crops. Yam/Maize is the most profitable cropping system in Nigeria. Embracing Yam/Maize intercrop and increased investment in yam production can contribute to improving the poverty status in Nigeria.

The adoption of YMT has the potential to improve farmer performance and wellbeing in Nigeria. YMT is a viable seed yam production technique. Yam production using YMT is more profitable than the traditional yam production techniques. Adopters of YMT in Nigeria outperformed non-adopters.

Declaration

I hereby declare that this thesis comprises only the original research work towards the Degree of Doctor of Philosophy and has not been presented for any other award. To the best of my knowledge due acknowledgement has been made in the text to all other material used. This thesis comprises no more than 100,000 words.

I have published the following papers from this thesis:

Amaefula A., Farquharson, R., Ramilan, T. and Asumugha, G.N. (2018). Evaluation of yam-based production enterprises in Nigeria, *The Nigerian Agricultural Journal*49 (1): 260-265 Available at: http://www.ajol.info/index.php/naj.

Amaefula A., Farquharson, R., Ramilan, T. and Asumugha, G.N. (2018). Limitations to yam production enterprise development in Nigeria, *The Agricultural Economics and Extension Research Studies* 6 (2):95-104

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Acronyms

AE	Allocative efficiency
ANOVA	Analysis of Variance
ATE	Average Technical Effect
DEA	Data Envelopment Analysis
EAs	Extension Agents
EE	Economic Efficiency
EMTR	Environmental Meta-technology Ratio
FAO	Food and Agricultural Organization
FOS	Federal Office of Statistics
g	grams
GDP	Gross Domestic Product
GM	Gross Margin
ICTs	Information Communication Technologies
IITA	International Institute of Tropical Agriculture
Kg	kilograms
LGA	Local Government Area
LLF	Log Likelihood Function
LR	Likelihood Ratio
LSD	Least significance difference
MLE	Maximum Likelihood Estimate

MPF	Metafrontier production function
MT	Metric tonnes
MTR	Meta-technology ratio
NBS	National Bureau of Statistics
NBS	National Bureau of Statistic
NPC	National Population Commission
NRCRI	National Root Crops Research Institute
OLS	Ordinary Least Squares
OPEC	Organization of Petroleum Exporting Countries
PSM	Propensity Score Matching
R&D	Research and Development
R&E	Research and Extension
SDGs	Sustainable Development Goals
SFA	Stochastic Frontier Approach
SPSS	Special Package for Social Scientists
TE	Technical efficiency
TE-MF	Technical efficiency of the metafrontier
TE-POOL	Technical efficiency of the pooled frontier
TE-REGION	Regional technical efficiency
TGR	Technology gap ratio
USD	US dollar
YMT	Yam Minisett Technology

Chapter One

1.0 Introduction

1.1 Background of the study

There is global food insecurity and poverty which can be attributed to poor performance of agricultural sectors in developing countries (Gitu, 2006). The majority of the world's poor are farmers who reside in the rural areas of developing countries (Dixon et al., 2001). Paradoxically, farmers are the most food insecure in Nigeria (Otaha, 2013; World Food Programme, 2015). These farmers are unable to produce adequate food for their families (Otaha, 2013). Improving farmer performance will contribute to food security and poverty alleviation in these countries.

Studies have shown that people earning their living from agriculture in developing countries are poorer than those who work in other sectors of the economy (Cervantes-Godoy & Dewbre, 2010; Vu & Glewwe, 2011). Asogwa (2012) reported a positive relationship between poverty and farm income in Nigeria. This supports the idea that farmers are poorer than those in other sectors of the economy and raises doubt about the profitability of agriculture in the developing countries. However, Serumaga-Zake and Naude (2002) argued that rich households are more likely to take investment risks than poor ones; therefore, they have higher earnings than the poor ones. The vast majority of farmers in developing countries are resource-constrained. An implication of this is lack of access to farm inputs such as land that could enhance farmer performance and wellbeing by increasing their chances of making more money and escaping poverty (farmer and farm family livelihood enhancement through performance improvement). Consequently, the farmers remain in poverty due to low investment in agriculture.

As earlier stated, farmers in developing countries are poor and resource-constrained. It is crucial to enhance the efficiency (ability to optimize output with a given input level) of farmers in Nigeria to enable them produce adequate food for their families and escape poverty. Optimizing the use of limited resources is a means of performance improvement of farmers (Singh, 2014). Enhancing the performance of farmers with the limited resources available to them will depend mainly on how technically, and economically efficient the farmers are. Improved economic efficiency among rural farmers, *ceteris paribus*, will lead to increase farmer income (Singh, 2014), better standard of living and poverty eradication. The estimation of technical efficiency enables policy makers and managers of farms to enhance performance through better farming practices. Efficiency studies can lead to the improvement in farm practices thereby enhancing both individual performance and the performance of the entire agricultural sector. Assessing the efficiency of Nigerian yam farmers will provide insight for optimal yam production; it will enable the production of yam in a cost effective manner. Research on efficiency in yam production will guide farmers on resource allocation and government on root and tuber crop enterprise development.

The operating environment and technologies used by farmers in the same enterprise differ. Technology appropriate for use in a region may not be ideal in another. Evaluating the performance of such enterprises without accounting for the impact of the environmental and/or technological constraints, could be misleading. Metafrontier analysis considers the impact of the environment and technology on technical efficiency (TE). Estimating the effect of variation in technology /environment among regions is required to enable researchers to tailor technologies to farmer's resource and environmental conditions (Mariano et al., 2010).

There is proliferation of efficiency studies in Nigeria. However, these studies fail to include the influence of the environment and technology on efficiency. As such, these could lead to bias evaluation of firms. Also, these studies would not lead to the development of location specific technologies. This current study is one of the pioneer studies that considered the effect of the environment/technology in evaluating the TE of farmers in Nigeria.

In addition to improving farmers' efficiency, an appropriate farming system /technology can improve farmer performance. The trend in profitability analysis in Nigeria is usually to determine the profitability of a particular crop or cropping system in a given region (for example, Asala & Ebukiba, 2016; Ibitoye & Onimisi, 2013). None of the earlier studies in Nigeria has compared the economic viability of the major crops in yam enterprise and the intercropping systems for yam. This present research evaluated the major cropping systems for yam in Nigeria to identify the most profitable intercrop. It also compares the profitability of the main crops in yam production enterprise. This analysis will identify the most profitable crop in yam production enterprise. It will also suggest the ideal intercrop for yam.

In a bid to ensure food security, new technologies have been developed and disseminated to farmers (Sanginga, 2015; Arokoyo, 1996). In spite of this, global food insecurity and poverty persist. There is the need to ascertain whether farmers are adopting new technologies and the efficacy of these technologies in improving farmer performance and reducing poverty. Most adoption studies in Nigeria are focused on the rate of adoption and factors influencing the adoption of technologies. The few studies that investigated the impact of technology on wellbeing/performance have failed to consider the counterfactual situation of such technologies, that is what the situation would be if technologies were not adopted (for instance, Adofu et al., 2013). Evaluating the impact of a technology without taking into account the counterfactual situation of the technology often gives misleading results (Wu et al., 2010, Mendola, 2007). This has hindered agricultural technology advancement in Nigeria. This present study employed Propensity Score Matching, a more appropriate method (Wu et al., 2010; Mendola, 2007), to determine the impact of YMT, a rapid seed yam multiplication technology, on yam farmer performance.

Studies have shown low adoption of YMT in Nigeria (Waziri, 2014). It is vital to assess the technology to confirm its economic viability and the reasons for its poor adoption. Economic studies on profitability of YMT in Nigeria, for instance Eyitayo et al. (2010), failed to compare this technology with the traditional methods to affirm its superiority over the already existing methods. This present study evaluated all the planting materials used for yam production in Nigeria. This is to confirm the superiority of YMT over the traditional planting materials for yam production in Nigeria. Establishing the advantage of YMT over the traditional yam methods will provide better information for farm and policy decisions.

1.2 The Nigerian economy

Nigeria is the most populous country in Africa, with a population of over 182 million people in 2015 (World Bank, 2017). It is a low-middle income country (The USAID

Land Tenure and Property Management, 2010; World Bank, 2015) and ranked 158 out of 182 developing countries in the United Nation Human Development Index for 2007 (The USAID Land Tenure and Property Management, 2010). Sixty-four percent of Nigerians live on less than one US dollar (USD) a day (The USAID Land Tenure and Property Management, 2010).

Nigeria is an agrarian economy with over 70% of the population engaged in agriculture (Yakubu and Akanegbu, 2015). A large proportion (52%) of Nigerians resides in rural areas (The USAID Land Tenure and Property Management, 2010). Most of these are poor and gain their living from agriculture (Mogues et al., 2008). In spite of the percentage of people engaged in agriculture, the country still depends on food imports. It spends over USD9.28 million daily on food importation (Olusoji et al., 2014). The country's industrial sector is mainly oil extraction and refining, which employs approximately 10% of the working population (Economy Watch, 2015).

The agricultural sector has played a significant role in the economic development of Nigeria. It dominated the economy in the mid-1970s (Trading Economics, 2015), contributing approximately 50% to Nigeria's Gross Domestic Product (GDP) (Olaniyi et al., 2015). However, its contribution to Nigerian GDP has been declining; it contributed 23% to the GDP in 2015 (National Bureau of Statistics (NBS), 2016).

There is potential for agricultural development in Nigeria (Inter-Reseaux, 2010; Chinedu & Okoro, 2009). However, this has not been harnessed to develop a sustainable agriculture. Nigeria has substantial agricultural resources (Inter-Reseaux, 2010; Chinedu & Okoro, 2009); it has fertile land (Yakubu & Akanegbu, 2015) and a wide range of climatic conditions that allow for production of a variety of food and cash crops (Asadu & Asadu, 2015; Inter reseaux, 2010). Nigeria has a land area of 909,890 square kilometres (NBS, 2010) and over 80% of the country is suitable for farming (The USAID Land Tenure and Property Management, 2010).

Nigeria is endowed with both natural and human resources (Nkwede, 2014). It is the sixth largest world exporter of oil (Central Intelligence Agency, 2016). The country exported over 2.2 million barrels per day (bbl/day) in 2013 (Central Intelligence

Agency, 2016). The petroleum export revenue represents over 90% of the total export earnings (Organization of the Petroleum Exporting Countries (OPEC), 2017). Nigeria had a GDP at market prices of approximately USD 484.6 million in 2015 (OPEC, 2017).

1.3 Yam production in Nigeria

Yam is a major staple widely accepted and consumed in Africa. All ethnic groups of Nigeria cherish and consume yam. Nigeria is the leading yam producing country (Food and Agricultural Organization (FAO), 2015). Although yam production in Nigeria has risen over time (FAO, 2012), yield has been declining (Ikeh et al., 2012). Increased yam production is due to expansion of land area under yam cultivation. Figure 1.1 presents Nigerian yam production and area harvested from 2008 to 2018. The Figure shows that the area of yam harvested and yam production have been increasing over time. However, there was a decline in yam production between 2017and 2018.

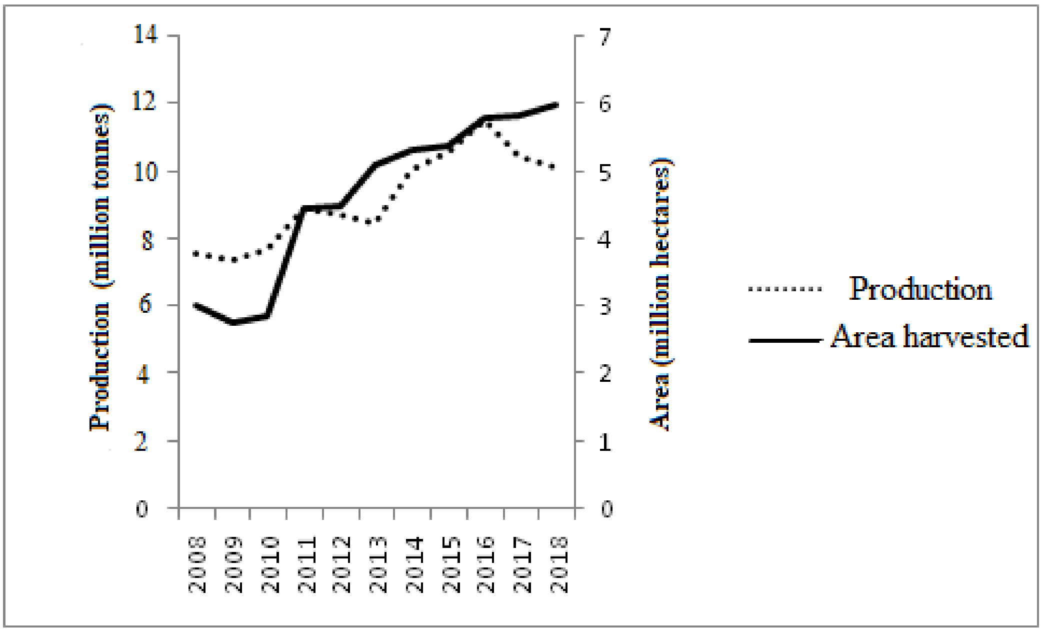


Figure 1.1: Nigerian yam production and area harvested from 2008 to 2018
Source: (FAO, 2020)

Yam contributes to wealth and food security of the people of sub-Saharan Africa but yam yield has declined. Figure 1.2 shows Nigerian yam yield and area harvested from 2005 to 2014. It reveals that yam yield and area harvested were undulating between

2005 and 2010. Yam yield decreased while area harvested increased in 2011. Decreasing yam yield will worsen the poverty status of farmers in Nigeria.

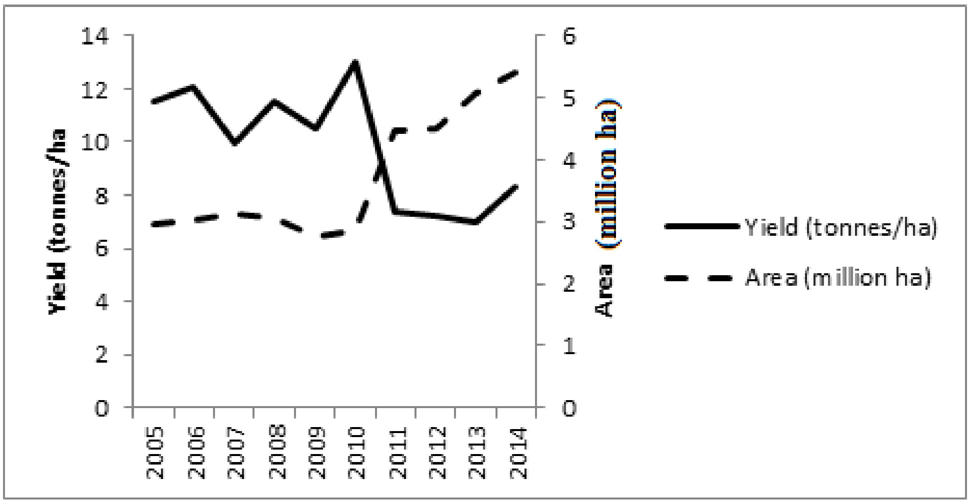


Figure 1.2: Nigerian yam yield and area harvested from 2005 to 2014
Source: FAO, 2017a

1.4 Objectives

Food situation and the conditions of Nigerian farmers are critical. Most previous studies have failed to proffer solution to the problem of food insecurity in the country due to the use of inappropriate methods. The persistent food insecurity in Nigeria has raised doubts about the potential of new technology to improve farmer performance and wellbeing. The aim of this study is to investigate the efficiency of yam farmers and the efficacy of new technology to improve farmer performance and wellbeing.

The specific objectives are:

1. Describe and compare yam production systems in the States;
2. Examine indicators and determinants of performance of yam producers. Performance indicators are technical and economic efficiency;
3. Examine the role of technology adoption on performance and wellbeing improvement, and to ascertain determinants of and constraints to adoption of improved technology.

1.5 Significance of the study

This research investigates the current level of yam farmer efficiency in these States (taking into consideration the influence of the environment on farmer performance) and how these could be improved. Efficiency studies enable researchers to test the presence and level of inefficiency in production (Ajibefun, 2003). They enable quantification and comparison of levels of efficiency. Efficiency studies are currently an important area of interest in the field of socioeconomics in Nigeria. The major methodological focus has been on estimating the efficiency and socioeconomic determinants of efficiency of a particular commodity in a State using the Stochastic Frontier or/and Data Envelopment Analysis (Anyaegbunam et al., 2016). These studies ignore the effect of differences in environment and technology on the performance of farmers. These earlier results are not detailed and cannot make suggestion on farmer performance improvement with regards to variation in environment and technology. An analysis which incorporates environmental differences or context is likely to be valuable. This research is an innovative study which aims to determine the influence of environmental factors and technological constraints on farmer efficiency in Nigeria. The Environmental Meta-Technology Ratio (EMTR) determined by this research will enable a comparison of environmental/technological effects on yam production efficiency.

New technologies have been developed and disseminated in Nigeria (Sanginga, 2015; Arokoyo, 1996), including YMT, with the view to curb the problem of scarcity of seed yam. The main idea of YMT is to multiply seed yam for yam production (see description of YMT in section 1.5). Previous studies on YMT in Nigeria were mainly to ascertain rate of adoption of the technology, determinants of adoption, and profitability of the technology. Few studies evaluated the impact of a technology on production performance and wellbeing (for instance, Adofu et al., 2013). However, the methods used by these previous researchers to evaluate the impact of technologies on production performance and wellbeing can give misleading results since they do not take into account the counterfactual situation of the technology (Mendola, 2007). Researchers need to ensure that the changes made by adopters are caused by the use of a technology rather than due to other factors that could influence the performance of the farmers. This current research uses an appropriate method to evaluate the impact of a technology on farmer performance in yam production.

This thesis determines the extra cost and benefit arising from the use of new yam technologies. This will reveal the ability of these technologies to improve the wellbeing of farmers; and the relevance of Research and Extension (R&E) in achieving food security and alleviating poverty.

This research is conducted to provide improved information as a basis for policy decisions. It will be relevant to governments in decision making towards realizing sustainable agricultural development and food security. Information provided by this research will inform governments regarding the current situation of yam farming and enable the formulation of accurate policy for yam enterprise development and food security in Nigeria.

This project will contribute to improving the wellbeing of farmers. Yam production is expensive. This research can enable yam production at reduce cost, thereby leading to a more profitability yam production and improved wellbeing of farmers in Nigeria.

1.6 Research questions

This research will provide answers to the following questions:

1. What is the contribution of yam to farm income?
   a. Is yam production a profitable enterprise?
   b. What benefits do yam farmers derive from yam production?
   c. What are the limitations to yam production in Nigeria?
   d. What are the determinants of yam output and cost of yam?

2. Are yam farmers technically and economically efficient?
   a. How efficient are yam farmers?
   b. What are the determinants of efficiency?
   c. Does regional difference in technology and environment affect farmer performance?

3. Can adoption of improved technologies influence farmer wellbeing and performance?
    a. What are the extra costs and benefits derived from YMT?
    b. What impact does adoption of YMT have on farm profit?
    c. How does the adoption of YMT improve farmer performance?
    d. What are the limitations to adoption of YMT?
    e. What are the determinants of adoption of YMT?

1.7 Hypotheses

The hypotheses tested are:

1. There is a positive relationship between inputs and yam output;
2. Yam output and the prices of inputs significantly affects the cost of yam;
3. Yam farmers are technically and economically efficient;
4. Efficiency is significantly influenced by the socioeconomic profile of farmers;
5. Access to facilities has a significant effect on efficiency of farmers;
6. Farmer decisions have a positive relationship with efficiency;
7. There are regional differences in environment and technology;
8. The socioeconomic characteristics of farmers affect the adoption of YMT;
9. There is no significant difference in efficiency between farmers who do or do not use YMT.

1.8 Thesis overview

Chapter One provides an introduction to this research work. It contains background information of the work which includes the underlying problems, the significance of yam, and the way forward to improving the performance and wellbeing of resource-constrained farmers. This chapter also contains the objectives, research questions, hypotheses and the thesis overview by chapter.

Chapter Two focuses on issues relating to poverty and food production in Nigeria. It describes the current poverty and food situation in the country, contribution of agriculture to economic development of the country, funding of research and extension. The chapter also contains Nigerian agricultural policies and their relevance, and how to boost food production in the country.

Chapter Three gives an overview of the yam industry in Nigeria. It reveals the significance of yam in the country. It details the agronomic practice of yam; the current situation of yam farming; and key issues in yam production, including land use for yam production, availability of planting materials, yam storage and marketing systems. Yam production techniques and new yam technologies are explained. This chapter also unfolds the potential of yam production enterprise and the limitations to yam production in Nigeria.

Chapter Four focuses on the research framework. In it are the theoretical, empirical and analytical frameworks. Efficiency and adoption theories are discussed. Concepts and terms are also defined in this chapter.

Chapter Five concerns data and method. It explains how the project was conducted and data used for the project. This chapter also contains the sampling procedure, method of data collection, analytical procedure, model specification, and hypothesis testing.

Chapter Six describes yam production in Nigeria, particularly in these three States. The characteristics of yam producing households are revealed. This chapter also shows the production and cost factors employed in yam production. Land issues including land fragmentation, flooding and other soil conditions are discuss. The benefits derived from yam production and the constraints to yam production are also presented.

Chapter Seven discusses the indicators of performance (technical and economic efficiency) of yam farmers and determinants are also discussed. Efficiency estimates of the respondents are determined. The determinants of technical, economic efficiency are ascertained, and elasticity and return to scale computed. The relationship between inputs and output, and price of input on cost are discussed. It presents the environmental conditions for yam production and access to inputs and facilities by farmers. The chapter also includes the effect of the environment and technology on the performance of yam farmers in these three States.

Chapter Eight provides information on Nigeria's farming systems. It describes the cropping systems for yam in Nigeria. It also evaluates the profitability of root and tuber crop enterprises. Yam cropping systems and the different planting techniques for yam are evaluated.

Chapter Nine provides insight on the adoption and profitability of YMT and the impact of technology adoption on performance were also determined. Awareness and use of improved technologies is discussed. Different planting materials for yam production are evaluated and hypothesis tested. It also presents the farmers' sources of agricultural information.

Chapter Ten presents important conclusions based on the research findings. It discusses the performance of yam farmers in the States and the solutions on how it can be improved are proffered. It examines yam output and cost and makes recommendations to boost yam output and reduce its cost. Environmental and technological results are presented and solutions to eliminating the effect of this gap are offered. The chapter discusses yam production and adoption of new yam technologies in the States. This chapter also assesses YMT and proposed ways of facilitating its adoption. It presents yam cropping systems and suggests the ideal cropping system for yam in the country. The contributions of this study to the sum of knowledge are discussed. It makes suggestion on areas of future research on yam production. Finally, it presents the summary of the entire research work.

1.9 Conclusion

This is the introduction chapter of this thesis. It discussed the underlying problems in yam production. It presented the objective and significance of the study. The questions addressed by this project were discussed. It also highlighted the hypothesis and presented the overview of the thesis.

Chapter Two

2.0 Poverty, Food Production and Nigerian Agricultural Policies

2.1 Introduction

This chapter reviews the poverty situation in Nigeria, including Nigerian food production issues, prospects, limitations and consequences of low production in the country. It also discusses Nigerian agricultural policies and relevance of agriculture in the development of Nigeria's economy.

2.2 Global food insecurity and poverty

Poverty and food insecurity are fundamental challenges in the contemporary world (FAO et al., 2014). This is evidenced by their importance in the Sustainable Development Goals (SDGs) (United Nations, 2015). Poverty eradication and food security have been ranked first and second respectively in the SDGs (United Nations, 2015). Food insecurity and poverty are issues of global concern. These problems are not solely applicable to developing countries; they affect every region but are different between regions in magnitude (FAO et al., 2014). They are more prevalent in the developing countries (FAO et al., 2014).

The World Food Summit of 1996 defined food security to exist when all people at all times have physical and economic access to sufficient, safe, nutritious food to maintain their dietary needs and food preference for an active and healthy life (FAO, 2003). Warr (2014) argued that there are degrees of food insecurity and, following this definition, it is not clear how to quantify the varying degrees of departure from full food security. He noted that it is insufficient to depend solely on aggregate economic growth or reduction in poverty incidence to deliver improved food security. He reported that higher food prices worsen undernourishment (a state of insufficient food intake to meet dietary energy requirement, lasting for at least one year (FAO et al., 2015) and suggested increased productivity without rises in food price. Ahmad (2003) argued that poverty is an effect and also the cause of low productivity which contributes to food insecurity. Poor farmers may lack the capacity to acquire adequate farm assets, adopt new technologies, afford better health and educational facilities, and invest on the farm. Poverty and food insecurity go hand in hand in the sense that poverty eradication is a prerequisite for the realization of food security. Increasing farmer performance is vital for achieving food security and poverty reduction.

World leaders are making substantial efforts to ensure food security and eradicate poverty; however, over eight hundred and five million people remain undernourished (FAO et al., 2014). There is progress in achieving global food security (FAO et al., 2014). The number of undernourished people has reduced from over 1 billion in 1990-92 to 805.3 million in 2012-2014 (FAO et al., 2014), although the progress is uneven between regions. There is insignificant progress in achieving food security in the developing world, especially in sub-Saharan Africa (FAO et al., 2014). Figure 2.1 shows global food insecurity trends from 2002 -2014. It establishes that there is success in achieving global food security with the number of undernourished people in most regions declining except in Africa.

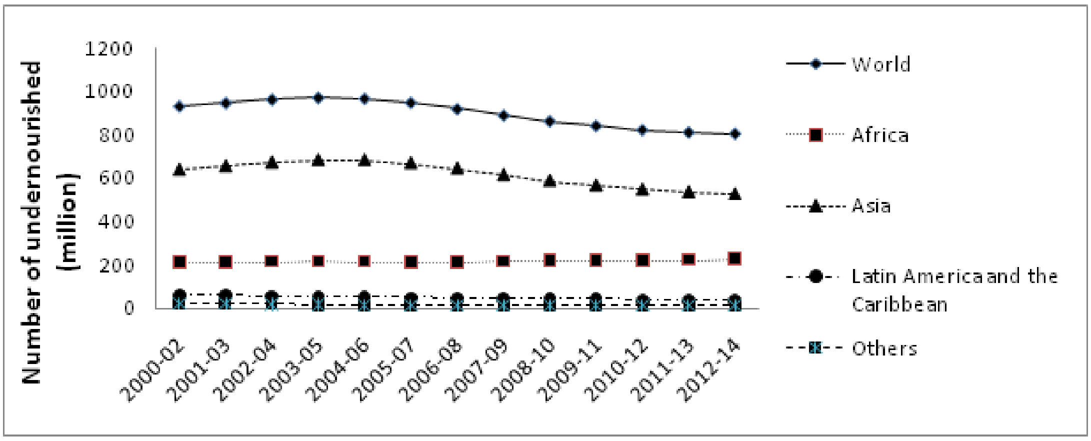


Figure 2.1: Global food insecurity trend
Source of data: (FAO, 2015)

Although Asia has the highest number of undernourished, there has been a significant progress in achieving food security in that region, with a remarkable reduction in the total number of undernourished. While other regions are making progress in combating hunger and poverty, Africa is becoming poorer and more food insecure. FAO et al. (2015) defined hunger as chronic undernourishment. Figure 2.1 shows a rise in number of undernourished in Africa, indicating increasing hunger intensification in the region.

Food insecurity is still a challenge (FAO et al., 2014). Global undernourishment decreased from 18.7% in 1990-1992 to 11.3% in 2012-2014 (FAO et al., 2014). This is a substantial reduction in over two decades. However, the number of undernourished people in the world is still high. It is better for success in global food security to be due to increased food production rather than to deaths, crises and disasters.

Sub-Saharan Africa has the highest prevalence of food insecurity (FAO et al., 2014). Food inadequacy is analogous to undernourishment (Food Security Monitoring System, 2016), see the definition of undernourishment in section 2.2. FAO et al. (2014) used food inadequacy as an indicator of food insecurity. Figure 2.2 shows food inadequacy levels in some sub-Saharan African countries. However, it shows that some countries in sub-Saharan Africa, particularly Sierra Leone, Togo, and Ghana are advancing in achieving food security (there is a decline in prevalence of food inadequacy in these countries). While other countries are making progress in achieving food security, Nigeria is lagging behind. The food situation in Nigeria has deteriorated.

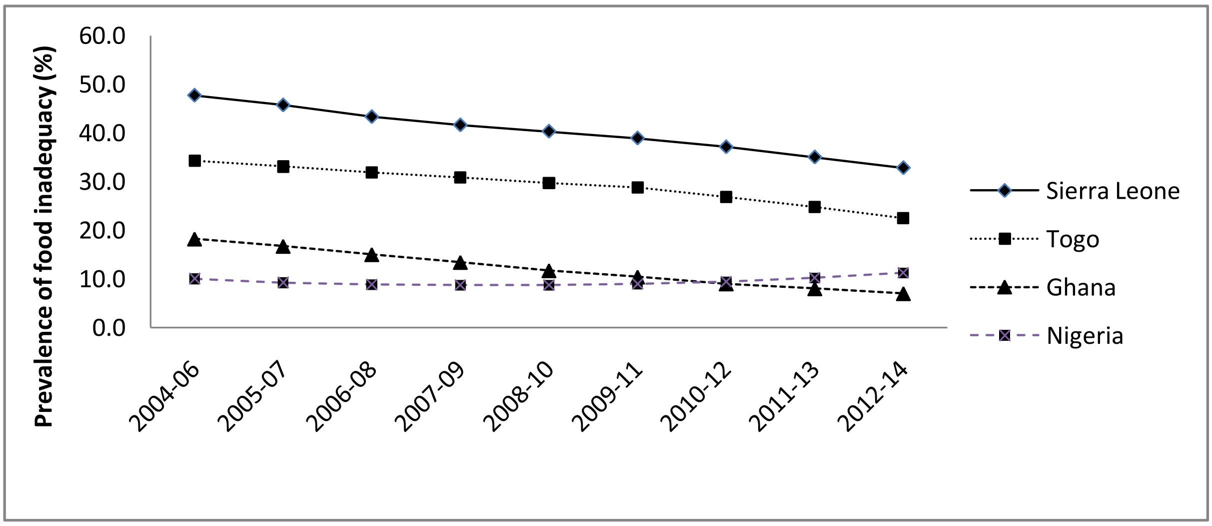


Figure 2.2: Food inadequacy of some selected countries in sub Saharan Africa
Source: (FAO, 2015)

The world population is growing rapidly (see Figure 2.3); this would mean more pressure on the existing agricultural resources. Global poverty and food insecurity may become worse without efforts to resuscitate the agricultural sector.

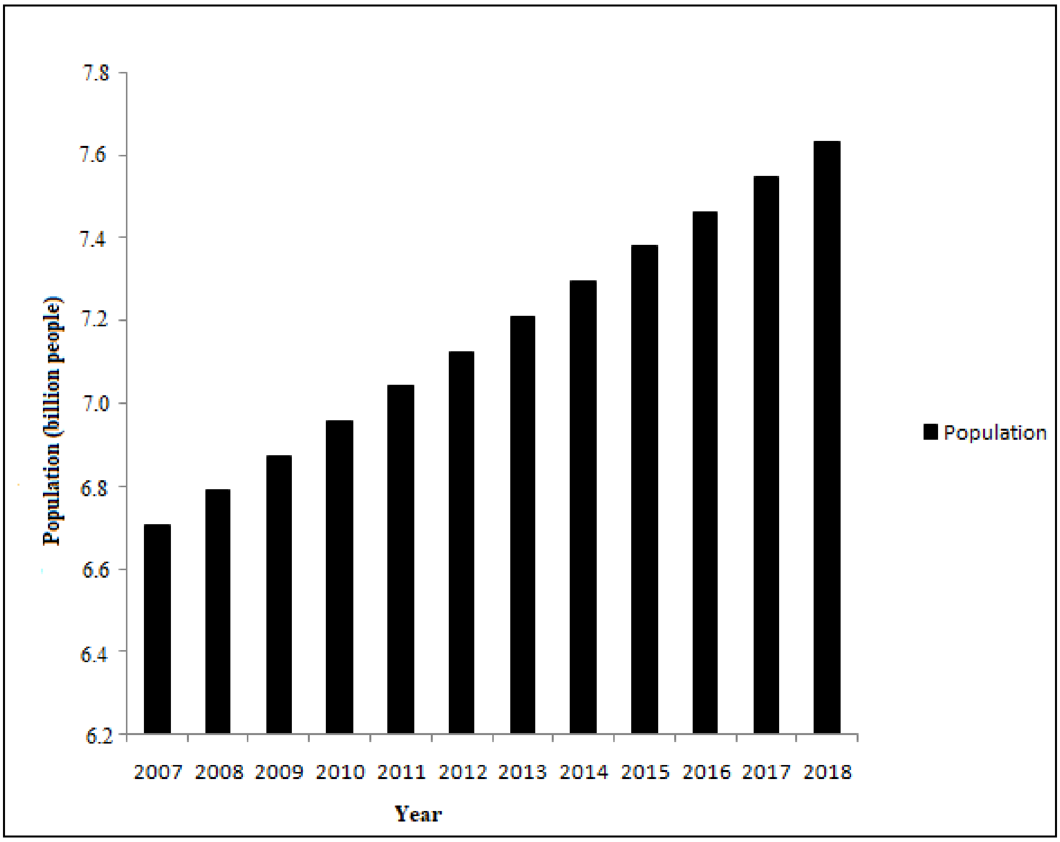


Figure 2.3: World population trend
Source: (FAO, 2019)

2.3 Issues relating to food production and poverty in Nigeria

Despite the natural resources available in Nigeria, the majority of Nigerians are poor. Nigeria was among the 50 richest countries in the early 1970s (Obadan, 2006). But poverty in the country is becoming more severe and Nigeria has retrogressed to the third poorest country in the world, after India and China, in terms of the aggregate number of poor in the country (Gabriel, 2014). Nigeria is home for 7% of the world's poor (Gabriel, 2014), two in every three Nigerians live below the extreme poverty line of USD1 per day (Obadan, 2006).

Nigeria spends a large amount of foreign exchange on importation of agricultural commodities. As earlier stated, Nigeria has the potential for agricultural development (see, section 1.2), but it still depends heavily on food imports. Nigeria's food production is insufficient to satisfy internal demand; hence, the country has to depend on food importation (Economy Watch, 2015). Figure 2.4 displays the quantity of selected major Nigerian food imports, which have increased steadily since 2002. The value of selected major agricultural imports of Nigeria are shown in Figure 2.5, these have increased substantially in recent years. The comparison of these graphs shows a sharp increase in value, presumably due to price rises for food.

Figure 2.4: Quantity of selected major Nigeria food imports
Source of data: (FAO, 2019)

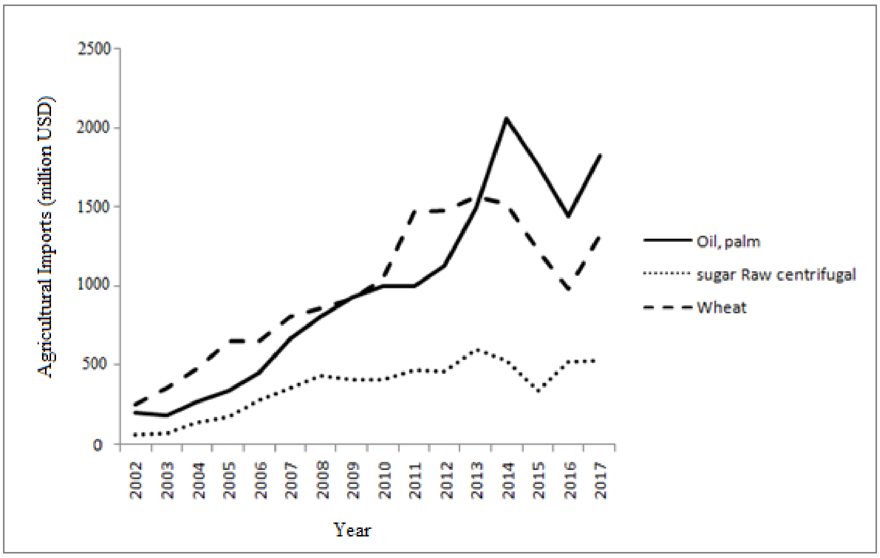


Figure 2.5: Value of selected major agricultural imports of Nigeria
Source of data: (FAO, 2019)

In contrast, the quantity of Nigeria's agricultural exports is low and variable (Figure 2.6). There is substantial fluctuation in agricultural exports from Nigeria over time which could be due to human, climatic, environmental and other factors. Figure 2.7 displays the value of selected agricultural exports. It shows that the value of Nigeria's exports is low compared to imports.

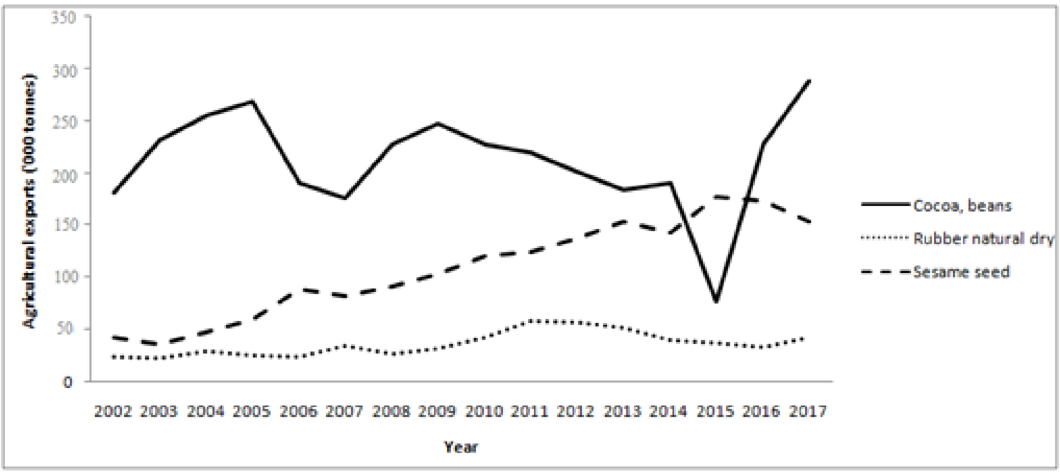


Figure 2.6: Quantity of selected agricultural exports
Source: FAO (2019)

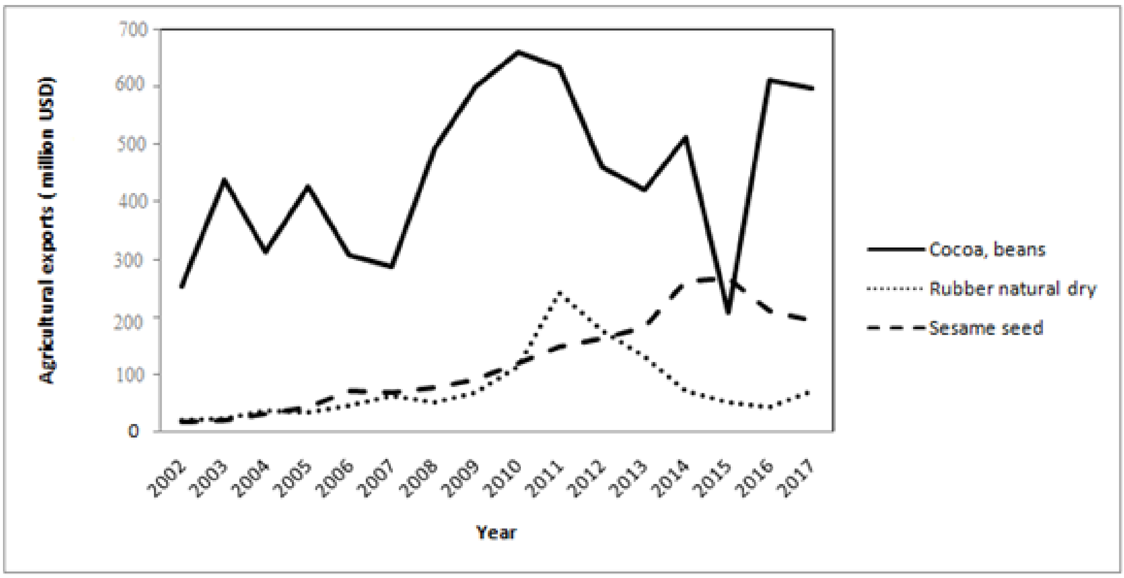


Figure 2.7: Value of selected agricultural exports
Source: FAO (2019)

Nigeria could be more food secure if its favourable agricultural endowment could be harnessed and the existing farming systems improved. Poverty and food insecurity in

Nigeria can be attributed to mismanagement of the countries resources by leaders and abandonment of the agricultural sector (Nkwede, 2014). Neglect of the agricultural sector (Yakubu & Akanegbu, 2015) has affected agricultural production in the country. Nigeria has become a net importer of food (Yakubu & Akanegbu, 2015). This jeopardizes the chance of sustainable growth. (Yakubu & Akanegbu, 2015).

Nigeria's food producers are mainly resource-constrained rural farmers, who are also the most food insecure (Otaha, 2013; World Food Programme, 2015). Ninety-five percent of Nigerian farmers are primarily subsistence farmers (Sanyal & Babu, 2010), who practice non mechanized farming and struggle to produce adequate food to feed their families. Figure 2.8 shows the tools typically used for farming in Nigeria. Poverty and hunger prevent farmers from producing adequate food to feed their families let alone feeding the entire nation (Otaha, 2013).

Figure 2.8: Examples of crude implements used for farming in Nigeria
Source: Author's Photograph

Agriculture was once the main source of the nation's foreign income (Economy Watch, 2015). Decline in Nigeria's production began with the advent of the petroleum boom in the early 1970s (Yakubu& Akanegbu, 2015). Neglect of agriculture for the oil sector has negatively impacted on Nigerian agriculture (Yakubu& Akanegbu, 2015). Nigeria, once a net food exporter, became a net importer of food in the mid-1970s (Verter & Becvarova, 2014).

The population of Nigerian is increasing steadily (see Figure 2.9) while that of Nigerian farmers is declining (Abdullahi et al., 2009). Rural urban migration and reduction in the farming population in Nigeria has contributed to low output (Abdullahi et al., 2009).

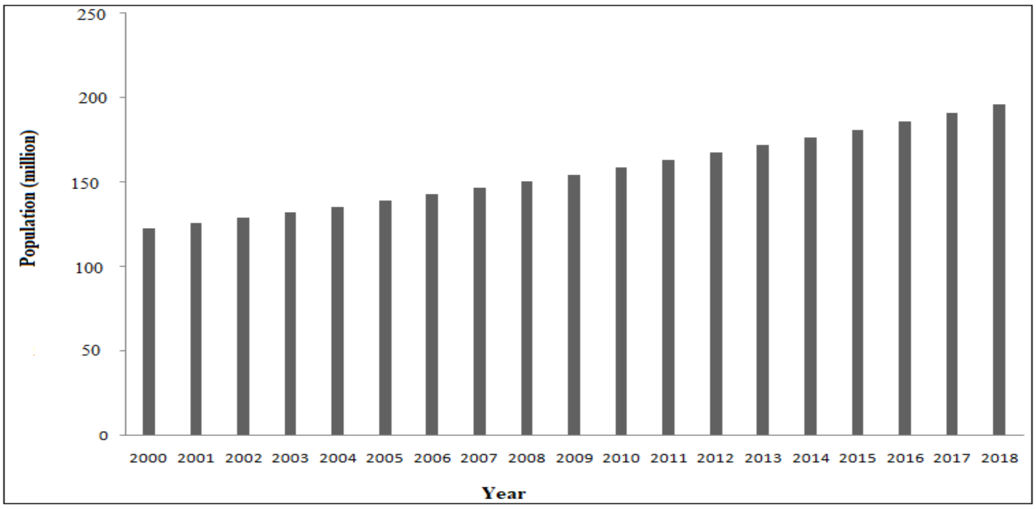


Figure 2.9: Nigeria's population trend
Source: (World Bank, 2019)

Most young people are leaving the rural areas where farming is practiced. An aging and decreasing farming population implies that farming households will have insufficient food for self-consumption, thus the country will depend even more on food importation. However, it is expected that young rural migrants who find employment elsewhere will make remittance to their families, thereby improving the wellbeing of their families.

Unfortunately, there is a rise in the percentage of unemployed Nigerians (Figure 2.10). Employment in Nigeria is highly competitive. Most youths who travel to the urban areas in Nigeria for so-called greener pastures are often unemployed (Adebayo, 2013). Most of them struggle to feed themselves and are unable to make remittance to their families.

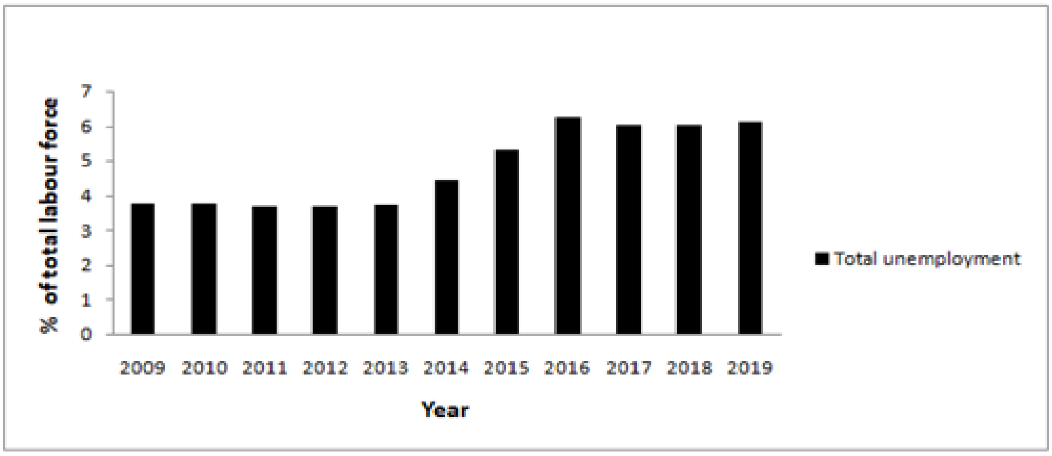


Figure 2.10: **Nigerian unemployed**
Source: (World Bank, 2020)

2.4 Funding and performance of the Nigerian agricultural sector

In contrast to the importance of agriculture to Nigeria's economy, the Nigerian agricultural sector is underfunded (Mogues et al., 2008; Olomola et al., 2014; World Bank, 2008)**.** Less than 2% of the Federal Government expenditure was allocated to agriculture between 2001 and 2005 (Mogues et al., 2008). This figure is well below the 10% goal set in the Maputa agreement by African leaders in 2003 (Mogues et al., 2008).

This low investment in the Nigerian agricultural sector is associated with a large portion of agricultural investment allocated to input subsidies and grain market stabilization (Ita et al., 2013). Approximately 60% of expenditure on agriculture was spent on input subsidies (especially on fertilizer) and output purchases (Mogues et al., 2008; World Bank, 2008). Insignificant agricultural spending is allocated to Research, Development and Extension (RD&E) (World Bank, 2008; Ahmad, 2003).

Developing countries are unable to attain a high production potential in the agricultural sector mainly due to inadequate funding of Research and extension (R&E) and under-investment in rural areas (Ahmad, 2003). The Nigerian agricultural sector is often ignored by governments contributing to low performance of the agricultural sector (Jerome, 2012).

Inadequate infrastructure in the rural areas also contributes to poor performance of the agricultural sector in Nigeria. Most rural areas have low-level infrastructure. Lack of or inadequate access to infrastructure has implications for farmer performance and wellbeing. This and other factors can contribute to production failure. The agricultural sector is often abandoned due to the preference of the ruling class in developing countries to make quick profit from importation rather than developing the farming sector (Jerome, 2012). Apparent neglect of the rural areas has contributed to food insecurity in Nigeria. A number of studies have suggested that improvement in infrastructure in rural areas can contribute to increased agricultural productivity and economic welfare (Gibson & Rozelle, 2003; Jacoby, 2000). Lack of or inadequate infrastructure in rural areas has made them undesirable for the youth (Jerome, 2012), resulting in rural-urban migration. Young farmers move to urban areas in search of a better life or greener pastures, leaving the aged in rural areas. This reduces the population of farmers in Nigeria. The country's total population is increasing (FAO, 2017a), but an aging and decreasing farming population implies that farming households will be unable to produce adequate food for consumption, therefore, the country will depend more on food importation.

Nigerian governments have implemented a number of policies and programmes aimed at ensuring food security. However, most of these policies have failed to accomplish their purposes (Jerome, 2012). They include Commodity Marketing Boards, a Farm Settlement Scheme, a Structural Adjustment Programme, a National Accelerated Food Production Programme (NAFPP), the Nigerian Agricultural Cooperation and Rural Development Bank (NACRDB), Operation Feed the Nation (OFN), Green Revolution, River Basin and Rural Development Authorities, an Agricultural Development Project, the National Agricultural Land Development Authority, and the Directorate for Food and Road and Rural infrastructure (DFFRI). Others are the Agricultural Credit Guarantee Scheme Fund (ACGSF), the Root and Tuber Expansion Project, the National Economic Empowerment and Development Strategies I & II, National Special Programme for Food Security, National Fadama program I & II program, and the Presidential Initiatives on Selected Commodities: Cassava, Rice, Cocoa, Vegetable Oil, Livestock (Eme et al., 2014; Izuchukwu,2011). However, these policies and projects are largely ineffective to ameliorate the food insecurity challenge in the country (Ita et al., 2013).

Appropriate policies are required to realize Nigeria's potential to produce adequate food. Agba et al. (2009) has reported thatfood insecurity and hunger have persisted due to inappropriate agricultural policies and poor implementation. Most of Nigerian agricultural policies have failed because they are based on insufficient studies and pilot surveys (Adebayo et al., 2009). Design, monitoring and evaluation, and discontinuity of policies, among other factors, reduce the success of agricultural policies in Nigeria (World Bank, 2008).Poor implementation of agricultural policies and programmes has resulted in food insecurity in Nigeria (Eme et al.,2014); thereby worsening the living conditions of the poor in the country (Dakyes & Mundi, 2013).

Nigeria is politically unstable; this has adverse effect on the nation's agricultural development. There have been inconsistent changes in policies and programmes in Nigeria (Achimugu Abubakar, Agboni, & Orokpo, 2012). Policies and programmes are often abandoned with changes of government (Nkwede, 2014; Otaha, 2013). Abandonment of policies is a setback to agricultural development in the country. Ita et al. (2013) have observed that lack of continuity of these policies and programmes constrains Nigerian agricultural development.

2.5 Conclusion

This chapter reviewed poverty and Nigerian food insecurity, which has intensified due to poor performance of the agricultural sector. Poor performance of the Nigerian agricultural sector could be attributed non-mechanization of the Nigerian agricultural system, inadequate, neglect of rural areas, and abandonment of agricultural policies. Mechanization of agriculture, adequate funding of R&D, investment in the rural areas, and implementation of agricultural policies will improve the performance of Nigerian farmers.

Nigeria has abundant agricultural resources but the country depends on food importation. Nigeria once depended on agriculture but the abandonment of the Nigeria agricultural sector for the oil sector has led to its poor performance. Investment in the Nigerian agricultural sector will improve the sector. This investment could be in agricultural R&D and infrastructure in rural areas.

Chapter Three

3.0 An Overview of the Global Yam Industry

3.1 Introduction

This chapter describes the physical features of yam, and its origin and significance in Nigeria. It includes its sociocultural, medicinal, nutritional and economic importance. The chapter also describes global yam output and supply. The agronomic practices involved in yam production are presented together with postharvest handling of yam in Nigeria (including storage, processing and marketing). Yam consumption in Nigeria with different food forms is presented. Current yam technologies and management are considered.

3.2 Description and origin of yam

Yam is a common name for species of the genus *Dioscorea*, which are annual or perennial herbaceous vines with heart shaped leaves and starchy tubers (International Institute of tropical Agriculture, IITA, 2009a). Yam has rough skin which varies from dark brown to light pink in colour (Schlegel, 2010). The inner part ranges in colour from white to bright orange in mature yams (Schlegel, 2010). The tubers vary in size and shape, the important cultivars are cylindrical in shape (Opara, 2003) and can weigh up to 70kg (Schlegel, 2010). Yams contain tannin cells and cells containing bundles of crystals (raphids) which are responsible for the itchiness of raw yam tuber when it comes in contact with human skin (Opara, 2003).

Over 600 species of yams exist (Lebot, 2009; Ike and Inoni, 2006), of which ten are cultivated for food (Lebot,2009; O'Sullivan, 2010). The White Yam, *D. rotundata* is the most important and common cultivated species (Akinola & Owombo, 2011; IITA, 2009a). *D. alata*, the Water Yam is the second most cultivated and the most widely distributed species (IITA, 2009a). White Yam is the most popular in West Africa while Water Yam is common in South Pacific (Opara, 2003).

Yams, like other root and tuber crops, were dispersed by Portuguese slave traders, Portuguese and Spanish missionaries, and Arab traders (Oke, 1990). Researchers believe that yams have a wide diversity of origin. They have suggested that *D. rotundata, D. cayenensis, D. Dumetorum*and*D. bulbifera* are indigenous to West Africa; *D. alata, D. esculenta* and *D. opposita* originated from South Asia. Tropical America is the centre of origin of *D. trifida*. Genetic studies have established that Water yam, *Dioscoreaalata* (which was thought to originate from Asia) is indigenous to Melanesia (Lebot, 1999). Although Oke 1990 has reported the origin of *D.esculenta* to be West Africa, O'Sullivian (2010) argued that its origin has not been established but could be Southeast Asia or Melanesia. O'Sullivan (2010) has also reported that *D. opposite* is also known as *D. batatas or D.japonica* and is the only species cultivated in the temperate regions. It is grown in China, Japan and recently in France.

3.3 Importance of yam

3.3.1 Sociocultural value

Yam is a highly valued crop in terms of sociocultural significance. Its cultivation began in Africa over 11,000 years ago (IITA, 2009a; O'Sullivan, 2010). The sociocultural value of yam is more important than its economic value (Ike and Inoni, 2006). It is referred to as 'king of all crops' and 'a male crop' by Nigerians. Its sociocultural importance is evidenced by the annual celebration of New Yam Festival in some yam-producing areas. It is celebrated in southern Nigeria at the beginning of the harvest season. It is a part of Nigeria's cultural heritage (Eyitayo et al. (2010)). Yam festival is also celebrated in Ghana (Global times, 2013) and Vanuatu (O'Sullivan, 2010). It has been embraced in Trelawny, Jamaica (Southern Trelawny Environmental Agency, 2011). In Tonga, the word for year is synonymous with yam and the names for months mark events in yam cycle (O'Sullivan, 2010). Yams are also sacred icons in the Maprik district of Papua New Guinea. Great Nigerian yam farmers are awarded titles and their children have yam-related names.

Yams are also used in fertility and marriage ceremonies (IITA, 2009a). The Pentecost Island 'land diving' (a ritual the people believe ensures a good harvest and fertility for men) is performed annually in the south-eastern part of the Island (O'Sullivan, 2010). It involves men jumping from a tall tower with yam vines tied to their feet. In the south-eastern part of Nigeria, yams must be presented by the groom to the bride's family during traditional marriage. In some parts of south-eastern Nigeria, a tuber of yam is given to the bride during traditional marriage by the male head of the bride's family. The bride carries the yam like a new born baby and presents it to the groom's mother or her representative. This is accompanied by a shout of joy at new birth (*Owowo*!), symbolizing fruitfulness (author's observation). Figure 3.1 shows yam presented to a bride during traditional marriage.

Figure 3.1: Yam presented to a bride during traditional marriage
Source: Author's photograph

3.3.2 Medicinal value of yam

Yams contain pharmacological substances (Lebot 2009) which are used in the manufacture of drugs. They contain steroids, dioscorine, saponin and sapogenin(Ike & Inoni, 2006). Dioscorine, the major alkaloid in yam, is a heart stimulant (Ike & Inoni, 2006). Yams also contain diosgenin (a sapogenin compound), which can be extracted and used as a base for drugs such as cortisone and hormonal drugs (Opara, 2003). Diosgenin is also used in genital disorder and during menopause as an aphrodisiac (Botanical-Online, 2015a)**.** Yams are used on the Rishiri Island in Japan as a folk medicine for the treatment for impotency (The Asia Mag, 2012). They contain phytoestrogen which increases woman's follicle stimulating hormones. Phytoestrogen has been linked to hyper-ovulation (i.e., the release of more than one egg which leads to twinning (Adea, 2013). Yams also contain dioscin, a natural progesterone which with phytoestrogen helps regulate the estrogen-progesterone balance, thereby reducing fibroids and endometriosis in women (Adea, 2013).

Most wild yam species are medicinal but contain toxins. They are not normally eaten except in times of food scarcity (Planiswami and Peter,2008). *D. villosa*, the Wild Yam is rich in dioscin, dioscorin and diosgenin (Botanical-Online, 2015b). These substances are toxic when consumed in large quantity, but when controlled have health benefits such as anti-inflammatory, soothing, hypatoprotective and cholesterol (Botanical-Online, 2015b)**.** The Chinese yam, *D. Opposite* is an edible and medicinal species. It contains allantoin, a substance with healing properties that accelerates the wound healing process. It is suitable for gastritis, ulcers and stomach pain (Botanical-Online, 2015a).

3.3.3 Nutritional value of yam

Yam is important in the diet of people in yam-producing areas (Opara, 2003). It comprises approximately 21% dietary fibre, is rich in carbohydrates, Vitamin C and essential minerals (IITA, 2009a), and has high content of moisture, dry matter, starch and potassium but is low in Vitamin A. The Vitamin C content of yam is approximately 5-10 mg. 100 g^{-1}(Opara, 2003). Some people in yam-producing areas consume yam daily (Verter & Bečvařova, 2015). It is a rich source of carbohydrates for many people in Africa. It contributes over 200 dietary calories per capita per day for over 150 million people in West Africa (Babaleye, 2003). It accounts for significant dietary intake in Tonga (20%), Solomon Island (8.1%), and Papua New Guinea (4.6%) (Opara, 2003).

Although low in protein and fat, yam has been found to be nutritionally superior to other root and tuber crops (Wanasundera & Ravindran, 1994). It has higher protein content than other root and tuber crops including potato and taro (Wanasundera & Ravindran, 1994). Its protein content is approximately four times higher than that of cassava and exceeds that of rice (in proportion to digestible energy) (Bradbury and Holloway, 1988). Although yam is sub-optimal in cysteine and methionine (sulfur - containing amino acid), its overall rating for essential amino acids is higher and superior to sweet potato (Bhandari et al. 2003). Yam is a moderately good source of minerals. It is richer than cassava and sweet potato for all minerals (Wanasundera & Ravindran, 1994).

3.3.4 Economic value of yam

Yam has greater value than other comparable staples; it is an important source of farm income (Babaleye, 2003) and a major employer of labour in Nigeria (Verter & Bečvařova, 2015). Figure 3.2 indicates the production of selected staples in Nigeria; the country produces more cassava than other crops. From Figure 3.3, it is clear that yam has a higher value than cassava and other staples.

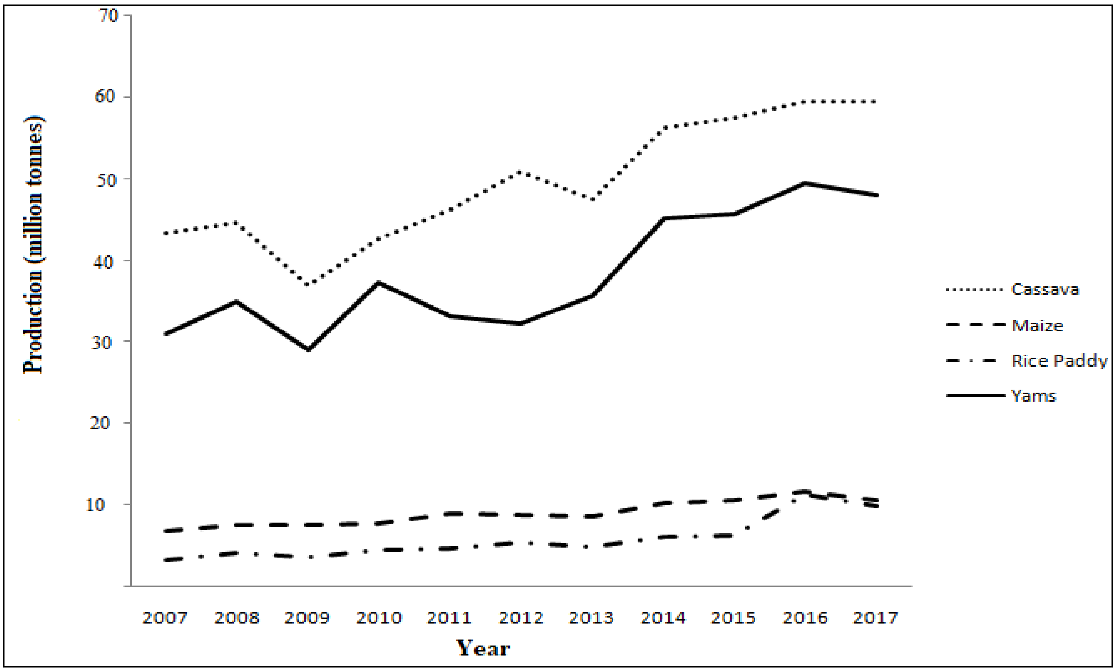


Figure 3.2: Production of selected staples in Nigeria
Source: (FAO, 2019)

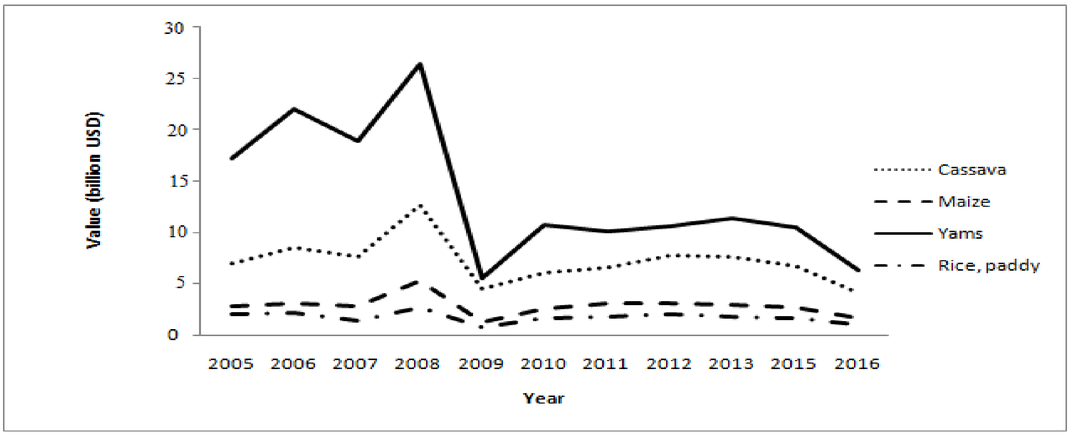


Figure 3.3: Value of selected staples in Nigeria (Billion USD)
Source: (FAO, 2019)

3.4 Global yam production

Africa accounts for a significant proportion of global yam production. Table 3.1 shows that over 96% of global yam production come from Africa. Most of the world yam production is from West Africa. West Africa accounts for approximately 91% of global yam production (FAO, 2015).

Table 3.1: **Percentage yam production by region**

Regions	Africa	America	Asia	Europe	Oceania
% yam production	96.1	2.7	0.5	0	0.7

Source: (FAO, 2015)

Nigeria contributes significantly to global yam output and is the leading yam producer in West Africa. Table 3.2 shows the leading yam producing countries in West Africa over the period 2008 – 2018. Nigeria produces approximately 39.8 million tonnes per annum. Nigeria alone contributes almost two-thirds of global yam production (FAO, 2015).

Table 3.2: Leading yam producing countries in West Africa (Average 2008 – 2018)

Countries	Nigeria	Ghana	Côte d'Ivoire	Togo
Production ('000 tonnes)	39835.39	6746.608	6156.370818	762.1485

Source: (FAO, 2019)

Increases in production reported for Nigeria are due to an increase in area under yam cultivation rather than increase in productivity. Figure 3.4 displays area harvested by leading yam producers. Nigeria harvested the largest land area but Ghana, which has a lesser yam area than Nigeria, has the highest yam yield among major yam producers (Figure 3.5). Yam yield in major yam producing areas have been declining over time, except in Ghana (see Figure 3.5).

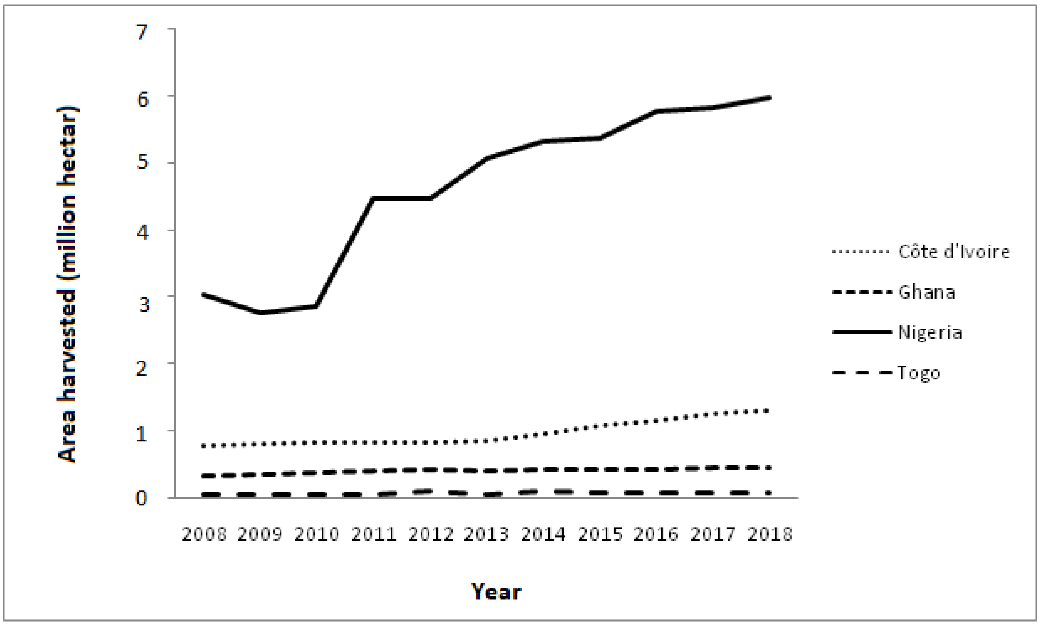


Figure 3.4: Yam area harvested by leading yam producers
Source of data: (FAO, 2019)

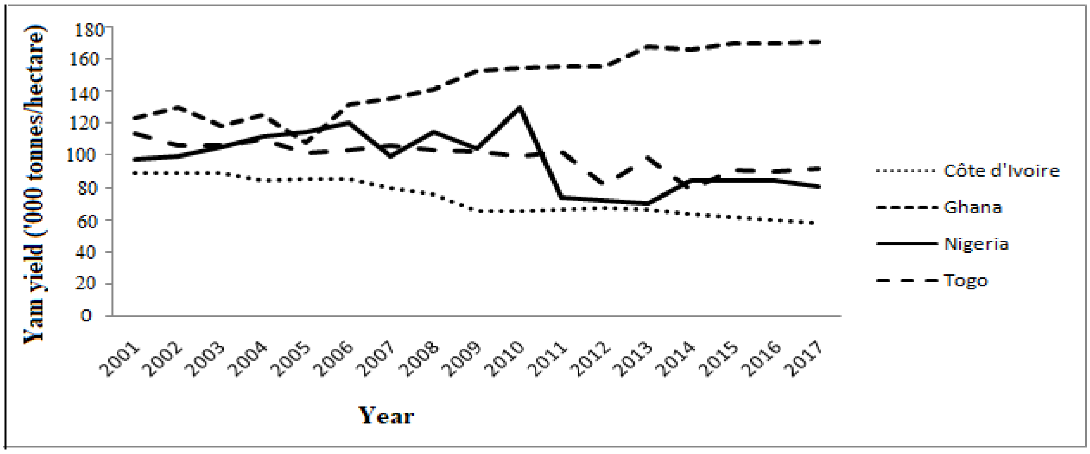


Figure 3.5: Yield from leading yam producers
Source of data: (FAO, 2019)

Being a leading yam producer does not imply a higher yield than other yam-producing countries. Yam does not yield better in the major yam producing areas. Figure 3.6 shows the top five countries by average yam yield. Currently, Japan has the highest global yam productivity, followed by Papua New Guinea then Tonga.

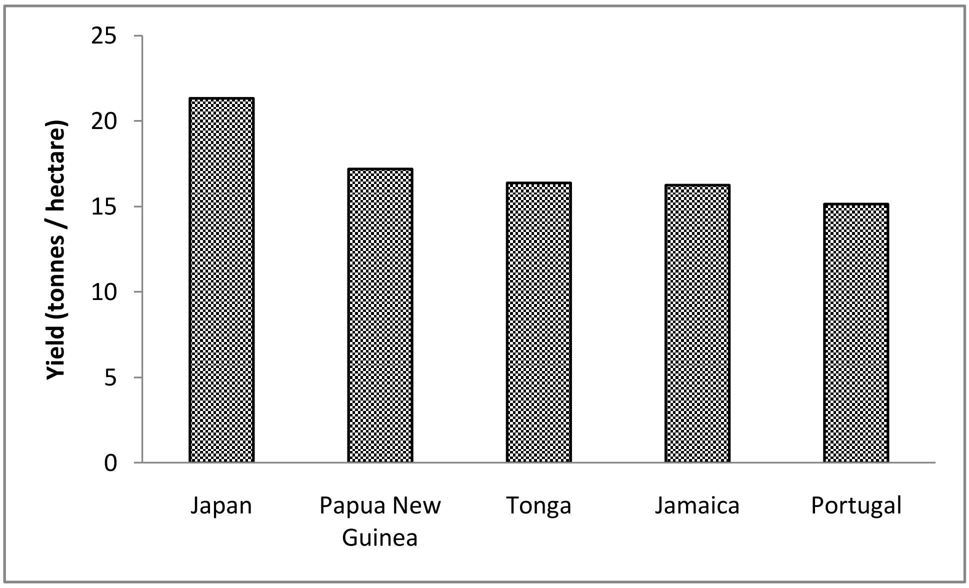


Figure 3.6: Top five countries with high yam yield
Source: (FA0, 2015)

3.5 Yam supply and export in West Africa

Figure 3.7 shows that Nigeria has the highest supply of yam among these five West African countries. However, Nigeria exports fewer yams than Ghana (Figure 3.8). This suggests that most of the yams produced in Nigeria are consumed within the country.

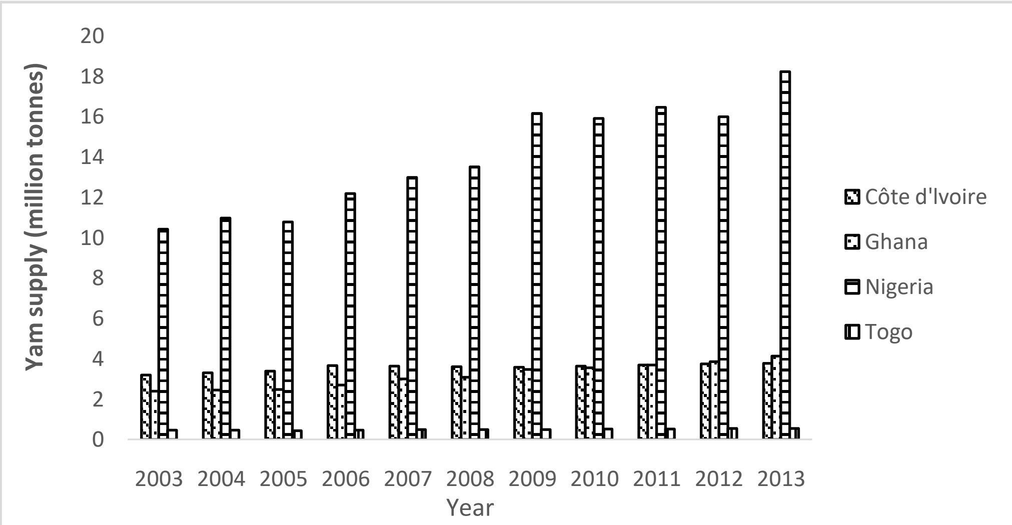


Figure 3.7: Yam supply by leading yam producers
Source: (FAO, 2017a)

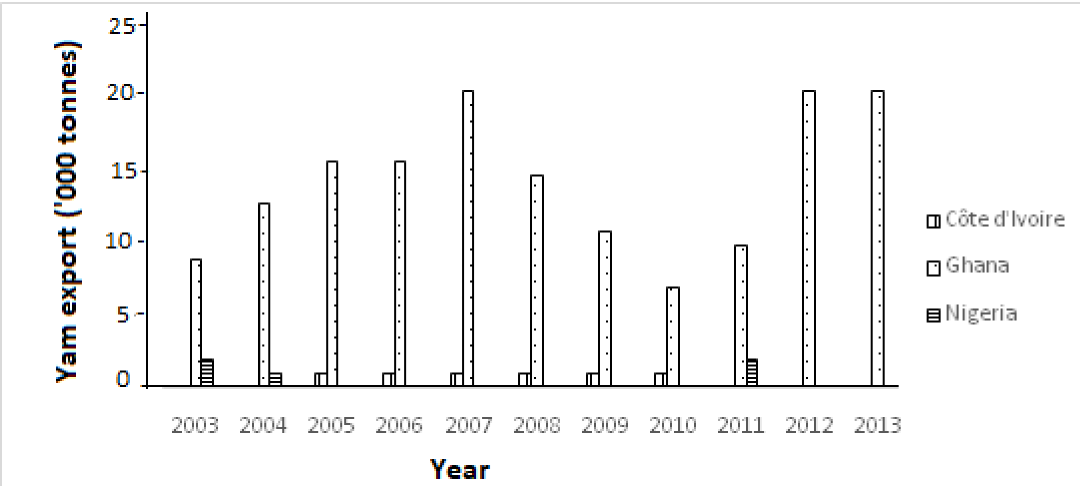


Figure 3.8: Yam export by leading yam producers
Source: (FAO, 2017a)

3.6 Status of yam farming

There is declining global yam productivity attributed to intensification of land use which has led to shortening fallow periods (O'Sullivan, 2010). Yam is nutrient-demanding (Carsky et al., 2010; Ajayi et al., 2006) and requires a fertile soil (Botanical-online, 2017). It is usually the first crop to be planted after a fallow period (Srivastava, et al., 2012). Reduction in fallow period and intensification of land use leads to soil nutrient depletion and increased pest and disease infestation (O'Sullivan, 2010). This contributes to low productivity if inadequate soil improvement measures, such as the use of fertilizers, are used. The yield and area of yam in Nigeria from 2005 to 2014 presented in Figure 1.2, indicated declining yam yield and increasing area of yam production since 2010. Table 3.3 shows the percentage annual growth rate of yam (2003-2013). It confirms that yam productivity is declining both locally and globally while land area under yam cultivation is growing. In addition to declining soil fertility and pest infestation, IITA (2009a) included high cost of labour as one of the causes of decreasing yam productivity. There is decreasing yield and low annual growth rate of yam production in Nigeria. Table 3.3 shows that global yam production is growing at 2.48% while that of Nigeria is growing at 1.38%. Further, global yield is declining at -1.03 per annum, while that of Nigeria is -1.77% per annum.

Table 3.3: Percentage annual growth rate of yam (2003-2013)

	Area harvested	Production	Yield
Nigeria	3.20	1.38	-1.77
West Africa	3.44	2.17	-1.23
Africa	3.47	2.42	-1.02
World	3.54	2.48	-1.03

Source: (FAO, 2015)

3.7 Agronomy of yam

Yams are grown in Africa, America, the Caribbean, South Pacific (Oceania) and Asia (IITA, 2009a).They thrive in well drained fertile soil (FAO, undated).

Yams are one of the most expensive crops to produce (NBS, undated), with significant labour inputs required. Yam production is labour intensive; labour constitutes approximately 40% of the total cost of production (Okoro, 2008). Nevertheless, yam cultivation is profitable and demand is high (IITA, 2009a)

3.7.1 Land preparation

Land preparation is labour-intensive, farms are usually cleared manually with machete. After clearing, dead vegetation is left to dry and is burnt, especially in the forest zone. Some is used for mulching. Stumps and roots are removed with hoe and spade; some shrubs are trimmed and left on the farm to be used as stakes (author’s observation).

Yams are planted on ridges, heaps/mounds or in holes. Mounds are mainly dug manually with hoes. Mound making involves elevating and tilling of the soil, the size of mound depends on choice. Figure 3.9shows manually dug mounds for yam production

Figure 3.9: Manually dug mounds for yam production in Nigeria
Source: Author's photograph

3.7.2 Planting

The availability and cost of seed yam are major constraints to yam production in Nigeria. Cost of planting material constitutes a large proportion of cost of yam production (IITA, 2009b). Households are more likely to save their seed yams for planting (NBS, undated). Farmers usually sell their seed yams after satisfying their consumption needs (Asumugha et al., 2009). Although seed yam specialists now exist in Nigeria, supply through this source is minimal (Phillips, et al., 2013).

Yams are planted using pieces of tuber (macro setts) or small whole tuber (seed yams) (IITA, 2009a). In Nigeria, early yam is planted in November while late yam is planted in February to April. Sett size is 100g to 500g, with 300g being the typical size (O'Sullivan, 2010).

A large amount of planting material is required for yam production (O'Sullivan, 2010), with the recommended planting distance for yam being one metre (a population of 10,000 plants per hectare) (Eyitayo et al., 2010). Five hundred milked plants can produce 2000-2500 seed yams of between 200-300g (Phillips et al., 2013). Figure 3.10 illustrates cutting of yams into setts.

Figure 3.10: Cutting of yam into setts
Photograph: G.N. Asumugha

Most farmers in Nigeria obtain planting material from previous harvests. Farmers reserve almost half of their harvested yam for planting (NBS, undated). Unfortunately, farmers often use low quality and disease-infested planting materials. Yams are vulnerable to pest and disease attack, leading to reductions in quality and quantity of seed yam especially during storage. The use of planting material from previous harvests will lead to a build-up of disease-causing organisms and reduction in yield (IITA, 2009b). Figure 3.11 shows seed yams stored for next season's planting.

Figure 3.11: Seed yams stored for next season planting
Source: Author's Photograph

3.7.3 Mulching

Some farmers mulch (covering of land with dry vegetation) after planting. Mulching prevents erosion and leaching and releases soil nutrients (when the mulch materials decompose). It also retains soil moisture, reduces soil temperature and suppresses weed load (O'Sullivan, 2010). Most farmers in Nigeria (especially in the savannah areas) plant yams before the rains; they mulch their yam farms to prevent the seed yams from drying.

Figure 3.12: Mulching of yam
Source: Author's Photograph

3.7.4 Fertilizer application

Yam is nutrient demanding and requires fertilizer due to constant soil nutrient depletion (see Section 3.6). The quantity of fertilizer required depends on soil and location. In Nigeria, 400kg (8bags) of NPK (15:5:15) is recommended for yam cultivation in the forest zone while six bags of NPK 15:15:15 and 2 bags of urea are recommended in the savannah zone (Agbaje and Aluko, 2009). Fertilizer is usually applied at 3-4 weeks in early planting and 8 weeks after planting for late planting (Agbaje and Aluko, 2009).

3.7.5 Weeding

The cost of weeding constitutes a large proportion of cost of yam production. Yam normally requires approximately four weedings. It is commonly undertaken using hoes or herbicides. The use of herbicide is a cost effective way of controlling weeds and intercropping can also be used to reduce weed load if well managed (O'Sullivan, 2010).

3.7.6 Staking

Staking is required for yam production but it is expensive and staking materials are becoming scarce (O'Sullivan, 2010; Phillips et al., 2013). Most yams yield better when staked, which increases light interception of the leaf canopy and ventilation around the leave (O'Sullivan, 2010). In Nigeria, yams are usually staked with bamboos and stick in the rain forest zone or with sorghum or maize straws in the savannah (Figure 3.13).

Figure 3.13: Staked yam
Source: Author's Photograph

Yam is also grown without stakes in the savannah zone (see Figure 3.14). Maize or sorghum is intercropped with yam and serve as staking materials in the savannah region of Nigeria (O'Sullivan, 2010).

Figure 3.14: Yam without stake
Source: Author's Photograph

3.7.7 Harvesting of yam

Yams are harvested at the end of vegetative growth, when the leaves begin to turn yellow (Opara, 2003). This is usually at the end of rainy season or beginning of dry season. Most edible yams mature between 8-11 months after planting (Opara, 2003).

Yam harvesting is labour-intensive and strenuous. In Nigeria, yam is manually harvested using diggers, sticks, spades and machetes; care is required to avoid tuber damage. Figure 3.15 demonstrates yam harvesting.

Figure 3.15: Yam harvesting
Source: Author's Photograph

Yams can be harvested once or twice. In the single harvest, the yams are harvested at full maturity (Opara, 2003). For double harvest, the yams are first harvested when they are not fully mature (this process is known as 'topping', 'beheading' or 'milking'), and they are harvested again at full maturity. The first harvest is for food while the second harvest is for production of seed yam for next season planting (Agbaje and Aluko, 2009). They are harvested at 4-5 and at 8-10 months after emergence (Agbaje and Aluko, 2009). Yield per hectare is between 8-50 metric tonnes (Opara, 2003).

Yams for long term storage are harvested during *harmattan* (very dry and windy season), usually between December and January (Opara, 2003). However, it is difficult and uneconomical to harvest yam at this time because the soil is dry and difficult to dig. Yams may also break during harvesting and fetch lower prices.

3.8 Postharvest handling of yam

3.8.1 Curing of yam

Harvested yams are cleaned by removing soil from the yams. Water is avoided as it could increase postharvest deterioration (Opara, 2003). Curing is the controlled drying of yam to heal any injuries during harvesting and postharvest handling. Yams are cured to reduce rotting during storage (Opara, 2003). The optimal conditions for curing are temperature (29°-32°C) and humidity (90-96%) for 4-8 days (McGregor, 1987). Farmers cure their yams by sun-drying them for a few days (Opara, 2003).

3.8.2 Sorting of yam

Sorting is the separation of yams depending on characteristics. Criteria for sorting include size, variety, and quality. Figure 3.16 illustrates sorting of yam depending on size.

Figure 3.16: Yams sorted according to size
Source: Author's Photograph

3.8.3 Yam storage in Nigeria

The harvested yams are carried to the storage facilities or market (they are placed vertically in baskets, basins, and bags to avoid breakage). They are either carried on the head, on shoulder or tied to a bicycle (Opara, 2003). Wheelbarrows are also used in moving yams to storage areas and market.

Yams store longer than other root and tuber crops, and they are available all year round. Harvested tubers stay dormant for 30-120 days depending on species, environmental conditions and time harvested (IITA, 2009a). They can store for up to six month without refrigeration (Opara, 2003). Therefore, they serve as a buffer against hunger (IITA, 2013) and are important for survival in West Africa.

Storage techniques for yam in Nigeria are inappropriate (author's observation, 2013). Traditional ways of preserving yam tubers includes leaving unharvested yam in the field until required, storing in barns and underground structures such as pits, ditches and clamps (Opara, 2003). Other ways of preserving yams include covering harvested yam with dry yam vines in the farm, putting harvested yams in ashes and covering with soil and storing in elevated thatch structure, huts and block houses. Figure 3.17shows some traditional yam storage facilities in Nigeria.

Barn storage of yam

A thatch structure constructed on an elevated land for yam storage

Yams covered with dry vines on elevated land (On-farm storage)

Yams stored inside a house

Figure 3.17: Some traditional yam storage facilities in Nigeria
Source: Author's Photographs

Yams are mainly stored in barns; these are vertical wooden structures in which yams are tied. They are located under shade and are suitable for long-term yam storage; yams can store for up to 6 months (Opara, 2003). Yam storage requires low temperature, good ventilation and regular inspection. The recommended storage temperature for yam is 12-16 °C (Opara, 2003). Low temperature reduces respiration rate but temperature below 12 °C (53.6 °F) can cause to chilling injury (Opara, 2003). Ventilation is required to prevent accumulation of water on yam skins, which can cause rot.

Significant quantities of yams are lost due to lack of storage facilities. Losses could be due to physical damage, pests, diseases and physiological processes such as sprouting, respiration and dehydration (Opara, 2003). The major postharvest disease is tuber rot, caused by fungi (Opara, 2003). Postharvest losses could be up to 60% (Opara, 2003).

3.8.4 Yam marketing in Nigeria

Yams contribute significantly to farm income (NBS, undated).They are the fifth most harvested crop in Nigeria following cassava, maize, sorghum and cowpea (NBS, undated). Farmers are more likely to sell other crops than yam. Yam production in Nigeria is subsistence; only 45 percent of farmers sell any portion of their harvested yams while those who are willing to sell their cassava, maize, and cowpeas are 62, 56, and 69 percent respectively (NBS, undated). Poor farmers consume less and sell more of their yam; the reverse is the case with wealthier farmers (NBS, undated).

In Nigeria, yams are mostly marketed fresh by both farmers and traders (Ike & Inoni, 2006). Farmers usually sell their yams in local markets. The price is agreed between the farmer and buyer. Traders buy yams from the local markets through the service of the buying agents (agents facilitate the transaction between farmers and large wholesalers) (Phillips et al., 2013). Traders can buy without the service of the service agents where a long-term relationship exists between farmers and traders. In some States, rural assemblers and local wholesalers buy yams from farmers and sell mainly to urban wholesalers at the rural market. Retailers at urban markets purchase yams from urban wholesalers. Traders earn significant profit from yam marketing. For example, Table 3.4 shows wholesalers' profit for yam in Ibadan and reveals that profits from yam marketing could be 19% to 27% of the sale price depending on the size of tuber. Traders earn more profit selling large tubers as these attract higher prices.

Table 3.4: **Wholesalers' profit for yam in Ibadan**

Wholesaler Buying price (from rural areas) ₦/tuber	Wholesaler Selling price (urban area) ₦/tuber	Marketing costs ₦	Profit ₦	Percentage of sale price (%)	Tuber size and season
100	170	37.5	32.5	19.12	Small – off-season / Medium – peak season
200	335	47	88	26.27	Medium – off-season / Large – peak season
300	500	67	133	26.6	Large – off-season

Source: Adapted from (Phillips et al., 2013)

Table 3.5 shows seasonality of Nigerian yam prices between the peak and non-peak periods (Phillips et al., 2013). The GM can be negative if farmers are unable to sell when prices are high (Phillips et al., 2013). Yams are more expensive in the off-season but farmers sell most of their produce at the peak season when prices of yam tubers are low (Phillips et al., 2013).

Table 3.5: **Seasonality of yam price in Nigeria (per 100 tubers)**

Tuber Size	Average Weight per tuber (kg)	Fresh Ware Yam (₦)	Peak Season (₦)	Non-peak Season (₦)
		Urban		
100 Large	4	14,500	12,000	60,000
100 Medium	2.5	9,500	6,500	30,000
100 Small	1.5	8,000	5,000	20,000
		Rural		
100 Large	4	9,000	7,000	30,000
100 Medium	2.5	7,000	5,500	20,000
100 Small	1.5	5,000	3,000	10,000

Source: Adapted from (Phillips et al., 2013)

Yams are transported from the rural to urban markets on trucks of various sizes (see Figure 3.18). The cost of transporting yam is expensive, accounting for 70% of marketing costs. Loading and offloading, agents' commission, marketing charges and others account for 10, 9, 9 and 2% respectively (Phillips et al., 2013).

Figure 3.18: Truck for transporting yams
Photograph: Okoye B.C.

Nigeria exports yams to neighbouring countries, the UK and the US (Phillips et al., 2013). However, most of the yams produced in Nigeria are consumed within the country.

3.9 Yam consumption

Yam is consumed in a variety of ways; it can be boiled, fried, roasted or baked (IITA, 2009b) and eaten with palm oil, sauce or soup (Author's observation). 'Pounded yam' (a common delicacy in Nigeria) is prepared by pounding boiled yam with wooden mortar or electric mixer. Advancement in technology has made this preparation less strenuous (there is instant pounded yam flour). The White Yam is preferred for preparing 'pounded yam' Yams are also used for preparing yam pottage. The Water Yam is preferred for preparing *ekpangnkukwo* (a delicacy of the Efik and Ibibio people of the south-south region of Nigeria). Yams are also sundried and milled into flour for preparing *amala* (a delicacy of the people of the south-western region of Nigeria). It is also used in the industries for the production of animal feed, starch, flour and confections (Opara, 2003). Residues from sifting and peels are used as animal feed (Opara, 2003).

A high quantity of nutrients, especially vitamins and minerals, is lost during industrial yam processing. The amount of nutrient loss depends on the amount of edible surface exposure during processing (Opara, 2003). Sun drying leads to loss of Vitamin B and minerals, though little mineral content is lost during this drying process (Opara, 2003). Pounding or grinding of yam into flour has a similar effect (Opara, 2003).

3.10 Improved yam technologies

Agricultural Research and Development (R&D) is generally believed to be significant in ensuring food security and alleviating global poverty. In order to reduce food insecurity, improved technologies, believed to boost agricultural productivity, have been developed and disseminated (Sanginga, 2015; Arokoyo, 1996), including improved varieties and YMT, in Nigeria. Despite this, there is still declining yam productivity (Amujoyegbe & Elemo, 2012). The issue is whether farmers are adopting these new technologies and the significance of the technologies on farm performance and farm family wellbeing.

It has been reported that scarcity and high cost of seed yam are major constraints to yam production (Bolarinwa & Oladeji, 2009). The cost of seed yam accounts for 50% of the total cost of yam production (Asiedu et al., 2009). Traditional methods of yam production use substantial quantities of yam (which could be consumed) as planting material (NBS, undated).Naturally, yam has a low multiplication rate. The multiplication ratio of yam using the traditional method is about 1-4 to 1-8 (IITA, 2009b). This means that a tuber of yam can only produce four to eight macro setts.

Seed yam production techniques have been developed to boost yam production. They include YMT, aeroponics yam (where yam plantlets are produce without soil), Semi autotrophic hydroponics (yam plantlets are grown in water), and bioreactor. There are also proliferation of improved yam varieties developed by National Root Crops Research Institute (NRCRI) and partners to boost yam production in the country. Seed yam multiplication using aeroponics, SAH, and bioreactor are complicated. YMT is the only available on-farm yam multiplication technique; it is a cost-effective way of producing seed yam (IITA, 2013).

YMT was developed by NRCRI (Okoro, 2008) to boost yam production in Nigeria by making planting material available to farmers at a reduced cost. It is a rapid seed yam multiplication technique whereby whole-yam tubers containing periderm and cortex parenchyma are cut into small setts of 25-100g and treated for seed yam production (Aighewi et al., 2014). YMT reduces the excessive use of yam tubers as planting material. From five to ten percent of harvested yam is required for seed yam production using YMT while from 30 to 50% is required for yam production using traditional yam production methods (Asiedu et al., 2009). YMT, increases the multiplication rate to 1-30 (IITA, 2009b). It is less complicated and can generate large yams with minimal inputs (Okoro, 2008). It has been reported to produce seed yams up to 900 grams (Ogbonna et al., 2011).

3.11 Conclusion

In conclusion, yams are important in West Africa and other yam-producing areas. It is nutritionally superior to other comparative crops including sweet potato and taro. It is more valued than other comparative crops evidenced by its sociocultural, medicinal, nutritional and economic importance.

Despite the significance of yam, its global productivity is declining due to high cost and unavailability of planting materials and labour; intensification of land use which has led to soil nutrient depletion; over dependence on the traditional farming systems and continued practice of non-mechanized farming.

As discussed, the traditional yam production techniques are expensive, labour-intensive, physically demanding and there is limit mechanization of yam farming in Nigeria. Large quantities of inputs, especially planting materials, are required for yam production using traditional methods. Over reliance on traditional farming systems contributes to food insecurity. Farmers usually use poor quality seed yams obtained from last harvest. However, the use of poor quality seed yams has contributed to declining yam productivity. There are no standard storage facilities for yam and this has contributed to significant loss of yam during storage.

There is an urgent need to improve the current state of yam farming to enhance yam production. The traditional production techniques for yam in Nigeria are inadequate to meet the demand from the Nigerian population. The use of hoe and machete for farming cannot feed the growing nation.

There is also a need for an alternative farming system for yam and the use of improved yam varieties in Nigeria. Mechanization of yam farming would reduce the drudgery of yam production but current production practices and varieties use limited mechanization possibilities (Opara, 2003). Developing the Nigerian farming system and embracing innovations such as YMT would facilitate the multiplication of improved yam varieties and encourage mechanization. This could increase yield and reduce the overall cost of yam production.

Chapter Four

4.0 A Review of Theories and Approaches for Measuring Efficiency

4.1. Introduction

The use of an appropriate research method is necessary. It is a *sine qua non* for obtaining the accurate research output. Research based on faulty methods can lead to misleading results. Selection of an ideal method for accomplishing the objective of any research starts with a thorough review of other research studies and existing theory to identify their strengths and weaknesses.

In previous chapters, the problem of global food insecurity due to poor performance of the agricultural sector, especially in the developing countries was identified. To address the problem of global food insecurity and poverty, it is appropriate to start with determining the performance of farmers (especially those in the developing countries, who are the most poor) and suggesting ways of optimizing the use of the scarce resources available to them. This will contribute to improving the performance of these farmers.

This chapter reviews theories and approaches in measuring efficiency. It is divided into nine sections. The first section, 4.1 gives a brief introduction of the chapter. Concepts and definitions in efficiency study are explained in section 4.2.Section 4.3 reviews the approaches for measuring efficiency. Concept of metafrotier is explained in section 4.4, section 4.5 presents empirical studies on efficiency. Section 4.6 describes enterprise evaluation. Section 4.7 discusses empirical studies on adoption. Section 4.8 discusses evaluation of farming system, while section 4.9 presents a brief conclusion of the Chapter.

4.2 Concepts and definitions in efficiency study

The words efficiency and productivity are often used interchangeably. However, efficiency and productivity are distinct concepts. Efficiency is the ability to optimize output given a given input level. A firm is considered more efficient if it can produce more output using the same input. Productivity is defined as the ratio of output(s) that is produced to the unit input(s) used (Coelli et al., 2005). To illustrate the difference between efficiency and productivity, consider firms using input (X) to produce output (Y) in Figure 4.1. Line 0P is a production frontier which represents the maximum output attainable from each input level (Coelli et al., 2005). Firms operate either on or below the production frontier; firms on the production frontier are efficient while those beneath are inefficient (Coelli et al. 2005). From Figure 4.1, firms B and C lie on the frontier and are efficient. Firm A lies below the frontier (it is inefficient). Firm A is inefficient because it could produce more output to attain the production level of Firm B without increasing input.

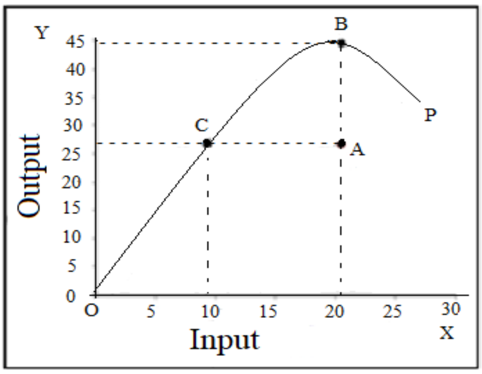


Figure 4.1: The production frontier and efficiency
Source: adopted from (Coelli et al., 2005)

The difference between efficiency and productivity is further explained in Figure 4.2. The gradient of a ray from the origin is the measure of the productivity (Coelli et al., 2005). Efficient firm B has a higher productivity than inefficient firm A (the ray (S_2) from the origin is higher at B). The ray from the origin is tangent to the production frontier at C (S_3); this is the point of maximum possible productivity (Coelli et al.,

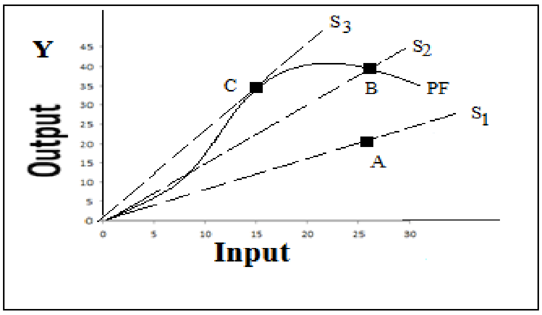


Figure 4.2: **An illustration of efficiency and productivity**
Source: adopted from (Coelli et al., 2005)

2005). Firms operating at other points of the production frontier have lower productivity. Firm C is the point of technical optimal scale (Coelli et al, 2005). A firm can explore economics of scale to move to the point C. An efficient firm B could increase productivity by exploring economics of scale.

Efficiency study enables testing and measuring efficiency in production. Coelli et al. (2005) included technical efficiency and economic efficiency (overall efficiency) as measures of performance. Technical efficiency is the ability to maximize output with a given level of input (Ajani & Olayemi, 2001; Bahasin, 2002). Economic efficiency is the cost effectiveness of an enterprise, showing how economically viable an enterprise (Coelli et al., 2005).

Production frontier represents the maximum output level attainable from each input level (Coelli et al., 2005). It can be used to evaluate the efficiency of a firm by comparing the observed and the potential outputs. Frontier functions can be classified as parametric or non-parametric, deterministic or stochastic, and cross-sectional or panel(Coelli et al. (2005). Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA) are parametric approaches while Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) are nonparametric and deterministic methods of estimating efficiency (Krüger, 2012; Sekhri, 2011). Coelli et al. (2005) grouped least square economic production models and SFA as parametric, and Total Factor Productivity (TFP) and Data Envelopment Analysis (DEA) as non-parametric.

Classification of these approaches is based on how the frontier is specified and estimated. Least square production models assume all firms to be technically efficient but deviate from the frontier due to measurement error which could be positive or negative (Coelli et al., 2005). The observed firms' outputs lie above and below the frontier. Output lies above the frontier if measurement error is positive and below if it is negative.

DEA and SFA do not assume all firms to be technically efficient (Coelli et al., 2005). In a deterministic production frontier, output is assumed to be bounded by a deterministic (non-stochastic) production function. The deterministic frontier does not account for measurement errors or other statistical ‘noise’. All deviation from the frontier is assumed to be due to inefficiency (Haghiri, 2003). All observations lie below the deterministic frontier.

In stochastic frontier models, output is assumed to be bound by a stochastic production function. The SFA presumes all deviations from the frontier are not completely under the control of the firm. It accounts for influences of noise on the frontier (Coelli et al., 2005; Haghiri, 2003). The stochastic frontier model assumes that all production units are successful in reaching the production frontier but deviate randomly.

The stochastic frontier model captures measurement error and statistical noise (v_i), which is not under the control of the farmer (and can be positive or negative), and stochastic noise (u_i) associated with inefficiency in the firm (Belloumi & Matoussi, 2006). Figure 4.3 is an illustration of the stochastic frontier concept. Input and output values are on the X and Y axes respectively. Firms A and B are using the same input quantity to produce different levels of output. Firm B produces more output than A and lies on the production frontier (highest attainable output level). Firm A is unable to reach the level of Firm B due to inefficiency (u_i) and statistical noise (v_i) such as measurement error, weather, use of faulty machinery and other sources. Farmers are unable to reach the stochastic frontier output due to inefficiency and stochastic noise.

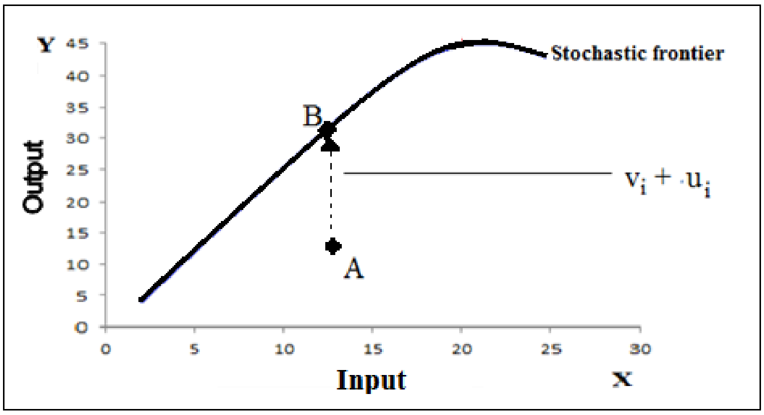


Figure 4.3: **An illustration of stochastic frontier**
Source: adopted from (Coelli et al., 2005)

Fig. 4.4 illustrates deterministic and stochastic frontier concepts, with one input and output for Firms A and B. In the stochastic frontier, output is either above or below the deterministic frontier. The stochastic frontier lies above the deterministic frontier if the error effect is positive (i.e. $v_i > 0$) as in firm A; and below if the error effect is negative (i.e. $v_i < 0$) as in Firm B. The OLS assumes all firms to be efficient but they can deviate from the frontier due to measurement error.

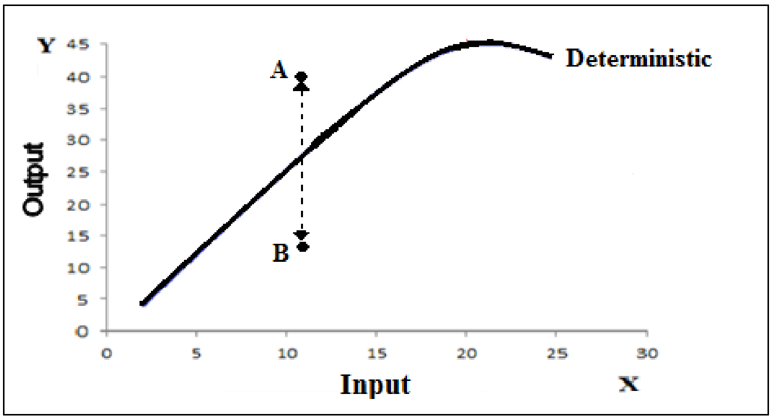


Figure 4.4: Deterministic and stochastic frontier
Source: Adopted from (Coelli et al., 2005)

4.3 Approaches to measuring efficiency

The piece-wise-linear convex hull approach to frontier estimation proposed by Farrell (1957) has led to development of the concept of the frontier production function for measuring firms efficiency. Farrell's (1957) approach is more in line with the economic definition of production function than the average production function adopted by earlier researchers (Wan & Battese, 1992).

Coelli (1995) discussed the various techniques used in efficiency measurement including their limitations, strengths and applications in agricultural production. Parametric (SFA) and non-parametric (DEA) are the two commonly used approaches in measuring efficiency (Coelli et al., 2005; Kruger, 2012). DEA is a non-parametric linear programming approach introduced by Charnes et al. (1978) used for calculating the relative efficiency of decision making units using multiple measures of inputs and output (Coelli et al., 2005; Wanke, 2012). The stochastic frontier production function is an econometric method independently proposed by Aigner et al. (1977) and Meeusen and Broeck (1977). The main strength of the SFA is that it captures stochastic noise and permits statistical testing of hypotheses pertaining to production, structure and degree of inefficiency (Coelli, 1995). This model incorporates a composite variable which comprise a two-sided symmetric term that captures random effects outside the control of the firm, along with a one-sided component that captures inefficiency (Haghiri, 2003). The weakness of parametric approach (SFA) is that it imposes an explicit parameter for the underlying technology and explicit distributional assumption for the inefficiency term (Sharma et al, 1999). The advantage of DEA is that it is parameter free, does not require the specification of technology or weight of different inputs and outputs (Chen et al. (2011); Rajesh and Mahapatra, 2009). DEA also constructs a production boundary above the data which allows production methods to be compared (Xue-yuan, 2010). The main weakness of the DEA is that it fails to account for measurement errors and other sources of statistical noise; it assumes all deviation from the frontier to be as a result of technical inefficiency (Coelli et al., 2005; Xue-yuan, 2010). The stochastic frontier production function is more realistic than the deterministic frontier (Lita & Stamule, 2011; Wan & Battese, 1992). The frontier estimate for inefficiency is likely to be sensitive to measurement error and/or other noise in the data because DEA is deterministic and attributes all the deviations from the frontier to inefficiencies(Coelli et al. ,2005). Recently developed nonparametric-stochastic order-m and order-α approaches combine the advantage of stochastic and DEA in estimating efficiency of production units. Order-m stochastic non-parametric efficiency measures combine the advantages of DEA and SFA. They are non-parametric and are also stochastic (Kruger, 2008). Kruger (2012) reported that the nonparametric-stochastic (order-m and order-α methods) are the least performing efficiency models. The SFA model outperforms other; it ranks first among other efficiency models (Kruger, 2012).

Parametric (stochastic frontier) and non-parametric (DEA) approaches are often applied to data on a sample of firms at a particular point in time and provide measures of firms' technical efficiency (Coelli et al. , 2005). Researchers have reported aggregation bias in the stochastic frontier model when using panel data (for example Oh, 2012). Oh (2012) found that farm-level data is more appropriate than aggregate data when using the stochastic frontier model due to aggregation bias which could produce misleading results. Least square economic production models and total factor productivity indices are applied to aggregate time series data and provide measures of technical change. SFA is appropriate for large sample sizes and large measurement errors while DEA is ideal when the sample size is small with small measurement error (Kruger, 2012).

The Stochastic frontier is commonly used in measuring technical efficiency of firms (Haider et al., 2011). It incorporates a symmetric disturbance term denoted as v_i and a one-sided disturbance term (u_i). The v_i term is independently and identically distributed $N(0,\sigma_v^2)$ with random errors independent of u_i, while u_i are non-negative random variables associated with technical inefficiency which truncate at zero of the normal distribution with mean μ_i and variance σ_u^2 [$N(\mu_i, \sigma_u^2)$]. The μ_i term is expressed as $\mu_i = Z_i\delta$, where Z is a vector of observable farm-specific variables associated with technical inefficiency, and δ is a vector of parameters to be estimated (Belloumi and Matoussi, 2006).

The Stochastic Frontier for a group of firms is expressed in implicit form as:

$$\mathrm{Y_i} = f(X_{i,}\beta_j)e^{v_i - u_i}, \qquad i = 1, 2, \ldots . N. \tag{4.1}$$

Here i = 1, 2, …, n, Y denotes output of the ith firm, X_i is a vector of the functions of actual input quantities used by the ith firm, and β is a vector of parameters.

The TE of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology (Coelli et al, 2005):

$$TE = Y_i/Y_i^*, \tag{4.2}$$

where Y_i is the observed output, Y_i^* is the frontier output (expected output).

Substituting equation 4.1 in 4.2,

$$TE = f(X_{i;}\beta)e^{v_i - u_i} \,/\, f(X_{i;}\beta)e^{v_i} \tag{4.3}$$

$$= e^{-u_i}, \text{ and} \tag{4.4}$$

$$TE_i = e^{-u_i} = Y_i / f(X_{i;}\beta)e^{v_i}. \tag{4.5}$$

In the equation above, TE_i is the technical efficiency of the i^{th} firm, also denoted as e^{-u_i} (e is exponent sign), Y_i and X_i are the observed output and input of individual firms respectively. The v_i symmetric error term captures deviation from the production frontier due to factors not under the control of the firm. These factors include measurement and specification error, and exogenous shocks such as weather conditions and machine performance. β_i is the estimated parameter. The u_i non-negative variable accounts for distance from the frontier due to inefficiency of the firm (Cullinane et al., 2002). The value of u_i falls between zero and one. A u_i value of zero implies that the firm is fully efficient. The greater the u_i value the more inefficient is the farm (Coelli et al., 2005).

4.4 Concept of the metafrontier

The SFA assumes that the production technology is the same, all the unobserved difference in technologies might be attributed to inefficiency. Until recently, researchers have compared the efficiency of enterprises in different locations using different production technologies without considering the effect of differences in technology and environment on the efficiency of such enterprises. Farmers producing the same output in different ecological zones may not use exactly the same production technology. A technology appropriate for use in one ecosystem might be unsuitable in another due to environmental constraints. Comparing the efficiency of such farmers would include bias if the environmental-technological constraints are not considered. Metafontier allows comparison of TE to accommodate differences in technologies across firms in the same industries (Boshrabadi et al.,2008).

Different authors have used different terms for TGR. O’Donnell et al. (2008) used Meta-Technology Ratio (MTR) while Villano et al. (2012) used the term Environmental Meta-Technology Ratio (EMTR). EMTR measures the ratio of the output of the frontier production function for a particular region to the potential output that is defined by the metafrontier production function, given the observed input (Battese& Rao, 2002). The higher the EMTR value, the closer the individual firm is to the metafrontier (Villano et al. , 2012). Lower EMTRs show that firms are further from the metafrontier.

In this study, the TGR will be referred to as EMTR to show the gap in production frontier with respect to environmental conditions following Villano et al. (2012). Deviation of the individual firm from the group frontier is attributed to inefficiency while deviation of the individual group frontier from the metafrontier is due to environmental/technological gap.

In Figure 4.5, line Z^1 is the metafrontier which envelops the group frontiers G^1 and P^1. Firms on the metafrontier are unaffected by environmental/technological conditions (Mariano et al., 2010). Those on the subgroup frontiers are efficient in their individual subgroup but are affected by the environment/technology constraints (Mariano et al., 2010). The distance between the metafrontier and subgroup frontiers is the EMTR. Firms on the metafrontier have EMTR of one while those on the subgroup frontiers have efficiency value of one (Mariano et al., 2010).

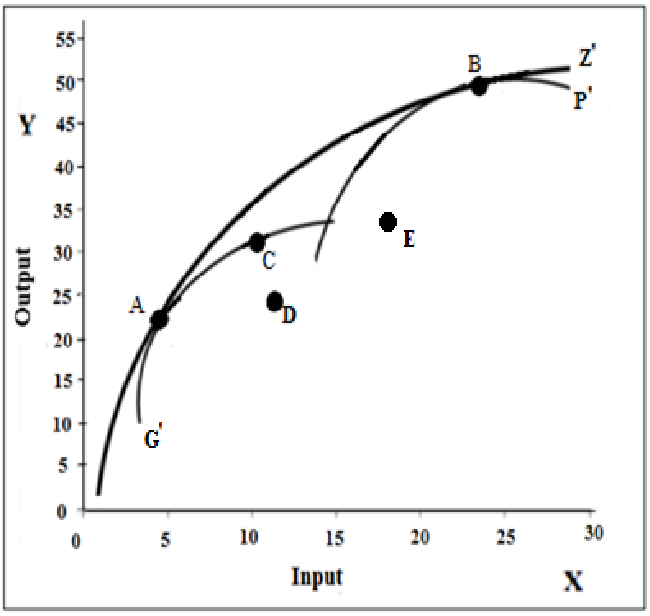


Figure 4.5: An illustration of metafrontier
Source: Adopted from Mariano et al., 2010

From Figure 4.5, a firm at point A lies on the subgroup frontier and metafrontier. At this point the firm is efficient and is not affected by environmental/technological constraints (Mariano et al., 2010). Similarly, a firm at point B lies on the frontier of the other subgroup and the metafrontier; this firm is also efficient and not subject to environment or/and technology differences. A firm at point C lies on the subgroup frontier but not on the metafrontier. This implies that the firm is efficient but is affected by environmental/technological constraints(Mariano et al., 2010). Firms not on the metafrontier and the subgroup frontiers (for example, firm D and E) are inefficient and affected by affected by environment/technology differences. The further a firm is from the frontier, the more inefficient the firm.

The potential output of a firm is constrained by the operating environment and the firm's technology. Metafrontier analysis enables the TE score to be corrected by the Technology Gap Ratio (TGR) (Villano et al.,2012). TGR accounts for the effect of the environment and technology on TE (it eliminates the effect of environment and technology on TE thereby putting all firms on an equal level for comparison). The existence of a technology gap in different ecosystems will lead to the development of technologies suitable for farmers' resource, socioeconomic and environment conditions (Mariano et al., 2010). To estimate the metafrontier, first the TE of the subgroup frontiers ($TE_{i(j)}$) are evaluated. The metafrontier which envelops the group frontier is then estimated. The gap between the metafrontier and the subgroup frontiers is determined. TE of individual firms with respect to the subgroup (j) is defined as the ratio of observed output to the highest attainable output (frontier output). It is expressed as:

$$TE_{ij} = \frac{Y_{ij}}{f(X_{ij},\beta_j)e^{v_{ij}-u_{ij}}} = e^{-u_{ij}}. \qquad (4.6)$$

The metafrontier is expressed as:

$$Y_i^* = f\left(X_{i,}\beta^*\right) = e^{X_i\beta^*}, \qquad (4.\ 7)$$

where Y_i* is the metafrontier output and β*is metafrontier parameter.

The observed individual firm's output defined by the group (j) frontier is expressed in terms of the metafrontier as:

$$Y_i = e^{-u_{ij}} \text{ x } \frac{f(X_{i,}\beta_j)}{f(X_{i,}\beta^*)} \text{ x } f\left(X_{i,}\beta^*\right)e^{v_{ij}}. \qquad (4.8)$$

Technical efficiency of i^{th} firm in the *j* ecological zone/subgroup is expressed as:

$$TE_{ij} = e^{-u_{ij}}. \qquad (4.9)$$

The EMGR is the ratio of the highest attainable individual group output to the highest possible metafrontier output expressed as:

$$EMGR = \frac{f(X_{i,}\beta_j)}{f(X_{ij\,,}\beta^*)} = \frac{e^{X_i\beta_j}}{e^{X_{ij}\beta^*}}. \quad (4.10)$$

Technical efficiency of the individual firm relative to the metafrontier is defined as the ratio of the observed firm's output to the obtainable metafrontier output. It is expressed as:

$$TE_{i(m)} = \frac{Y_{ij}}{f(X_{i,}\beta^*)e^{v_{ij}}}. \quad (4.11)$$

Technical efficiency of metafrontier which is equivalent to the Total Factor Product (TFP) can be rewritten as:

$$TE_{i(m)} = TE_{ij} \text{ x EMGR}. \quad (4.12)$$

4.5 Empirical studies on efficiency

DEA and SFA are the commonly used approaches in efficiency estimation (Coelli, 2005).DEA efficiency results can be misleading for agricultural application where random errors are highly significant (O'Donnell, 2008). Coelli (1995) recommends the use of SFA for agricultural applications. SFA is appropriate for large sample sizes and large measurement errors while DEA is ideal when the sample size is small with small measurement error (Kruger, 2012).

Stochastic frontier production function can be estimated using maximum likelihood or corrected ordinary least squares method (Coelli, 1995). The ML estimation of stochastic frontier outperforms the COLS and should be used instead of COLS whenever possible (Coelli, 1995). Collier et al. (2011) observed that the COLS model is limited by its inability to properly account for measurement error. The SF model is usually estimated using likelihood-based methods (Belotti et al., 2013). However, Belotti et al. (2013) reported that the SF analysis could include exogenous variable that affect the production frontier and the distribution of inefficiency. Unobserved variables could be correlated with noise in the SF model (Bravo-ureta et al., 2012).

Coelli (1995) observed that some studies used OLS to evaluate production and cost functions. OLS estimates average production function which assumes that firms are100 percent efficient (Ahmed, 2003). OLS model is limited by its inability to properly account for measurement error (Collier et al., 2011).

Coelli (1995) surveyed the recent developments in frontier functions estimation and efficiency measurement. He reported that SFA is the most popular method used in estimating efficiency despite its limitations. The major criticism of SFA is that it has no a priori justification for the selection of distributional form for the u_i (Coelli, 1995). This problem can be addressed by the specification of general distributional forms such as truncated normal distribution and the two-parameter gamma. However, the efficiency measure resulting from this may be sensitive to distributional assumption (Coelli, 1995). None of the frontier methods of estimating efficiency is perfect. (Coelli, 1995)

Researchers have used different functional forms to model production functions. These include Cobb-Douglas, quadratic and normalised quadratic, and Translog (Rao, undated). The Translog model is very commonly used (Rao, undated). The Cobb-Douglas model is easy to estimate and interpret and requires the estimation of fewer parameters. However, the disadvantage of the Cobb-Douglas model is that it imposes several a priori restrictions on the production elasticities and substitution elasticities. It assumes all firms to have the same elasticities, and that substitution elasticities are unity (Dawson and Lingard, 1984; Battese and Coelli, 1992; Rao, undated). Flexible functional forms, such as the Translog function make no such restriction (Wilson et al., 1998). The disadvantage of Translog function is that it is more difficult to interpret; it requires the specification of many parameters and can suffer from curvature violation.

Cobb-Douglas is the commonly used functional form despite its limitations (Coelli 1995; Bravo-ureta and Pinheiro, 1993). In Cobb-Douglas model, return to scale are restricted to take the same value across firm and elasticities of substitution are assumed to be equal to one (Coelli, 1995). Translog function has also been used in literature (Coelli, 1995). It imposes no restriction on return to scale or substitution possibilities; however, it is susceptible to multicollinearity and degree of freedom problem (Coelli, 1995). These problems can be avoided by jointly estimating the translog function with first order conditions for profit maximization (Coelli, 1995).

Researchers often evaluate the determinants of efficiency using two-steps (Greene, 2012; Coelli, 1995). Obayelu et al. (2017) employed the two-step method to ascertain the determinants of technical inefficiency. In the first stage, they determined TE using stochastic frontier function; in the second stage Tobit regression was used to determine factor affecting technical inefficiency.Hallam and Machado (1996) explored the determinants of TE using a two-step procedure, they estimated the stochastic frontier function then regressed the estimates upon a vector of variables assumed to express differences in u_i (technical inefficiency). Dawson and Lingard (1984) and Battese and Coelli (1995) have criticized the two-step procedure of measuring efficiency which many researchers have used in efficiency estimation on the grounds that it violates the assumption of the identically and independently distributed technical effect of the stochastic frontier. Inefficiency effects are assumed to be independently and identically distributed in the first stage, while they are assumed to be a function of the firm specific factors in the second stage (which implies that they are not identically distributed).The two-step inefficiency estimation incorporates exogenous effect (Greene 2012) and leads to biased estimation of results (Belotti et al., 2013). Battese and Coelli (2002) proposed one-stage production frontier with composed errors and inefficiency. Battese and Coelli's model has an advantage over the two-stage efficiency measure in that it incorporates farm-specific factors in the measure of efficiency.

Some authors have conducted efficiency studies on yam in Nigeria using one-stage method. Ike & Inoni (2006) investigated the determinants of yam production and economic efficiency using stochastic frontier production function, which incorporates inefficiency variables. They reported that labour material inputs are factors affecting yam output in Nigeria, while education, farming experience, and access to credit are the major determinants of technical inefficiency. Michael (2011) determined the TE of yam farmers in Nigeria using the stochastic parametric approach. Onyenweaku et al. (2005) also applied stochastic frontier production function to evaluate TE of yam farmers in Nasarawa State, Nigeria. None of the previous studies on yam in Nigeria considered the effect of environment / technologies on the performance of farmer.

The SFA assumes that the production technology is the same; the unobserved difference in environment/technology might be attributed to inefficiency. Comparing the efficiency of such farmers can lead biased result if the environmental-technological constraints are not considered. Difference in technology could be addressed using metafronteir analysis. Difference in technology could be addressed using metafronteir framework, latent class model, random parameter model, switching regression model and state contingent frontier (see Villano et al., 2010). These methods have shown that omission of environmental variables can lead to bias in the estimation of efficiency parameter and technical efficiency. The metafrontier framework proposed by Battese and RAO 2002 enables for the estimation of TGR in addition to the estimated parameters and technical inefficiency.

Metafrontier analysis is relatively new in developing countries (Villano et al., 2010). Some studies have employed metafrontier analysis in crop production. Villano et al. (2010) used the metafrontier approach to determine varietal differences in Pistachio production in Iran. They proved that metafrontier method is valid and enabled technical efficiency scores to be corrected by the coefficient of the TGR. Boshrabadi et al. (2008) used metafrontier analysis to determine the technical efficiency and environmental technology gaps in wheat production in Iran. To the best of my knowledge Ayinde et al. (2009) is the only study on metafrontier analysis in Nigeria. They investigated the determinants of technical efficiency and varietal-gap of rice production in Nigeria. The current research differs from other efficiency studies in that it employs metafrontier approach to estimate efficiency of yam farmers in Nigeria.

4.6 Evaluation of a technology

The common evaluation method of the impact of a technology is the before and after approach, whereby mean outcome of the treatment group is compared before and after intervention. This method provides information on trend the observed change cannot be attributed to the innovation since other factors could be responsible for the change (Bravo-Ureta et al., 2012). In order to attribute the observed change to the intervention, it is better to compare the treatment group with a group similar to the treatment group except that it is not subject to the intervention. This can be achieved by using PSM (Bravo-Ureta et al., 2012).

Technologies are not randomly assigned to farmers. If they were, then the effect of adopting a technology on their wellbeing would be the income difference between the adopters and non-adopters. The adoption of technology is based on self-selection which is influenced by the socioeconomic characteristics of the farmers. Before an observed change is attributed to the adoption of a particular technology, it is necessary to determine what the situation would be if the technology was not adopted. The observed change could be due to other factors rather than the adoption of the technology. One possible way of eliminating selection bias is the use of Propensity Score Matching (PSM), in which the behaviour of a given adopter is inferred by matching them with an equivalent non-adopter (Wu et al., 2010). The use of PSM in assessing the impact of a technology on farmers' performance eliminates the interference of other factors that can influence performance.

Before estimating non-parametric propensity score, the first step is to ascertain the determinants of adoption of the technology. Logit and Probit models are standard approaches to measuring binary dependent variables. These two approaches give similar results. Farmers are then grouped based on similarity in conditions that could influence adoption of technology. Several matching criteria have been developed and used in literature; they include: nearest neighbour matching (NNM), kernel matching, and stratification matching. The most commonly used approaches are NNM and Kernel matching (Emmanuel et al., 2016). Adopters and non- adopters of the technology are then regressed based on their performance for all the significant determinants of adoption. This eliminates the interference of other determinants of adoption.

The Probit/Logit model is expressed implicitly as:

$$Y_i = b_0 + b_i X_i + E, \qquad (4.11)$$

where Yi has the value of either 0 or 1

The effect of a technology is the difference between the wellbeing of farmer adopting a technology (A=1) and not adopting the technology (A=0) expressed as:

$$E^{T} = (Y_i^{1} - Y_i^{0}) \tag{4.12}$$

In reality, farmers either do or do not adopt a technology. The wellbeing of a farmer is either Y_i^1or Y_i^0.

The unobserved wellbeing is the counterfactual situation. This is what the situation of the farmers would have been had they not adopted the technology. The observed wellbeing of the farmer can be written as:

$$Y_i = A\, Y_i^{1} + (1-A)\, Y_i^{0}. \tag{4.13}$$

According to Wu et al. (2010), the quantity of interest in the counterfactual framework is the Average Treatment Effect (ATE). The ATE for the whole sample is the weighted average of the treatment effect for the adopters and non-adopters (Wu et al., 2010). The ATE for the whole sample is the expected effect of the technology across all farmers expressed as:

$$ATE = P.\,[E\,(Y^{1}|A=1) - E\,(Y^{0}\,|A=1)] + (1-P).\,[E\,(Y^{1}|A=0) - E\,(Y^{0}\,|A=1)], \tag{4.14}$$

where P is the probability of adopting improved technology (A=1), E $(Y^0 |A=1)$ is the expected value of non-adopters adopting the technology while E $(Y^1|A=0)$ is the expected value of adopters not adopting the technology. The counterfactual states, E $(Y^0 |A=1)$ and $E(Y^1|A=0)$ are unobserved. The counterfactual wellbeing of the farmers should be constructed in estimating the ATE.

The ATE for the adopters can be written as:

$$ATE_A = (E^{T}|A=1) = E\,[\,(Y^{1}|A=1] - E\,[\,(Y^{0}|A=1] \tag{4.15}$$

The problem of self-selection bias is obvious in the above equation as the condition E $[(Y^0|A=1]$ is unobservable. The non-adopters can be used to compare the adopters if the condition E $[(Y^0|A=1] = [(Y^0|A=0]$ is satisfied.

The mean observed characteristics before and after matching were compared to satisfy balancing property of the covariates. This is achieved if most of the observed characteristics are not statistically different (Bravo-Ureta et al., 2012).

4.7 Empirical studies of adoption

There have been many studies on adoption of agricultural technologies in Nigeria. Most of these studies focussed on evaluating the rate of adoption, profitability of new technologies, and factors affecting the adoption of agricultural technologies (e.g. Gbegeh & Akubuilo (2013) determined factors influencing the adoption of YMT in Nigeria; while Nchinda et al. (2010) ascertained the determinants of YMT in Cameroon. Few studies in Nigeria have evaluated the impact of new technologies on farmers' wellbeing, income being an indicator of wellbeing. Adofu et al. (2013) investigated the economic impact of improved agricultural technology on cassava productivity by comparing income before and after adoption of innovation. These earlier studies failed to take into consideration the counterfactual situation of farmers (that is, what the situation would have been if the technology was not adopted). Wu et al. (2010) observed that assessing the impact of a technology without considering the counterfactual situation of such technologies gives misleading results. As such, this method gave a biased estimate of the impact of such technologies on farmers' performance/wellbeing. This has affected policies on agricultural technology advancement.

PSM is not a common approach in developing country (Bravo-Ureta et al., 2012). PSM has been used in agriculture by Mendola (2007)who assessed the effect of agricultural technology on poverty reduction in rural Bangladesh. Wu et al. (2010) used PSM in assessing the impact of agricultural technology adoption on farmers' wellbeing in rural China. Bravo-Ureta et al. (2012) combined the stochastic frontier framework and impact assessment methodology to compare TE of treated and control group using cross-sectional data. They used PSM to address bias from observed variables, and selectivity correction model to address possible self-selection arising from unobserved variables using selectivity correction model for stochastic frontier introduced by Greene (2010).

Basley and Case (1993) are of the opinion that the use of cross-sectional data (information obtained at a point in time) for impact assessment adopted by most researchers can be problematic if there is dynamic structure in the adoption decision. They argued that cross-sectional data provides only a snapshot at that time of evaluation. The diffusion of the technology may be incomplete at that point in time. Nevertheless farm and farmers' characteristics associated with accepting the technology can be determined using cross-sectional data (Basley and Case, 1993).

To the best of my knowledge, Obaleye et al (2017) was the only study in Nigeria that combined technical efficiency and impact assessment method. They evaluated the impact of NERICA adoption on TE of adopters and non-adopters in six baseline States of Nigeria using Local Average Treatment Effect. They also used tobit model for the determinants of TE (i.e. the two-stage method).

This study investigated the potential of improved yam technologies for performance and wellbeing improvement among yam farmers in Nigeria using metafrontier and PSM respectively.

4.8 Evaluation of farming systems

Current agricultural economic studies in Nigeria include technological development, acceptability of new technologies and assessment of their impact (Norman, 2002). Evaluating a farming system or a technology requires the use of a proper analytical tool. Cash flow measures (CFM) such as Net Cash Flow (NCF), show how much cash the farmer generates in relation to how much cash is spent by the household to meet its needs. NCF is the difference between farmer receipts (i.e. income generated) and payments (amount spent). CFMs do not account for non-cash items; therefore, they give an incomplete picture of the performance of a farm. Income and profitability measures include gross farm income (GFI), which is a measure of the revenue received from all resources used on the farm. It is the product of the yield and market price. The difference between the GFI and the total farm expenditure is the net farm income. GM analysis, a measure of partial farm performance(Dillon & Hardaker, 1980), is used in a mixed farming system to compare actual or potential profitabilities of individual enterprises. GM of an enterprise is computed by subtracting the variable costs (costs that vary with the scale of production) from the GFI attributed to that enterprise (the value of all farm output) (Dillon & Hardaker, 1980). Total farm GM is the sum of all individual enterprise GMs.

The effect of a change in the way of operating a farm on farm profit can be determined using partial farm budgeting (Dillon & Hardaker, 1980). Farm budgeting is a useful farm planning method. It is a convenient way of comparing the profitability of alternative farming techniques or a new technology (Dillon & Hardaker, 1980). The proposed change is profitable if the gain associated with the change is greater than the cost.

4.9 Conclusion

This chapter has examined the concepts and terms used in this research. It also reviewed theories and studies on efficiency, evaluation of farming systems, and adoption of improved technologies. It also highlighted empirical studies on efficiency and adoption.

Chapter Five

5.0 Data and Method

5.1 Introduction

This chapter describes the methods used in this project. The chapter is organized into six sections. Section 5.1 is an introduction of the chapter. The study area is described in section 5.2. The sampling procedure and the survey data are described in section 5.3and 5.4respectively. The analytical procedure, statistical models, and the proposed hypothesis tests are presented in section 5.4, 5.5 and 5.6 respectively.

5.2 The study area

This study was conducted in Nigeria which is located in West Africa. Geographically, Nigeria lies between longitude $3^0$and 14^0 E and latitude 4^0 and 14^0N (NBS, 2010). The country has an area of 923,769 square kilometres. Approximately 909,890 of the area is land while 13,879 is water (NBS, 2010). Nigeria has borders with the Republics of Benin and Niger in the west; Cameroon in the east; Niger and Chad in the north, and the Gulf of Guinea in the south (NBS, 2010). It is consists of 36 States and the Federal Capital Territory. Figure 5.1 is a map of Nigeria showing States and their geographical locations. Nigeria has 774 Local Government Areas (LGAs) (Akinyele, 2009), 200 ethnic groups and 500 languages (Achimugu et al., 2012). However, English is the official language in Nigeria (OPEC, 2017).

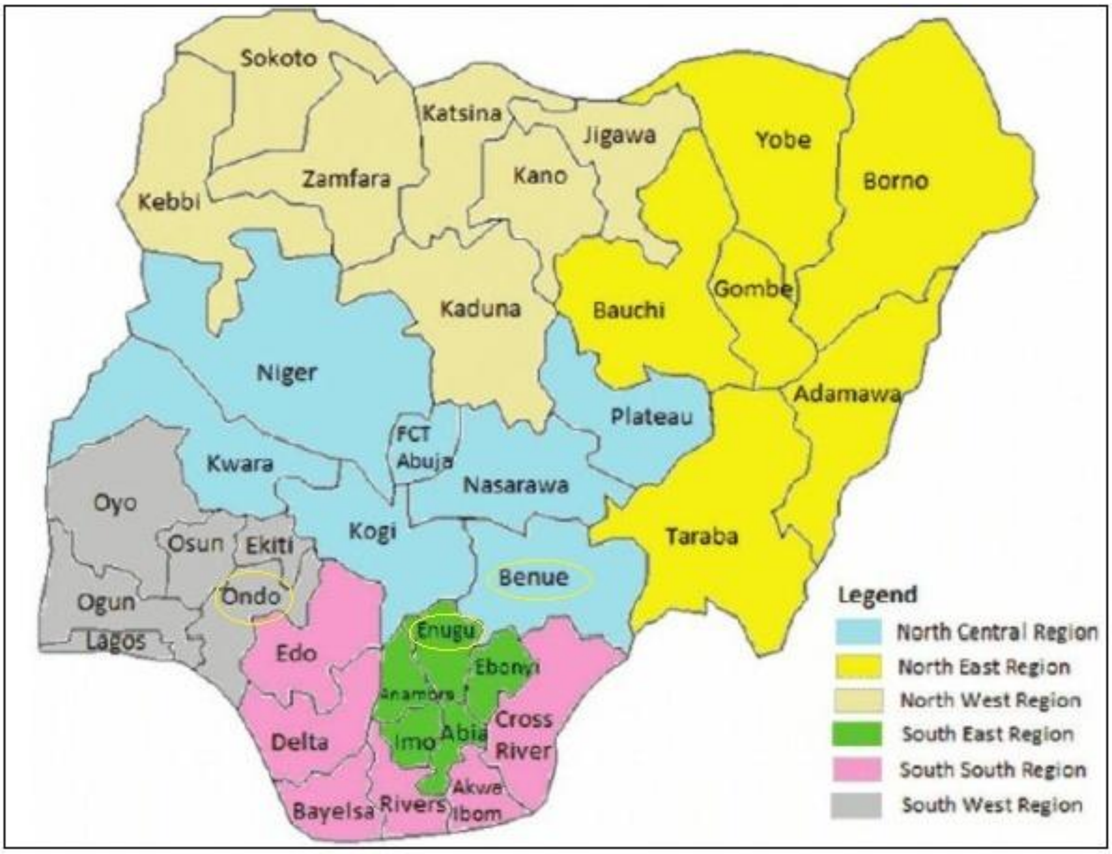


Figure 5.1: Map of Nigeria showing States and geographical zones
Source: adopted from Nigerianfact, 2020

This research was conducted in Nigeria because it is the leading producer of yam. States producing over 1.2 million metric tonnes of yam were randomly selected. States selected for this research were Benue, Enugu and Ondo. They are among the top yam-producing States. These are located in different regions in Nigeria. They also have different farming systems and employ different techniques for yam production. Two major yam-producing LGAs were randomly selected from each State. The selected LGAs are Buruku and Katsina-Ala in Benue State, Nkanu-east and Uzo-Uwani in Enugu State, and Owo and Ose in Ondo State.

5.2.1 Geo-climatic condition of Nigeria

Nigeria is a tropical country with a wide climatic variation (World Weather and Climate Information, 2017). Annual rainfall varies from below 1250 to above 4000mm. Highest total precipitation is recorded in the southeast while the lowest in the north (The Geography Site, 1991). Average, maximum and minimum annual temperatures are

26.4^{0}C, 33^{0}C and 21^{0}C respectively. Average annual precipitation is 1626mm and sunshine hours are 1885 per annum (Climatemp, 2012). Table 5.1 presents the geo-climatic conditions of the selected States. Benue has the lowest rainfall and highest temperature; Ondo has the highest rainfall while Enugu State has the lowest temperature.

Table 5.1: Geo-climatic condition of selected States

States	**Land Area (Sq. Km)**	**Max temp (^{0}C)**	**Min temp (^{0}C)**	**Mean annual rainfall (mm)**
Benue	30,800	35	21	1,290
Enugu	7,534	30.6	15.86	1,700
Ondo	15,820	33.5	17.9	over 2,000

Source: NBS, 2010

The wide range of climate variation in Nigeria allows for diversification of crops. Crops are grown in a variety of mixes. Most Nigeria farmers plant their crops randomly; they do not follow any particular cropping patterns or spacing (author's observation). There are regional differences in cropping patterns and type of crops sown.

5.2.2 Benue State of Nigeria

Benue State is located in the north-central Nigeria (Figure 5.1) and occupies an area of 30,800 square kilometres (Table 1.1). The State falls within longitude 7^0 47' and 10^0 0'E and latitude 6^{0}25' and 8^0 8' N. Benue is bound in the north by Nassarawa, in the east by Taraba, in the west by Kogi, in the south by Cross River, in the south-west by Enugu and in the south-east by Cameroon. Figure 5.2 is a map of Benue State showing LGAs. The State is made up of 23 LGAs and had a population of 4.8 million in 2006 (National Population Commission, NPC, 2015).

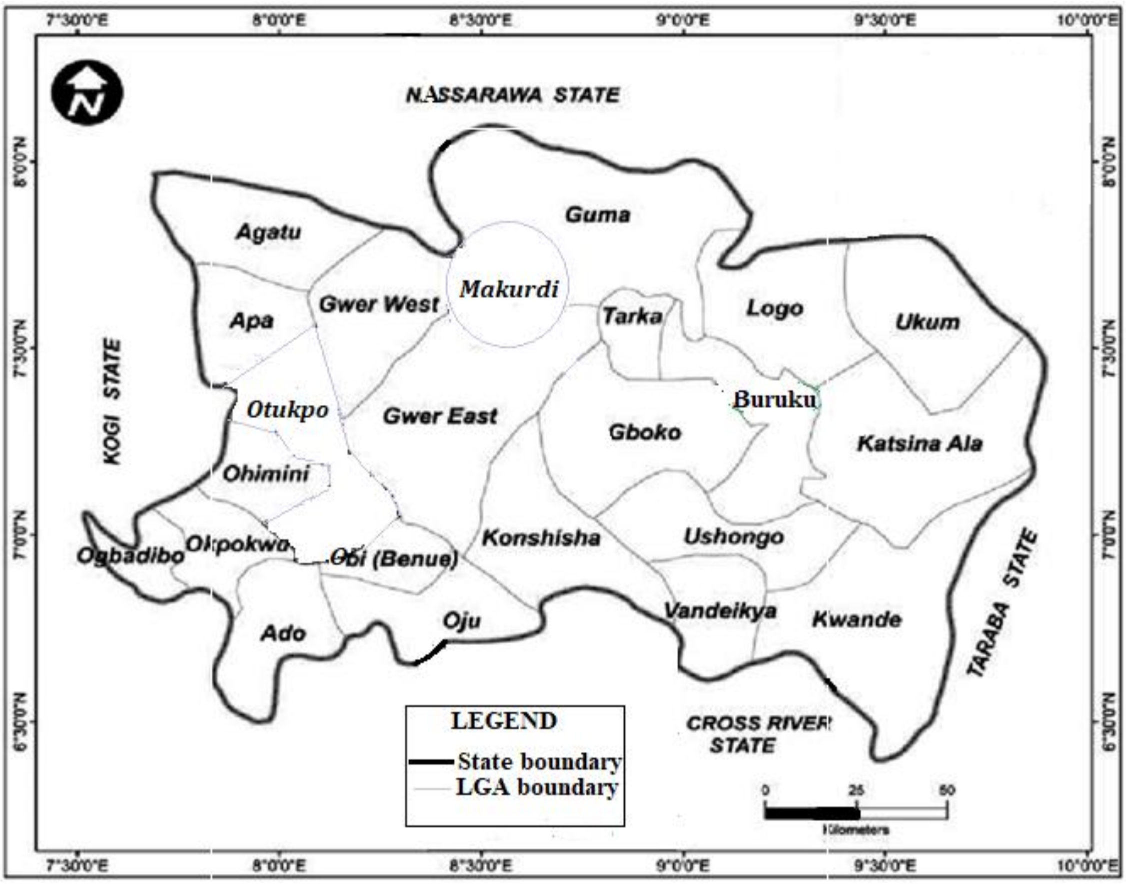


Figure 5.2: Map of Benue State showing LGAs
Source: Francis et al. (2014)

5.2.3 Enugu State

Enugu State falls within latitude 06^0 28'N and longitude 07^{0}33'E with an average altitude of 137m. It is located in the south-eastern part of Nigeria (see Figure 5.1) and is comprised 17 LGAs. It has a land area of 753,400 hectares (NBS, 2010) and had a population of over 3 million people in 2006 (NPC, 2015; NBS, 2010).Figure 5.3 is a map of Enugu State showing LGAs.

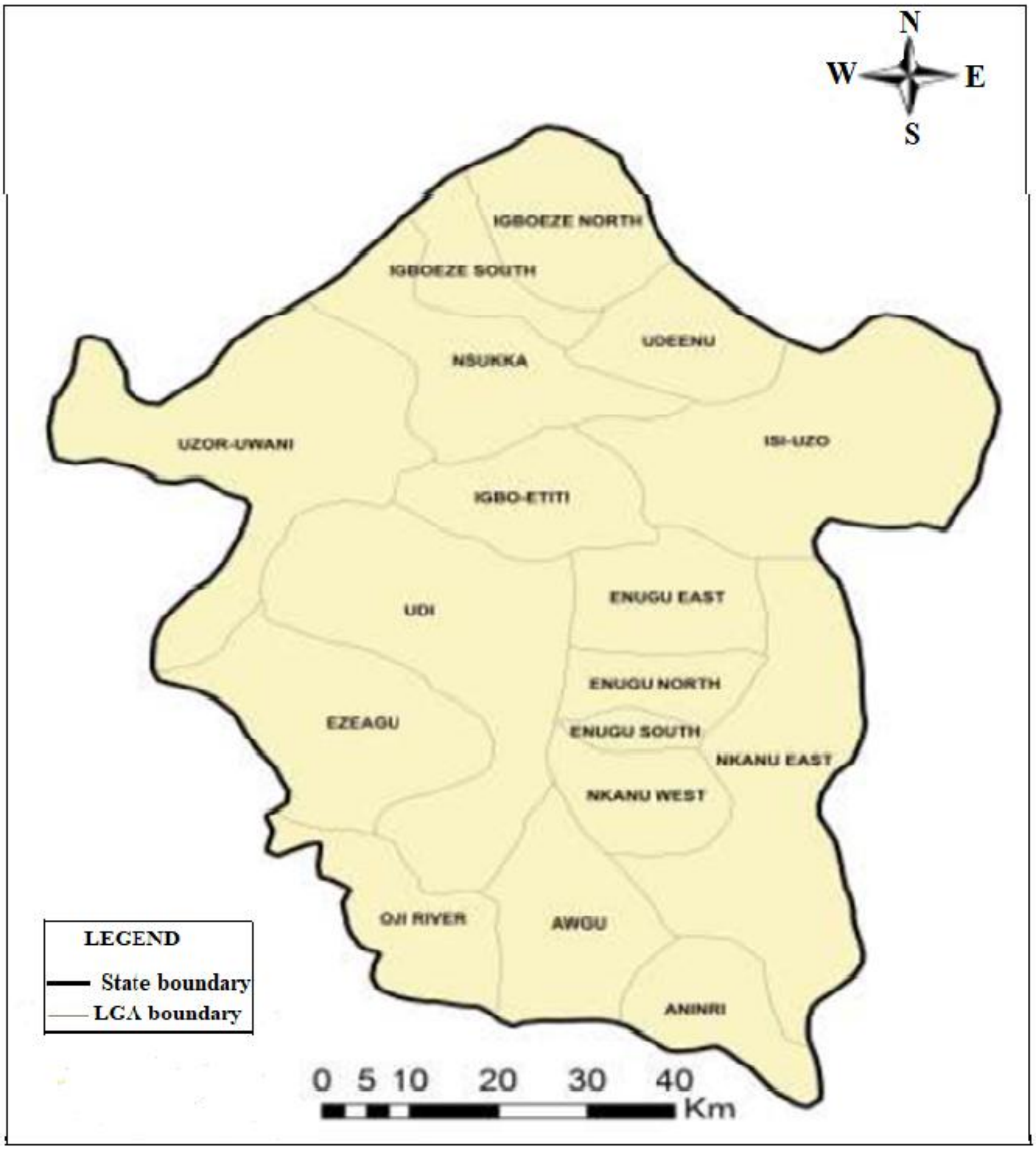


Figure 5.3: Map of Enugu State showing LGAs
Source: Ani et al. (2018)

5.2.4 Ondo State

Ondo State is located in the south-west region of Nigeria (Figure5.1). It falls within latitude 7^0 10' N and longitude 5^0 05' E of the Equator (National Geospatial Intelligence, 2012). The State has boundary with Ekiti and Kogi in the north, Edo in the east, Oyo and Ogun in the west and by Atlantic Ocean in the south (see Figures5.1 &5.4). Ondo is

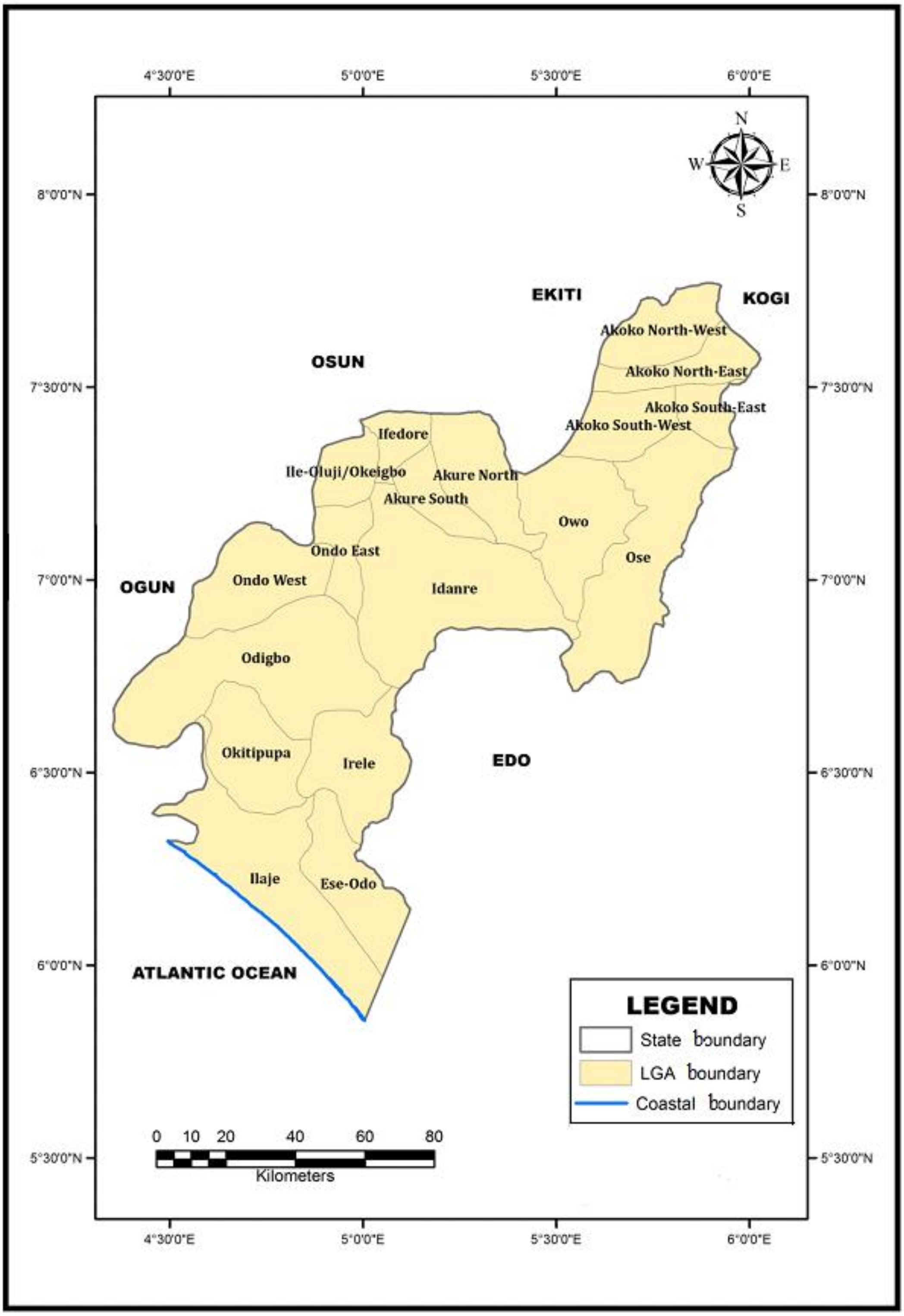


Figure 5.4: Map of Ondo State showing LGAs
Source: Gamer, 2020

comprised of 18 LGAs, has an area of 1,582,000 hectares (NBS, 2010) and a population of over 3.4 million people in 2006 (NPC, 2015). Figure 5.4 is a map of Ondo State showing the LGAs.

5.3 Sampling procedure

The survey was conducted in Nigeria because Nigeria is the leading producer of yam in the world. The target population were yam farmers in the selected States. A representative sample was used since it would be costly and time consuming to sample the entire population of yam farmers in the study area. The sampling framework is unavailable due to inadequate records. Therefore, Nigerian researchers use a population of sixty respondents as a good representation of an LGA (for instance, Okoye et al., 2006; Amaefula et al., 2006).

A multi-stage random sampling technique was used to elicit cross-sectional data from yam farmers in top yam-producing areas of Nigeria. Figure 5.5 displays the top yam-producing States of Nigeria. They include Nassarawa, Benue, Taraba, Enugu, Niger, Kaduna, Cross River, Ondo, Ekiti and Kogi. Benue has the highest yam production than the other States while kogi has the lowest. The first stage involved a random selection of three yam producing agro-ecological zones, the agro-ecological zones selected were guinea savannah, tropical rainforest with derived savannah, and low land rainforest with sub savannah. The second stage involved a random selection of three States producing a minimum of 1.2 million metric tonnes of yam per annum from the zones.

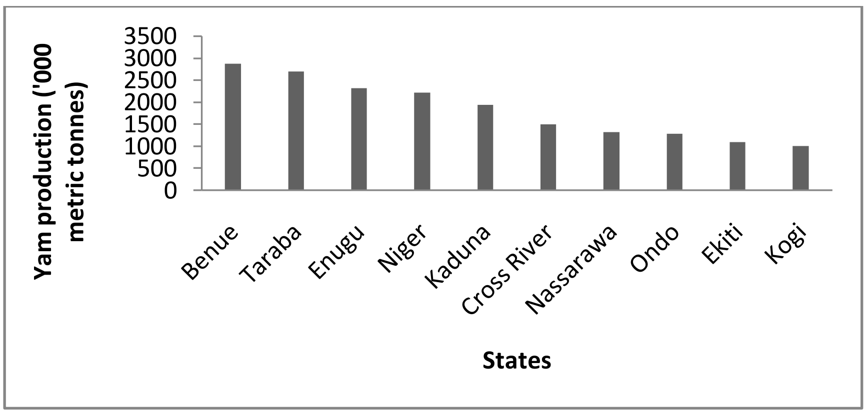


Figure 5.5: Top yam-producing States of Nigeria
Source of data: (Open Data for Africa, 2015)

The States were Benue, Enugu and Ondo, which are located in guinea savannah, tropical rainforest with derived savannah, and low land rainforest with sub savannah and agro-ecological zones of Nigeria respectively. The States are also located in different geopolitical zones of Nigeria - see Figure 5.1 (farmers in these States use different techniques for yam production). The next stage of sampling involved randomly selecting two major yam-producing LGAs from each State. The LGAs selected were Buruku and Katsina-Ala in Benue State, Nkanu-east and Uzo-Uwani in Enugu State, and Owo and Ose in Ondo State. The survey data and method of data collection are discussed below.

5.4 Survey data and data collection method

Data used for this analysis was derived from household survey conducted between September to December, 2013. The face-to-face interview was the preferred to the other survey methods such as the computer based survey, telephone interview and mail survey due to the poor communication infrastructure (internet connectivity, telephone and postal coverage) in the study area. Face-to-face interview enables clarification of questions. This is an appropriate method to use in the developing country context (Otieno, 2012). Trained enumerators - seven researchers from National Root Crops Research Institute, Umudike and two extension agents from Ondo and Benue States assisted in data collection. The questionnaire was administered in English. Six extension agents (one in each LGA) were employed to interpret to the illiterate farmers. The respondents were adults, 18 years and above, who usually make the farm decisions. Before commencing the administration of the questionnaire, the purpose of the research was explained to the prospective respondents. Data were extracted from only those who met the criteria for selection (yam producers within the age limit who are involve in decision making). The consent of the qualified yam farmers was sought and the confidentiality of their responses assured.

Data were extracted from yam farmers by using a well-structured questionnaire (Appendix A) and by direct observation. To ensure the validity and appropriateness of the survey instrument, it was overseen by my project supervisors. The questionnaire was also pre-tested (it was first administered to twenty yam farmers) and adjusted to ensure that it was adequate to achieve the purpose it was meant.

The survey instrument was administered in the LGAs based on availability of respondents (a minimum of sixty yam farmers from each LGA). Data were extracted from four hundred and eleven respondents. Information obtained from three hundred and sixty respondents was used for the study; questionnaires with incomplete information were discarded.

Issues captured in the questionnaire include farmer's socioeconomic characteristics(such as age, gender, household size, farm size, type of land ownership, level of education, farming experience, marital status among others); resource endowment data (such as land availability, access to infrastructure including financial institution, Research and Extension (R&E) activities, hospital, schools, machinery, irrigation facilities and good roads); and resource utilization data (such as labour, land use, access to credit and amount borrowed and use of fertilizer). Input and output data for the farm activities were also collected. Data were collected on costs, returns and income, farming systems (information on cropping patterns and duration of crops), and attitudinal data (such as farmers' responses to issues of use of YMT, yam varieties, fertilizer and ICTs). Other data collected include environmental data (availability and accessibility of infrastructure; physical conditions of the soil such as slope of land, fallow period, fertility, flooding and irrigation of farm); techniques used by farmers; input and output data for the different techniques for yam production and data on farmer's health.

5.5 Description of variables

This section describes how the variables used in this research were measured and the computations and transformations made. For technical efficiency analysis, output is the dependent variable (Y). Farm size, labour, quantity of fertilize, quantity of seed yam, and depreciated cost of capital input are the independent variables (Xs). Yam output is the total weight in kilogramme of harvested yam in the production cycle. Farm size is the area of land under yam production in hectare. Labour is the number of man-days employed for paid and unpaid work on the farm (one man-day equal to eight hours). Quantity of fertilizers is measured in kg. Seed yam used is the weight of seed yam in kilogramme. The depreciated cost of capital input was calculated by using the straight line method. The farmers were asked the lifespan of the inputs they use; this varies among farmers as it depends on usage and maintenance. The variables were mean corrected (the mean of the variables were subtracted from the individual observations)

The variables used for economic efficiency analysis are cost of production (the dependent variable) is the amount in Naira the firm spends in producing yam in the season. Rent on land is the cost of renting a hectare of land used for yam production. For land owners, rent on land is the cost of a hectare of land in the place where the farm is situated. Wage rate is the average farm wage in the respective LGAs for both paid and unpaid labour. Depreciated cost of capital inputs is as defined above. Output of yam is also as defined above but a covariate in this context. The variables were also mean corrected.

The socioeconomic variables for evaluation of determinants of efficiency include gender, age, household size, primary occupation, members of agricultural organization, marital status, health issues, land ownership, farm size, education, extension visit, credit use and number of income sources. Dummy variable was used to capture the gender of the respondents (one was assigned to male and zero to female). Age is how old the farmers are, captured in years. Household size is the number of household members. Occupation of the respondent was captured with binary variables, one for full-time and zero for part-time farmers. Membership of organization was also capture with dummy variables (one for members and zero for non-members). Farm size is the area of the land (in hectare) allocated to yam production. Education is the years of schooling (formal education). Extension visit is the number of times of extension contact. Credit use was capture with dummy variables (one for those who obtained loan and zero for those who did not). Number of incomes is the number of places the farmer generates income from. The variables were correlated using SPSS, and correlated variables were excluded from the analysis.

The decision variables used in this thesis are sources of agricultural information sources of planting materials, time of planting and harvesting, use of fertilizer and ICTs, staking and weeding of yam farm. The sources of agricultural information considered in this thesis (agricultural information from fellow farmers and agricultural information from EAs) were captured with dummy variables, one for farmers who obtained information from fellow farmers or Extension Agents and zero for those who did not. Sources of planting materials (own farm, market and extension agents) were also captured with a dummy variable, farmers who obtained planting material from those sources were assigned one while those who did not were assigned zero. Time of planting is the month yam was planted, while time of harvesting is the month it was harvested. Use of fertilizer is the quantity of fertilizer used. Use of ICTs is the use of handset for farm business; it was also captured with a dummy variable, one for yes and zero for no. Staking is the number of stakes used, and weeding of yam farm is the number of times farm was weeded.

The access to inputs and facilities used in this evaluation include access to research and extension, access to financial institutions, access to irrigation facility, access to hospital, access to good road, access to market, and availability of school were captured with binary variable one for yes and zero for no. Difficulty acquiring farm input, access to machinery, access to fertilizer, adequacy of seed yam, and adequacy of labour were also assigned allocated yes or no. farm distance from home was measured in kilometre. Means to farm is how the farmers got to their farms (walking = 0, bicycle = 1, motorcycle = 2, vehicle = 3). Farm fragmentation is the number of farms own by the farmer. Use of handset for farm business was captured with binary variable (yes =1, no = 0).

5.6 Analytical procedure

5.6.1 Approaches to achieving objective one

The first objective of this research, to describe and compare yam production systems in the States, was realized by providing answers to the first set of research questions on describing and comparing yam production system (section 1.7). This was accomplished by the use of survey (see section 5.4), descriptive analysis, economic and econometric models.

Descriptive statistics such as mean, frequency and percentage were used to describe the socioeconomic characteristics of yam farmers, the quantities of production and costs of producing yam, and benefits and limitations to yam production in the States. Farm-level economic results were compared using GM analysis to determine the profitability of yam and the contribution of yam to farm income. Maximum likelihood estimates of stochastic frontier production and cost functions (Frontier 4.1c) were used to determine factors influencing production and cost of yam respectively. Two production and cost functions (Translog and Cobb-Douglas) were compared for goodness-of-fit. Cobb-Douglass and Translog models were employed in this study based on literature; they are the commonly used function for frontier estimation. The decision on the determinant of output and cost of yam were made based on the lead model. The metafrontier analysis also generates factors influencing yam production.

Translog and Cobb-Douglas functions were tested for goodness-of-fit using the likelihood ratio test (LR). The LR test for comparing the models is statistically defined as: $LR(\lambda) = -2(LLF_r - LLF_u)$ (Greene, 2012); where LLF_r is the log likelihood function of the restricted model (Cobb-Douglas)and LLF_u is the log likelihood function of the unrestricted model (Translog). The Cobb-Douglas model is obtained by the restriction $\beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} \ldots\ldots = \beta_{20} = 0$ (see Greene, 2012). LR test was conducted to prove the null hypothesis (H_0) that the parameter estimates of Cobb-Douglas production function satisfy the restriction. The null hypothesis is rejected when LR is higher than the critical value (x^2) (Greene, 2012), if the Cobb-Douglas function does not satisfy the restriction that at least one of the parameters is equal to zero ($H_0 = \beta_{ij} = 0$), it shows that at least one of the parameters is not equal to zero ($H_1 = \beta_{ij} \neq 0$). The degree of freedom is the number of restriction (Greene, 2012), that is difference between the restricted and unrestricted parameters.

ANOVA was used to test the hypothesis that the mean regional output, production inputs, prices of input, and farmer characteristics were significantly different. The hypotheses that production inputs determine yam output; yam output and input prices affect the cost of yam were tested with t-test. The t-value was generated from Frontier 4.1.The null hypothesis (H_0) that at least one of the parameters is equal to zero is rejected when the t-value is greater than t tabulated (from t-table) at 10%, 5% or 1%.

5.6.2 Methods of accomplishing objective two

The second objective of this project was to examine indicators and determinants of performance of yam producers (section 1.7). This was achieved by addressing the research questions on levels of efficiency (technical, existence of regional difference in technology/environment on farmer performance).
The indicators of the performance of yam producers and factors influencing them were evaluated using econometric models. Estimates of efficiency are normally developed using stochastic production and cost functions (Frontier 4.1). The efficiency values of the lead model were used to determine the efficiency of yam farmers and factors influencing them. The efficiency estimate of the stochastic frontier production and cost function were used to analyze the technical efficiency (TE) and economic efficiency (EE) respectively. The presence of regional difference in technology/environmental between States was established using metafrontier analysis. The metafrontier was estimated using Shazam code, following O' Donnell *et al*. (2008).

The hypothesis that yam farmers are efficient was determined using LR test. In this context, the LR test is statistically defined as: LR (λ) = $-2(LL_r - LL_u)$ where LL_r is the value of log likelihood function of the average function and LL_u) is the value of the log likelihood function of the frontier function. The null hypothesis is rejected when the log likelihood ratio is higher than critical values at 1%, 5 % or 10%. This shows that the inefficiency parameter is equal to zero (γ=0), which indicates efficiency in yam production. The test was carried out at 5% level of significance (Siplamen & Lansink, 2005).

The hypotheses that farmer socioeconomic profile, decision, and access to facilities affect their performance were tested with t-test. T-value was obtained from the Frontier 4.1 result. The null hypothesis (H_0) that the variables do not affect performance is rejected when the t-value is greater than t tabulated at 10%, 5% or 1%.

The null hypothesis that the regional frontiers are the same was tested using the generalized LR test (Villano et al., 2012). In this test, LL_u model is the sum of log likelihood of the States while the LL_r is the log likelihood of the pooled frontier.

Before estimating the MPF, the regional frontiers were tested for environmental and technological differences. This was performed by testing the null hypothesis that the regional frontiers are the same. There would be no reason to perform the metafrontier production analysis if data were generated from the same frontier with the same technology (Battese et al., 2004) and if the stochastic frontiers across regions are similar (that is to say that the operating environment/technologies are the same among regions). In that case, it is appropriate to use the pooled stochastic frontier to estimate the TE.

5.6.3 Approach to realizing objective three

The third objective of this project is to examine the role of technology adoption on performance and wellbeing, and to ascertain determinants of and constraints to adoption of improved technology (see section 1.5). This was achieved by conducting GM analysis, partial budgeting, PSM and logistic regression.

GM analysis and partial budgeting were used to assess the economic viability of YMT and the planting materials for yam production. We did not perform whole-farm analysis, since GM and partial budget was considered to be sufficient.

The impact of adoption of YMT on TE was determined using PSM. Wu et al. (2010) and Mendola (2007) used PSM to determine the impact of technology adoption on wellbeing/poverty. PSM was performed using Stata Software. Matching algorithms such as Nearest Neighbour Matching (NNM) and Kernel Matching were conducted to categorize farmers into groups based on similarities of conditions that could influence adoption of technology. The performances of adopters and non-adopters of the technology were then compared. The adopters of the YMT were considered to be those who practice the major components of the technology (cutting of tubers into minisetts and replanting the harvested seed yams).

The hypothesis that the performance of adopters and non-adopters of YMT is significantly different was tested using a t-test. A Z-test was performed to test the hypothesis that the characteristics of yam farmers affect the adoption of YMT.

5.7 Model specification

The Cobb-Douglas productions function for estimation of production factors is expressed in implicit form as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k \, logX_{ik} + \ v_i - u_i \tag{5.1}$$

Where Y_i = yam output of i^{th} farmer in kg, X_{ik} are vectors of inputs where X_1 = farm size in hectares, X_2 = labour in Man-days, X_3 = fertilizer used in kg, X_4 = seed yam used in kg, X_5 = depreciated cost of capital, and v_i is the random error not under the control of the farmer. The u_i captures technical inefficiency relative to stochastic frontier, and b_0 and b_k are estimated parameters. Note that log is logarithm notation.

Translog production function for estimation of production factors is specified as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k \, logX_{ik} + 0.5 \sum_{k=1}^{5} \sum_{m=1}^{5} b_{km} \, logX_{ik} \, LogX_{im} + v_i - u_i \tag{5.2}$$

where Y = output of yam, X_1 = land area in hectares, X_2 = labour in man-days , X_3 = fertilizer used in kg, X_4 = seed yam used in kg, X_5 = depreciated cost of capital inputs, v_i = random errors not under the control of the farmer, u_i captures technical inefficiency relative to stochastic frontier, and $b_0$and b_k are estimated parameters.

The Cobb-Douglas cost function for the estimation of cost factors is defined as:

$$Log\, C_i = \alpha_0 + \alpha_1 \mathrm{logW}_1 + \alpha_2 \mathrm{logW}_2 + \alpha_3 \mathrm{logW}_3 + \alpha_4 \mathrm{logW}_4 + \alpha_5 \mathrm{logY} + \mathrm{v}_i + u_i \tag{5.3}$$

where C_i = cost of production of i^{th} farm, W_1 = rent on land in Naira per hectare, W_2 = wage rate in Naira per man-day, W_3 = price of seed yam in Naira, W_4 = price of inputs, Y = output of yam, v_i are random errors not under the control of the farmer, u_i capture technical inefficiency relative to stochastic frontier, and α_{0}- α_5 are estimated parameters. Note that log is logarithm notation

The Translog cost function for estimating cost factors is expressed as:

$$Log\ C_i = \alpha_0 + \alpha_1 logW_1 + \alpha_2 logW_2 + \alpha_3 logW_3 + \alpha_4 logW_4 + \alpha_5 logY + 0.5\alpha_6 logW^2{}_1 + \alpha_7 logW^2{}_2 + \alpha_8 logW^2{}_3 + \alpha_9 logW^2{}_4 + \alpha_{10} logY^2 + \alpha_{11} logW_1 log\ W_2 + \alpha_{12} logW_1 logW_3 + \alpha_{13} logW_1 logW_4 + \alpha_{14} logW_1 logY + \alpha_{15} logW_2 logW_3 + \alpha_{16} logW_2 logW_4 + \alpha_{17} logW_2 logY + \alpha_{18} logW_3 logW_4 + \alpha_{19} logW_3 logY + \alpha_{20} logW_4 logY + v_i + u_i \quad (5.4)$$

where C_i = Cost of production of i^{th} farm, W_1 = rent on land in Naira per hectare, W_2 = wage rate in Naira per man-day, W_3 = price of seed yam in Naira, W_4 = price of inputs, Y= output of yam, v_i and u_i are as defined above, and α_0-α_{20} are estimated parameters.

Factors affecting technical inefficiency were determined by simultaneous estimation of technical efficiency with the inefficiency variables (single-stage approach). Translog production function with inefficiency variable incorporated is specified in compact form as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k\ logX_{ik} + 0.5 \sum_{k=1}^{5} \sum_{m=1}^{5} b_{km}\, logX_{ik}\ LogX_{im} - Z_{ik}\beta_k + v_i - u_i \quad (5.5)$$

where Y = output of yam in kg, X_{ik} is a vector of inputs where X_1 = land area in hectares, X_2 = labour in man-days, X_3 = fertilizer used in kg, X_4 = seed yam used in kg, X_5 = depreciated cost of capital, v_i and u_i are as defined above, b_k and β_k are vectors of estimated production and inefficiency parameters respectively, Z_{ik} is a vector of socioeconomic variables influencing technical efficiency; where Z_1 = gender (male = 1, female = 0), Z_2 = age of farmers in years , Z_3 = household size (number of household members), Z_4 = primary occupation, Z_5 = member of agricultural organization (member = 1, non-member = 0), Z_6= marital status, Z_7 = health issues (yes = 1, No = 0), Z_8= land ownership (owner =1, non-owner = 0), Z_9 = farm size (ha), Z_{10}= level of education (years of schooling), Z_{11} = extension visit (number of times), Z_{12} = credit status (access to credit = 1, no access = 0), Z_{13}= number of income sources; and log is logarithm notation.

Farmer decision making ability influencing technical inefficiency was also verified using the single-stage approach specified implicitly as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k\, logX_{ik} + 0.5\sum_{k=1}^{5}\sum_{m=1}^{5} b_{km}\, logX_{ik}\, LogX_{im} - \mathrm{M}_{ik}\theta_k \; + \mathrm{v}_i - u_i \qquad (5.6)$$

where Y_i and X_{ik} are as defined above, M_{ik} is a vector of decision variable affecting technical efficiency where M_1 = agricultural information from fellow farmers (yes = 1, no = 0), M_2 = agricultural information from EAs (yes = 1, no = 0), M_3 = planting material from own farm (yes=1, no = 0), M_4 = planting material from market (yes =1, no = 0), M_5= planting material from fellow farmers (yes =1, no = 0), M_6 = planting materials from Extension Agents, M_7 = time of planting, M_8 = time of harvesting, M_9 = quantity of fertilizer (kg), M_{10} = use of ICTs (user = 1, non-user = 0), M_{11} = use of YMT (yes =1, no = 0), M_{12}= staking of yam, M_{13} = number of times of weeding, v_i and b_k are as defined above, and θ_k is a vector of estimated efficiency parameter.

Facilities affecting technical inefficiency of yam farmers are expressed in compact form as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k\, logX_{ik} + 0.5\sum_{k=1}^{5}\sum_{m=1}^{5} b_{km}\, logX_{ik}\, LogX_{im} - \mathrm{H}_{ik}\mathrm{d}_k \; + \mathrm{v}_i - u_i \qquad (5.7)$$

where Y_i, X_{ik}, b_0 and b_k are as defined above; H_i is a vector of facilities affecting efficiency of yam farmers where H_1= access to research and extension (yes = 1, no = 0), H_2 = access to financial institutions (yes = 1, no = 0), H_3 = access to irrigation facility (yes = 1, no = 0), H_4 = access to hospital (yes = 1, no = 0), H_5 = access to good road (yes = 1, no = 0), H_6 = difficulty acquiring farm input (yes = 1, no = 0), H_7 = access to machinery (yes = 1, no = 0), H_8 = access to fertilizer (yes = 1, no = 0), H_9 = adequacy of seed yam (yes = 1, no = 0),H_{10} = adequacy of labour (yes = 1, no = 0), H_{11}= farm distance from home (km), H_{12} = means to farm (walking = 0, bicycle = 1, motorcycle = 2, vehicle = 3), H_{13}= farm fragmentation (number of farms), H_{14} = access to market (yes

= 1, no = 0), H_{15} = availability of school (yes = 1, no = 0), H_{16} = use handset for farm business (yes =1, no = 0), v_i and u_i, are as defined above, and d_k is a vector of inefficiency parameter.

Socioeconomic determinants of economic efficiency were identified by using the single-stage approach specified implicitly as:

$$Log\ C_i = \alpha_0 + logW_{ik} + \alpha_q logY_i - Z_{ik}\beta_k + v_i + u_i \qquad (5.8)$$

where C_i = cost of production, W_i is a vector of input prices whereW_1 = rent on land in Naira per hectare, W_2 = wage rate in Naira per man-day, W_3 =price of seed yam in Naira, W_4 = price of capital inputs, Y = output of yam, and $\alpha_{0,}$ α_k and α_q are estimated cost parameters, Z_{ik}, β,v_i, and u_i are as defined above. Note that log is logarithm notation

Farmer decision factors influencing economic efficiency were also verified using the single-stage approach specified implicitly as:

$$Log\ C_i = \alpha_0 + logW_{ik} + \alpha_q logY_i - M_{in}\theta_n + v_i + u_i \qquad (5.9)$$

where C_i and X_{ik} are as defined above, M_{ik} is a vector of decision variable affecting yam production where M_1 = agricultural information from fellow farmers (yes = 1, no = 0), M_2= agricultural information from EAs (yes = 1, no = 0), M_3= planting material from own farm (yes =1, no = 0), M_4 = planting material from market (yes = 1, no = 0), M_5 = planting material from fellow farmers (yes = 1, no = 0), M_6 = planting materials from Extension Agents, M_7 = time of planting, M_8 = time of harvesting, M_9= quantity of fertilizer (kg), M_{10}= use of ICTs (user = 1, non-user = 0), M_{11}= use of YMT (yes = 1, no = 0), M_{12}= staking of yam, M_{13}= number of times of weeding, $v_{i,}u_i$ and $b_k$are as defined above, and θ_k is a vector of the estimated parameter.

Facilities affecting technical efficiency of yam farmers (refer to section 5.5.2) were also estimated simultaneously with technical efficiency using:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k\ logX_{ik} - H_{ik}d_k + v_i - u_i \qquad (5.10)$$

where Y_i, X_{ik}, b_0 and b_k are as defined above; H_i is a vector of facilities affecting efficiency of yam farmers where H_1 = access to research and extension (yes = 1, no = 0), H_2 = access to financial institutions (yes = 1, no = 0), H_3 = access to irrigation facility (yes = 1, no = 0), H_4 = access to hospital (yes = 1, no = 0), H_5 = access to good road (yes = 1, no = 0), H_6 = difficulty acquiring farm input (yes = 1, no = 0), H_7 = access to machinery (yes = 1, no = 0), H_8 = access to fertilizer (yes = 1, no = 0), H_9 = adequacy of seed yam (yes = 1, no = 0), H_{10} = adequacy of labour (yes =1, no = 0), H_{11} = farm distance from home (km), H_{12} = means to farm (walking = 0, bicycle = 1, motorcycle = 2, vehicle = 3), H_{13} = farm fragmentation (number of farms), H_{14} = access to market (yes = 1, no = 0), H_{15} = availability of school (yes = 1, no = 0), H_{16} = use handset for farm business (yes =1, no = 0), v_i and u_i, are as defined above, and d_k is a vector of technical inefficiency parameter.

The factors affecting the adoption of YMT in the States were evaluated using probit regression model. The model is expressed explicitly a as:

$$Y_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 \quad 5.11$$

Where Y is adoption of YMT(Yes =1, No = 0), β_s are parameters to be estimated, P is probability to adopt, 1-p is probability not to adopt; X_1= gender(male = 1, female = 0, X_2 = age (years), X_3= primary occupation farmers = 1, non-farmers = 2), X_4 =education (years), X_5 = time of planting (months), X_6=quantity of fertilizer (kg), X_7 = Farm size (hectare), X_8 labour (man-days) and X_9 = extension visit (number of times)

5.8 Conclusion

To summarize, a multi-stage sampling technique was used to elicit data from yam farmers in Nigeria of yam production for this research. Descriptive statistics, economic and econometric models were used for the assessment. The hypotheses were tested using t-tests, z-test, ANOVA, LR test, and the generalized LR test.

Chapter Six

6.0 Yam Production in Nigeria

6.1 Introduction

This chapter describes yam production, the socioeconomic characteristics of yam farmers and the conditions of use for yam production in Nigeria. Yam farmer access to farm inputs and facilities, and hindrances to the acquisition of inputs and facilities are discussed. The chapter also highlights the benefits of and limitations to yam production in Nigeria.

This analysis used information obtained from the three sampled States to represent the entire country. From the sampling technique used for this project (see section 5.3), cumulative data of the States is a good representative of the country. Each yam-producing State had equal chance of being selected.

6.2 Characteristics of yam in Nigeria

This section describes and compares Nigerian yam production systems. It also specifies the conditions of use for yam production in Nigeria and access to inputs and facilities by Nigerian yam farmers.

6.2.1 Socioeconomic profile of Nigerian yam farmers

The descriptive statistics obtained from SPSS was used to determine the socioeconomic characteristics of yam producers in Nigeria. ANOVA was performed to ascertain similarities in socioeconomic status of the farmers between States. The socioeconomic characteristics of yam farmers in Nigeria are presented in Table 6.1. The Table reveals that Nigerian yam farmers were mostly middle-aged males with large families. On average, the farmers had secondary education. The majority of the farmers in Nigeria were experienced in yam farming. However, they had small farms and limited contact with extension agents. The distribution of socioeconomic characteristics of the farmers in Nigeria, as presented in Appendix C, shows that most of the Nigerian farmers were married and farming was their primary occupation. The ANOVA result indicates that the socioeconomic profiles of Nigerian yam farmers differ significantly between regions.

Table 6.1: Socioeconomic characteristics of yam farmers in Nigeria

Variables	Nigeria	Benue	Enugu	Ondo
Average age (years)	47.2	45.0^{b}	52.0^{a}	44.7^{b}
Gender (% of male farmers)	85.0	88.3^{a}	79.2^{b}	87.5^{ab}
Average household size (number of household members)	8.2	10.8^{a}	7.5^{b}	6.4^{b}
Average farming experience (years)	20.7	22.9^{a}	23.2^{a}	16.0^{b}
Average farm size (hectare)	1.5	2.2^{a}	0.9^{c}	1.4^{b}
Extension visit (number of times)	4.1	3.7^{b}	2.1^{b}	6.5^{a}
Average education (years)	9.3	9.6^{a}	7.8^{b}	10.4^{a}
Member of Organization (%)	37.8	38.3^{ab}	27.5^{b}	47.5^{a}
Access to credit (%)	46.9	45.0^{b}	44.2^{b}	51.7^{a}
Health issues (%)	21.9	32.5^{a}	21.7^{b}	11.7^{b}

Source: Field Survey, 2013

Note: a,b,c letters denote significant differences (at 0.05 level) in variables across regions in a descending order of magnitude. Variables with the same superscript are similar.

The majority of Nigerian yam farmers are in their active age. Table 6.1 discloses that an average yam farmer in Nigeria was 47 years old. This supports Omojola (2014) who stated that the age of 90.3% of yam farmers in Osun State of Nigeria was 49. Most yam farmers were in the age range of 40-59 (Appendix C). Older farmers were more involved in yam production in Enugu than in other States. The mean age of yam farmers in Enugu was markedly different from those in other States. There were younger farmers in Ondo compared to other States. The average age of yam farmers in Benue and Ondo were similar.

The result of this investigation demonstrates that yam production in Nigeria is dominated my males. Table 6.1 shows that Males were more involved in yam production in Nigeria than females. This supports Omojola (2014) in Osun State and Nlerun (2006) in Rivers State both in Nigeria, who reported that males were more involved in yam production in Osun and River States respectively. Eighty-five percent of Nigerian yam farmers were male (Table 6.1). This is in line with Izekor and Alufohia (2014) who observed that 83.33% of yam farmers in Edo State were male. More males were engaged in yam production in Benue State. Enugu had a lower number of males who were involved in yam production in Nigeria. There was no significant difference in male involvement in yam farming between Ondo and the other States. Generally, females did not participate actively in yam production in Nigeria. Only 15% of the interviewed yam farmers were female. More females were involved in yam farming in Enugu than in other States. Benue had the lowest population of female who were involved in yam production. The unequal gender involvement in yam production in Nigeria could be due to the laboriousness of yam production which requires more energetic men (Omojola, 2014).

This study also indicates that most of the yam farmers in Nigeria were married (Appendix C). Benue State had more married yam farmers. The State had the lowest population of unmarried farmers. There was no record of divorced and widowed farmer in Benue. Enugu had fewer married couples than the other States. The State had the highest number of estranged and widowed farmers. Ondo had the highest percentage of unmarried farmers.

This thesis establishes that Nigerian yam farmers have large households. An average Nigerian yam farmer had a household size of eight members. Most yam farmers in Nigeria had household size of between 6-10 members (Appendix C). Enugu State had more farmers with this household range. Benue State had more farmers with household size of above ten members. There were more households with less than six members in Ondo State. Benue had the largest household size while Ondo had the lowest. The household size for Ondo and Enugu was similar.

This research indicates that most Nigerian yam farmers have some form of education (Appendix C). The majority of Nigerian farmers had secondary education. An average yam farmer had 9.3 years of education (Table 6.1). This is in line with Mgbada et al. (2016) who noted that the mean level of education for Nigerian farmers was 9.4 years. Sixteen percent of the yam farmers in Nigeria had no formal education. More educated farmers were involved in yam production in Ondo than in other States. The State had the highest percentage of farmers with tertiary education. There were more farmers with secondary education in Benue than in other States. The ANOVA result for testing the mean difference in the socioeconomic variables of the farmers in Nigeria (see Table 6.1) proved that Ondo and Benue States had reached a similar level of education. Enugu had the largest number of illiterate farmers. The State had more farmers with primary education.

This analysis reveals that farming is the primary occupation of most Nigerian yam farmers, approximately 95% (Appendix C). Enugu had the highest population of farmers whose primary occupation was farming while Benue had the lowest.

From this thesis, it is obvious that there are many experienced yam producers in Nigeria. An average Nigerian yam farmer had farming experience of above 20 years. Ondo, Benue and Enugu farmers had mean farming experiences of 16, 22.9 and 23.2 years respectively. The majority of farmers in Nigeria had farming experience between 6-15 years (Appendix C). There were more experienced yam farmers in Enugu than in other States. Enugu State had more farmers with farming experience of above 36 years. Nevertheless, the State had more farmers with less than six years farming experience. The results indicated that there was no significant difference in farming experience between Enugu and Benue States (see Table 6.1). Ondo yam farmers were less experienced in yam production.

The study indicates that an average Nigerian yam farmer has a small farm. Yam producers in Nigeria had a mean farm size of 1.5 hectares (Table 6.1). Farm size was significantly different among regions. Benue had the largest farm size while Enugu had the lowest. Assurance of land access should be a priority for Nigerian government policy. Policy makers should aim at redistributing land to yam farmers to enhance production and income generating ability for poverty alleviation and sustainable agriculture.

The result of this investigation also shows that most Nigerian farmers are not members of agricultural organizations (Table 6.1). Approximately 38% of the yam producers were members of farming associations (where information on agriculture, particularly on production and marketing of yam were disseminated). Members also had information on input acquisition and discounts on inputs. More yam farmers in Ondo belonged to agricultural organizations. Membership of agricultural organization in Ondo was not significantly different from Benue. Enugu had few members of agricultural organizations, which was also similar to Benue State.

This project discloses that Nigerian yam farmers have poor interaction with extension agents. An average Nigerian yam farmer has four extension visits per annum (Table 6.1). Ondo had more extension contact which was significantly different from other States. Extension is an important vehicle for agricultural technology dissemination. Increased access to extension services can be achieved through adequate funding of extension.

This research further reveals that most Nigerian yam farmers lack access to funds. Over 50 percent of Nigerian yam farmers lack access to credit for yam production (Table 6.1). Ondo State yam farmers have more access to funds than those in other States. Enugu yam farmers had less access to credit which is not significantly different from that of Benue. Financial institution should be located in close proximity to the farmers to increase farmers' access to fund. Awareness on credit acquisition by farmers should be created to inform them on how to obtain loans from financial institutions.

Finally, the socioeconomic analysis detects that Nigerian yam farmers are faced with some health issues. Approximately twenty two percent of the farmers had health challenges (Table 6.1). This was more severe in Benue and less in Ondo. The percentage of farmers in Ondo and Benue who had health challenges was similar. Establishment of health centres in these areas, and improvement in the conditions and management of the already existing ones will help improve the health conditions of farmers.

6.2.2 Farmer access to inputs and facilities in Nigeria

An assessment of farmer access to farm inputs and facilities in Nigeria discloses that most Nigerian yam farmers have difficulties accessing farm inputs and facilities. Appendix D.1.1 shows availability and use of inputs in Nigeria. The majority of Nigerian yam farmers had difficulties accessing farm inputs and credit facilities. Farmers in Benue State had more difficulties access farm inputs. It was less difficult to access inputs in Ondo State.

Nigerian yam production is largely non-mechanized (Author's observation, 2013). This research shows that it is uncommon among farmers to use farm machinery in Nigeria. The farming system for yam production in Nigeria hinders successful mechanization (Opara 2003). This is because of the haphazard arrangement of crops and the use of much staking materials, which prevent easy movement through the farm (authors observation, 2013). Therefore, farmers depend on manual labour for yam production. Generally, insignificant percentage of yam farmers had access to farm machinery in Nigeria (Appendix D.1.2). Those farmers who have access to farm machinery usually use them for land cultivation (Author's interview with farmers, 2013). Enugu yam farmers had more access to farm machinery. Development of a better farming system for yam in Nigeria would encourage mechanization and reduce the drudgery in yam production.

Surprisingly, in spite of the complaint about unavailability and high cost of labour in Nigeria, most of the yam farmers admitted that they used sufficient labour. However, over 37% of the yam farmers in Nigeria employ inadequate labour for yam production; this figure is high. As expected, Benue State had access to labour than other States followed by Enugu then Ondo. Labour accessibility coincided with the household size in the respective States. This supports the fact that the larger the household size the more farmer access to labour. Labour market policies that will absorb excess labour from large families by creating non-farm employment opportunities will provide income for on-farm investment. Also, Yam farmers should be encouraged to use affordable labour-saving devices.

This investigation supports that Nigerian farmers employ inadequate inputs for yam production, Verter and Becvarova (2015) reported that insufficient inputs hinder yam production in developing countries including Nigeria. Appendix D.1.1 indicates that the vast majority of yam farmers in Nigeria used fertilizer for yam production. Nevertheless, they used below the recommended quantity of fertilizer (see chapter 3). Fewer farmers in Ondo used fertilizer for yam production. Although yam is nutrient demanding and thrives on fertile soil (see yam production in chapter 3), unexpectedly some Nigerian farmers deliberately avoid the use fertilizers for yam production. Most

Ondo farmers did not use fertilizer because they believe that it causes decay of yams (Author's discussion with farmers, 2013). Some farmers in Ondo thought they had fertile lands and did not require fertilizers (Author's discussion with farmers, 2013). Government should subsidize inputs, especially fertilizer, to increase its use for yam production.

The evaluation of farmer access to facilities in Nigeria indicates that majority of Nigerian yam farmers lack access to financial institutions (see Appendix D.1.2). This is in line with Izekor and Olumese (2010) who noted that yam farmers lack access to credit facilities. Ondo yam farmers had more access to financial institution. Benue State had poor access to financial institutions. This research stipulates that poor access to financial institutions prevents yam farmers from acquiring loan to purchase sufficient inputs for yam production. Significant percentage of Nigerian yam farmers had difficulties obtaining loans (Appendix D.1.1). It was more difficult to access loans in Benue State. This confirms Verter and Becvarova (2014) who observed that lack of finance is a major constraint to yam production in Logo LGA of Benue State. Ondo farmers had less difficulty acquiring farm loans. Establishing formal and non-formal credit sources in the rural areas will increase access to loan by yam farmers.

Agricultural research and extension facilitate the development of a nation's agriculture (FAO, 2017b). Generally, Nigerian yam farmers lack access to research and extension services that could increase their awareness and adoption of new technologies for performance improvement. This result revealed that research institutes are far from farmers' location. Hence, it was difficult for most yam farmers to access it (Appendix D.1.2). Insignificant number of the yam farmers in Enugu State indicated that they are at close proximity to research institutes. None of the farmers in Benue and Ondo States agreed that they are located close to research institutes. From Appendix D.1.2, most Nigerian farmers have insufficient access to extension services. However, most farmers in Benue State had access to extension services; over 62% of the farmers in Benue had access to extension services. Negligible number of Enugu farmers had access to extension agents. Poor access to research and extension services limit farmers' awareness and adoption of new technologies and improvement in their performance.

Research and extension should be an important area of interest for Nigerian government policy. Research outreach programme, and establishment of research outstations in rural areas, where the farmers are, will increase farmers' access to research.

The result reveals that Nigeria has rural markets and poor road networks. From Appendix D.1.2, above 92% of the yam farmers in Nigeria had access markets in their villages. Almost all the farmers in Enugu accepted that there are markets in their communities. Unfortunately, the rural areas lack good access roads. Less than a quarter of Nigeria yam farmers had rural roads in their community (Appendix D.1.2). Lack of good rural roads deters the performance of farmers in Nigeria (Afolabi et al, 2016).The road networks in Benue were better than those in other States. The rural roads in Enugu were worst. Few farmers (8.3%) agreed that there are access roads in their communities in the State. Agricultural produce is often denied access to the urban areas where it is mostly needed. Due to this situation, the food always perishes in the rural areas where it is produced. Ituma (2013) noticed deterioration of yam in Ebonyi State (Nigeria) due to lack of appropriate storage facilities. Provision of access roads in rural area of Nigeria (where food is produced) is crucial for food security and poverty reduction in the country.

This analysis indicates that there are health facilities in the rural areas of Nigeria. The majority of the yam farmers had health facilities in their communities (Appendix D.1.2). More farmers in Benue had access to health facilities.

Appendix D.1.2 also indicates that there are schools in the rural areas of Nigeria. Over 98% of the yam farmers indicated that they have access to schools in their communities (Appendix D.1.2). In fact all the yam farmers in Enugu State admitted that there are schools in their communities. However most of the schools in the rural communities lack facilities and are in deplorable conditions (Authors Observation, 2013). Adequate funding and proper management of schools in the rural areas will impact on the educational outcome and managerial ability of the farm household.

This research further reveals that access to water is a serious issue in Nigeria. Nigerian yam farmers lack access to potable water and irrigation facilities. Approximately 64%

of yam farmers in Nigeria lack access to drinkable water (Appendix D.1.2). This situation is more critical in Enugu State where approximately 17% of the yam farmers had access to clean water. Few yam farmers (5.8%) had access to irrigation facilities. Nigerian farmers practice rain-fed agriculture (Appendix D.1.2). Most yam farmers in Nigeria do not irrigate their farms; they depend on rainfall for yam production. Provision of water in the rural area will improve the standard of living of farmers. Nigerian government policy should address the issue of low investment on rural infrastructure, especially water supply.

6.2.3 Input acquisition challenges in Nigeria

This research also evaluated the challenges of farm inputs acquisition in Nigeria. Appendix D.2 highlights the limitations to input acquisition in Nigeria. Approximately 46% of the respondents indicated lack of fund as the major constraint to input acquisition in Nigeria. Nigerian farmers are poor and lack the funds to acquire sufficient farm inputs. The Appendix also shows that unavailability of inputs hinders its acquisition in the country. High cost of input is another limitation to input acquisition. Approximately 13.3% of the respondents indicated high cost of input as a constraint to input acquisition in Nigeria. Few farmers have reported that untimely delivery of inputs such as fertilizer and planting materials prevents the use of inputs by yam farmers in Nigeria. Input subsidy and effective input delivery system should be important areas of focus for the Nigerian government. The distribution of input to Nigerian farmers can be expedited through the involvement of governmental and non-governmental agricultural organizations in input distribution.

6.2.4 Sources and adequacy of planting material

An analysis of the adequacy of planting material used for yam production in Nigeria has shown that some Nigerian yam farmers use insufficient planting material for yam production. Adequacy of planting material for yam production in Nigeria is presented in Appendix D.3.1. In Nigeria, over forty percent of the farmers used inadequate planting materials for yam production. The adequacy of planting material differs between regions. Benue has a relatively higher adequacy in the use of planting material while

Enugu had the lowest. Adoption of yam multiplication techniques, particularly YMT will make planting materials available to farmers.

Further investigation into the sources of planting materials used for yam production in Nigeria has revealed that Nigerian yam farmers use poor quality planting material obtained mainly from their own farms for yam production. The majority of the farmers obtained planting materials mainly from their farms. Appendix D.3.2 displays the sources of planting material for yam production in Nigeria. The ranking of the sources of planting material used for yam production is presented in Appendix D.3.3. The main sources of planting material for yam production in Nigeria are own farms, local markets and fellow farmers. Planting materials from these sources often have poor quality and are disease infested. Enugu farmers obtained planting material from own farm and the market than farmers in other States. The percentage of farmers who got planting material from fellow farmers was more in Benue State. The traditional yam production method in Nigeria is a setback to yam enterprise development. This method encourages the use of poor quality planting material. Aighewi et al. (2015) observed that seed yams are subject to contamination with pests and disease pathogens in the traditional yam production system in Nigeria. Seed yam from previous harvest is used in the traditional yam production system. As reported earlier, IITA (2009b) observed that the use of such planting material leads to a build-up of disease causing organisms and reduction in yield. Few Nigerian yam farmers acquire planting material from research institutes and ADPs. It is therefore necessary to strengthening the research-extension-farmer synergy for input distribution in Nigeria.

The result of the analysis of the type of planting material used for yam production shows that seed yam obtained from YMT was the least used type of planting material for yam production in Nigeria. Appendix D.3.4 presents the ranking of types of planting materials used for yam production in Nigeria. From the appendix, Nigerian yam farmers mainly use macro setts (henceforth cut setts) for yam production. This method of yam production requires the use of yam tubers meant for food as planting material. A significant quantity of planting material is required for yam production using this technique (O’Sullivan, 2010). Adoption of seed yam multiplication technique would reduce the use of yam tubers meant for consumption as planting material. The traditional method of yam production cannot suffice. Development of an alternative farming system for yam that would increase the availability and affordability of planting materials, boost yam yield and reduce the cost of yam production would contribute to the development of the Nigerian yam enterprise.

6.2.5 Constraints to planting material acquisition in Nigeria

The result of the constraints of planting material acquisition in Nigeria shows that planting material for yam production in Nigeria is expensive. Ranking of the limitations to planting material acquisition in Nigeria is displayed on Appendix D.3.5. The major limitations to planting material acquisition in Nigeria are high cost of planting materials, lack of fund to purchase them, and unavailability of planting materials. Distribution of improved seed yam to farmers, and adoption of seed yam multiplication technique, such as YMT, will make planting materials available to farmers. Provision of credit to farmers will enable them purchase sufficient input for yam production.

6.2.6 Sources of capital for yam production in Nigeria

The investigation of the sources of capital for yam production in Nigeria indicates that Nigerian yam farmers obtain funds for yam production mainly from non-farm activities. Appendix D.4 highlights the sources of capital for farm activities in Nigeria. The vast majority of the farmers (approximately 97%) used non-farm income for yam production. Most of the yam farmers obtained loans from friends and relations. More Enugu farmers borrowed funds from friends and families. Matthew and Uchechukwu (2014) also reported that the friends and relations were the major sources of credit for farmers in Nsukka LGA of Enugu State. Other farmers obtained loans from local saving schemes. Those who obtained funds from the local saving schemes were more in Benue State. Few Nigerian farmers borrowed money for yam farming from the commercial banks; more farmers in Ondo fall into this category. Farmers in the State had more access to financial institutes and were able to obtain loans from the Banks. Other sources of farm income in Nigeria include cooperatives, money lenders and gifts.

6.2.7 Hindrances to credit acquisition in Nigeria

An analysis was performed to determine the hindrances to farmer access to credit in Nigeria. Appendix B.5 displays the hindrances to loan acquisition in Nigeria. Yam farmers are interested to obtain loan (Author's observation, 2013). However, lack of financial institutions is the major limitation to loan acquisition in Nigeria (it ranks highest in order of severity).Commercial banks are concentrated in the urban areas in Nigeria. Farmers in the rural areas have difficulty accessing financial institutions. This makes it difficult for farmers to secure loans. Unavailability of loan is another reason why farmers are unable to obtain loan in Nigeria. Many Nigerian yam farmers are ignorant of loan acquisition from the financial institutions. They lack knowledge on bank loan acquisition procedure even when loans are available; this hinders them from obtaining loans from the Banks. Sensitizing farmers on loan acquisition and establishing financial institutions in the rural areas will increase farmer access to credit. Access to credit would enable them purchase the required inputs for yam production.

6.2.8 Soil conditions for yam production in Nigeria

An analysis of the soil types used for yam production in Nigeria indicates there is a wide range of soil type for yam production in Nigeria. Appendix D.6.1 displays the soil types for yam in Nigeria. Yams are mostly plant on loamy and sandy loam soils in Nigeria. Few farmers plant yams on sandy, clay, sandy clay, gravelly sandy loam, gravelly sand, and gravelly clay soils. Yam should be planted on appropriate soil, and soil test conducted before planting; this will provide information on soil condition and soil nutrient requirement.

The result of the analysis of the slope of the soils for yam production in Nigeria indicates that the majority of the yam farmers planted on flat land (Appendix D.6.2). Ondo yam farmers planted yams more on flat land. Some farmers plant yams on slope.

This research proves that Nigerian yam farmers allow yam farms to fallow for a long time. Appendix D.6.3 presents that fallow periods for yam in Nigeria. An average Nigerian yam farmer allows the yam farm to fallow for about three years. This practice is common with Enugu farmers. Most farmers in Benue allow their farms to fallow for one year. More Ondo yam farmers allow their farms to fallow for four years. However, some yam farmers in Nigeria particularly in Benue practice continuous cropping. The fallow period for yam in Nigeria can be reduced with the adoption of better management practice and farming systems.

Nigerian yam farmers are experiencing change in the climatic conditions. Some of the farmers have observed recent waterlogging of yam farms that were not previously affected by flood. Appendix D.6.4 reveals waterlogging of yam farms in Nigeria. Approximately 15% of the farms were waterlogged. More than half of the flooded farms were initially not flooded. Over 90% of the farmers did nothing about the situation. Some farmers construct channels, make big mounds and bonds and others abandoned their farms.

6.3 Benefits derived from yam production

This study also determined the benefit farmers derive from yam production in Nigeria. Appendix E.1 displays the percentage of farmers who have benefited from yam production in Nigeria. It shows that almost all the yam farmers in Nigeria have benefited from yam production.

Yam production has been beneficial to farmers in Nigeria. The farmers have done remarkable thing from yam production. Appendix E.2 highlights the benefit farmers derive from yam production in Nigeria. The major achievement from yam production was feeding of family. Farmers were also able to train their children and self, build houses and purchase more land. Some farmers were able to acquire traditional titles, and married more wives with the proceeds from yam production.

6.4 Limitations to Nigerian yam production enterprise development

This investigation indicates that lack of funds, high cost of fertilizer and unavailability and high cost of planting materials constrain agro-enterprise development in Nigeria (Appendix F.1). Surprisingly, despite the decreasing population of farmers and the high cost of labour, yam farmers in Nigeria neglected to give any credit to high cost of labour inputs as a major limitation to agro-enterprise development.

This research suggests that the majority of Nigerian yam farmers desire to expand the scale of yam production (Appendix F.2). Farmers in Benue were more willing to expand yam production. Negligible percentage of the farmers (4%) is reluctant to expand production. A further investigation into the constraints to expansion of yam production enterprise in Nigeria reveals that lack of fund and unavailability and high cost of planting materials limit the expansion of yam production enterprise in the country (Appendix F.3). This is consistent with Omojola (2014) who reported that yam production in Osun State of Nigeria is mostly limited by lack of capital, scarcity of planting material and high cost of planting material. Yam farmers are mostly poor and have insufficient funds to purchase the inputs required for yam production (Appendix F.1).

6.5 Conclusion

The characteristics of yam farmers and the condition of use for yam production have been described in this chapter. The limitations and benefits of yam farming in Nigeria were also presented. This chapter has shown that farming is the primary occupation of most Nigerian yam farmers. The farmers have small farms and poor access to inputs and facilities. Nigerian yam farmers had poor access to financial institutions. Therefore, it was difficult for the farmers to obtain loans to purchase sufficient inputs for yam production. The chapter has also indicated that there is poor dissemination of agricultural information and technology in Nigeria. Farmers have poor access to research and extension. They obtain agricultural information from sources that may be unreliable. They also use insufficient and poor quality planting material obtained mainly from their farms.

Chapter Seven

7.0 Performance of Nigerian Yam Farmers

7.1 Introduction

This chapter presents the variables employed in yam production. The chapter also examines the indicators of performance (technical and economic) of yam farmers in Nigeria and their determinants. The impact of environment/technology on farmer performance is also determined.

7.2 Yam production variables

The production variables employed in yam production in Nigeria were compared using descriptive statistics obtained from SPSS. ANOVA was performed to ascertain similarities in variables between States. The result of the analysis of the production variable employed in yam production shows a wide variation in output and production inputs used for yam production in Nigeria (Appendix G). All the variables used for yam production are significantly different between States. Table 7.1 presents difference in production variables for yam in Nigeria.

Table 7.1: Differences in production variables across regions

Variables	Nigeria	Enugu	Ondo	Benue
Variables per farm				
Output (kg)	14796.94	9771.80^{c}	14467.58^{b}	20151.44^{a}
Farm size (ha)	1.51	0.90^{c}	1.41^{b}	2.22^{a}
Planting material (kg)	2301.76	1374.33^{c}	2013.42^{b}	3517.53^{a}
Fertilizer (kg)	88.17	119.11^{a}	36.18^{b}	109.23^{a}
Labour (Man-days)	363.76	181.97^{c}	393.10^{b}	516.19^{a}
Capital input (depreciated cost, ₦)	2593.40	1854.71^{b}	3054.91^{a}	2870.59^{a}
Variables per hectare				
Yield kg/ha	12,743.44	12945.71^{a}	14235.97^{a}	11048.64^{b}
Planting material (kg/ha)	2259.54	1996.91^{b}	2725.24^{a}	2056.48^{b}
Fertilizer kg/ha	104.19	220.41^{a}	34.46^{b}	57.71^{b}
Labour (Man-days/ha)	263.23	257.66^{b}	292.43^{a}	239.61^{b}
Capital input (N/ha)	3195.60	3974.89^{a}	3936.96^{a}	1675.83^{b}

Source: Field Survey, 2013

Note: a,b,c letters denote significant differences (at 0.05 level) in variables across regions in a descending order of magnitude. Variables with the same superscript are similar.

The result shows that an average Nigerian yam farmer produced approximately 12,743.44 tonnes of yam per annum on a 1.5 hectare land (see Table 7.1). This implies that average on-farm yield of yam in Nigeria is about 8.5 tonnes. The largest yam output was recorded in Benue State. Enugu had the lowest yam output in Nigeria. There was a significant difference in yam production between States. Nevertheless, Benue State, which had the highest output, had the lowest yield. Ondo State had the highest yam yield, which is similar to Enugu. The volume of production obtained in Benue can be attributed to a large farm size among other factors rather than a high yam yield.

The result also indicates that Benue farmers have more access to land. The State had the highest mean farm size; this is followed by Ondo, then Enugu. An Average farmer in Benue, Ondo and Enugu had farm sizes of approximately 2, 1.4 and 1 hectare respectively (Table 7.1). There was more deviation on farm size in Benue and Ondo than in Enugu (Appendix G).

This research establishes that planting materials are more accessible in Benue than in other States. Benue yam farmers used more planting material than other States (Table 7.1). Enugu farmers had less access to planting material. The State used the lowest quantity of planting material for yam production. There was more variation in quantity of planting material employed in yam production in Benue (Appendix G). However, per hectare comparison of the quantity of planting material used for yam production indicated that Ondo used the highest quantity (Table 7.1). Ondo which used more planting material had the highest yam yield. This suggests that yam yield increases with the use of more planting material. This contradicts most studies on stocking density such as Mgbada et al. (2016) who reported an inverse relationship between the quantity of planting material and yield. It can be deduced from this result that planting material is crucial to increase yam productivity in Nigeria. Therefore, devising an effective distribution channel for seed yam in Nigeria, and adopting seed yam multiplication technique will improve the performance of yam farmers in Nigeria.

The result reveals that the quantity of fertilizer use for yam production in Nigeria is low. Nigerian yam producers use insufficient fertilizer for yam production. On average, yam farmers in Nigeria used approximately 88kg of fertilizer (less than two bag of fertilizer) on a 1.5 hectare farm (Table 7.1). Enugu State used the highest quantity of fertilizer (Table 7.1). An average Enugu yam farmer used more fertilizer (119.12kg). However, this value is below the fertilizer requirement for yam production in Nigeria (Agbaje and Aluko, 2009).

This evaluation also shows that an average Nigerian yam farmer employs approximately 364 man-days of labour for yam production (Appendix G).Benue State used more labour than other States. The lowest labour for yam production in Nigeria was used in Enugu State. Ondo employed more labour relative to farm size than the other States (Table 7.1). This could imply that labour was over-utilized in the State or that yam production in Ondo State is more labour intensive.

Lastly, this investigation detects that Ondo farmers incur more cost on capital inputs than those of other States. Ondo, Benue and Enugu yam farmers spent ₦3055, ₦2871 and ₦1855 on capital inputs respectively. Despite Benue's large scale of production, an average yam farm in Benue used similar capital input as those in Ondo (Table 7.1). Ondo and Enugu had similar cost of capital input per hectare. This could imply over-utilization of capital input in Ondo and Enugu States. This differs from the findings of Izekor and Alufohia (2014) who observed an increasing return to scale of inputs in Edo State of Nigeria; indicating that input is being underutilized in the State.

7.3 Determinants of yam production in Nigeria

Frontier 4.1c software was used to estimate the production function for yam in Nigeria. Input and output data of the farms were used to estimate maximum likelihood (see equation in section 5.6). Frontier 4.1c software automatically generates maximum likelihood estimates. The result of the Cobb-Douglas production function indicates that farm size, quantity of planting material, labour and capital input influence yam output in Nigeria. The diagnostic statistics were significant in the entire frontier except the Likelihood Ratio (LR) test for Benue. Tables 7.2 and 7.3 present the results of the maximum likelihood estimates (MLE) of Cobb-Douglas and translog production functions for yam in Nigeria and States respectively. The coefficients of the Cobb-Douglas function depict elasticities (Greene, 2012; Coelli et al., 2005). A positive coefficient implies that increases in the variables would boost output while a negative sign indicates that increases in the variables would reduce output.

Table 7.2: Maximum Likelihood Estimates of Cobb-Douglas production function for yam in Nigeria

Production Factors	Parameter	Nigeria	Benue	Enugu	Ondo
Intercept	b_0	0.18***	0.097**	0.22***	0.21***
		(0.018)	(0.043)	(0.042)	(0.038)
Farm size	b_1	0.60***	0.68***	0.62***	0.39***
		(0.035)	(0.13)	(0.069)	(0.15)
Planting material	b_2	0.11***	0.041	0.13***	0.13***
		(0.021)	(0.034)	(0.045)	(0.034)
Fertilizer	b_3	0.0024	0.0031	0.0021	0.0095***
		(0.0026)	(0.0058)	(0.0065)	(0.0035)
Labour	b_4	0.11***	0.022	0.12***	0.33**
		(0.027)	(0.12)	(0.041)	(0.15)
Capital input	b_5	-0.016	0.025	0.018	-0.075**
		(0.034)	(0.0601)	(0.091)	(0.042)
Sigma-squared	σ^2	0.066***	0.025***	0.11***	0.043***
		(0.0082)	(0.0090)	(0.026)	(0.010)
gamma	γ	0.82***	0.59**	0.83***	0.79***
		(0.056)	(0.31)	(0.11)	(0.13)
Log likelihood function		121.03**	80.46***	10.24***	62.31***
LR test		17.63***	0.56	5.82***	2.69***

Source: Computed from frontier 4.1c result, 2015
The estimated standard errors are given in parentheses correct to two-significant digits. The coefficient estimates are given to the same number of digits.
***and ** is significant at 1% and 5% respectively.

The Cobb-Douglas production function establishes that yam output is influenced by farm size, planting material and labour (Table 7.2). Farm size had positive coefficients and was significant at 1% probability level in all frontiers. Increased farm size would boost yam output in Nigeria. This supports a priori expectation of increasing marginal productivity of farm size. It also confirms the findings of (Mariano et al., 2011; Anyaegbunam et al., 2016; Ohajianya et al., 2014; Alene and Hassan, 2003). As expected, farmers who had large farms produce more yams than those who have small ones. The magnitudes of the coefficients differ between frontiers. The magnitude of farm size was higher in Benue State. This indicates a higher output elasticity of farm size (responsiveness of output to change in farm size) in the State. Ondo State had the lowest coefficient of farm size, signifying a lower output elasticity of farm size in the State. Ondo had larger farms than Enugu (Table 7.1); however, there was more marginal productivity of farm size in Enugu than Ondo. This implies that Ondo can still increase the output considering the area of land it cultivates. It is essential for Nigerian yam farmers to increase their scale of production in order to boost yam production in the country.

Table 7.2 indicates that quantity of planting material is a very significant determinant of yam output in all the frontiers except in Benue. It had positive coefficients and was significant at 1%. This shows that yam output increases with quantity of planting material. Increased quantity of planting material would boost yam production in Nigeria. This agrees with a priori expectation that there would be a marginal increase in output accruing from the additional planting material used. It is also in consonance with (Mariano et al., 2011) who observed a positive relationship between seed and rice output in the Philippines. Farmers are advised to increase the quantity of planting material they use until MP = 0 (at the end of stage two of production) for output maximization. Nonetheless, it is more economical to produce at the point of optimal scale (see section 4.2).

From the result, fertilizer significantly influences yam output in Ondo State. It was significant at 1% with a positive coefficient. This shows that increasing the quantity of fertilizer in the State would boost yam production. This disproves the perception of yam farmers that Ondo State has fertile soil, and yam production in the State does not require the use of fertilizer. This result brings to light the need for the use of fertilizer for yam production in Ondo. Yam farmers should be encouraged to use fertilizer for yam production.

The analysis also signifies that labour is a significant determinant of output in Nigeria, except in Benue State. It had positive coefficients in all the frontiers; implying that output increases with the use of more labour for yam production. This supports the findings of Backman et al. (2011). This investigation contradicts Ashagidigbi et al. (2011); Alene and Hassan (2003) and Amaefula et al. (2009) who reported a negative correlation between labour and production. There was increasing marginal productivity of labour in Nigeria. More output response to change in labour was observed in Ondo State. Labour is essential for output maximization. Farmers are underutilizing labour in Nigeria, particularly in Ondo. Underutilization of labour could be as a result of unavailability of work-force or high cost of labour in the rural areas, which prevent farmers from employing sufficient labour for yam production. Labour could be augmented with labour saving devices. Farmers could use simple and affordable machinery for yam production to improve their performance.

The result of the investigation reveals that capital input affect yam output. It was significant only in Ondo State. Unexpectedly, it had a negative coefficient; suggesting that the use of more capital input in the State would decreases yam output. A unit increase in the use of capital input in Ondo State would lead to 0.07 unit decrease in output. This indicates over utilization of capital input in the State.

The diagnostic statistics were all significant except the LR test for Benue. Enugu has the highest variation in output due to inefficiency. The variance ratios (gamma) for Nigeria, Benue, Enugu and Ondo were 0.82, 0.59, 0.83 and 0.79 respectively. Gamma (γ) depicts the variation in output that is due to inefficiency. For instance, a variance ratio of 0.83 observed for Enugu signifies that 83% of the total variation in output in Enugu is due to inefficiency.

The Translog production function was also used to evaluate yam production in Nigeria (section 5.6). The result of the Translog model indicates that similar variables influence yam output in Nigeria but with different magnitudes between models. Table 7.3 displays the MLE for yam in Nigeria (Translog production function). It supports that farm size, quantity of planting material and labour are the significant determinants of yam output in Nigeria. The Table also detects that quantity of planting material influences yam output in Benue. The diagnostic statistics for all frontiers were significant except the variance ratio (γ) and LR test for Ondo. Data were mean corrected to zero; therefore the first order derivatives of the Translog production function are the elasticities at sample means (Coelli et al., 2005).

Similar to the Cobb-Douglas model, the result of the Translog model shows that farm size was significant in all the frontiers except in Ondo. It had positive coefficient in all the frontiers. This indicates increasing marginal productivity of farm size. Yam output increases with increase in farm size. The Table also shows that doubling farm size

Table 7.3: Maximum Likelihood Estimates of Translog production function for yam in Nigeria

Production Factors	Parameters	Nigeria	Benue	Enugu	Ondo
Constant term	b_0	0.039**	0.076*	0.12	0.11
		(0.050)	(0.048)	(0.11)	(0.33)
Farm size	b_1	0.49***	0.56***	0.52***	0.11
		(0.057)	(0.14)	(0.10)	(0.14)
Planting material	b_2	0.12***	0.090**	0.11**	0.18***
		(0.026)	(0.048)	(0.050)	(0.072)
Fertilizer	b_3	0.014	0.034	0.036	0.0045
		(0.011)	(0.039)	(0.031)	(0.029)
Labour	b_4	0.25***	0.093	0.23***	0.55***
		(0.054)	(0.13)	(0.068)	(0.15)
Capital input	b_5	-0.015	0.047	0.11	-0.035
		(0.035)	(0.060)	(0.11)	(0.069)
Farm size^2	b_6	1.16***	0.38	1.01***	3.97*
		(0.25)	(2.04)	(0.40)	(2.55)
Planting material^2	b_7	0.19***	0.42***	0.17	-0.01
		(0.080)	(0.14)	(0.17)	(0.55)
Fertilizer^2	b_8	0.0076	0.0077	0.013	0.012
		(0.0068)	(0.012)	(0.013)	(0.023)
Labour^2	b_9	0.14*	-0.83	0.11	6.30***
		(0.10)	(1.50)	(0.16)	(1.02)
Capital input^2	b_{10}	0.14	0.69 *	-0.16	-0.33
		(0.18)	(0.47)	(0.66)	(0.31)
Farm size*planting material	b_{11}	-0.39***	-0.79*	-0.31**	0.66
		(0.10)	(0.50)	(0.16)	(0.54)
Farm size *fertilizer	b_{12}	-0.0053	0.033	0.0058	0.073
		(0.011)	(0.11)	(0.029)	(0.13)
Farm size *labour	b_{13}	-0.63***	0.21	-0.67***	-5.20***
		(0.13)	(1.61)	(0.19)	(1.37)
Farm size *capital input	b_{14}	0.052	-1.22**	0.42	0.50
		(0.16)	(0.70)	(0.36)	(0.62)
Planting material * fertilizer	b_{15}	-0.0067	0.013	-0.025*	-0.021
		(0.0062)	(0.018)	(0.017)	(0.018)
Planting material * labour	b_{16}	0.20***	0.50	0.23**	-0.68**
		(0.074)	(0.44)	(0.11)	(0.32)
Planting material *capital input	b_{17}	-0.11*	-0.12	-0.44**	-0.14
		(0.080)	(0.24)	(0.23)	(0.27)
Fertilizer* labour	b_{18}	0.0027	-0.020	0.0014	-0.089
		(0.0098)	(0.10)	(0.016)	(0.14)
Fertilizer*capital input	b_{19}	0.017**	-0.031	0.0082	0.023**
		(0.0095)	(0.040)	(0.035)	(0.013)
Labour*capital input	b_{20}	0.0019	1.16**	0.21	-0.30
		(0.14)	(0.59)	(0.22)	(0.71)
Diagnostic Statistic	σ^2	0.053***	0.026***	0.10***	0.047
Sigma – squared		(0.0071)	(0.0071)	(0.027)	(0.038)
Gamma	γ	0.81***	0.78***	0.91***	0.97***
		(0.066)	(0.16)	(0.10)	(0.28)
Log likelihood function		152.72***	92.06***	28.54***	80.95***
LR		15.20***	1.98**	6.80***	6.64***

Source: Frontier 4.1 results, 2015

The estimated standard errors are given in parentheses correct to two-significant digits. The coefficient estimates are given to the same number of digits.

***, ** and *are significant at 1, 5 and 10% respectively. Standard Errors are given in parentheses.

would lead to further increase in its coefficient in Nigeria. Doubling farm size will further increase the output of yam in Nigeria. In the prevailing technology used for yam production in Nigeria, especially in Enugu and Ondo, farmers can double farm size. There would be more than proportionate increase in output with increase in farm size in Nigeria.

The Translog model detects that quantity of planting material influences yam output in Nigeria. Its coefficients were positive and significant in all the frontiers. This shows that increasing the quantity of planting material used for yam production would boost yam output in the country. The coefficient of planting material was highest in Ondo and lowest in Benue. This implies a more positive output response to increase in quantity of planting material in Ondo than in other States. The Table further illustrates that doubling the quantity of planting material in Nigeria and its States would lead to a further increase in its coefficient except in Ondo State.

The result supports that labour is a significant variable influencing yam output in all frontiers except in Benue. It had a positive coefficients indicating increasing marginal productivity of labour. The coefficient of labour was higher than those of other variables in Ondo State. This shows that output responded more to labour than to other inputs in the State. The Table further reveals that doubling labour would lead to a more than proportionate increase in output in Ondo. This supports the idea that it is crucial to increase labour to boost yam production in the State. Farmers are advised to employ more labour for yam production. Those in Ondo can double labour used for yam production.

The coefficient of variance ratio was highest in Ondo State (0.97). This indicates that 97% of the total variation in output was due to inefficiency in Ondo. Benue had the lowest variance ratio (0.78), meaning that 78% of the total variation in output in Benue State was due to inefficiency.

The factors influencing yam production in Nigeria were also determined from the metafrontier analysis. The analysis was performed with Shazam 11.1 software. Table 7.4 displays the result of the metafrontier analysis. The metafrontier model indicates

Table 7.4: Metafrontier estimation of yam production in Nigeria

Production Factors	Parameters	Metafrontier
Constant term	b_0	-0.042***
		(0.016)
Farm size	b_1	0.55***
		(0.053)
Planting material	b_2	0.15***
		(0.028)
Fertilizer	b_3	0.0092
		(0.012)
Labour	b_4	0.20***
		(0.047)
Capital input	b_5	-0.031
		(0.038)
Farm size^2	b_6	1.11***
		(0.27)
Planting material^2	b_7	0.28***
		(0.091)
Fertilizer^2	b_8	0.0036
		(0.0041)
Labour^2	b_9	0.065
		(0.12)
Capital input^2	b_{10}	0.12
		(0.20)
Farm size*planting material	b_{11}	-0.42***
		(0.11)
Farm size *fertilizer	b_{12}	0.0096
		(0.019)
Farm size *labour	b_{13}	-0.53***
		(0.14)
Farm size *capital input	b_{14}	- 0.049
		(0.20)
Planting material * fertilizer	b_{15}	-0.0067
		(0.012)
Planting material * labour	b_{16}	0.20**
		(0.088)
Planting material *capital input	b_{17}	-0.10
		(0.090)
Fertilizer* labour	b_{18}	- 0.0015
		(0.014)
Fertilizer*capital input	b_{19}	-0.0057
		(0.019)
Labour*capital input	b_{20}	0.081
		(0. 18)

Source: Shazam 11.1, 2016

***, ** and *are significant at 1, 5 and 10% respectively.

The estimated standard errors are given in parentheses correct to two-significant digits. The coefficient estimates are given to the same number of digits.

The standard error was estimated using parametric bootstrapping (Otieno, 2011; Villano, et al., 2012) that similar to Nigeria (Pooled) frontier, farm size, planting material and labour significantly affects yam output in Nigeria. They had positive coefficients and were significant at 1% probability level.

From the analysis, farm size had a positive relationship with output and was significant at 1% probability level. This implies that increase in farm size would lead to increase in output. This supports a priori expectation that there will be marginal increase in output with increase in farm size. Doubling farm size would boost yam production in Nigeria. This confirms that there is increasing marginal productivity of farm size in Nigeria.

The Table also reveals that planting material has positive relationship with output. It was significant at 1% with a coefficient of 0.15; indicating that a unit increase in planting material led to 0.15 units increase in output in Nigeria. Increased quantity of planting material will boost yam output in Nigeria. Doubling the quantity of planting material used for yam production will boost yam output in the country.

The result also shows that labour is a significant determinant of yam output in Nigeria. It had a coefficient of 0.20 and was significant at 1%. This implies that a unit increase in labour led to 0.20 unit increases in yam output. Labour is essential for yam production in Nigeria. The use of cheap and inexpensive machines would augment labour and boost yam production in the country.

7.4 Selection of lead model for yam production in Nigeria

The hypothesis that production inputs affect yam output was tested with a t-test. Table 7.5 illustrates the selection of lead production model. T-value was obtained from the Frontier 4.1c result. The ratio of the two likelihoods (Cobb-Douglass and Translog) generated from the Frontier 4.1c were compared using LR test (section 5.6) to determine which model to prefer. The null hypothesis ($H_0 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10 \ldots\ldots} = \beta_{20} = 0$) is rejected and the alternate hypothesis ($H_{1,}$ at least one of the $\beta_{ij} \neq 0$) accepted if the LR is greater than the critical value obtained from the chi-squared Table (Greene, 2012). This indicates that Translog is the lead model. The degree of freedom is the number of restrictions (in this case 15). The result shows that the Translog model is the appropriate model for yam production in Nigeria. The Cobb- Douglas model was rejected for yam production in Nigeria except in Benue State.

Table 7.5: Selection of lead production function

Test	frontier	Hypothesis	LR Test	Degree of freedom	Critical value (5%)	Decision	Lead model
Cobb-Douglas satisfies the restriction	Nigeria	$H_0 : b_{ij}=0$	63.38	15	24.38	Reject H_0	Translog
	Benue	$H_0 : b_{ij}=0$	23.20	15	24.34	Accept H_0	Cobb-Douglas
	Enugu	$H_0 : b_{ij}=0$	36.60	15	24.38	Reject H_0	Translog
	Ondo	$H_0 : b_{ij}=0$	37.38	15	24.38	Reject H_0	Translog

Source: Field Survey, 2013

7.5 Elasticity and return to scale of input use for yam production

The investigation of the elasticity and return to scale of yam production reveals that Nigerian yam farmers are experiencing decreasing return to scale except those in Enugu State. Table 7.6 presents elasticities and return to scale of yam production. As earlier stated, the first order derivatives of the Translog production function are the elasticities at sample mean (data were mean corrected to zero). The sum of the first order parameters is the return to scale (Coelli et al., 2005). The production function exhibits decreasing, constant and increasing return to scale if the elasticity is less than, equal to or greater than one respectively (Coelli et al., 2005). A production function is said to exhibit decreasing return to scale if a proportionate increase in all inputs results in less than proportionate increase in output. Increasing return to scale implies that increase in inputs leads to more than proportionate increase in output. If a proportionate increase in inputs results in the same proportionate increase in output, the production function exhibits constant return to scale (Coelli et al, 2005). Yam farmers in Enugu State are experiencing increasing return to scale. This is in line with the findings of Izekor and Alufohia (2014) who observed an increasing return to scale of yam production in Edo State. The use of more input led to a more than proportionate increase in output in Enugu State. More input is required to boost yam production in Enugu State. Currently Enugu State is operating in an irrational stage of production, stage one. This proves that farm inputs are underutilized in the State. Enugu yam farmers should increase inputs to move to stage two of production. The result shows that there is a high output response to farm size in Nigeria, especially in Enugu and Benue. There is increasing marginal productivity of farm labour in Nigeria. Labour has the highest output elasticity in Ondo. This indicates that labour is the most valuable input for yam production in the State. Labour is underutilized in Nigeria, particularly in Ondo. Izekor and Alufohia (2014) observed an increasing return to scale of inputs in Edo State, Nigeria; indicating that they are underutilized in the State. Government subsidy on inputs will improve the performance of yam farmers in Nigeria.

Table 7.6: Elasticity and return to scale of yam production

Production Inputs	Nigeria	Benue	Enugu	Ondo
Farm size	0.49	0.68	0.52	0.11
Planting material	0.12	0.04	0.11	0.17
Fertilizer	0.01	0.03	0.04	0.00
Labour	0.25	0.02	0.23	0.55
Capital input	-0.01	0.02	0.11	-0.03
Return to scale	0.86	0.76	1.01	0.80

Source: Frontier 4.1 results, 2015

7.6 Technical efficiency in yam production

This section estimates the TE of yam farmers in Nigeria and the effect of technology and environment gap on the TE of yam farmers in the country. It also determines the factors influencing the TE of yam farmers in Nigeria.

7.6.1 Technical efficiency estimates for yam farmers

TE estimates were obtained from the production function of the lead model(see section 7.4). Frontier 4.1c software was used for the estimation. Table 7.7 presents stochastic frontier estimates of TE for yam farmer in Nigeria.

The result establishes a high TE estimate for yam in Nigeria. Some studies have shown high TE estimates in developing countries. Anyaegbunam et al. (2016) recorded that the technical efficiency estimate of sweet potato farmers in south-east region of Nigeria was 0.80. Mekonnem et al. (2012) reported a mean TE estimate of 86% for agriculture in developing countries. Majority of yam farmers in Nigeria had TE above 0.80. The mean TE for yam farmers in Nigeria was 0.86. This shows that Nigerian yam farmers are 86% efficient. Some level of inefficiency exists among the farmers in the country. There is room for efficiency improvement in Nigeria. A high TE estimate indicates the need to focus on investment that shifts the production frontier outwards.

Benue State outperformed those in other States relative to environment and technology available in the States. The State had the highest mean TE (0.91). A mean TE value of 0.91 reported for Benue suggests that an average farmer in the State was 91% efficient with respect to the prevailing environmental conditions and the technology available in the State. Most farmers in Benue had TE above 0.90. The maximum TE estimate for Benue State was 0.97. The most technically efficient farmer in Benue State was 97% efficient. Benue also had the highest minimum. There was a slight variation in TE in Benue State. This shows that yam farmers in Benue State were at par in yam production. They performed almost similar relative to the technology and environmental conditions. This could mean a less diverse environment/technology and similar yam production technique in the State.

From Table 7.7, Ondo State had high TE estimates. Most yam farmers in the State had TE of above 0.90. The State had a mean TE value of 0.85, indicating that an average farmer in Ondo was 85% efficient. Ondo State had the highest maximum TE (0.99); the most technically efficient farmer in Nigeria was 99% efficient and from Ondo. The State had a high variation in TE estimates which could be attributed to diverse environment and gap in the use of technology in the States.

Enugu was the less technically efficient State relative to the technology available in the State; Enugu State had the lowest TE estimate. An average farmer in Enugu State was 80% efficient relative to the technology available in the State. Enugu State had the lowest maximum and minimum TE estimates of 0.96 and 0.43 respectively. In Enugu State, the most technically efficient farmer was 96% efficient, while the least technically efficient yam farmer was 43% efficient. Majority of the yam farmers in Enugu had efficiency between 0.81 and 0.90. The variation in TE score was highest in Enugu. This suggests that farmers in the State were not at par in yam production. The low mean TE reported for Enugu could be due to a high variation in TE score within the State.

Table 7.7: Stochastic frontier estimates of technical efficiency for yam farmer

Technical efficiency	Nigeria	Benue	Enugu	Ondo
≤0. 50 (%)	0.3	0.00	2.5	0.00
0.51-0.60 (%)	1.1	0.00	5.00	3.3
0.61-0.70 (%)	3.60	0.00	10.8	9.2
0.71 – 0.80 (%)	17.2	1.7	21.7	15
0.81- 9.0 (%)	48.6	35	37.5	34.2
≥0.91 (%)	29.2	63.3	22.5	38.3
Mean technical efficiency	0.86	0.91	0.80	0.85
Maximum technical efficiency	0.97	0.97	0.96	0.99
Minimum technical efficiency	0.49	0.79	0.43	0.56
SD	0.08	0.04	0.12	0.10

Source: Frontier 4.1, 2015

7.6.2 Hypothesis testing for technical efficiency in yam production in Nigeria

LR test (see section 5.6.1) was performed to test the hypotheses that yam farmers are technically efficient). In this test, the statistical significance of γ parameter (H_0: $\gamma = 0$) is determined; this compares the stochastic frontier function and the average production function. Table 7.8 presents the result of the test of hypothesis. The LR was obtained from frontier 4.1c result. The degree of freedom for this test is one. The null hypothesis (H_0) that the farmers are efficient is rejected if the LR test is greater than the critical value.

Table 7.8: Test of hypotheses

Test	Regions	Hypothesis	LR Test	Degree of freedom	Critical value (5%)	Decision	Implication
There is technical efficiency	Nigeria	$H_0 : \gamma = 0$	15.20	1	2.71	Reject H_0	Not fully technically efficient
	Benue	$H_0 : \gamma = 0$	0.56	1	2.71	Accept H_0	Fully technically efficient
	Enugu	$H_0 : \gamma = 0$	6.80	1	2.71	Reject H_0	Not fully technically efficient
	Ondo	$H_0 : \gamma = 0$	6.64	1	2.71	Reject H_0	Not fully technically efficient

Source: Field Survey, 2013
The critical value (x^2) was obtained from (Kodde and Palm, 1986)

Surprisingly, despite the high efficiency estimates observed in Nigeria, The result shows that Nigerian yam farmers are not fully technically efficient. The null hypothesis that farmers are technically efficiency was rejected for Enugu, Ondo and the pooled frontiers. Benue farmers were technically efficient in yam production.

7.6.3 Environment-technology gap across regions

This analysis proves that yam production differs among States in Nigeria. Table 7.9 displays the test of hypothesis that the group frontiers are similar. The hypothesis that the environment /technology for yam production is the same between States (section 1.8) was tested using generalized likelihood ratio test (see section 5.6.2). The sum of the log likelihood of the Translog model was used because the Translog model is the preferred frontier in all production frontiers except in Benue State.

Table 7.9: **Test of the null hypothesis that regional frontiers are the same**

Log Likelihood Function for States	Log Likelihood Function for Nigeria	Generalized likelihood Ratio Test	Critical Value (5%)	Decision
201.55	152.72	97.66	55.19	Reject null hypothesis

Source: Field Survey, 2013
The critical value (x^2) was obtained from (Kodde and Palm, 1986)

The generalized likelihood that the group frontiers are the same was LR=97.66 and significant at 1% (using chi-squared distribution at 40 degree of freedom). The hypothesis that the States frontiers are the same was rejected. The pooled frontier is inappropriate to estimate the TE of farmers in the country due to the presence of environment-technology gap. This justifies the estimation of MPF for yam in Nigeria.

The metafrontier analysis was used to determine the interference of the technology / environment on farmer performance in Nigeria. The Command for matafrontier analysis using SHAZAM version 11.1 is presented in appendix H. Table 7.10 displays the TE and EMTR estimates for yam farmers in Nigeria.

The metafronier result demonstrates that there exists gap in technology/environment between regions in Nigeria. However, some farmers in all the States were at par in yam production relative to the environment/technology defined by the metafrontier. All the frontiers were tangent to the metafrontier; the States have maximum EMTRs of one.

This indicates that some farmers are performing optimally in yam production in all the States.

Enugu yam farmers were closer to the metafrontier than those of other States. The State had the highest mean EMTR (0.91). This suggests that an average yam farmer in Enugu produces 91% of their potential output using the same input and technology presented by the metafrontier. It can be inferred from this evaluation that eliminating the effect of the environment and/or technology on the TE of farmers, an average yam farmer in Enugu outperforms those in other States. This shows Enugu has unfavourable environment/technology for yam production. On average, Enugu farmers are optimizing the use of inputs but the constraining environmental conditions/technology prevents the farmers from attaining a high regional TE in yam production. The State had a high deviation in EMTR which could imply a more diverse environment/technology in the State. Improving the environmental conditions/technology for yam production in Enugu and adoption of new technology will enhance farmer performance and boost yam production in the State.

An average farmer in Benue State could produce 89% of their potential output with the technology defined by the metafrontier. The minimum EMTRs were similar for Benue and Enugu (0.58). This indicates that the lowest performing farmers in Benue and Enugu performed equally, with respect to the technology defined by the metafriontier. The deviation in EMTR was less in Benue. From this, it can be deduced that eliminating the impact of technology on the performance of yam farmers, Benue will be less technically efficient than those of Enugu.

This research indicates that Ondo yam farmers performed worst in yam production relative to the technology defined by the metafrontier. Yam farmers in the State are further from the metafrontier. This State had the lowest mean EMTR. This implies that eliminating the interference of the environment and technology on farmer performance, it would be the worst performing State. The maximum output that could be produced by an average yam farmer in Ondo using inputs available in the State and the technology in Nigeria is 86% of the maximum output that could be produced using the same input and the technology presented by the metafrontier. Ondo State had the lowest minimum

EMTR (0.47); this shows that the worst performing farmers with respect to the technology defined by the metafrontier was from Ondo State. There is sub-optimal utilization of inputs in Ondo. The farmers are distant from the metafrontier. There was more deviation in EMTR in Ondo. This can be interpreted that there is a notable difference in the environment /technology in Ondo State. Some farmers in Ondo could explore the technology /environment available in the State than others. It could also mean that there is a more diverse environment/technology for yam production in Ondo.

From the Table, Benue State had a higher regional TE than other States. The deviation in regional TE was less in Benue State. This indicates a dense distribution of TE in the State, there was low gap in performance among farmers in Benue. The lowest regional TE and the highest deviation in TE were observed in Enugu State. This indicates a sparse distribution of TE in Enugu State. The reason for this deviation could be due to the gap in the use of technology or the diverse environmental conditions in the State. The lower regional TE reported in Enugu State could be because of adverse environmental conditions.

The result of the analysis reveals that Benue and Ondo farmers outperformed those in Enugu on the Pooled frontier. Benue and Ondo State had similar mean TE-POOL (0.87) which was greater than that of Enugu (0.83). The implication of this is that an average yam farmers in Benue and Ondo State performed equally and more than those in Enugu. The maximum TE-POOL was similar for all the State, indicating that the most technically efficient farmers in all the States performed equally. It can be construed from this that some farmers in Enugu State have ideal environment and technology for yam production in Nigeria. The variation in TE-POOL was highest in Enugu. There is a wide distribution of TE in the State which could be due to gap in the use of technology or diverse environmental conditions in the State.

The Table further illustrates that the MPF gave the lowest estimates of TE in all the States. Benue had the highest mean TE-MF score (0.80). This shows that on average, Benue produced 80% of the maximum output that could be produced using the input level defined by the metafrontier. Enugu and Ondo States had similar mean TE-MF (0.73). Mean farmers in Enugu and Ondo States produced 73% of their maximum output with the technology defined by the metafrontier. This implies that eliminating the effect of the environment/technology on farmers' performance, and an average yam farmer in Enugu will perform same as those in Ondo. Farmers in Ondo had the highest maximum TE-MF (0.98) while Benue had the lowest (the ideal yam producer with respect to the input level define by the metarfontier was from Ondo). Eliminating the interference of technology and environment on farmer TE, the ideal farmer in Ondo and Enugu would outperform those in Benue. The low mean TE-MFs recorded for Enugu and Ondo could be attributed to a wide distribution of the TE-MF within the States. It is apparent from this analysis that farmers in Enugu and Ondo States performed more than those in Benue State with respect to the technology defined by the metafrontier.

The worst farmer in Enugu State in terms of the technology defined by the metafrontier outperformed the less efficient farmer in Ondo States. This implies that on a neutral ground, the worst farmer in Enugu outperformed those in Ondo. It can be inferred from this result that the less performing farmers in Ondo State were able to explore technology/environment to be ahead of those in Enugu.

This investigation supports that comparing the technical efficiency of farmers without considering the interference of the environment/technology could give a bias estimate. For instance, the test of hypothesis of full technical efficiency of Nigeria and States, with the efficiency estimates obtained from stochastic frontier estimates, (see section 7.6.2) showed that Benue was the only technically efficient State in yam production. The metafrontier analysis revealed that Benue had a favourable environmental conditions and /or technology for yam production in Nigeria. Farmers in Benue were efficient because they could explore technologies and the favourable environmental conditions in the State to attain a high regional technical efficiency. The metafrontier analysis also proved that Enugu State yam farmers outperformed those in others States. The Stochastic frontier analysis shows that Enugu yam farmers are inefficient. This is because Enugu yam farmers are producing in a more restrictive environment and technology. The Stochastic frontier analysis does not account for the environment/technology gap.

Table 7.10: Technical efficiency and environment-metatechnology ratio of yam farmers

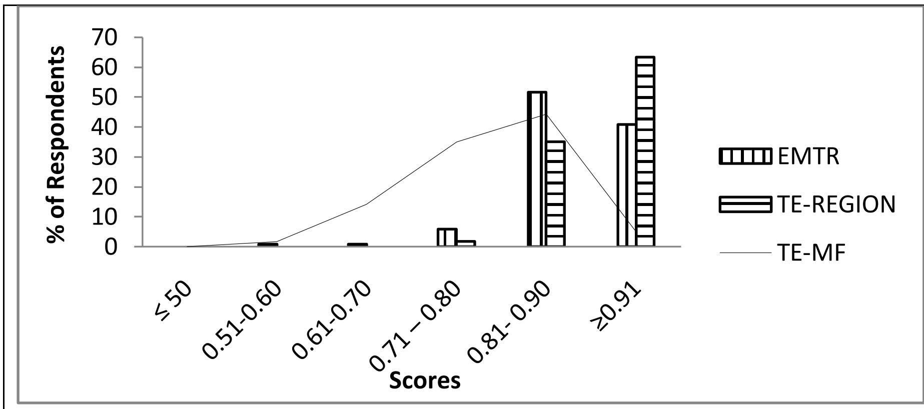
Regions	Estimates	Mean	Standard Deviation	Minimum	maximum
Benue	TE -REGION	0.91	0.04	0.79	0.97
	TE-POOL	0.87	0.06	0.71	0.96
	TE- MF	0.80	0.08	0.52	0.94
	EMTR	0.89	0.07	0.58	1.00
Enugu	TE - REGION	0.80	0.12	0.43	0.96
	TE -POOL	0.83	0.10	0.49	0.96
	TE- MF	0.73	0.13	0.43	0.95
	EMTR	0.91	0.10	0.58	1.00
Ondo	TE - Region	0.85	0.10	0.56	0.99
	TE -POOL	0.87	0.07	0.66	0.96
	TE-MF	0.73	0.13	0.40	0.98
	EMTR	0.86	0.12	0.47	1.00

Source: Frontier 4.1 and Shazam results, 2015

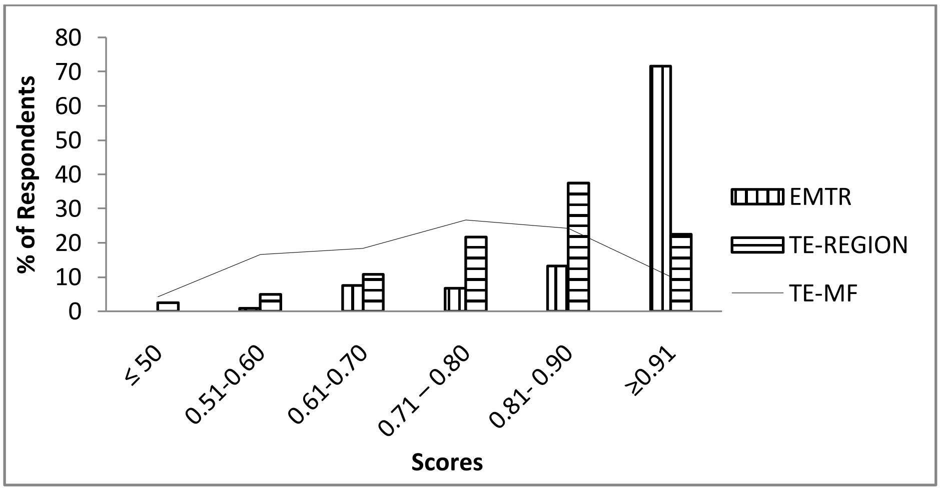
7.6.4 Distribution of the TE-MF, EMTR and TE-REGIONS in Nigeria

The analysis of the distribution of TE-MF, EMTR and TE-REGION proves that the technology/environment for yam production in Enugu State is below standard. The distribution of the TE-MF, EMTR and TE-REGIONS in Nigeria is displayed in Figure 7.1. From the Figure, more farmers in Enugu (71.7%) had EMTR above 0.90. This indicates that most of the farmers in Enugu could produce over 90% of their potential output with the technology defined by the metafrontier. Less than half of the population of Ondo and Benue farmers could produce over 90% of their potential output. This suggests that Enugu State yam farmers outperformed those in other States relative to the metatechnology (technology defined by the metafrontier).

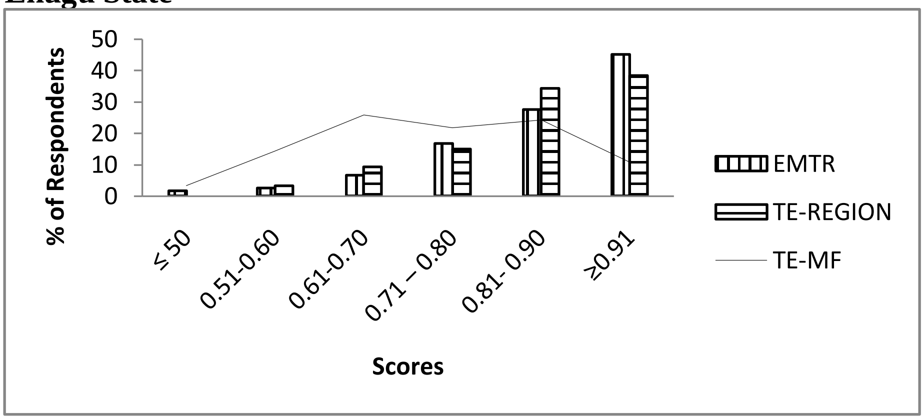
This investigation proves that eliminating the influence of the environment and technology on efficiency, yam farmers in Enugu State outperformed those in other States. The result shows that Benue and Ondo States have favourable environments/ technologies for yam production. These States had higher regional TE than Enugu. Most farmers in Benue and Ondo had TE-REGION above 90% while majority of the farmers in Enugu had TE-REGION of between 0.81-0.90. However, Enugu yam farmers are closer to the metafrontier (the State performed more than other States relative to the metatechnology).Yam farmers who had TE-REGION above 90% in Benue and Ondo could explore technologies and the favourable environment available in the States to



Benue State



Enugu State



Ondo State

Figure 7.1: Distribution of the TE-MF, EMTR and TE-REGION
Source: Stochastic and metafrontier analysis, 2015

attain these TE-REGION levels. The Figure also shows that 22.5% of farmers in Enugu had TE-REGION above 90%. This indicates that few farmers in Enugu could attain TE-

REGION above 90% given the prevailing technology /environment in the State. Although Enugu State had low regional TE, majority of the farmers produced above 91% of their potential output with the metatechnology. This supports that Enugu farmers are operating in a constrained environment and technology. Nevertheless, some farmers in the State could adopt technology to attain a high TE-REGION. For instance; approximately 37.5% of the farmers in Enugu could produce 81-90% of output on the regional frontier while only 13.3% could produce this level of output with the technology defined by the metafrontier. The farmers who attained this level on the Enugu regional frontier adopted technology or had favourable environment. This signifies a wide variation in the use of technology and environment for yam production in Enugu.

7.7 Determinants of technical efficiency of yam farmers in Nigeria

Factors influencing the TE of yam farmers were determined using Frontier 4.1c software. The inefficiency parameters were simultaneously generated with the efficiency estimates in a single equation. The result of the socioeconomic, Farmer decision and access to facilities influencing technical inefficiency are presented in Table 7.11, 7.12 and 7.13 respectively. A positive sign implies that the variable increases inefficiency, while a negative sign shows that it decreases inefficiency.

The result of this analysis indicates that the socioeconomic characteristics of yam farmers in Nigeria influence their technical efficiency. Gender, age, primary occupation marital status, farm size, land ownership, education, the use of credit and number of income sources were the significant determinants of technical efficiency of yam farmers in the study area (Table 7.11).

From the Table, the gender of a farmer influences their performance. It was significant in all the frontiers, except in Benue State. Its coefficient was negative and significant at 1% and 10% in Nigeria and Enugu frontiers respectively. Increased male involvement in yam production in Nigeria, particularly in Enugu State, improves the performance of farmers; this result contradicts (Nyariki, 2011). Yam is considered a “male’s crop” in

7.7.1 Socioeconomic determinants of technical efficiency of yam farmers in Nigeria

Table 7.11: **Socioeconomic determinants of technical inefficiency in yam production in Nigeria**

Efficiency factor	Parameter	Nigeria	Benue	Enugu	Ondo
Intercept	β_0	0.17	-0.37	0.53*	0.11***
		(0.23)	(0.54)	(0.38)	(0.031)
Gender	β_1	-0.22***	0.02	-0.17*	0.24)*
		(0.065)	(0.11)	(0.11)	(0.15
Age in years	β_2	0.0035**	0.0012	-0.0013	0.11
		(0.0019)	(0.0029)	(0.0039)	(0.035)***
Household size	β_3	0.0040	0.00097	0.0079	-0.00296
		(0.00597)	(0.0044)	(0.013)	(0.0056)
primary occupation	β_4	0.035	-0.059	0.18	-0.46***
		(0.12)	(0.12)	(0.23)	(0.15)
Membership of organizations	β_5	-0.016	0.087	-0.0044	-0.022
		(0.056)	(0.083)	(0.093)	(0.042)
Marital Status	β_6	-0.12***	0.083	-0.054	0.30***
		(0.048)	(0.19)	(0.078)	(0.088)
Health issues	β_7	0.049	0.000036	0.023	-1.56
		(0.061)	(0.085)	(0.998)	(1.94)
Land ownership	β_8	-0.15***	-0.06*	-0.27**	-0.195
		(0.017)	(0.04)	(0.12)	(0.26)
Farm size	β_9	-0.00076	0.0016	-0.0098	-0.027**
		(0.0036)	(0.0053)	(0.0071)	(0.012)
Education in Years	β_{10}	0.099**	0.083	0.032	-3.85***
		(0.052)	(0.11)	(0.083)	(1.79)
Extension visit	β_{11}	-0.0066	0.0101	-0.0074	0.36
		(0.0052)	(0.0079)	(0.0090)	(0.42)
Credit use	β_{12}	-0.084*	-0.016	-0.07	-0.77
		(0.054)	(0.069)	(0.099)	(0.75)
Number of income sources	β_{13}	0.087*	0.066	0.078	0.042
		(0.058)	(0.096)	(0.096)	(0.099)

Source: computed from frontier 4.1 results, 2015
***, **,* are significant at 1%, 5%, and 10% respectively
Standard error are given in parenthesis

Nigeria, men outperformed women in yam production. However, its coefficient was positive at 10% probability level in Ondo; signifying that female were more technically efficient in yam production in the State. This could be attributed to the fact that females have innate managerial ability and could effectively allocate resources. The current yam production techniques in Nigeria are laborious and require more energetic men. Development of a less strenuous yam production method will encourage more women into yam production. Nevertheless, women can continue in yam production since female yam farmers in Ondo outperformed their male counterparts.

This analysis also shows that older farmers are more technically inefficient than younger ones. Age had a positive relationship with technical inefficiency in Nigeria, especially in Ondo. It was significant at 5% and 1% in Nigeria and Ondo frontiers respectively. The older the farmer, the less technically efficient they become. Although, age correlates with experience, it is expected that the longer the farmers stay in yam production, the more experience they gain. It is a known fact that level of activities decreases with age. Youths are more energetic than men and could do farm work easier and faster. This is in line with other studies such as (Anyaegbunam et al., 2016; Ohajianaya, 2014; Mariano et al., 2011; Amaefula, 2007) who observed a negative relationship between age and technical efficiency. This finding contradicts Belbase and Grabowski (1995).

Primary occupation is a significant factor influencing the performance of yam farmers. Ondo is the only State with a significant impact of occupation on TE. It had a negative relationship with technical inefficiency in the State and was significant a 1%. This implies that full-time yam farming enhances the performance of farmers in the State. Therefore, specialization on yam farming should be encouraged to boost yam production in Nigeria, particularly in Ondo.

This study indicates that marital status could have a positive or a negative impact on the performance of yam farmers. Its coefficient was negative and significant at 1% in Nigeria. The marital status of yam farmers had a negative influence on technical inefficiency in Nigeria. This implies that TE increases with more married people engagement in yam production in Nigeria. This supports from the findings of Chiremba and Masters (2003) who found that married settlers outperformed the unmarried ones in Zimbabwe. However, It had a positive coefficient in Ondo and was significant at 1%; indicating that involvement of married people in yam production decreases performance. Married and unmarried farmers can engage in yam production in Nigeria.

The Table establishes that land ownership and the area of land own determine the performance of yam farmers in Nigeria. Land ownership had a negative relationship with technical inefficiency in all the frontier, except in Ondo State; indicating that TE increases with land ownership. This confirms the findings of (Al-Feel and Al-Basheer, 2012; Bojnec and Latiuffe, 2009). Land owners are more technically efficient than landless farmers. Government policies on land distribution to yam farmers will improve the performance of yam farmers in Nigeria. Farm size had a negative impact on technical inefficiency in all frontiers, except in Benue. Ondo State is the only State with significant effect of farm size on TE. Large-scale farmers are more technically efficient than small scale farmers in Nigeria. Increased farm size enhances the performance of yam farmers in Ondo. This affirms the observation of (Reddy and Bantilan (2012); Rahman & Hasan (2011); Alene and Hassan (2003). However, it differs from the findings of (Anyaegunam et al. (2016), Amaefula et al. (2009), Okoye et al. (2007); Ahmad (2003) who reported a negative relationship between farm size and efficiency. Performance improvement in yam production in Nigeria can be achieved through expansion of land area under yam production.

The result also shows that education influences the TE of yam farmers in Nigeria. It had a positive relationship with education in Nigeria frontier; implying that education increases inefficiency in yam production. Most educated farmers in Nigeria are part-time farmers and are less dedicated to farm work. However, it coefficient was negative in Ondo State. Education enhances the TE of farmers in the State. This supports the report of (Amaefula et al., 2010). Education improves managerial ability; educated farmers are more knowledgeable and can make better choices. Investment in public education will improved the educational outcome of farm families.

From the Table, the use of credit enhances the performance of yam farmers in Nigeria. It had a negative effect on technical inefficiency, implying that credit improves the TE of yam farmers in the country. In Nigeria, financial institutions are located mainly in the urban areas. Farmers have limited access to credit facilities. Therefore, establishing credit institutions in the rural areas and reducing interest rate on loan will increase farmer access to credit, and boost their performance.

Lastly, the Table indicates that number of income sources had a positive relationship with technical inefficiency, and was significant at 10% in Nigeria. In Nigeria, yam farmers with more income sources are less technically efficient. This supports the report of (Backman et al., 2011).Farmers with more income sources are often part-time farmers with diverse income generating activities; they devote less time to farming. Full time yam farming will improve the performance of yam farmers in Nigeria.

7.7.2 Effect of farmer decision on technical efficiency of yam farmers in Nigeria

An assessment of the effect of farmer's decision-making ability on technical inefficiency indicates that the ability of farmers to make appropriate decisions regarding farm activities determines their performance. Table 7.12 shows farmer's decision-making variables influencing technical inefficiency of yam farmers in Nigeria. The decision variables significantly affecting farmer's technical inefficiency include source of agricultural information and planting material, time of planting and harvesting, quantity of planting material, quantity of fertilizer used, the ICTs for farm business, the use of YMT, staking and weeding of yam farm.

From the Table, agricultural information and its source determine the performance of yam farmers. This supports the findings of (Rahman and Hasan 2011) that source of agricultural information is a managerial variable influencing efficiency. Access to agricultural information is a significant factor influencing the TE of yam farmers. Agricultural information from fellow farmers had a negative impact on the technical inefficiency. Its coefficient was significant at 5% and Enugu. This shows that farmers who obtained agricultural information from relations in Enugu State were technically efficient.

The Table demonstrates that source of planting material influences the TE of yam farmers in Nigeria. This is in line with Rahman and Hasan (2011) who included source of planting material as a factor influencing efficiency in Bangladesh. Planting material from own farm had a positive and significant effect on technical inefficiency in Nigeria. It was significant at 5%. The use of planting material from farmer's own farm reduces the TE of yam farmers in Nigeria. Fellow farmer is another significant source of planting material in Nigeria, particularly in Enugu. It had a positive relationship with technical inefficiency in Nigeria. Its coefficients were significant at 5% and 1% for Nigeria and Enugu frontiers respectively. This indicates that the more farmers source for planting material from fellow farmers, the lower the TE. Therefore, it is inappropriate for farmers to obtain planting material from fellow farmers in Nigeria,

Table 7.12: Farmer decisions influencing technical inefficiency of yam farmers in Nigeria

	Parameters	Nigeria	Benue	Enugu	Ondo
Intercept	θ_0	-0.41 (0.44)	-0.084 (0.313)	-0.33 (0.76)	-0.28 (0.81)
Agricultural information fellow farmers	θ_1	-0.089 (0.081)	0.057 (0.055)	-0.43** (0.19)	-0.021 (0.052)
Agricultural information from EAs	θ_2	-0.0064 (0.053)	0.096 (0.076)	0.16 (0.21)	0.023 (0.051)
Planting material from own farm	θ_3	0.604** (0.304)	0.215 (0.184)	0.099 (0.34)	0.047 (0.114)
Planting material from market	θ_4	-0.0079 (0.052)	0.050 (0.055)	-0.14 (0.15)	0.083 (0.077)
Planting material from fellow farmers	θ_5	0.12** (0.069)	-0.032 (0.059)	0.45*** (0.14)	0.014 (0.055)
Planting material from Extension Agents	θ_6	0.15 (0.11)	0.058 (0.129)	0.093 (0.16)	0.11 (0.14)
Time of planting	θ_7	-0.0741** (0.0378)	-0.0085 (0.025)	-0.13*** (0.0604)	-0.015* (0.0091)
Time of harvesting	θ_8	-0.0424*** (0.0167)	-0.0042 (0.012)	-0.034*** (0.011)	-0.045** (0.020)
Quantity of fertilizer used	θ_9	-0.0015*** (0.00058)	-0.00085 (0.0018)	-0.00044 (0.00051)	-0.00060 (0.00052)
Use of ICTs	θ_{10}	-0.16* (0.12)	0.046 (0.086)	-0.035 (0.26)	0.71 (0.84)
Use of YMT	θ_{11}	-0.17*** (0.0828)	-0.029 (0.069)	-0.12 (0.16)	0.26** (0.11)
Staking of yam	θ_{12}	-0.000055*** (0.000021)	-0.000022 (0.000088)	-0.000046 (0.000056)	0.047 (0.11)
Number of times of weeding	θ_{13}	0.12* (0.088)	-0.022 (0.058)	0.35* (0.25)	-0.0038 (0.098)

Source: computed from frontier 4.1 results, 2015
***, **,* are significant at 1%, 5%, and 10% respectively
Standard error are given in parenthesis corrected to two-significant digits

Enugu State in particular. Therefore, it is improper for yam farmers to obtain planting material from the own farm and fellow farmer.

The Table reveals that time of planting and time of harvesting are significant factors affecting the TE of yam farmers in Nigeria. Unexpectedly, time of planting had a negative influence on technical inefficiency and was significant at 1% probability level. This implies that TE of Nigerian yam farmers increases with delayed yam planting. Farmers who planted yam early were less technically efficient. Delayed yam planting enhances farmer performance in Nigeria. TE of yam farmers in Nigeria is also determined by time of harvesting. It had a negative relationship with inefficiency in Nigeria, except in Benue State. Late harvest of yam increases farmers' TE. Farmers who harvest yams early are more technically inefficient, except in Benue State.

This evaluation demonstrates that the quantity of fertilizer use for yam production has a significant impact on yam farmers TE. Its coefficient was negative and significant at 1%. This means that TE increases with the use of fertilizer. Farmers who used more fertilizer were technically efficient. Farmers should be encouraged to use fertilizer for yam production.

This result shows that the use of ICTs determines the performance of yam farmers in Nigeria. It had a negative relationship with inefficiency in the country; implying that it enhances TE. The use of ICTs, especially handset improves the TE of yam farmers in Nigeria; this affirms Nair et al. (2012).

The use of YMT affects the performance of yam farmers in Nigeria. It had a negative effect on TE in Nigeria and was significant at 1%. This shows that TE of yam farmers Increases with the use of YMT. Farmers who practice YMT in Nigeria, were technically efficient. In Contrast, the use of YMT had a positive effect on technical inefficiency in Ondo adopters of YMT in Ondo were less technically efficient The reason for this could be that farmers in this State do not adopt the full package of YMT. Therefore, the use of the full YMT package would enhance farmer performance in Enugu. Adoption of the full package of YMT will improve the performance of yam farmers in the country.

From the Table, staking of yam affects the TE of farmers in Nigeria. It had a negative and significant effect on technical inefficiency of yam farmers in Nigeria frontier. This indicates that TE increases with the use of staking materials for yam production in Nigeria. This supports the findings of (O'Sullivan, 2010; National Agricultural Research Institute, 2006) who observed that staking is important for the improvement of yam production. Farmers who stake yam were more technically efficient.

This investigation establishes that weeding of yam farm determines the TE of yam farmers in Nigeria, particularly in Enugu State. Contrary to expectation, it had a positive and significant impact on inefficiency in Nigeria. This suggests that farmers who weed their yam farms more frequently were less technically efficient. Over weeding of yam farm could expose yam farm to excessive heat resulting to low yield.

7.7.3 Effect of access to facilities on technical efficiency of yam farmers in Nigeria

The evaluation of the facilities affecting yam farmers TE in Nigeria reveals that farmer access to facilities determines their TE in yam production in Nigeria. Table 7.13 displays the facilities influencing TE of yam farmers in Nigeria. The Table shows that the TE of yam farmers in Nigeria is determined by difficulties acquiring farm input, adequacy of seed yam and labour, access to fertilizers adequacy of seed yam and land fragmentation. TE is also affected by access to financial institutions, market, good road and hospitals. Other determinants of TE of yam farmers include access to farm machinery, irrigation facilities, potable water means to farms and farm distance from home.

From the Table, access to financial institution significantly influences TE in Nigeria. It had a positive and significant relationship in TE and significant at 10%. This indicates that increased access to financial institution reduces the TE of yam farmers in Nigeria. Those farmers who had physical access to financial institution were less technically efficient. This confirms the observation of Backman et al. (2011) that access to microfinance has positive relationship with inefficiency. Financial institutions are concentrated in the urban areas of Nigeria. The farmers spend valuable time to arrive at the bank and access fund from the bank. Establishment of banks in the rural areas will have positive impact on the performance of the rural farmers. The investigation also detects that access to irrigation facilities is a significant determinant of the TE of yam farmers in Benue. It had a negative and significant relationship with technical inefficiency in the State. This shows that the more access to irrigation facilities in these State, the more technically efficient the farmers become. Irrigation facilities increase the TE of yam farmers in Benue. Irrigation is required for yam production in Benue State. Geographically, Benue is located in the derived savannah region of Nigeria. Increased access to irrigation facilities would boost yam production in the State.

Table 7.13: Facilities influencing technical inefficiency of yam farmers in Nigeria

Factor	Parameter	Nigeria	Benue	Enugu	Ondo
Constant	d_0	-0.68 (0.73)	0.13 (0.81)	-0.01 (0.75)	-0.54* (0.41)
Access to research and extension	d_1	0.61 (0.55)	-0.25 (0.57)	-0.28 (0.47)	0.00 (0.00)
Access to financial institutions	D_3	0.52* (0.38)	0.12 (0.11)	-0.28 (0.47)	0.06 (0.05)
Access to irrigation facility	D_2	-0.28 (0.23)	-0.56** (0.30)	-0.18 (0.40)	0.05 (0.07)
Access to hospital	D_4	0.04 (0.12)	0.06 (0.10)	-0.13 (0.26)	-0.04 (0.07)
Access to good road	D_5	-0.33 (0.27)	0.001 (0.06)	-1.14*** (0.43)	-0.09** (0.05)
Difficulty acquiring farm input	D_6	0.21 (0.18)	0.01 (0.06)	0.80** (0.47)	0.09** (0.04)
Access to machinery	D_7	0.26* (0.17)	0.06 (0.07)	0.57** (0.27)	0.18*** (0.04)
Access to fertilizer	D_8	0.05 (0.11)	-0.20 (0.79)	0.28 (0.38)	-0.15*** (0.04)
Adequacy of seed yam	D_9	0.01 (0.08)	-0.07* (0.06)	-0.04 (0.16)	0.02 (0.05)
Adequacy of labour	D_{10}	-0.05 (0.08)	0.02 (0.05)	-0.04 (0.17)	-0.10*** (0.03)
Farm distance from home	D_{15}	0.02* (0.01)	0.002 (0.01)	-0.18 (0.22)	0.001 (0.006)
Means to farm	D_{11}	-0.10** (0.06)	-0.03 (0.04)	0.06 (0.07)	-0.04** (0.02)
Access to market	d_{12}	0.15 (0.18)	0.05 (0.08)	-1.27*** (0.43)	0.12** (0.06)
Farm fragmentation	D_{13}	-0.08 (0.06)	-0.05* (0.04)	-0.18 (0.10)	-0.09*** (0.04)
Availability of school	d_{14}	0.09 (0.10)	0.15 (0.28)	-0.01 (0.75)	0.04 (0.04)
Use handset for farm business	d_{16}	0.30 (0.29)	-0.06 (0.11)	0.47** (0.26)	-0.07 (0.19

Source: computed from frontier 4.1 results, 2015
Standard error are given in parenthesis corrected to two significant digits
***, **and * are significant at 1%, 5% and 10% respectively.

Table 7.13 indicates that access to good road affects farmer performance in Enugu and Ondo. It had a negative effect on TE in the States. Access to good road in Enugu and Ondo enhances the TE of yam farmers. Yam farmers who have access road in their community have easy access to their farms; they get to their farms with vehicle; and conserve strength for farm work. Construction of road in the rural areas will improve the performance of farmers in Nigeria.

This analysis also reveals that access to farm inputs influences the performance of yam farmers in Nigeria. Difficulties acquiring inputs had a positive and significant influence on inefficiency in Enugu and Ondo States. This suggests that access to farm inputs increases TE in Enugu and Ondo. Yam farmers who had difficulties acquiring farm inputs were less technically efficient. Therefore, increased access to inputs in these States will improve the performance of yam farmers. Input subsidies and effective input distribution strategy in Nigeria will increase farmers' access to input.

The Table proves that access to farm machinery and irrigation facilities affects the performance of yam farmers in Nigeria. Access to farm machinery influences the performance of yam farmers in Nigeria, except in Benue State. Contrary to expectation, it had a positive and significant relationship with the technical inefficiency in yam production. This implies that TE decreases with the use of farm machinery. Farmers who had access to machinery were less technically efficient. This could be attributed to the fact that it is difficult to access farm machinery in Nigeria. Due to administrative bottle-neck in the country, farmers might spend significant time that ought to be employed for productive farm work accessing farm machinery. The machines might also arrive at the farms late. Strengthening research-extension-farmer input linkage and establishing 'farmer help line' in the country will reduce the huddles in farm input acquisition.

The result indicates that TE of yam farmers in Nigeria is determined by adequacy of farm inputs such as seed yam, labour and fertilizer. This analysis also indicates that access to fertilizer significantly determines the TE of yam farmers in Ondo. It had a negative and significant effect on TE in the State. Its coefficient was significant at 1%. This implies that increased use of fertilizer enhances farmers TE in Ondo. Technically efficient farmers in Ondo used fertilizer for yam production. Seed yam had a negative relationship with inefficiency of yam farmers in Benue State and was significant at 10%. This infers that increased use of planting material improves the TE of yam farmers in Benue. This evaluation proves that adequacy of labour improves the performance of yam farmers in Ondo State. Access to labour in Ondo had a negative impact of technical inefficiency and was significant at 1%. Farmers who employed adequate labour were technically efficient in yam production. The use of adequate seed yam, labour and fertilizer is essential for yam production in Nigeria. However, these inputs are scarce and expensive relative to farmers' income. Therefore, policies that will enable easy access to input by farms will improve the Nigerian agricultural system for food security and poverty alleviation in the country.

From this evaluation, access to market is an important determinant the TE of yam farmers in Enugu and Ondo States. It was significant at 1% and 5% in Enugu and Ondo States respectively. It had a negative coefficient in Enugu State. This indicates that access to market increases farmer's TE in the State. Yam farmers in Enugu who had access to market were technically efficient. They spend less time in the market to sell their yams. Contrary to Enugu State, its coefficient was positive in Ondo. This suggests that increased access to market in Ondo decreases the performance of yam farmers in the State. Farmers who had access to market in Ondo were less technically efficient. The reason for this could be that it takes time for farmers to sell their yam in Ondo. Farmers spend productive time to sell their produce in the market.

Surprisingly, the Table indicates that the use of scattered plots for yam production improves the performance of yam farmers. Land fragmentation has negative impact on the technical inefficiency of yam farmers. Its coefficients were 10% and 1% in Benue and Ondo respectively. This signifies that the use of fragmented land for yam production in these States enhances TE. This is in contrast with (Kilic et al., 2009) who noticed that farmers who had few plots were more technically efficient. This also contradicts the findings of (Backman et al., 2011; Nyariki, 2011) who observed that owners of more plots were more inefficient. The use of scattered plot for yam production could be a strategy for averting risks in yam production. For instance, fire or disease outbreak in a particular location might destroy the entire farm.

The Table shows that farm distance from home and the means farmer reach their yam farms determine their TE in Nigeria. Farm distance from home had a positive relationship with TE in Nigeria. This demonstrates that the farther the yam farms the more technically inefficient the yam farmers. Owners of distant farms are less technically efficient. Farmers who have distant farms arrive at their farms late and are often exhausted when they get to the farm. The Table also reveals that the means to farm affects farmer's technical efficiency in Nigeria, particularly in Ondo State. It had a negative impact on technical inefficiency of yam farmers in Nigeria, particularly in Ondo State. This could be interpreted that the use of vehicle to yam farms improves performance. Vehicle expedites movement and enables farmers to conserve energy for farm work.

Finally, the evaluation reveals that use of handset for farm business influences the TE of yam farmers. Ondo was the only State with a noticeable effect of ownership of handset on TE. Its coefficient was significant at 5% with a positive sign. This indicates that TE decreases with ownership of handset. The reason for this could be that the farmers use their handsets for transactions not relating to yam farming.

7.8 Cost of yam in Nigeria

This section presents the cost of yam in Nigeria and its determinants. The hypothesis that cost variables influence the cost of yam in Nigeria was tested and the lead cost model for yam selected.

7.8.1 Cost variables for yam production in Nigeria

The descriptive statistics on cost of yam production was performed with the SPSS analytical tool. The result of the cost of yam production is displayed in Table 7.14. It establishes that the cost of yam production is relatively high in Nigeria. An average yam farmer in Nigeria spent ₦749, 305 to produce 14,797 kg of yam (this is equivalent to ₦51 per kg of yam). There is significant difference in cost variables used for yam production across regions in Nigeria.

Table 7.14 indicates that Benue farmers spend more than other farmers on yam production. As earlier reported, the State also had a higher yam production that the other States. The ANOVA result for ascertaining the difference in cost variables reveals that Benue and Ondo State has similar cost of production. What is interesting about this finding is that Benue has a noticeably higher yam output than Ondo. The high cost of production observed in Ondo could be due to high cost of inputs in the State. As expected, Enugu which had the lowest yam output also had the lowest cost of production. Per hectare comparison of cost of yam production shows that Ondo had the highest cost of yam production while Benue had the lowest. The reason for the high cost of production in Ondo could be due to high cost of inputs.

Table 7.14: Differences in cost variables across regions

Variables	Nigeria (mean)	Benue (mean)	Enugu (mean)	Ondo (Mean)
Variable input per farm				
Cost (₦)	749,305	973,666[a]	428,739[b]	845,510[a]
Output (kg)	14,797	20,151[a]	9,772[c]	14,468[b]
Depreciated cost of capital input (₦)	2,393	2,871[a]	1,851[b]	3,055[a]
Rent on land (₦)	11,628	21,149[a]	5,033[b]	8,700[b]
Price of planting material (₦ /kg)	48	47[ab]	45[b]	52[a]
Wage rate (₦ /man-day)	1,494	1,067[b]	1,812[a]	1,602[a]
Price of fertilizer (₦ /kg)	83	113[a]	91[b]	44[c]
Variable per ha				
Cost ₦/ha	499,537	438,588.	476,377	599,653
Rent ₦/ha	7,752	9,527	5,592	6,170
Wage ₦/ha	355,324	248,097	366,366	446,629
Capital input (₦/ha)	1,595	1,293	2,057	2,167
Price of planting material ₦/ha	72,631	74,470	68,717	74,254
Price of fertilizer ₦/ha	5,733	5,560	12,043	1,129

Source: Field survey, 2013
Note: a,b,c letters denote significant differences (at 0.05 level) in variables across regions in a descending order of magnitude.

The Table further demonstrates that Ondo yam producers incur more cost on capital inputs than other States. The State had the highest cost of capital input per farm and relative to farm size. This could imply that inputs are costly in the State. A decrease in the cost of capital input would reduce the cost of yam in Ondo State. Although, it is expected that Benue, which had the highest yam production would spend more on inputs. The reason for the high cost of capital input observed in Ondo State could be that inputs are expensive in the State.

Benue farmers spent higher amount on rent than those in other States (Table 7.14). The high rent on land recorded for Benue State is not an indication of high cost of land in the State; rather, it supports the fact that farmers in Benue State have large farms and spend more on land rent. Enugu yam producers spent less on land rent (farmers have smaller farms compared to the other States).

From the Table, planting material is more expensive in Ondo. Farmers in the State had the highest price of planting material. There is access of planting material in Benue, more planting material is used in Benue than other State relative to farm size. The State also had the lowest price of planting material. Ondo State incurs more cost on yam production.

The Table reveals that labour is expensive in Enugu State. Enugu had the highest wage rate. This could be due to unavailability of labour in the State. Nevertheless, a further investigation of the significant difference in wage rate between States indicates that Enugu and Ondo had similar wage rate. Ondo State had the highest cost of labour per hectare; this suggests that the State employed more labour than Enugu. Labour is cheaper in Benue than in other States. Benue spent the lowest on wage. There was easy availability of labour in Benue; hence, the low wage rate in the State. The State also had large families which release labour for farming. The use of labour-saving devices will reduce the cost of yam production in Nigeria, and improve the standard of living of farmers in the country. Large families can release labour to non-agricultural sectors to increase the income generating power of the farm household. This, among other factors will contribute to wellbeing improvement in Nigeria.

This result shows that fertilizer is more costly in Benue State. The State had the highest price of fertilizer while Ondo had the lowest. The price of fertilizer was significantly different among regions. Although fertilizer is cheaper in Ondo than other States, Ondo yam farmers used less quantity of fertilizer for yam production. This supports the fact that most Ondo yam farmers are reluctant to use fertilizers. Enugu used the largest quantity of fertilizer. The State also spent more than other States on fertilizer.

Comparing the cost of yam production on per hectare basis, Table 7.14 indicates that yam production in Ondo is more expensive. The State had the highest cost of yam production. Ondo had the highest expenditure on wage and capital input. Benue had the lowest cost of production. It had the lowest expenditure on labour and capital input. Surprisingly, Benue which has more land area spent more on land rent while Enugu which has a less land mass had the lowest expenditure on land rent. The Table also indicates that Benue State had the highest cost of planting material. Enugu State had the lowest expenditure on planting material. The State spent more than other States on fertilizer.

7.8.2 Determinants of cost of yam in Nigeria

Frontier 4.1 software was used to determine the cost of yam in Nigeria. The result of the Cobb-Douglas stochastic cost function for yam in Nigeria indicates that all cost factors were significant determinants of cost of yam in Nigeria. However, price of fertilizer had no effect on cost of yam in Benue and Ondo. Cost was not influenced by capital input in Enugu State. The diagnostic statistics were significant at 1% level of significance. Table 7.15 presents the MLE of Cobb-Douglas cost function for yam in Nigeria. A positive sign implies that an increase in the variables increases the cost of yam.

Yam output determines the cost of yam in Nigeria (Table 7.15). It had a positive coefficient and was significant at 1% in all frontiers. This infers that cost of yam rises with increased yam output; farmers would incur more cost if they increased their scale of production. Benue will incur more cost to expand yam production than other States. Less cost is required to increase the scale of yam production in Ondo. It is easier for Ondo yam farmers to increase their scale of production. Nigerian yam farmers are poor and lack fund to expand production. The coefficient of output was highest in Benue frontier and lowest in Ondo. This indicates that the responsiveness of cost to change in output was highest in Benue. This can be interpreted that there would be a more noticeable change in cost of yam in Benue with change in output. Therefore, farmers should have access to credit to enable them increase production. For this to be accomplished, financial institutions should be located in close proximity to the farmers.

Table 7.15: Maximum likelihood estimate of Cobb-Douglas stochastic frontier cost function for yam in Nigeria

Variables	Parameters	Nigeria	Benue	Enugu	Ondo
Intercept	α_0	2.59*** (0.23)	2.74*** (0.45)	2.54*** (0.59)	2.45*** (0.29)
Output (kg)	α_1	0.59*** (0.036)	0.74*** (0.087)	0.53*** (0.069)	0.51*** (0.059)
Capital input (₦)	α_2	0.15*** (0.047)	0.20** (0.10)	0.11 (0.12)	0.10** (0.047)
Rent on land (₦)	α_3	0.26*** (0.032)	0.16*** (0.052)	0.20*** (0.067)	0.46*** (0.057)
Price of planting material (₦ /kg)	α_4	0.21*** (0.051)	0.24** (0.11)	0.30** (0.13)	0.16*** (0.050)
Wage rate (₦ /man-day)	α_5	0.49*** (0.044)	0.51*** (0.076)	0.51*** (0.094)	0.35*** (0.079)
Price of fertilizer (₦/kg)	α_6	0.0040* (0.0028)	0.0016 (0.0074)	0.024*** (0.0069)	0.00070 (0.0035)
Diagnostic statistics					
Sigma-squared	σ^2	0.088*** (0.0099)	0.053*** (0.014)	0.14*** (0.032)	0.033*** (0.0080)
Gamma	γ	0.87*** (0.040)	0.69*** (0.17)	0.91*** (0.082)	0.77*** (0.13)
LLF		81.41***	41.49***	6.50***	77.34***
LR test		27.53***	2.36***	2.43***	3.69***

Source: Frontier 4.1 result, 2015
***, ** and *are significant at 1, 5 and 10% respectively.
Standard error are given in parenthesis corrected to two-significant digits

Table 7.15 also demonstrates that capital input is a significant determinant of cost of yam except in Enugu. It had a positive and significant relationship with cost. The use of more capital input increased the cost of yam in the States. This supports a priori expectation that farmers would incur more costs if they purchased capital input at high price. The magnitude of the coefficient of capital input was highest in Benue. Reduction in the cost capital input would have more impact on cost of yam in Benue than in other States. Thus, decreased cost of capital inputs in Nigeria will contribute to the reduction of cost of yam in the country. Input subsidy is crucial to reduce the cost of yam production in Nigeria.

The Table further indicates that rent on land determines the cost of yam in Nigeria. It coefficient was positive and was significant at 1% in all frontiers. This implies that a high rent on land increases the cost of yam in Nigeria. Farmers who rent expensive land incur a more production cost. Reduction in the cost of renting land in Nigeria will decrease the cost of yam. More cost response occurred on rented land in Ondo, indicating that increased rent would have more effect on cost of yam production in the State. Reduction in land rent would reduce the cost of yam in Ondo.

The Table also shows that price of planting material affects the cost of yam in Nigeria. It had a positive and significant relationship with cost in all frontiers. This demonstrates that high cost of planting material increases the cost of yam production in Nigeria. This is consistent with a priori expectation that farmers would incur more costs if they purchased planting material at a high price. Its coefficient was highest in Enugu State. The responsiveness of cost to change in price of planting material was more pronounced in Enugu State. This shows that change in the cost of planting material would affect the cost of yam more in Enugu State. Therefore, any change in the price of planting material in Nigeria, especially in Enugu will have more effect on cost.

The result reveals that high wage rate increases the cost of yam in these States. It has a positive and significant effect on cost. Its coefficient was significant at 1% in all frontiers. Wage rate is high relative to farmer income, especially in Enugu. These farmers who pay higher wage will incur a high cost of production.

The analysis also indicates that price of fertilizer influences the cost of yam in Nigeria. It had a positive and significant effect on cost. This indicates that cost of yam rises with increased price of fertilizer. Reduction in the price of fertilizers will lower the cost of yam in Nigeria, particularly in Enugu State.

From the analysis, there was more cost response to output, which was followed by wage rate, then capital input in all frontiers (Table 7.15). The only exception was Ondo which had more cost response to capital input than wage rate. This implies that these three variables are crucial for controlling the cost of yam in Nigeria. It could be construed from this result that input subsidy will increase the affordability of inputs by farmers and reduce the cost of yam production in Nigeria.

The Table shows that the diagnostic statistics were significant at 1% in all the frontiers. Variance ratio for Nigeria frontier was 0.87. This implies that 87% of variation in cost is due to inefficiency. There was more variation in cost due to inefficiency in Enugu (91%) and least variation in cost due to inefficiency in Benue (69%).

The result of the Translog model indicates that cost factors influences the cost of yam in Nigeria. Table 7.16 presents MLE of Translog stochastic frontier cost function for yam in Nigeria. The cost factors influencing the cost of yam in Nigeria include yam output, rent on land, and wage rate, capital input and fertilizer.

Output influences the cost of yam in Nigerian (Table 7.16). It had a positive and significant relationship with cost. It was significant at 5% in Nigeria with a coefficient of 2.37. It shows that production of more yams would raise the cost of yam. In fact, there will be more than proportionate increase in the cost of yam with production of more yams. The coefficient of output in Ondo was 0.82 and was significant at 10%. This shows that a unit increase in output raises the cost of yam by 0.82 units. Surprisingly, doubling yam output would reduce the cost of yam in Nigeria. Output squared had a lower coefficient in all frontiers. This indicates a reduction in the responsiveness of cost to change in output. The coefficient of output was negative and significant in Ondo. This signifies that there would be a reduction in the cost of yam if Nigerian yam farmers could double yam production, particularly in Ondo State.

From this Table, it is clear that capital inputs influences the cost of yam. As expected, capital input had a positive relationship with cost of production in Enugu. Its coefficient was 4.10. This implies that increase in the use of capital input leads to more than proportionate increase in the cost of Enugu. A unit increase in capital input would lead to over 4 units rise in cost. Reduction in the cost of capital input would reduce cost of yam in Enugu State. Unexpectedly, capital input had a negative and significant effect on cost in Benue State. This signifies that high cost of capital input reduces the cost of yam in Benue State. However, capital input squared had a positive relationship with cost of yam in Benue. Doubling capital input in Benue would lead to more than proportionate increase the cost of yam.

The Table also shows that, rent on land affects the cost of yam in Nigeria. It had a negative effect on cost in Nigeria and was significant at 1%. This implies that increased land rent decreases the cost of yam in Nigeria. This contradicts a priori expectations that farmer would incur more cost when they rent more land. Farmers have scale advantage when they rent large farms. Contrary to the Nigerian frontier, rent on land had a positive

Table 7.16: Maximum likelihood estimate of Translog stochastic frontier cost function for yam in Nigeria

Variables	Parameters	Nigeria	Benue	Enugu	Ondo
Intercept	α_0	4.47	15.95*	-12.15***	1.57
		(4.42)	(12.40)	(4.68)	(3.11)
Output	α_1	2.37**	4.39	-0.35	0.82*
		(1.11)	(3.73)	(2.44)	(0.62)
Capital input	α_2	-0.15	-7.14**	4.10*	0.091
		(1.33)	(3.99)	(2.67)	(1.55)
Rent on land	α_3	-2.11***	-0.12	-1.53	0.55***
		(0.85)	(1.78)	(1.92)	(0.082)
Planting material	α_4	0.065	2.66	-1.28	0.55
		(1.61)	(3.94)	(4.25)	(2.051)
Wage rate	α_5	2.56**	-0.19	8.0061***	0.63
		(1.36)	(2.93)	(2.98)	(0.58)
Fertilizer	α_6	0.00093	-1.40***	0.15	0.046
		(0.079)	(0.39)	(0.31)	(0.11)
Output^2	α_7	0.10	1.004	-0.071	-0.40*
		(0.20)	(0.80)	(0.42)	(0.28)
Capital input^2	α_8	-0.022	2.05**	-1.18	-0.22
		(0.31)	(0.97)	(0.97)	(0.30)
Rent on land^2	α_9	0.031	0.076	0.085	-0.084
		(0.15)	(0.28)	(0.35)	(0.28)
planting material^2	α_{10}	0.051	0.49	2.78*	0.11
		(0.35)	(1.13)	(2.17)	(0.31)
Wage rate^2	α_{11}	-0.60**	-0.30	-1.40**	0.34
		(0.34)	(0.52)	(0.83)	(0.37)
Price of Fertilizer^2	α_{12}	-0.015	-0.026	-0.037	0.0028
		(0.021)	(0.052)	(0.039)	(0.037)
Output x Capital input	α_{13}	-0.39**	-1.52**	-0.35	-0.0064
		(0.21)	(0.76)	(0.42)	(0.20)
Output x Rent on land	α_{14}	-0.0066	0.11	-0.13	0.075
		(0.14)	(0.40)	(0.34)	(0.23)
Output x Planting material	α_{15}	0.046	1.13*	0.81*	-0.13
		(0.23)	(0.78)	(0.50)	(0.25)
Output x Wage rate	α_{16}	-0.19	-0.38	0.29	-0.094
		(0.17)	(0.51)	(0.35)	(0.29)
Output x Price of fertilizer	α_{17}	0.010	-0.058	0.037*	0.021
		(0.010)	(0.071)	(0.027)	(0.017)
Capital input x rent on land	α_{18}	0.44***	0.18	0.74**	0.16
		(0.19)	(0.33)	(0.45)	(0.22)
Capital input x Planting material	α_{19}	-0.28	-1.20*	-0.17	-0.11
		(0.26)	(0.79)	(0.80)	(0.27)
Capital input x wage rate	α_{20}	-0.27	0.65	-0.73**	0.11
		(0.22)	(0.75)	(0.44)	(0.33)
Capital input x Price of fertilizer	α_{21}	0.0050	0.20***	-0.081*	0.0088
		(0.013)	(0.076)	(0.050)	(0.015)
Rent on land x planting material	α_{22}	0.22	0.066	-0.49	0.31
		(0.20)	(0.41)	(0.49)	(0.25)
Rent on land x wage rate	α_{23}	0.16	-0.25	-0.042	-0.27
		(0.13)	(0.27)	(0.31)	(0.28)
Rent on land x Fertilizer	α_{24}	-0.021**	0.00064	-0.020	-0.017
		(0.010)	(0.043)	(0.025)	(0.015)
Planting material x Wage rate	α_{25}	0.046	0.072	-0.16	-0.44
		(0.31)	(0.65)	(0.59)	(0.51)
Planting material x Price of fertilizer	α_{26}	-0.0029	0.0047	0.084*	-0.018
		(0.016)	(0.061)	(0.058)	(0.021)
Wage rate x Fertilizer	α_{27}	0.013	0.24**	0.0047	0.0072
		(0.014)	(0.11)	(0.044)	(0.024)
sigma-squared	σ^2	0.080***	0.038***	0.050	0.026***
		(0.0090)	(0.012)	(0.088)	(0.011)
gamma	γ	0.86***	0.61***	0.16	0.72***
		(0.042)	(0.26)	(2.43)	(0.28)
log likelihood function		95.95***	56.09***	15.79***	86.39***
LR test of the one-sided error		24.58***	0.80	0.00053	1.41*

Source: frontier 4.1 Result, 2015

***, ** and *are significant at 1, 5 and 10% respectively.

Standard error are given in parenthesis corrected to two significant digits influence on cost in Ondo State. A high rent on land increases the cost of yam in Ondo State.

The result demonstrates that wage rate is a significant factor influencing the cost of yam in Nigeria. It had a positive coefficient, an indication that high wage rate increases the cost of yam in Nigeria. Yam farmers would incur more cost if they increased the cost wages in Nigeria, particularly in Enugu. Contrary to expectation, doubling wage would lead to a reduction in the cost of yam in Nigeria. It had a negative effect on cost of yam and was significant at 5%. This shows that high wage rate decreases the cost of yam. Yam farmers would incur less cost if they doubled wage.

This investigation indicates that price of fertilizer had a positive relationship with cost of yam in all the frontiers except in Benue State. Its coefficient was significant only in Benue State. It had a negative coefficient in Benue and was significant at 1%. This shows that increase in the price of fertilizer decreases the cost of yam in Benue.

The result also indicates that price of planting material affect the cost of yam. Planting material squared had a positive coefficient in Enugu and was significant at 10%. Doubling the cost of planting material increased the cost of yam in Enugu.

The diagnostic statistics were significant except the variance ratio-gamma (γ) and sigma squared for Enugu State. Gamma (γ) shows the variation in output that is due to inefficiency. The variance ratio for Nigeria, Benue, Enugu and Ondo were 0.86, 0.61, 0.16 and 0.72 respectively. A variance ratio of 0.86 obtained in Nigeria indicates that 86% of variation in cost of yam in Nigeria is due to inefficiency. There is more variation in cost of yam due to inefficiency in Ondo than in other States.

7.8.3 Hypothesis testing and selection of cost model for yam in Nigeria

The hypotheses that yam output and input prices affect the cost of yam were tested with t-tests. Table 6.17 demonstrates the selection of lead model. T-values were generated from the Frontier 4.1 result. The ratio of the two likelihoods (Cobb-Douglass and Translog) obtained from the frontier 4.1 were compared using LR test (section 5.5) to determine the ideal model. The null hypothesis at least one of the parameters is equal to zero ($H_0 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10 \ldots\ldots} = \beta_{27} = 0$) is rejected and the alternate hypothesis

(H_1, at least one of the $\beta_{ij} \neq 0$) accepted if the LR is greater than the critical value obtained from the chi-squared Table (Greene, 2012). This indicates that Translog is the lead model. The degree of freedom is the number of restrictions (in this case 15). The Cobb-Douglas model is the ideal model for the estimation of cost of yam in Nigeria.

Table 7.17: **Selection of lead cost model**

Test	Frontier	Hypothesis	LR Test	Degree of freedom	Critical value (5%)	Decision	Choice/ implication
Cobb Douglas satisfies the restriction (cost)	Nigeria	H_0:b_{ij}=0	29.08	21	32.08	Accept H_0	Cobb-Douglas
	Benue	H_0:b_{ij}=0	29.20	21	32.08	Accept H_0	Cobb-Douglas
	Enugu	H_0:b_{ij}=0	18.58	21	32.08	Accept H_0	Cobb-Douglas
	Ondo	H_0:b_{ij}=0	18.10	21	32.08	Accept H_0	Cobb-Douglas

Source: Field Survey, 2013

7.9 Economic efficiency in yam production in Nigeria

This section evaluates the EE of yam farmers in Nigeria. It also determines the relationships between the socioeconomic status of yam farmers, farmer decisions and access to facilities and EE.

7.9.1 Economic efficiency estimates for yam farmers in Nigeria

The economic efficiency estimates were obtained from Frontier 4.1c analytical software. The Cobb-Douglas cost function was chosen as the lead model for all the frontiers (see hypothesis testing, section 7.8.3). Therefore, the EE of yam farmers in Nigeria was estimated using the Cobb-Douglas cost function. 7.18 displays the distribution of EE of yam farmers in Nigeria. The result reveals that yam farmers in the study areas have high economic efficiency estimate. However, the farmers are not fully economically efficient in yam production. The majority of the farmers had EE above 0.80. An average Nigerian yam farmer is 82% economically efficient (has EE estimate of 0.82). Most of the farmers (43.6%) had efficiency between 0.81-0.90. The maximum EE in Nigeria was 0.97 while the lowest was 0.45. The least economically efficient farmer in Nigeria must have a cost saving of 54% (1-(0.45/ 0.97) 100) to attain the level of the most economically efficient farmer.

Table 7.18: Distribution of economic efficiency of yam farmers in Nigeria

Economic efficiency	Nigeria	Benue	Enugu	Ondo
≤0. 50 (%)	0.8	0.0	4.2	0.0
0.51-0.60 (%)	5.3	0.0	8.3	0.0
0.61-0.70 (%)	9.2	3.3	20.8	1.7
0.71 – 0.80 (%)	21.4	14.2	16.7	10.0
0.81- 9.0 (%)	43.6	50.8	35.0	40.0
≥0.91 (%)	19.7	31.7	15.0	48.3
Mean EE	0.82	0.86	0.77	0.89
Maximum EE	0.97	0.96	0.96	0.97
Minimum EE	0.45	0.61	0.42	0.62
Standard deviation	0.11	0.07	0.13	0.06

Source: Frontier 4.1 Result, 2015

An average farmer must have a cost saving of 16% (1-(0.82/0.97) 100) to attain the level of most economically efficient farmer. Ondo had the highest mean EE (0.89) while Enugu had the lowest. More farmers in Ondo had EE of above 80%. Enugu had the lowest percentage of farmers with EE above 80%. There was high variation in EE among farmers in Nigeria. Ondo State had the highest maximum EE. Similar maximum economic efficiency estimates were obtained in Benue and Enugu. Ondo also had the highest minimum EE while Enugu had the lowest. There was more variation in EE in Enugu than in other States.

7.9.2 Test of hypothesis that Nigerian yam farmers are fully economically efficient

LR test was also conducted to test the hypotheses that yam farmers are economically efficient. The result of the test of hypothesis on full economic efficiency is presented on Table 7.19. The null hypothesis (H_0) that the farmers are efficient is rejected if the LR

Table 7.19: Test of hypothesis on full economic efficiency

Test	Regions	Hypothesis	LR Test	Degree of freedom	Critical value (5%)	Decision	Implication
There is economic efficiency	Nigeria	$H_0 : \gamma = 0$	27.53	1	2.71	Reject H_0	Not fully efficient
	Benue	$H_0 : \gamma = 0$	2.36	1	2.71	Accept H_0	Fully efficient
	Enugu	$H_0 : \gamma = 0$	2.43	1	2.71	Accept H_0	Fully efficient
	Ondo	$H_0 : \gamma = 0$	3.69	1	2.71	Reject H_0	Not fully efficient

Source: Field Survey, 2013

The critical value (X^2) was obtained from (Kodde and Palm, 1986) test is greater than the critical value. The Table indicates that yam farmers in Nigeria were not fully economically efficient. Nevertheless, farmers in Benue and Enugu States were economically efficient in yam production.

7.9.3 Socioeconomic determinants of economic efficiency of yam farmers in Nigeria

The socioeconomic factors influencing the inefficiency of yam farmers were obtained using stochastic frontier 4.1c. The economic inefficiency parameters were estimated with the economic efficiency in a single cost equation (i.e. the single-stage method). Table 7.20 displays the factors influencing the EE of yam farmers in Nigeria. A positive sign implies that the variable decreases efficiency. From the Table, the EE of Nigerian yam farmers was influenced by their socioeconomic status such as gender, age, household size, membership of organizations, health status, land ownership, and farm size. Other socioeconomic factors influencing EE include: education, extension visit, and number of income sources.

The result shows that gender influences the EE of yam farmers in Benue and Ondo. It had positive coefficients in both frontiers. This shows that EE decreased with more male involvement in yam production in the States. Female yam farmers were more economically efficient than male counterparts. They are better managers and more prudent than men. Increase in female involvement in yam production would increase the EE of yam famers in Nigeria.

The Table shows that the age influences the EE of yam farmer in Nigeria. It had a negative relationship with economically inefficiency in Benue and was significant at 10%. This implies that older yam farmers are more economically efficient. Age correlates with experience. Farmers gain more experience as they continue in yam production. Also, older yam farmers are wiser in resource management. However, the coefficient of age was positive in Ondo; indicating that it reduces EE in the Sate. This shows that younger farmers were more economically efficient in Ondo. Young farmers are innovators; they adopt technologies easily to improve their performance.

Table 7.20: Socioeconomic determinants of economic inefficiency of yam farmers in Nigeria

Variables	Parameters	Nigeria	Benue	Enugu	Ondo
Intercept	β_0	-0.302	0.14	-0.15	0.17
		(0.56)	(0.32)	(0.65)	(0.22)
Gender (male=1 female=0)	β_1	0.051	0.22**	-0.11	0.013*
		(0.085)	(0.12)	(0.13)	(0.0082)
Age in years	β_2	0.0027	-0.0043*	0.0023	0.14*
		(0.0031)	(0.0297)	(0.0044)	(0.094)
Household size	β_3	0.0061	0.0067	-0.0012	0.0044*
		(0.0074)	(0.0053)	(0.014)	(0.0033)
Primary occupation	β_4	-0.11	-0.024	-0.15	0.00086
		(0.14)	(0.13)	(0.25)	(0.015)
Membership of organizations	β_5	-0.13*	-0.15**	-0.13	-0.12
		(0.097)	(0.073)	(0.12)	(0.11)
Marital Status	β_6	0.086	0.054	0.15	0.056
		(0.082)	(0.058)	(0.13)	(0.066)
Health issues	β_7	0.066	0.11*	0.103	-0.056
		(0.075)	(0.069)	(0.11)	(0.058)
Land ownership	B_8	-0.12**	-0.094***	0.082*	-0.058
		(0.055)	(0.028)	(0.057)	(0.087)
Farm size	β_9	-0.0075	-0.0011	-0.000396	-0.12**
		(0.0065)	(0.0067)	(0.0068)	(0.055)
Education in Years	β_{10}	-0.061	-0.14***	-0.022	-0.0081**
		(0.053)	(0.05)	(0.11)	(0.0042)
Extension visit	β_{11}	-0.0073	0.011*	-0.013	-0.067**
		(0.0083)	(0.0084)	(0.011)	(0.0396)
Credit use	β_{12}	0.039	0.011	0.094	0.0065
		(0.063)	(0.067)	(0.103)	(0.0071)
Number of income sources	β_{13}	0.084	0.15**	-0.017	-0.0299
		(0.082)	(0.076)	(0.11)	(0.059)

Source: Frontier 4.1 Result, 2015
***, ** and *are significant at 1, 5 and 10% respectively.
Standard error are given in parenthesis

The result detects that household size reduces the performance of farmers. Ondo is the only State with significant effect of household size on EE. The coefficient of household size was a positive; signifying that large households are less economically efficient.

Membership of organization affects the EE of yam farmers in Nigeria (Table 7.20). It had a negative and significant relationship the inefficiency of yam farmers in Nigeria and Benue State frontiers. Membership of agricultural organizations increases farmers EE. Members of agricultural organizations were more economically efficient in Nigeria, particularly in Benue State. This supports the report of Ibitoye (2012) that members of agricultural cooperative society in Kogi State, Nigeria benefited economically.

The investigation reveals that health status of farmers affects their performance. It had a positive relationship with inefficiency in Benue State; suggesting that farmers with health issues were less technically efficient. Improvement in the health conditions of farmers will enhance their performance. Therefore, increased investment in health facilities in the rural areas would enhance farmers' performance in Nigeria.

From the Table, it is clear that land ownership and the area of land own determine the performance of yam farmers in Nigeria. Land ownership had a negative and significant impact on farmer's economic inefficiency in Nigeria and Benue frontiers. This shows that land owners were more economically efficient than landless owners in Nigeria, particularly in Benue State. However, land ownership decreases the EE of yam farmers in Ondo State. Its coefficient was positive and significant at 10% in the State; suggesting that owners of land in Ondo were less economically efficient. As expected, farm size improves the EE of yam farmers in Nigeria; it had a negative relationship with inefficiency. Its coefficient was significant only in Ondo State. Owners of large farms were more economically efficient. Large farm owners will employ economics of scale to be more economically efficient. This is in line with the findings of (Onyenweaku and Nwaru, 2005).

The result shows that education and extension contact influence the EE of yam farmers in Nigeria. Education had a negative effect on economic inefficiency. It was significant in Ondo and Benue States. Education increases the EE the of yam farmers in the States. This supports the report of (Amaefula et al., 2010). Extension visit had a negative coefficient and was significant at 5% probability level in Ondo. This demonstrates that frequent extension contact increases farmers EE in Ondo State. This is in line with a priori expectation that extension is an important tool for technology and innovation transfer. It also confirms the findings of Ezeh et al. (2010) who noted a positive impact of extension contact on efficency). In Ondo, extension has positive impact on the performance of farmers because the State government supports Agricultural Development Project (ADP) in the State. Adequate of extension services is crucial to enhance the performance of yam farmers in Nigeria. Conversely, Extension had a positive impact on EE in Benue State; it decreases the EE of yam farmers in the State.

Lastly, this analysis demonstrates that number of income sources is a significant factor influencing the EE of yam farmers. Its coefficient was positive and significant at 5% in Benue. This indicates that more income source decreases farmers EE. This is in affirms(Backman et al., 2011) who observed a positive effect of off-farm income on inefficiency. Farmers with more income sources are often part-time farmers. Full time yam farming should be encouraged in Nigeria.

7.9.4 Impact of farmer decision on economic efficiency in Nigeria

The impact of the decisions of yam farmers on EE was determined using the stochastic frontier 4.1c software. The parameter of the inefficiency was using the single-stage method. Table 7.21 displays the decision variables influencing EE of yam farmers in Nigeria. The analysis supports the idea that the decisions of yam farms affect their EE. The decision variables significantly influencing the EE of yam farmers include sources of agricultural information and planting materials, time of planting and harvesting, quantity of fertilizer used, use of YMT, number of times of weeding, and staking of yam.

Farmer's decision on agricultural information and their sources influence the performance of yam farmers in Nigeria. This is in line with the findings of (Rahman and Hasan, 2011). The source of agricultural information has a significant influence on the EE of yam farmers in Nigeria. Fellow farmer is the only significant source of agricultural information in Nigeria. Enugu was the only State with significant impact of information from fellow farmers on EE. It coefficient was negative; implying that it increases the EE of yam farmers in the State**.**

The Table shows that source of planting material influenced the performance of yam farmers in the study area. Obtaining planting material from own farm affected yam farmer. Benue was the only State with a significant effect of planting materials from own farm. It had a negative and significant relationship with EE. The use of planting material from own farm in Benue State decreased yam farmer's EE. Farmers who obtained planting materials from their farms were less economically efficient. Nigerian farmers obtain planting materials mainly from own farm. Okorley and Addai (2010) also reported that Ghanaian yam farmers rely on planting materials from their own farms. These materials are low yielding and diseases infested (Okorley and Addai, 2010). Farmers lack the capacity to produce clean planting material. The use of such planting materials will lead to the production of unattractive and poor quality yams.

Table 7.21: **Decision variables influencing economic efficiency of yam in Nigeria**

Variables	Parameters	Nigeria	Benue	Enugu	Ondo
Intercept	θ_0	0.26 (2.26)	0.38 (0.41)	-0.16 (0.28)	-0.25** (0.15)
Agricultural information fellow farmers	θ_1	-0.021 (0.027)	0.048 (0.041)	-0.100* (0.075)	-0.049 (0.042)
Agricultural information from EAs	θ_2	0.014 (0.023)	-0.036 (0.039)	-0.054 (0.085)	-0.022 (0.0501)
Planting material from own farm	θ_3	0.022 (0.042)	0.112** (0.060)	0.052 (0.166)	-0.0402 (0.066)
Planting material from market	θ_4	-0.017 (0.024)	-0.012 (0.041)	0.040 (0.073)	0.012 (0.052)
Planting material from fellow farmers	θ_5	0.033* (0.021)	0.022 (0.036)	0.073 (0.058)	0.074** (0.043)
Planting material from Extension Agents	θ_6	-0.16*** (0.037)	0.089 (0.081)	-0.17*** (0.072)	0.108 (0.0903)
Time of planting	θ_7	0.0029 (0.0037)	0.0025 (0.012)	-0.016 (0.013)	-0.011 (0.0084)
Time of harvesting	θ_8	0.00054 (0.0031)	-0.00072 (0.011)	-0.0011 (0.0049)	-0.033*** (0.013)
Quantity of fertilizer used	θ_9	0.00035*** (0.000092)	0.00042*** (0.00015)	0.00053*** (0.00016)	0.000036 (0.00024)
Use of ICTs	θ_{10}	0.064* (0.043)	0.019 (0.061)	0.084 (0.094)	0.22 (0.18)
Use of YMT	θ_{11}	-0.0078 (0.0249)	-0.057* (0.0402)	0.104** (0.057)	-0.103 (0.11)
Staking of yam	θ_{12}	0.0000101** (0.0000058)	0.000018 (0.000041)	-0.0000073 (0.000021)	0.000015** (0.0000069)
Number of times of weeding	θ_{13}	0.072*** (0.024)	0.0048 (0.041)	0.103** (0.051)	0.13*** (0.023)

Source: Frontier 4.1 Result, 2015
***, ** and *are significant at 1, 5 and 10% respectively.
Standard error are given in parenthesis

Planting material from fellow farmer influences the EE of yam farmers in the Benue and Ondo State. Obtaining planting material from fellow farmers decreased yam farmer's economic efficiency in Nigeria. Therefore, fellow farmer is an unreliable source of planting material in the study area.

This analysis also shows that planting material from extension agents affects yam farmer's performance in Nigeria. The use of planting material from extension agents increased the EE of yam farmers in Nigeria, particularly in Enugu State. It was significant at 1% in Nigeria and Enugu State frontiers with a negative sign. This signifies that acquiring planting materials from EAs increases EE of yam farmers. Farmers who obtained planting materials from EAs were economically efficient. Government policy on input distribution by ADP will boost yam production in Nigeria.

From the Table, the timing of different farm operations influences the performance of farmers. Time of harvesting is a significant determinant of the EE of yam farmers in Nigeria. Surprisingly, time of harvesting had a negative influence on the EE of yam farmers. Enugu was the only frontier with a significant influence of time of harvesting. Its coefficient was significant at 1%. This signifies that late harvesting increases farmers' EE in the State. Farmers who harvested yam late in Enugu were more economically efficient than those who harvested early. They allow their yam to reach full maturity before harvesting them. They also sell yams in festive period when the demand and price of yam are high. Although farmers incur more production cost when the yams are left on the field for a long time, the benefit outweighs the cost. However, this contradicts Planfarm (undated) who observed that early grain harvesting improves yield and grain price with little or no effect on cost.

The quantity of input used determines the performance of Nigerian farmers. From the Table, it is obvious that quantity of fertilizer had positive effect on EE of yam farmers in Nigeria. It was significant in all the frontiers effect in Ondo, implying that the use of fertilizer decreased farmer's EE. Nigerian yam farmers who used fertilizer for yam production were less economically efficient. Farmers who use fertilizer for yam production incur more cost. Therefore, subsidy on fertilizer will enhance the livelihood of farmers.

This investigation also proves that the number of stakes used for yam production affects the EE farmers in Nigeria. It had positive and significant impact on EE in Nigeria, especially in Ondo. This shows that EE decreased with the use of more stakes for yam production. Farmers who used more staking materials for yam production were less economically efficient in Nigeria, particularly in Ondo State.

The Table shows that number of times of weeding had a very significant effect on EE in Nigeria. Its coefficient was positive in all frontiers, except in Benue State. This suggests that frequent weeding of yam farms decreases farmers EE. Farmers who weeded their yam farms often were less economically efficient. Farmers who weeded their yam farms often were less economically efficient in Nigeria. They incur more cost when they weed their yam farms frequently. O'Sullivan (2010) noticed that yam usually require four times of weeding in the season. This represents a significant proportion of the production cost.

Staking of yam decreases the economic viability of yam production. The use of stakes for yam production had a positive impact on the economic inefficiency of yam farmers in Nigeria especially in Ondo. Farmers who used more staking material for yam production were less economically efficient. Staking materials are scarce and expensive (O'Sullivan, 2010); this increases the cost of yam production.

Lastly, the analysis establishes that as YMT determines the EE of yam farmers in Nigeria. The Table also demonstrates that the use of YMT had a negative impact on economic inefficiency in Enugu. This shows that EE of Nigerian yam farmers increases with the use of YMT in the State. Farmers who practiced YMT were economically efficient in Enugu State. Nigerian yam farmers should be encouraged to adopt YMT for performance improvement. This agrees with the studies of Rahman and Hasan (2011)that modern technology has positive relationship with efficiency. Surprisingly, its coefficient was positive in Benue State; implies suggests that farmers who practiced YMT were less economically efficient.

7.9.5 Impact of access to facilities and inputs on economic efficiency of yam farmers in Nigeria

This investigation reveals that farmer access to inputs and facilities determines the EE of yam farmers in Nigeria. The factors affecting the EE of yam farmers were determined using the frontier 4.1c. The inefficiency parameters were estimated using the single-stage method. Table 7.22 presents the facilities influencing EE of yam farmers in Nigeria.

This investigation shows that access to facilities such as credit, irrigation, health facilities, and good rood influences the performance of yam farmers in Nigeria. Access to financial institution had a positive impact on economic inefficiency in Nigeria and Enugu frontiers. Its coefficient was significant at 10% and 5% in Nigeria and Enugu frontier respectively. This implies that access to financial institution increases farmers' economical inefficiency in Nigeria, particularly in Enugu. Increased farmer access to financial institutions hinders the performance of yam farmers in Nigeria, especially in Enugu. This supports the findings of Backman et al. (2011) that access to microfinance has positive relationship with inefficiency. This implies that farmers who had access to microfinance were more inefficient. The reason for this could be that financial institutions are located in the urban areas. Farmers spend time and money to access the banks. Another reason for this could be those bank interest rates are high. Farmers who have access to bank spend pay high bank charges. Therefore, establishment of financial institutions in the rural area and low interest rate on loan will enhance the performance of rural farmers. Access to irrigation facility significantly affects the EE of yam farmers in Nigeria. It had a negative effect on EE and was significant at 1% and 2% in Nigeria and Enugu frontier respectively. This indicates that the use of irrigation facilities increases the EE of yam farmers in Nigeria. Farmers who had access to irrigation facilities were economically efficient. Access to good road is also a significant factor influencing the EE of yam farmers Nigeria. It had a negative impact on EE in all the frontiers but was only significant in Benue State. This implies that farmers who had access to good road were economically efficient. Good rural roads facilitate rural activities. Therefore, construction of rural road will enhance the performance of farmers.

Table 7.22: Facility influencing economic efficiency of yam farmers in Nigeria

Variables	Parameters	Nigeria	Benue	Enugu	Ondo
Constant	d_0	-0.199**	-0.180	-0.25	0.22
		(0.124)	(0.257)	(0.73)	(0.25)
Access to research and extension	d_1	0.026	0.0013	0.0051	0.0020
		(0.066)	(0.0039)	(0.0054)	(0.0025)
Access to financial institutions	d_2	0.086*	0.0088	0.33**	-0.054
		(0.063)	(0.0999)	(0.19)	(0.081)
Access to irrigation facility	d_3	-0.253***	0.015	-0.51**	-0.059
		(0.067)	(0.1003)	(0.28)	(0.14)
Access to hospital	d_4	0.00035	0.044	0.072	-0.042
		(0.00142)	(0.077)	(0.17)	(0.091)
Access to good road	d_5	-0.0078	-0.051*	-0.0082	-0.00015
		(0.047)	(0.037)	(0.17)	(0.070)
Difficulty acquiring farm input	d_6	-0.0999**	0.0398	-0.17**	0.082
		(0.044)	(0.054)	(0.094)	(0.054)
Access to machinery	d_7	0.051	-0.0010	-0.0040	0.21
		(0.049)	(0.062)	(0.14)	(0.080)
Access to fertilizer	d_8	0.096**	0.120	0.39*	-0.0060
		(0.057)	(0.199)	(0.24)	(0.067)
Adequacy of seed yam	d_9	-0.027	-0.087**	-0.069	0.19
		(0.043)	(0.043)	(0.11)	(0.078)
Adequacy of labour	d_{10}	-0.071**	0.024	-0.092	-0.13**
		(0.041)	(0.047)	(0.094)	(0.062)
Farm distance from home	D_{11}	0.011***	0.0097	0.014**	0.012
		(0.0036)	(0.0097)	(0.0084)	(0.0058)
Means to farm	d_{12}	0.0074	-0.033*	0.084**	-0.045
		(0.017)	(0.023)	(0.044)	(0.033)
Farm fragmentation	d_{13}	0.024	0.031*	0.023	-0.047
		(0.0196)	(0.022)	(0.041)	(0.048)
Access to market	d_{14}	0.00012	-0.00072	-0.028*	0.0034
		(0.0036)	(0.0045)	(0.017)	(0.0030)
Availability of school	d_{15}	0.016	0.052	-0.25	-0.012
		(0.055)	(0.121)	(0.73)	(0.044)
Use handset for farm business	d_{16}	0.127***	0.081*	0.22*	-0.30
		(0.054)	(0.055)	(0.14)	(0.23)

Source: Frontier 4.1 result, 2015
***, ** and *are significant at 1, 5 and 10% respectively.
Standard error are given in parenthesis corrected to two-significant digits

From the Table, it is conspicuous that input availability and accessibility determine farmers' performance in Nigeria. Difficulty acquiring farm input had a negative and significant effect on economic inefficiency in Nigeria and Ondo frontiers. Farmers who had difficulties acquiring inputs were more economically efficient, they incur less production cost. The use of fertilizer influenced yam farmer performance. This is in line with the findings of Rahman and Hasan (2011). Access to Fertilizer had a positive relationship with EE in Nigeria and Enugu frontier. Its coefficients were 5% and 10% for Nigeria and Enugu respectively. This indicates farm Nigerian yam farmers, particularly those in Enugu, who had fertilizer for yam production, were less economically efficient. In Nigeria, fertilizers are expensive relative to farmers' income. Farmers who use fertilizer for yam production acquire more production cost; hence are less economically efficient. Subsidy on fertilizer will reduce the cost of yam production and improve the wellbeing of rural households. The result also shows that adequacy of seed yam affects the EE of yam producers in Nigeria. Benue was the only State with a significant effect of seed yam on the EE of yam farmers. It had a negative relationship with economic inefficiency in the State; implying that the use of adequate planting material increases EE in Benue. Farmers who used adequate planting material in Benue State were more economically efficient. Therefore, yam farmers in Nigeria should use adequate quantity of planting material for yam production to enhance their performance. Therefore, adoption of seed yam multiplication technique such as YMT would enable the production of yam at reduced cost. Adequacy of labour also determined the EE of yam farmers in Nigeria. It had a negative and significant influence on EE in Nigeria and Ondo frontiers; implying that labour increases the EE of yam farmers. Yam production in Nigeria is labour intensive and cost of labour is high in Nigeria. The use of inexpensive machines will improve the performance of yam farmers in the study area.

This analysis reveals that proximity to farm and means to farm influence the performance of yam farmers in Nigeria. This analysis indicates that farm distance from home affects the EE of yam farmers in Nigeria. It had a positive and a significant impact of economic inefficiency and was significant at 1% and 5% in Nigeria and Enugu frontiers respectively. This implies that the further the farms from home, the less economically efficient the farmers. Farmers who had distant farms were less economically efficient. Means to farm determines the performance of farmers. It had a negative impact on inefficiency in Benue; signifying that farmers who went to farm with vehicles were efficient. Conversely, the use of vehicle to farm deters the performance of yam farmers in Enugu. Benue State has good road network farmers spend less on transportation. Enugu State has poor road network, cost of transportation is high in the State. Farmers who transport to their farms incur more. Therefore, construction of rural roads will improve the wellbeing of rural farmers.

The Table shows that land fragmentation is a significant determinant of the performance of yam farmers in Nigeria. It had a positive and significant effect on economic inefficiency in Enugu State. Fragmentation of land decreases the EE of yam farmers in the State. It is less economically efficient to have fragmented land; farmers who have fragmented farms spend time and resources visiting farms, thereby incurring more production cost.

The Table also indicates that access to market determines the performance of yam farmers. It had a negative impact on economic inefficiency. Farmers who had market access were economically efficient. There could access inputs and sell their products easily.

Finally, the result reveals that the use of ICTs for agricultural business enhances farmers' performance. Surprisingly, the use of handset for farm business had a positive impact on technical inefficiency. It was significant in all the frontiers except in Ondo. Farmers who used handsets for farm business were less economically efficient in Nigeria. This contradicts the findings of (Nair et al.,2012) that the use of information communication technologies enhances farmers' performance. Farmers incur more transaction cost when they use handsets for farm business. Although handset is expected to expedite farm business and make transactions easy; Nigerian yam farmers have poor networks.

7.10 Conclusion

In summary, this analysis establishes that lack of fund, availability and high cost of planting material are the major constraints to yam production. Nigerian yam farmers have small farms and use insufficient quantity of planting material, fertilizer and labour. These factors had positive effect on yam output and technical efficiency of yam farmers in Nigeria. All the cost variables are increasing factors of cost. The cost of yam will increase as the prices of these variables rise. Therefore reduction in the prices of these variables would contribute to decreasing the cost of yam in Nigeria.

This research also stipulates that Nigerian yam producers are poor and lack fund to purchase sufficient farm inputs. This research stipulates that the establishment of financial institutions in close proximity to the farmers and low interest rate will increase farmer access to fund to boost production.

The operating environment for yam production differs in Nigeria. Enugu State has a more restrictive environment for yam production in the country. Improvement in the farming conditions of Enugu will boost yam production in the State. Tailoring new technology to suit the environmental conditions and developing an alternative farming system for yam would contribute to improving the performance of yam farmers in Nigeria.

The high technical efficiency estimate reported for yam suggests the need to shift the production frontier forward. This could be achieved by adopting improved technologies and mechanization of Nigerian yam farming.

Chapter Eight

8.0 Yam Production Techniques and Economics of Yam Production in Nigeria

8.1 Introduction

This chapter describes and compares yam production techniques in the predominantly yam-growing States of Nigeria. It provides answers to the questions on economic viability of the cropping systems for yam and the major crops in yam production enterprise.

8.2 Cropping systems for yam in Nigeria

Yam is mainly intercropped in Nigeria. There are numerous cropping systems for yam in Nigeria. Appendix I.1 displays the number of intercrops for yam in Nigeria. It revealed that there were over 100 cropping systems for yam in the country. Ondo State had more number of yam intercrops. There were fewer intercrops for yam in Benue State than in the other States. Appendix I.2 presents the percentage crop combination for yam in Nigeria. It shows that there are mainly two to four crop combinations for yam in Nigeria. However, some yam farmers in the country practice sole cropping. There are more farmers who practice monocropping in Benue than in other State. Most farmers in the State combine only two crops. The majority of farmers in Ondo had four crop combinations. Yam farmers in Enugu State combine mainly five crops.

Surprisingly, yam alone is the dominant cropping system for yam in Nigeria, especially in Benue State (Appendix I.3). Although, I have earlier reported that yam is mostly intercropped in Nigeria. A further investigation of the various cropping systems indicates that sole yam is the conspicuous cropping system for yam in Nigeria. This is due to the infinite crop combinations for yam in the country. Yam is primarily intercropped with cassava in Nigeria. Other major intercrops for yam in Nigeria include Yam/Maize, Cassava/Yam/ Maize, Yam/Cassava/Pepper and Yam/Maize/Pepper (Appendix I.3).

The result of this investigation reveals that yam is usually planted in Nigeria in April (Appendix I.4). The majority of yam farmers in Benue and Enugu States planted yam in April. Nevertheless, in Ondo State, yam is normally planted in November. There is a wide distribution of time of sowing of the major crops in yam enterprise (Appendix I.5). Cassava is planted between February and December. Most farmers in Nigeria planted cassava in May. Maize is normally planted on yam farms from January to December. However, none of the farmers indicated that they planted maize in November. Majority of the farmers planted maize in April. Okro is introduced on yam farm mainly in April. Pepper is usually planted on yam farm between April and May.

This research shows that yam is usually harvested in Nigeria at eight month (Appendix I.6). Most of the farmers in Benue and Enugu States harvested yam at eight month. However, in Ondo State, yam is mainly harvested at seven months. Some Nigerian yam farmers allow their yams on the field for up to a year. Yam is usually harvested in Benue and Enugu State during the festive period. The majority of farmers in Benue and Enugu harvested yam between December and January respectively (Appendix I.7). At this period, it is difficult to harvest yam due to hardness of the soil. Farmers incur more cost of harvest but sell yam at a higher price due to high demand. In Ondo, most farmers harvest yam in July (rainy season).Yam is less strenuous to harvest at this time; the farmers spend less on harvesting but sell at a lower price due to low demand. Cassava and pepper are harvested all year round in Nigeria (Appendix I.8). They are mainly harvested in May. Most Nigerian yam farmers harvest maize in June. Yam farmers harvest okro mainly in August.

8.3 Profitability of selected root and tuber crops

In this investigation, we assume that all commodities produced were sold. The result of this research reveals that yam production in Nigeria is more expensive than other root and tuber crops, huge capital outlay is required (Table 8.1). However, it is profitable. It has a higher GM than other root and tuber crops. This indicates that it is more profitable than other root and tuber crops. Farmers generate more income per hectare yam production than from other root and tuber crops. However, an economic analysis of the crops based on return per Naira shows that cassava is the most economically viable root and tuber crop. It had a return per Naira of 1.93. This implies that cassava is profitable by returning ₦1.93 for every ₦1 invested. Yam has a return.

Table 8.1: **Economic evaluation of selected root and tuber crops**

Items	Yam	Cassava	Sweet potato	Cocoyam
Revenue (₦/ha) (A)	901,399	375,296	319,567	314,465
Planting material for yam	72,631	25,715	15,267	58,806
Fertilizer for yam	16,779	10,921	14,379	7,813
Staking material ₦/ha	53,219	-	-	-
Organic manure for yam	17,423	2,587	1,988	23,203
Pesticide for yam	8,127	1,826	2,833	7,614
Herbicide for yam	9,377	1,562	5,636	8,280
Land preparation	69,717	61,618	61,632	62,958
Planting	16,352	10,258	7,165	10,795
Fertilizer application	3,848	4,505	4,330	5,654
Mulching	4,910	-	-	1,167
Staking	32,727	-	-	-
Application of pesticide and herbicide	7,464	4,443	998	3,915
Weeding	91,146	50,569	49,597	34,043
Harvesting	92,738	20,437	39,614	20,190
Variable cost (B)	496,458	194,442	203,439	244,439
GM=A-B	404,941	180,854	116,128	70,026
Return per Naira	1.82	1.93	1.57	1.29

Source: Field survey, 2013
Note: 1 USD = ₦160

per Naira of 1.82. This shows that it is profitable by returning ₦1.82 for every ₦1 invested. Although cassava has a higher return per naira than yam, since an average Nigerian has small farm, it is advisable for the farmers to invest in yam production for more effective and profitable use of land.

An economic evaluation of the major crops in yam production enterprise demonstrates that yam has a higher GM than the other crops (Table 8.2). Yam farmers generated more money relative to farm size. Comparing the enterprises on return per Naira shows that pepper production is more profitable than the other crops. It had a higher return per Naira (2.10). This signifies a return of ₦2.10 for every ₦1 invested in pepper production.

Table 8.2: Gross margin of major crops in yam production enterprise

Items	Yam (₦)	Cassava (₦)	Pepper (₦)	Maize (₦)	Okro (₦)	Melon (₦)
Revenue (₦/ha) (A)	901,399	375,296	350,116	295,516	196,280	236,638
Planting material for yam	72,631	25,715	8,752	8,987	7,777	9,557
Fertilizer for yam	16,779	10,921	10,128	10,995	14,192	7,342
Staking material(₦/ha)	53,219	-	-	-	-	-
Organic manure for yam	17,423	2,587	9,245	8,313	8,436	5,648
Pesticide for yam	8,127	1,826	7,763	8,769	8,081	4,609
Herbicide for yam	9,377	1,562	7,155	6,029	7,353	5,020
Land preparation	69,717	61,618	64,778	61,732	63,367	59,573
Planting	16,352	10,258	8,341	9,366	8,575	10,403
Fertilizer application	3,848	4,505	7,070	8,681	6,521	6,540
Mulching	4,910	-	-	-	-	-
Staking	32,727	-	-	-	-	-
Chemical application	7,464	4,443	5,276	18,126	4,553	3,915
Weeding	91,146	50,569	26,025	32,828	29,391	28,099
Harvesting	92,738	20,437	11,808	20,273	12,069	21,037
Variable cost (B)	496,458	194,442	166,342	194,098	170,314	161,744
GM=A-B	404,941	180,854	183,774	101,419	25,966	74,895
Return per Naira	1.82	1.93	2.10	1.52	1.15	1.46

Source: Field survey, 2013
Note: 1 US $ = ₦160

8.4 Economic analysis of the major cropping systems for yam in Nigeria

The result of this investigation detects that all the dominant yam cropping systems are profitable (Table 8.3). Yam /Maize intercrop was the most profitable cropping system. It had the highest Net Return and Return per Naira (2.76). It returns ₦2.26 to every ₦1 invested. Yam/cassava /maize intercrop was the least profitable cropping system. It had the lowest profit and return per Naira (1.75). This signifies a return of ₦1.75 for every ₦1 invested in Yam/Cassava /Maize intercrop. This research also reveals that sole yam is more profitable than Yam/Cassava intercrop. It had a Net Return of 2.65. It is profitable by returning ₦2.65 to every ₦1 invested. This research has stipulates that it is less profitable to intercrop yam with cassava. Yam only cropping system was more economically viable than yam intercrops with cassava. Similar to yam, cassava is nutrient-demanding; intercropping cassava with yam will create room for competition for nutrient. In addition, the plant architecture of cassava does not encourage its intercrop with yam. Cassava is usually branched and provides canopy. Intercropping it with yam will reduce yam yield and make its production less profitable. Excluding cassava from yam cropping system will make yam production more profitable.

Table 8.3: **A comparative economic analysis of major yam cropping systems in Nigeria**

Items	Yam	Yam/Cassava	Yam/Maize	Yam /Cassava/Maize
Revenue Yam	1,225,576	841,534	1,170,267	886,871
Revenue from cassava	-	328,214	-	296,450
Revenue from maize	-	-	326,282	186,925
Total revenue (A)	1,225,576	1,169,749	1,496,549	1,370,246
rent	15,416	15,315	15,124	15,026
Depreciated cost of capital	1,484	4,770	3,554	7,226
Price of planting material	60,625	84,065	83,663	100,282
stakes ₦ /ha	86,813	46,963	82,692	412,134
Fertilizer	-	23,241	19,731	16,778
Organic manure	6,000	-	-	-
Herbicide	12,000	1,980	1,846	5,580
pesticide	-	1,563	-	157,985
Land preparation	62,794.79	91,542	69,717	99,684
Planting	15,953	28,700	20,471	39,065
weeding	101,462	133,492	126,300	155,691
Harvesting	99,875	126,917	118,154	146651
TFC	16,900	20,085	18,678	22,252
TVC	445,523	538,464	522,575	762,930
TC (B)	462,423	558,549	541,254	785,182
profit (A-B)	763,153	611,200	955,296	585,064
Return per Naira	2.65	2.09	2.76	1.75

Source: Field survey, 2013
Note: 1 US $ = ₦160

8.5 Conclusion

This research reveals that yam production is profitable but large capital outlays are required. Yam production is more profitable than other comparable crops. All the intercropping systems for yam are profitable. Increased yam production will improve the standard of living of farmers and reduce poverty in the country.

Chapter Nine

9.0 Agricultural Information Dissemination and Improved Technology Adoption in Nigeria

9.1 Introduction

This section investigates yam production techniques in Nigeria. Information dissemination, awareness and use of new technologies are discussed. It determines the impact of adoption of YMT, on yam farmer's performance. It also confirms the determinants of and limitations to adoption of yam technologies in Nigeria and the extra cost and benefit of adoption of YMT.

9.2 Agricultural information dissemination in Nigeria

The source of information determines its authenticity. This investigation supports that Nigerian yam farmers mainly obtain agricultural information from fellow farmers. This confirms Rimi et al (2015) who noted that the major source of agricultural information in Katsina State of Nigeria was fellow farmers. Appendix J.1 displays the sources of agricultural information in Nigeria. The ranking of the sources of agricultural information in Nigeria is presented in Appendix J.2. Fellow farmer is the major source of agricultural information in Nigeria, followed by extension agent then the television. Enugu yam farmers obtained agricultural information from fellow farmers and relatives, and research institutes than those of other States. Benue State yam farmers had more extension contacts while Enugu State had the lowest. More farmers in Ondo than other States obtained agricultural information from the television. Information is usually altered down the communication line (Talloo, 2007). Therefore, yam farmers are likely to obtain low quality information from other farmers. This could have adverse effect on their performance. Improved information and knowledge-base will facilitate the adoption of improved technologies in Nigeria.

The result of the evaluation of the use of ICTs by Nigerian yam farmers shows that a majority of the farmers use ICTs for agricultural business transactions. Appendix J.3 presents the use of ICTs by Nigerian yam farmers. Handset was the mainly used ICT for yam business transaction in Nigeria. However, some farmers did not use ICTs for farm business in Nigeria. Appendix J.4 highlights the reasons why farmers did not use ICTs for farm business in Nigeria. Farmers were unable to use handset for farm business due to lack of networks. Most yam farmers in Nigeria were unfamiliar with the use of other ICTs such as the internet, computer, fax, email, Google and Facebook. Those farmers who indicated that they used these ICTs were young educated farmers (Authors interview with Nigerian yam farmers, 2013).

9.3 Awareness and use of new technologies in Nigeria

This investigation confirms that there is poor dissemination and low adoption of new technologies in Nigeria (Appendices K.1, K.1.1, K.1.2, and K.2). Mgbenka et al. (2016) noted that Nigerian farmers rarely feel the impact of a technology due to its poor dissemination among other factors. Low awareness and poor adoption of agricultural technology is due to ignorance. The dissemination of improved technologies is essential to facilitate its awareness and adoption. The Nigerian research and extension services, which are mainly responsible for the dissemination of agricultural information in Nigeria is underfunded (Mogues et al., 2008; Olomola et al., 2014; World Bank, 2008), which obstructs their activities. Adequate funding of Research and extension will increase technology adoption in Nigeria

There is lack of awareness of improved technologies in Nigeria. Appendix K.1.1 presents the awareness and use of improved yam varieties in Nigeria. Most Nigerian yam farmers are unaware of improved yam varieties. The result also indicates that insignificant proportion of Nigerian farmers have received training on the use of improved technology (Appendix K.2). Few Nigerian yam farmers were trained on new yam varieties. More farmers in Benue were trained on new yam varieties.

There is low adoption of YMT due to lack of awareness of the technology. Nigerian farmers, especially those in Ondo were unaware of YMT (Appendix K.1.2). This supports Waziri (2014) who reported that low adoption of agricultural technology is due to lack of awareness of the technology. Appendix K.1.2 shows awareness, training and the use of YMT in Nigeria. Approximately 26% of yam farmers in Nigeria have tried

YMT. The number of those farmers in Ondo who have tried the technology is discouraging. Generally, most of the farmers who tried YMT have adopted it. Insignificant proportion of those farmers in Nigeria who tried the technology discontinued using it. None of the farmers in Ondo who tried the technology discontinued with it. The adoption of YMT was highest in Enugu and lowest in Ondo. However, an insignificant proportion of the (Less than 10%) were trained on YMT in the State (Appendix K.1.2). Benue State had the highest number of trained farmers while Enugu had the lowest.

9.4 Limitations to the use of improved yam technologies in Nigeria

The result of the analysis also reveals that improved yam verities are scarce in Nigeria. Appendix L.1 presents the limitations to use of improved varieties in Nigeria. Unavailability and high cost of improved varieties hinder its use in Nigeria. Most Nigerian yam farmers lack knowledge on the use of improved varieties.

An investigation into the reasons for non-adoption of YMT reveals that Nigerian yam farmers are ignorant of the technology. Appendix L.2 displays the reasons for non-adoption of YMT in Nigeria. Lack of knowledge is the major limitation to YMT adoption in Nigeria. This assessment supports that Ondo yam farmers are unaware of YMT. Few farmers did not adopt YMT because they thought it was time consuming and complex. Some farmers have insufficient fund to adopt YMT. Generally, approximately 24% of yam farmers have no reason for not practicing YMT. Half of the population of yam farmers in Enugu do not have any reason for not adopting YMT.

9.5 Determinants of adoption of Yam Minisett Technology in Nigeria

Table 9.1 presents determinants of adoption of YMT in Nigeria. A positive relationship means that increases in the variables would facilitate adoption while a negative sign means that the variables impede adoption. The factors influencing the adoption of YMT in Nigeria include gender, age, primary occupation, education time of planting and quantity of fertilizer.

Table 9.1: Determinants of adoption of Yam Minisett Technology in Nigeria

Variables	Parameter	Coefficient	Standard Error	Z value
Intercept	β_0	-0.81	0.56	-1.44
Gender (male=1, female =0)	β_1	0.50	0.26	1.91**
Age (years)	β_2	0 .017	0060	2.80***
Primary occupation(farmers =1, Non farmers=2)	β_3	-0.84	0.34	-2.46***
Education (years)	β_4	0.0073	.016	0.45
Time of planting (months)	β_5	-0.10	.025	-3.96***
Quantity of fertilizer (kg)	β_6	0 .0012	00056	2.16**
Farm size	β_7	-0.047	0.11	-0.43
Labour (Man-days)	β_8	0.000084	.00048	0.18
Extension visit (number of times)	β_9	0.0055	.0093	0.59
LR = 49.16***				
Log likelihood = -172.18				

Source: Result of probit analysis, Stata 13 software
*** and ** are significant at 1 and 5% respectively.

Table 9.1 shows that the adoption of YMT in Nigeria is influenced by gender. The coefficient of gender was positive and significant at 10%. This implies that male yam farmers adopted the technology more that their female counterparts. Male am farmers are more inclined to adopt YMT. Nigeria is a male-dominant country; men preside over most activities including household and farm decisions. In extreme cases, women are prevented from interacting freely, especially with the men. This hinders them from obtaining information to enhance their performance. There should be gender equality in Nigeria.

This project demonstrates that farmer’s age affects the adoption of Yam Minisett Technology. This supports Gbegeh and Akubuilo (2013); Adegbola and Adekambi (2010); Okoedo-Okojie and Onemolease (2009); Agwu et al. (2008) that technology adoption is influenced by age. Age had a positive relationship with Yam Minisett Technology adoption and was significant at 1%. This is consistent with (Nchinda, 2010) who observed a positive relationship between age and adoption of Yam Minisett Technology in Cameroon. However, it contradicts a priori expectation that youths are innovative and could easily adopt innovations. It also differs from (Gbegeh and Akubuilo, 2013) who reported a negative relationship between age and adoption of Yam Minisett Technology in Nigeria. Older farmers have few activities and are more specialized in farming. Hence, were more inclined to adopting Yam Minisett Technology.

Occupation also determines the adoption of YMT in the study area. It had a negative effect on YMT adoption and was significant at 1%; implying that full-time farmers adopt YMT than part-time farmer. Therefore, specialization on yam production will encourage the adoption of YMT in Nigeria.

This project also establishes that time of planting is a significant determinant of adoption of YMT in Nigeria Time of planting had a negative effect on YMT adoption and was significant at 1%. It retards farmer's inclination of adopting the technology. Delayed yam planting decreases the adoption of YMT. Farmers who plant yams late are unlikely to adopt YMT.

This study proves that farmer's disposition to adopt a technology and ideal conditions facilitate technology adoption. For instance, fertilizer is a prerequisite for seed yam production using YMT (Kogi State ADP 2003, 1997). It had a positive impact on YMT adoption and was significant at 5%. The use of fertilizer increases the adoption of YMT. Farmers who use fertilizer for yam production can easily adopt the technology. Therefore, availability of fertilizer will increase farmers' tendency to adopt YMT.

9.6 Profitability of Yam Minisett Technology

This research shows that YMT is a viable seed yam production technique. Table 9.2 displays the GM of YMT production in Nigeria. The Table shows that YMT is profitable by returning ₦309,116 per hectare and ₦2.53 per Naira invested. In Nigeria, yam farmers spend ₦ 54.31 to produce a kg of seed yam using YMT.

Table 9.2: **Gross Margin of seed yam production usingYam Minisett Technology (per hectare)**

Items	Value (₦)
Revenue at ₦89.91/kg (A)	780,559
Seed preparation	17,857
Staking materials	29,157
Planting material	50,514
Fertilizer	40,175
Organic manure	2,673
Pesticide	17,114
herbicide	15,341
land preparation	69,946
Planting	55,641
weeding	51,748
Fertilizer application	31,491
Staking	34,361
Mulching	4,910
Harvesting	50,514
Variable cost (B)	471,443
GM=A-B	309,116
Return per Naira = A/B	2.53
Yield (C)	8,681
Producers price of seed yam (₦ /kg) = B/C	54.31

Source: Field Survey, 2013
Note: 1 USD = ₦160

A partial budget for the adoption of YMT, presented on Table 9.3 supports that yam production using YMT is profitable. From Table 9.3, the extra benefit of adopting YMT is ₦513, 102 per hectare

Table 9.3: A partial budget for the adoption of Yam Minisett Technology (per hectare)

Losses (₦)	Gains (₦)
Extra cost: Production of seed yams using YMT=471,443 **Extra benefit** = 984,545- 471,443 =513,102	**Cost Saved**: Planting material for yam production =211,556 **Extra Revenue**: Leftover seed yam at₦89.91/kg= 569,003 Yield increases=203,986 **Total Gain**(cost saved + extra Revenue): 984,545

Source Field Survey, 2013
Note: 1 USD = ₦160.

Three traditional seed yam production techniques were compared with YMT. The revenue due to yield increases was computed by subtracting the average revenue of the three methods from the revenue obtained from yam production using seed yam from YMT.

9.7 A comparative economic analysis of yam production techniques in Nigeria

A comparative analysis of yam production using the different planting materials for yam production in Nigeria reveals that yam production using YMT is more profitable than the other yam production techniques. Table 9.4 presents analysis of yam production techniques.

Table 9.4: **An analysis of yam production techniques (per hectare)**

Items	YMT	Cut sett	Milk yam	Mini-tuber
Yield of yam	12,356	9,321	9,878	9,194
Revenue (yam production enterprise) @ ₦70.55/kg	871,690	657,582	696,912	648,619
Revenue (YMT) @ ₦89.91/kg	780,559	-	-	-
Total Revenue (A)	1,652,249	657,582	696,912	648,619
Cost of planting materials	-	99,551	100,238	138,812
Fertilizer	16,779	16,779	16,779	16,779
Staking N/ha	53,219	53,219	53,219	53,219
Organic manure for yam	17,423	17,423	17,423	17,423
pesticide for yam	8,127	8,127	8,127	8,127
Herbicide for yam	9,377	9,377	9,377	9,377
Clearing	20,819	20,819	20,819	20,819
Gathering of thrashes	3,278	3,278	3,278	3,278
Stumping	5,377	5,377	5,377	5,377
Ploughing	10,387	10,387	10,387	10,387
Mounds	29,856	29,856	29,856	29,856
Planting	16,352	16,352	16,352	16,352
Fertilizer application	3,848	3,848	3,848	3,848
Mulching	4,910	4,910	4,910	4,910
Staking	32,727	32,727	32,727	32,727
Weeding	91,146	91,146	91,146	91,146
Pesticide Application	7,464	7,464	7,464	7,464
Harvesting	92,738	92,738	92,738	92,738
Variable Cost for yam production enterprise (B)	423,827	523,378	524,065	562,639
Variable Cost for seed yam production (C)	471,443	-	-	-
Total Variable Cost (D) =B+C	895,270	523,378	524,065	562,639
GM =A-D	756,979	134,204	172,847	85,980
Return per Naira	1.845532	1.256419	1.32982	1.152816

Source: Field Survey, 2013

Yam production using seed yam from YMT yielded higher than seed yam from milk yam, cut sett and mini tuber. It had higher GM and return per Naira than other methods. Table 9.5 supports that YMT is more profitable than other planting materials. Farmers gain ₦584, 132-₦670, 999 per hectare by adopting YMT. YMT enables the production of clean planting material (see seed yam production using YMT in chapter 3). It is treated with antimicrobial substances such as apron plus (Kogi State ADP, 2003), aldrin dust or marshal dust or 'minisett dust' (Kogi State ADP, 1997) to control pest and disease attack, hence, yields more than the traditional planting materials. In addition, the other planting materials are usually cut for planting. This exposes the planting materials to diseases and rot, and reduces their yields. Yam farmers generated more revenue from yam production using seed yam from YMT.

Table 9.5: Advantage of Yam Minisett Technology over other planting materials for yam production

Items	Cut sett	Milk yam	Mini-tuber
Additional cost of using YMT(₦)	371,892	371,205	332,631
Additional Revenue(₦)	994,667	955,337	1,003,630
Additional profit using YMT(₦)	622,775	584,132	670,999

Source: Field Survey, 2013

Note: Additional cost and revenue of using YMT instead of the traditional methods in this Table were computed by subtracting the Total Variable Costs (D) and Total revenues respectively of the traditional yam production techniques from yam production using YMT in Table 9.4.

9.8 Impact of improved technology adoption on the performance of yam farmers in Nigeria

The impact of YMT adoption on the performance of yam farmers in Nigeria was determined using PSM. The matching was performed using Stata 13. Three matching algorithms, the nearest neighbour matching, kernel matching and stratification matching, were used to confirm the impact of YMT on performance. The balancing property was satisfied by the matching, there was no significant difference in the mean of the covariates after matching. This implies that the treated and control groups are similar in characteristics). Figure 9.1 presents the graph of the matched farmers. The region of common support is 0.05 - 0.761. The result shows that there was overlap (some of the farmers were off the area of common support).

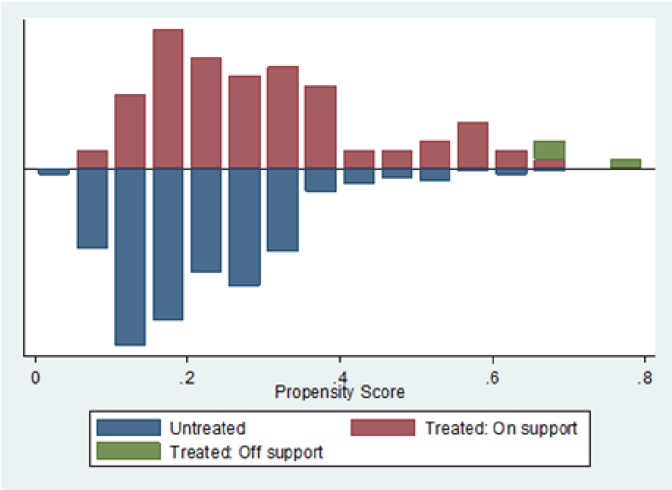


Figure 9.1: The graph of the matched farmers

This investigation reveals that adoption of YMT improves the performance of yam farmers in Nigeria. Table 9.6 shows the difference in mean technical efficiency before propensity score matching. The Table indicates that there was no significant difference in the mean TE estimates of adopters and non-adopters before the PSM. Table 9.7 displays the average treatment effect of YMT on TE of yam farmers. The average treatment effect was positive and significant for all the matching algorithms. Adopters of YMT were more technically efficient than non-adopters. This also justifies the use of PSM to assess the impact of a technology on performance. This also confirms that YMT adoption enhances the performance of yam farmers in Nigeria. Therefore, appropriate YMT dissemination strategy should be employed to scale-up adoption of YMT in Nigeria. Adequate funding of research and extension will accelerate the adoption of improved technology in the country.

Table 9.6: **Difference in mean technical efficiency before propensity score matching**

Technical efficiency	Mean	Bias	Standard error	Sig. (2-tailed)
Non-adopters	0.85	0.00	0.01	
adopters	0.86	0.00	0.01	0.51

Source: Field Survey, 2013

Table 9.7: Average treatment effect of Yam Minisett Technology on technical efficiency

Matching Algorithms	Treated	Control	ATT	Std. Err.	T value
Nearest Neighbor Matching	85	60	0.036	0.015	2.356*
Kernel	85	265	0.021	0.012	1.749*
Stratification	83	267	0.026	0.011	2.360*

Source: Field Survey, 2013

9.9 Conclusion

This research supports the idea that comparing the impact of a technology on performance/wellbeing without considering the counterfactual situation of the technology gives a biased estimate. The adoption of YMT has the potential to improve the performance of yam farmers in Nigeria. YMT is a viable seed yam production technique. Yam production using YMT is more profitable than the traditional methods. Adopters of YMT in Nigeria outperformed non-adopters. Adopting new yam technologies (for instance, YMT) will boost yam production in Nigeria.

Chapter Ten

10.0 Conclusion

10.1 Preview

This chapter presents important conclusions based on the research findings and it is divided into six sections. The first section (section 10.1) highlights the content of the current chapter. Section 10.2 discusses yam production and adoption of new yam technologies in Nigeria. It reports on the performance of yam farmers in the study areas and proffers solutions on how it can be improved. It also examines yam output and cost and makes recommendations to boost yam output and reduce its cost. In addition, environmental and technological issues are addressed and solutions to eliminate the effect of environment-technology gap among farmers are offered. It also discusses YMT and proposes ways of facilitating its adoption. Section 10.3 presents the contributions of this study to the sum of knowledge. Section 10.4 discusses the limitation to the study. Section 10.5 makes suggestions for future research regarding yam production improvement. Finally, section 10.6, summarizes the entire research work.

10.2 Yam production and adoption of new yam technologies in Nigeria

This investigation has employed descriptive, economics and econometrics models to investigate the yam production enterprise. It was undertaken to enhance the performance of yam farmers and adoption of new yam technologies to improve farmer wellbeing. It has analysed yam production and cost, the efficiency of yam farmers, and adoption of YMT and their determinants and suggested how these could be improved. It has detected the existence of environment-technology gap among regions and made recommendations on how it could be closed.

This research has found that yam production is profitable. It is more profitable than other comparable crops including cassava. Farmers have made some achievements with yam production in the States. Yam /maize intercrop is the most profitable cropping system.

The project has established that yam farmers have high efficiency estimates. Some of the farmers are optimizing the use of resources. However, there is still room for farmer performance improvement. Benue State was technically efficient in yam production. Enugu and Benue were economically efficient in yam production in Nigeria. The project has also indicated that farmer's socioeconomic characteristics, decisions and access to facilities influence their performance in Nigeria.

The results of this research has shown that yam enterprise development in the study areas is impeded by lack of fund, high cost of fertilizer and unavailability and high cost of planting material. The traditional yam production technique is labour intensive and requires the use of enormous quantity of yam as planting material. This method is expensive and discourages mechanization of yam production. Nigerian yam farmers use poor quality planting material for yam production. The use of good quality planting material will increase yam yield in the country. Commercial seed yam production should be encouraged to enable the production of good quality planting materials to boost yam production in the country. This research recommends specialization in seed yam production in Nigeria. This will make quality planting materials available for yam production.

Agricultural information/new technology dissemination is crucial for technology adoption and yam farmer performance improvement in Nigeria. Low adoption of new yam technology in Nigeria is due to ignorance and poor dissemination of technologies. Research and extension are the ideal sources of agricultural information in Nigeria. Farmers should obtain agricultural information from appropriate sources. The main source of agricultural information in Nigeria (fellow farmers) could be unreliable. This research recommends adequate funding of research and extension in Nigeria to facilitate their activities in Nigeria.

This project has found that the use of Information Communication Technologies enhances farmer performance. A vast majority of farmers in the study areas used Information Communication Technologies for farm business. The use of Information communication technologies for agricultural information/technologies dissemination by research institutes and Agricultural Development Projects will facilitate the dissemination of technologies. Thus, this research recommends the use of Information communication technologies by research and extension for agricultural information dissemination.

This study suggests that an enabling environment would facilitate technology adoption in Nigeria. For instance, fertilizer is a prerequisite for YMT. Availability and reduction in the cost of fertilizer could encourage its adoption. Therefore, the creation of enabling environment for technology adoption in Nigeria is recommended.

Enhancement of the living conditions of yam farmers would increase the performance and facilitate new technology adoption in Nigeria. Establishment of rural health facilities and improvement in the quality of service at the facilities would improve the efficiency in yam production.

From this research, it is clear that Nigerian yam farmers lack access to financial institutions and obtain loans mainly from friends and relations. Financial institutions are mainly located in the urban area. Farmers should have access to financial institutions to enhance their performance and adoption of new technologies. This thesis recommends the establishment of financial institutions within the reach of farmers (in the rural areas where the majority of farmers are) to ease their access to credit, and educating farmers on loans acquisition. There should be considerable interest rate for farmers and monitoring of loan given to them to avoid diversion of agricultural loans.

The haphazard nature of the Nigerian farming system prevents the mechanization of yam production. The development of a better farming system for yam in Nigeria will encourage its mechanization. This research recommends the development of an alternative farming system for yam production to encourage its mechanization in Nigeria.

This research supports the fact that there are poor road networks in Nigeria. Consequently, the crops produced in the rural areas often perish in the areas. Construction of rural road, the development of storage structures and value addition of yam to extend its shelf-life are recommended to reduce yam waste in Nigeria. Also recommended is middlemen/agents involvement in yam marketing to reduce time wasted in selling yams and avail farmers ample time for other farm activities.

The soil requirement for yam production in Nigeria varies. Generally, yams are planted on well-drained loamy soil. Farmers often allow their farms to fallow for a long period of time, usually 3 years. The development of an appropriate farming system for yam in Nigeria could lead to reduction of the fallow period for yam and effective utilization of agricultural lands.

This study also supports the fact that Nigerian farmers are experiencing climate change and unbelievably, a majority of the farmers are ignorant of climate change mitigation and often abandon their farms. Teaching farmers on how to cope with climate change will contribute to improving the Nigerian agriculture.

This project has also proved yam output increased with farm size in Nigeria. However, an average Nigerian yam farmer had small farm size. Farmers in Nigeria are encouraged to increase their farm size. Nigerian land reform policy should aim at redistributing lands to farmers to enable them increase land area under yam production.

The findings of this thesis suggest that labour is underutilized in Nigeria particularly in Ondo State. Labour increases yam output in Nigeria. However, labour is expensive relative to farmer income in the country and usually unavailable when required. Therefore, affordable labour-saving devices such as cheap machinery should be used for yam production in Nigeria.

The result of the analysis supports the fact that output is an increasing factor of cost. It also indicates that less cost is required to increase yam production in Ondo compared to other States. At the current technology and resources used for yam production, Ondo can effectively increase yam output (scale of production) with less implication on cost. Increase in the scale of production in Benue State requires more cost than other States.

It also shows that wage rate is a determinant of cost of yam production in Nigeria. It affects the cost more in Enugu. Reduction in wage rate will decrease the cost of yam in Nigeria, especially in Enugu State. Nigeria yam farmers should be rational in decisions on labour. Also, mechanization of yam farming should be encouraged in Nigeria. The use of inexpensive labour- saving devices will augment labour and reduce the cost yam production in the country.

The result of this project has shown that capital input affects the cost of yam production in Nigeria. It has more effect on cost in Benue. Reduction in the cost of capital input in Nigeria, especially in Benue State, will reduce the cost of yam. Government intervention on input subsidy will contribute to reducing the cost of yam and boost yam production in Nigeria.

The project has revealed that rent on land increased cost of yam in Nigeria. Its effect was felt more in Ondo than other States. Reduction in rent on land would reduce the cost of yam in the country. This research therefore recommends reduction in cost of renting land in Nigeria. Land reform that would encourage the allocation of land to farmers will decrease the cost of acquiring land by farmers in Nigeria.

The analysis has also indicated that planting material increased output and cost of yam. It affects cost more in Enugu State. Decrease in the price of planting material will reduce the cost of yam in Nigeria. This research recommends the use of an ideal method of producing seed yam at reduced cost in Nigeria. This can be accomplished through YMT adoption for seed yam production in Nigeria. This will contribute to reducing the price of planting material and the use of quality seed yam for yam production in Nigeria.

This study has established that planting material is an increasing factor of output. Farmers in Nigeria have to use more planting material to boost yam production and improve their efficiency. They should purchase planting materials from reliable sources. Research institutes and Agricultural Development Projects should adopt appropriate input dissemination strategies to ensure that planting materials reach yam farmers in good condition and time.

This research has shown that price of fertilizer increases the cost of yam in Nigeria. Reduction in the cost of fertilizer will reduce the cost of yam production in Nigeria. Subsidy on fertilizer would contribute to reducing the cost of yam. This can be achieved through government intervention on fertilizers distribution. Fertilizers should be sold at the official price and distributed to farmers by the approved institutions. This will eliminate adulteration and excessive gain on fertilizer by marketers.

The most obvious result of this investigation is the existence of environment-technology gap in yam production between regions in Nigeria. Benue and Ondo have favourable environmental/technology for yam production in Nigeria. Farmers in Benue are efficient because they could explore technologies and the favourable environment in the State to attain a high regional technical efficiency. The technical efficiency score of yam farmers in Benue could be increased if farmers would maximize the use of inputs. Ondo yam farmers are technically inefficient in yam production because most of the yam farmers in Ondo State are not exploring the available technology/environment. Optimizing the use of input and exploring the suitable conditions for yam production in Ondo will enhance farmer performance. This research stipulates that at the current level of technology and input used for yam production in Nigeria, Ondo would be ahead of yam production in if farmers in the State could explore the technologies and optimize the use of resources in the State. This research recommends the intensification of the use of inputs in Ondo and advancement in technology in Benue.

This investigation supports that comparing the technical efficiency of farmers between regions without considering the environment/technology gap could give results. The matafrontier analysis indicated that Enugu State yam farmers outperformed those in other States. Enugu yam farmers are producing in a more restrictive environment/technology. The technology used for yam production in Enugu is below standard. However, some farmers in Enugu could explore the technologies/ environment to attain a high regional technical efficiency. This shows variation in the use of technology and diverse environmental conditions in Enugu. Yam farmers in Enugu should adopt improved yam technologies to be at par with farmers in other States. Since the operating environments for yam production in Nigeria differ, developed technologies should be environmental specific.

This thesis has revealed gender disparity in yam production in Nigeria based on superstitious beliefs, which limits female involvement in yam production. This study encourages gender equality in yam production. Female are as effective as men in yam production. Both genders should be equally involved in yam production in Nigeria.

It suggests full-time yam production irrespective of how land is own. Landless yam farmers were more economically efficient than land owners while land owner were more technically efficient than the landless ones. Specialized yam production would increase farmer performance and the adoption of YMT. Farmers should be encouraged into yam production undermining their experience and level of educated. They should stay on yam production to gain experience in order to improve their economic efficiency.

YMT is profitable and yam production using YMT is more profitable than the traditional methods of producing yam. It also supports the fact that adoption of YMT improves the performance of yam farmers in Nigeria. Therefore, Nigerian yam farmers, particularly those in Enugu, should be trained on new yam technologies and encouraged to adopt the full technology package.

Furthermore, it suggests the dissemination of new yam technologies to farmers to expedite its adoption. Yam farmers should be encouraged to belong to farming organizations such as cooperative. This will facilitate their accesses to agricultural information, farm inputs and equipment. Technologies should be evaluated before they are disseminated to farmers.

From this investigation, it is apparent that the use of staking material is essential to improve farmer performance in Nigeria. Nevertheless, over-staking of yam farms should be avoided. Future research on yam staking should ascertain the ideal quantity of stakes for yam production.

10.3 Contribution to knowledge

This research has made a valuable contribution to existing knowledge on yam production in diverse ways. The contributions are arranged in order of importance.

It is one of the pioneer works on farmer performance evaluation in Nigeria using the metafrontier analysis. Through the use of this type of analysis, it has provided a new dimension regarding investigating the performance of farmers taking into consideration the impact of environment and technology.

This study has extended our knowledge of assessing the impact of a technology on performance in Nigeria. It has justified the efficacy of the Propensity Score Matching in evaluating the impact of a technology on performance. It has also provided insight for determining the impact of a technology on performance. Following this research, researchers are now able to use the PSM to evaluate the impact of technologies rather than the inappropriate methods usually employed by researchers which often give misleading results.

It has contributed to the existing sum of knowledge by strengthening some findings in this research area but also has contradicted some previous work. In addition, it can serve as reference tool for efficiency, profitability and YMT adoption studies. Researchers using this method of analysis can use this as a reference material.

The findings of this research could promote gender equality in yam production in Nigeria and it has specifically demonstrated that women are as effective as men in yam production. This disproves some of the traditional beliefs in some areas in Nigeria that prevent women from being actively involved in yam production.

In addition, this research has made a meaningful contribution to enhancing yam production and reducing its cost in Nigeria. It has evaluated yam output and cost and their determinants and made contributions to yam production at reduced cost. It has also identified the presence of environment-technology gap and suggested ways of closing this. It has also identified factors influencing the performance of yam farmers and proffered solutions on how this can be improved.

Finally, it has proved that YMT is a profitable seed yam production technique. It has ascertained the determinants of its adoption and made recommendations that will enhance its adoption in Nigeria.

10.4 Limitation to study

This research was conducted within the limit of available fund. Only three yam-producing States were used to represent the entire country. This might be insufficient to represent the entire country. Also, this research was conducted during the period of societal unrest in the northern part of Nigeria; the enumerator could not reach some major yam-producing area in the problem areas.

Data collection for research purposes is a herculean task as most Nigerian farmers have no farm records. Most databases in Nigeria have incomprehensive aggregate data which are often inadequate for economic and econometric analysis. Consequently, most farm-based efficiency studies in the country are based on cross sectional data. The use of cross sectional data might lead to misjudging of firms to be inefficient in the short run.

10.5 Suggestions for future research

This research has provided in-depth knowledge on yam production, new yam technologies and performance of yam farmers in Nigeria. The points are arranged in order of importance. However, there are other relevant production issues outside the scope of this work that need to be addressed. It has also reached some conclusions that require further investigation. Based on the research findings, existing conditions for yam production in Nigeria and other relevant issues, this research makes these suggestions for future research:

This research has observed lapses in the Nigerian databases and suggests that field survey be conducted to generate reliable and sufficient production data from Nigerian farmers. Field surveys to elicit information from farmers and upgrade the Nigerian database will be useful for future research studies. Nigerian farmers should be trained on record-keeping to improve the quality of data in the country. Enlightening farmers about record-keeping would be useful in collecting quality data for research work.

Further studies are required to investigate the effect of time on farmer performance in Nigeria. This will enable the investigation of any changes in farmer performance over time. With this, the effect of a technology over time could be determined. This would be achieved by comparing the movement of the production frontier (upward or downward shift) over time. This will also allow researchers to determine technological advancement.

This research recommends further research on other relevant ways of improving farmer's productivity such as breeding and use of improved varieties, pest and disease control measures, soil improvement and among others. This will contribute to boosting yam production in the country.

Further investigation on yam should determine the ideal weeding frequency and time, and the quantity of stakes for yam production in different regions in Nigeria. This research recommends agronomic and economic studies on weed management and yam staking. These studies will confirm the appropriate weeding schedule and quantity of stakes for yam production in different regions.

The Nigerian fertilizer distribution channels and the current fertilizer policies need to be assessed. Currently, there is a dual market for fertilizer in Nigeria. Fertilizers are sold by government agencies at subsidized price and on the open market. Most Nigerian yam farmers lack access to fertilizer. This could be due to diversion or high cost. This research has proved that fertilizer is crucial for YMT adoption and to improve the performance of yam farmers in Nigeria. It is a known fact that some Nigerian fertilizer marketers adulterate fertilizer in order to make more financial gain through fertilizer marketing. Investigating the fertilizer distribution channels and development of appropriate fertilizer policy could improve the price and quality of fertilizer distributed to farmers.

Finally, this project recommends the reviewing of the Nigerian land policies and enactment of future policies that will redistribute lands to farmers. The common practice in Nigeria is the resumption of rural lands (usually owned by the poor) by the government, with or without compensation, and distributing them to the rich for development (normally house construction). This research stipulates that a change in this system of land distribution in favour of the farmers will contribute to the development of the Nigerian agricultural sector. Therefore, investigating the Nigerian land distribution system and the development of strategies to redistribute land to farmers is recommended.

10.6 Summary

This research has evaluated the Nigerian yam production and offered solutions that will improve farmer performance, increase the adoption of new yam technologies and boost yam production. It has shown that Nigerian yam farmers have high efficiency estimates; however, there is still potential for improvement in farmer performance in the country. Also, it has also proved the existence of a gap in the environment and technologies in the country and suggested ways of closing this. Furthermore, this research has provided insight into evaluating the performance of farmers. It has also provided a new perspective in assessing the impact of technologies on farmer performance and wellbeing in Nigeria. It has also suggested areas for future research that will contribute to improving Nigerian yam production enterprise.

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Appendices

Appendix A: Research Questionnaire

This research is on New Technologies and Yam Production Efficiency in Nigeria: Potential for Improved Household Wellbeing.

You are expected to tick or make short comments where applicable

Questionnaire Number	Name of Enumerator	Name of Respondent	Village/ Community	Local Government Area	Agricultural Zone	State	Date collected

A. Personal data

1.

Age	Gender (Male=M, female=F)	Family size	Educational Level A= No formal edu. B. primary C=secondary D=tertiary	Years of Education	Occupation 1	Occupation 2	Annual Farm Income	Annual off-farm Income	Org. membership/ membership of cooperative (member=1,non-member=0)

2.

Marital Status	Farming experience (number of years):	Experience in yam farming (number of years)

3.

Sources of farm income							
Amount							

B1.Land allocation for farm activities

4. What area of land is allocated to farm activities? ------------------------------------

5. Assuming land is shared into ten (10) parts, what proportion of land do you allocate to the following uses

	Crop production	Animal production	Unused land	Other uses------------------
Proportion				

B2. Land allocation for crop production

6. Land owned and cultivated (local unit)

Gender	Owned	Total area of land available for farming	Total area cultivated	Rented value of cultivated land (₦/year)
a) Joint				
b) Husband				
c) Wife				
d)Total				

Note: Find out hectare equivalence of local unit

7.

crops	yam	cassava	Yam minisett			
Proportion						
Name of varieties used						

Note: Proportion of crops is the share of a particular crop in the crop production system / intercrop assuming land is shared into ten parts

C. Cropping system

8. What type of cropping system do you practice? A. Sole cropping B. intercropping C. both

9.

Intercrop	Crop a (main crop)	Yam	Yam minisett			
	Crop b					
	Crop c					
	Crop d					
	Crop e					
Time of planting (month)	Crop a (main crop)					
	Crop b					
	Crop c					
	Crop d					
	Crop e					
Month harvested	Crop a (main crop)					
	Crop b					
	Crop c					
	Crop d					
	Crop e					
Duration (months)	Crop a (main crop)					
	Crop b					
	Crop c					
	Crop d					
	Crop e					
Share/proportion of land allocated to						

D. Input and output data

10. Capital inputs used for crop production (all crops produced)

Equipment	Enterprises used in	Number	Unit price(₦)	Lifespan	Remark
Tractor					
Cutlass					
Hoe					

11. **Non-capital (variable) inputs used for crop production (excluding yam minisett)**

Inputs	**Planting material1 --------**	**Planting material 2----------**	**Planting material 3 ------------**	**Planting material 4 --------- -**	**Fertilizer**	**Organic Manure**	**Pesticide**	**Staking material**	
Enterprise used in									
quantity									
Unit									
Price (₦ /unit)									
Total Value									

Note: if bag or basin is used, specify the size (e.g. 25kg bag, 50kg bag, small basin etc.)

E. **Labour used for crop production (for the whole farm excluding yam minisett)**

12.

Operations	**Labour type(s)**	**Number of people**	**Hours employed/day**	**Number of days**	**N/day (wage rate) + cost of feeding workers**
Clearing					
Gathering of thrashes					
Stumping					
Ploughing					
Mounds					
planting					
Weeding 1					
Weeding 2					
Weeding 3					
Fertilizer application					
Staking					
Harvesting					
Moving produce home					
Moving produce to the market					

F. Output /income for the whole crop enterprise (excluding yam minisett)

13.

Crop / Output	Yam						
Quantity							
Price/unit							
Value of output (₦)							

Note: If basin or bag is used, specify the size, kg, basins, bag, wheelbarrow, e.t.c)

G. Yam Minisett Intercrop

14. Non-capital inputs used for yam minisett production

Inputs	Fertilizers	Organic manure	pesticides	Staking sticks	Crop 1 ---------	Crop 2 --------	Crop 3 ----------	Crop 4 --------	
Enterprise									
Quantity									
Unit									
Price(₦ /unit)									

15. Labour used for yam minisett Production

Operations	Labour type(s)	Number of people	Hours employed/day	Number of days	N/day (wage rate)
Clearing					
Gathering of thrashes					
Stumping					
Ploughing					
Mounds					
planting					
Weeding 1					
Weeding 2					
Weeding 3					
Fertilizer application					
Staking					
Harvesting					
Moving produce home					
Moving produce to the market					

16. Output from yam minisett enterprise

Crop / Output	Seed yam						
Quantity							
Price/unit							
Value of output (₦)							

G.

17. Output/Income for yam under different technologies

Method of whole yam production	Area	Output	Total Income
Yam Production using seed yam			
Yam production using cut setts			
Yam production using milk yam			
Yam production using Variety A---------------			
Yam production using Variety B----------------			

18.

Do you have problems obtaining loans from financial institutions?	**Yes** **No**
If yes, what problems do you encounter in obtaining loan? Rank in order of severity	a.High interest rate b. Unavailability of loan c. Lack of financial institution in locality d. Lack of knowledge on how to obtain loan e. Not interested in loan. f. Others specify----------------------
Do you have difficulties acquiring farm inputs?	**Yes** **No**
If yes, what are the difficulties in acquiring farm inputs?	
Do you employ enough labour?	**Yes** **No**
If no, what are your reasons for not employing enough labour	
Has yield been increasing over the years?	**Yes** **No**

19. Soil fertility

Use fertilizer	Yes ☐ No
If no reason for not using fertilizer?	
Is your yam farm waterlogged?	Yes ☐ No
If yes, is waterlogging a recent problem on your on your far?	Yes ☐ No
How do you solve the problem of waterlogging?	
How long do you allow your farm to fallow?	(a)Practice continuous cropping (0 fallow) (b) 1-2years (c) 3-4years (d) above 4 years
What type of soil do you plant yam on?	(a)Sandy (b) Loamy (c) Clay (d) Sandy clay (e) Sandy loam
Slope of your farm	(a) Flat land (b) Gentle (c) Steep
Do you irrigate your farm?	Yes No
How much does it cost to irrigate your yam farm/year?	₦

20.Access to research information

What are your sources of agricultural information?	a. Fellow farmers, b. Relations , c. Radio/ television ,d. Extension agents (ADP), e. Research institutions (NRCRI/,IITA), f. Others specify----
Do you have contact with extension agents?	Yes No
How often do extension agents visit you?	
How often do you visit the extension agent?	

21. Use of improved yam technologies

Technologies	**Not aware** (Yes / No)	**Aware** (Yes / No)	**tried** (Yes / No)	**Use** (Yes / No)	**Discontinued** (Yes / No)
Improved varieties					
Yam minisett					

22. Use of improve yam technology

Have you received training on yam minisett technology?	Yes □ No □
Have you received training on use of improved varieties?	Yes □ No □
What variety of yam do you plant?	(a)Improved (b)Local (c)Both
what are your reasons for not using improved varieties (rank in order of importance)	(a)Lack of access to improved yam varieties (b) Improved verities are expensive (c) Not available (d)Difficult to get €Prefer the local varieties (f)Others specify---------------------------------
What is the reason(s) for not practicing yam minisett technology?	
If improved, what varieties do you use?	
If local, what varieties do you plant?	
What are your reasons for not using yam minisett technology?	
Source of planting material (rank in order of importance)	(a)Own farm (b) Research institutions (c) Market (d) Fellow farmers (e) Extension Agents (f) Others specify--------------
What type of planting materials do you use	(a) Mini sett (b) Mini tubers (c) Milk yam (d) Cut sett
Do you use the required quantity of seed yam?	Yes □ No □
If no, what are your reasons for not using adequate seed yam	(a) Costly (b) Unavailable (c) Do not have money to buy enough seed yam (d) Do not have time for planting (e) Do not need much yam on the farm/ prefer other crops (f) Do not have the strength to cultivate much yam (g)Others specify------------------------
Are you willing to expand production if you have more seed yam?	Yes □ No □
If no, what are your reasons for not willing to expand yam production?	
What are the limitations to yam production? Rank in order of importance	(a) Fund (b)Availability of land (c) Access to fertilizer (d)High cost of fertilizer (e) Availability of seed yam (f) others specify------------------

23. Socioeconomic benefits derived from yam production

Has yam production being beneficial to you?	Yes No
Have you been able to do any remarkable thing with revenue from yam production?	Yes No
If yes, what have you been able to achieve from yam production? Rank in order of importance. Rank most important as 1)	a) Feed family---------- (b)train self in school---------- (c) train children in school-------- (d) acquire more land -------(e) build houses------ (f) acquire titles------ (h) marry more wives------ (i)------------------(j)---------

24. Use of ICTs

What information communication technologies do you have access to?	(a)Handset (b) telephone (b)computer (c) internet (d)fax (e)Emails (g)Google (h)Facebook (f) ----------------
If yes, which of these ICTs do you use for farm business?	(a)Handset (b) telephone (b)computer (c) internet (d)fax (e)Emails (g)Google (h)Facebook (f)others ----------------
If no, how do you get farm information on (yam varieties, agricultural technologies, market information)?	Yes No
What are your reasons for not using ICTs for farm business?	(a)Do not know about ICTs (b)Not available in locality (C) Cannot afford them (d) others---

25. Proximity to infrastructure

How far is your farm from your house?	
How do you get to the farm?	
How much do you pay to get to the farm?	₦
Are there markets in the locality?	Yes No
How many yam farms do you have?	
how far is your farm from the market?	
Are there schools in your community?	Yes No
How far is your house from school?	
Are there hospitals and health centres in your community in your community?	Yes No
Are there research institutions in your community?	Yes No
Are there Financial Institutions in the community?	Yes No
Do you have potable water in your locality?	Yes No
Are there irrigation facilities in the community?	Yes No
Are there good roads in your community?	Yes No
Do you have access to farm machinery	Yes No
Do you use farm machinery?	Yes No

26. Limitations to adoption of Yam Minisett Technology

Do you practice yam minisett technology?	**Yes** ☐ **No**
If no. what are your reasons for not practicing yam minisett technology	(a)Lack of knowledge (b)Complexity of the technology (c)Lack of time to practice it (d)It is expensive to practice (e)Lack of fertilizer input (f)Lack of fund (g) Others specify---------------------------------
Is there any health issue that you think affects your farm activities?	

Appendix B: Frontier 4.1c software instruction file

Code	**Interpretation**
1	error components model, 2=te effects model
cng1-dta.txt	data file name
cng1-out.txt	output file name
1	1=production function, 2=cost function
y	logged dependent variable (y/n)
360	number of cross-sections
1	number of time periods
360	number of observations in total
5	number of regressor variables (xs)
n	mu (y/n) [or delta0 (y/n) if using te effects model]
n	eta (y/n) [or number of te effects regressors (zs)]
n	starting values (y/n)

Appendix C: Distribution of socioeconomic characteristics of yam farmers in Nigeria

Variables	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Age				
≤19	0.3	0.8	0.0	0.0
20 – 39	29.1	33.4	20.0	34.2
40 -59	46.2	45.0	43.3	50.0
≥60	24.4	20.8	36.7	15.8
Total	100	100	100	100
Gender				
Male	85.0	88.3	79.2	87.5
Female	15.0	11.7	20.8	12.5
Total	100	100	100	100
Household size				
<6	28.3	22.5	25.8	36.7
6-10	53.6	42.5	65.0	53.3
11-15	12.5	20.0	7.5	10.0
>15	5.6	15.0	1.7	0.0
Total	100	100	100	100
Education				
No formal education	16.4	13.3	24.2	11.7
Primary	23.9	16.7	31.6	22.5
Secondary	35.3	42.5	27.5	36.6
Tertiary	24.4	27.5	16.7	29.2
Total	100	100	100	100
Farming Experience				
≤5	11.1	7.5	14.2	11.7
6-15	35.3	30.0	25.0	50.8
16-25	24.7	24.2	25.0	25.0
26-35	13.3	20.8	13.3	5.8
≥36	15.6	17.5	22.3	6.7
Total	100	100	100	100
Primary Occupation				
Farmer	94.6	94	95.1	94.8
Civil Servant	0.4	0	0	1.3
Others	4.8	6	4.9	3.8
Total	100	100	100	100
Marital Status				
Single	6.6	4.5	7.3	7.8
Separated and widowed	1	0	2.4	0.6
Married	92.5	95.5	90.2	91.6
Total	100	100	100	100

Source: Field Survey, 2013

Appendix D: Conditions of use for yam production in Nigeria

D.1: Availability of inputs and access to facilities by yam farmers in Nigeria

D.1.1: Availability and use of inputs

Farmers situation	Nigeria	Benue	Enugu	Ondo
Have difficulty acquiring farm input	76.4	86.7	85.8	56.7
Employ adequate labour	62.5	68.3	60.0	59.2
Use fertilizer	78.6	99.2	90.0	46.7
Have difficulty obtaining loan	66.5	86.7	65.9	50.3

Source: Field Survey, 2013

Appendix D.1.2: Access to facilities in Nigeria

Facilities	Nigeria	Benue	Enugu	Ondo
Schools in the community	98.4	96.7	100.0	98.3
Hospitals in the community	86.7	90.0	86.7	83.3
Research Institutes at close proximity	1.7	0	5.0	0
Financial Institutions (Banks)	7.5	3.3	5.0	14.2
Water	36.4	45.8	16.7	46.7
Irrigation facilities	5.8	4.2	7.5	5.8
Access road	23.6	35.8	8.3	26.7
Machinery	23.1	14.2	34.2	20.8
Extension Services	45.4	62.2	18.3	53.5
Market	92.1	88.1	99.2	88.4

Source: Field Survey, 2013

Appendix D.2: Limitations to input acquisition in Nigeria

Limitations	Farmers (%)
Lack of fund	46.0
Unavailability of input	20.8
Untimely inputs	2.6
High cost of input	13.3

Source: Field Survey, 2013

Appendix D.3: Planting material for yam production in Nigeria

D.3.1: Adequacy of planting material for yam production in Nigeria

Region	Nigeria	Benue	Enugu	Ondo
Use adequate planting material (%)	58.5	62.2	53.8	59.4

Source: Field Survey, 2013

Appendix D.3.2: Sources of planting material for yam production in Nigeria

Sources of planting material (%)	Nigeria	Benue	Enugu	Ondo
Research Institute	2.5	3.3	1.7	2.5
Extension Agent	9.2	7.5	16.7	3.3
Own farm	93.6	93.3	96.7	90.8
Market	73.1	68.3	80.8	70
Fellow farms	54.7	60.8	52.5	50.8

Source: Field Survey, 2013

Appendix D.3.3: Ranking of sources of planting material used for yam production in Nigeria

Sources of planting material	4 (%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
Own farm	82.9	9	1.4	0.2	36.16	1
Research institute	0	0.5	1.2	0.5	0.44	5
Market	21.1	31	20.9	0.2	21.94	2
Fellow farmers	10.2	29.1	10.7	0.5	15	3
Extension agents	1.4	0	2.1	0.2	1	4

Source: Field Survey, 2013
Note: 1- 4 denote scores in increasing order of magnitude; the most important was ranked1.

Appendix D.3.4: Ranking of types of planting material used for yam production in Nigeria

Types of planting material	4 (%)	3 (%)	2 (%)	1 (%)	Weighted average	Rank
YMT	17.5	3.6	1.2	0	8.32	4
Mini tuber	32.7	5	3.8	0	15.34	3
Milk-yam	34.8	6.2	4.7	0.2	16.74	2
Cut sett	51.5	12.1	5.2	0.2	25.29	1

Source: Field Survey, 2013
Note: 1- 4 denote scores in increasing order of magnitude; the most important was ranked 1. The percentage of the variables did not add up to one hundred because zero score was excluded.

Appendix D.3.5: Ranking of the limitations to planting material acquisition

Limitations	4 (%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
costly	16.1	1.9	0.5	0	7.11	1
unavailability	3.3	1.4	0	0	1.74	3
Lack of fund	16.1	1.7	0.2	0	6.99	2
Lack of time	0.2	0	0	0	0.08	6
Do not need more seed yam	0.2	0	0.5	0.2	0.2	5
No strength to plant more	0.9	0.2	0.2	0.2	0.48	4

Source: Field Survey, 2013
Note: 1- 4 denote scores in increasing order of magnitude; the most severe was ranked 1. The percentage of the variables did not add up to one hundred because zero score was excluded.

Appendix D.4: Sources of capital for yam production

Income Sources	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Non-farm income	97.1	97	94.3	99.4
Bank loan	6.6	6.7	4.1	8.4
Local Saving Scheme	14.1	26.9	5.7	9.7
Loan from friends and relations	24.8	14.2	29.3	30.5
Money lender	1.5	2.2	0	1.9
Loan form cooperative	4.9	0.7	5.7	7.8
Gift	1.5	0	3.3	1.2

Source: Field Survey, 2013

Appendix D.5: Hindrances to loan acquisition in Nigeria

Problems	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
High interest rate	15.4	3.1	8.3	1.2	0.2	7.8	4
Unavailability of loan	16.1	15.6	9.7	0.9	0	11.6	2
Unavailability of Financial Institution	25.1	14.9	5	0.5	0	13.4	1
Lack of knowledge on how to obtain loan	18.7	9.2	7.3	0.5	0	10.2	3
Reluctant to obtain loan	4	1.2	1.9	0.2	0	2.1	5
Other problems	1.7	0.2	0.2	0	0	0.7	6

Source: Field Survey, 2013

Note: 1- 5 denote scores in increasing order of magnitude; the most important was ranked 1.The percentage of the variables did not add up to one hundred because zero score was excluded.

Appendix D.6: Soil used for yam production in Nigeria

Appendix D.6.1: Types of soil for yam production in Nigeria

Soil types	Farms (%)
Sandy	8.3
Loamy	37.0
Clay	7.6
Sandy clay	6.4
Sandy loam	30.1
Gravelly sandy loam	4.5
Gravelly Sand	0.7
Gravelly Clay	0.7

Source: Field Survey, 2013

Appendix D.6.2: Slope of land used for yam production in Nigeria

Slope	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Flat	81.7	61.7	78.7	87.9
Gentle slope	18.0	34.4	15.0	8.7
Steep slope	4.3	3.9	6.3	3.4

Source: Field Survey, 2013

Appendix D.6.3: Fallow periods for yam in Nigeria

Fallow period	Nigeria	Benue	Enugu	Ondo
Continuous cropping	10.7	25.9	2.3	4.5
1 year	25.4	40.7	23.5	13.5
2 year	1.4	1.5	3	
3 year	38.9	14.1	53.8	47.7
4 year	16.8	1.5	14.4	32.4
No idea	6.9	16.3	3	1.9

Source: Field Survey, 2013

Appendix D.6.4: Waterlogging of yam farms in Nigeria

Waterlogging problem (%)	Recent (%)	Do nothing (%)	Construct channels (%)	Make big mounds/ridges (%)	Make bonds (%)	Abandon farm (%)
14.7	7.8	93.4	2.8	2.4	0.9	0.5

Source: Field Survey, 2013

Appendix E: Farmers who have benefited from yam production and the benefits derived

Appendix E.1: Percentage of farmers who have benefited from yam production

Response	Benefited (%)	Done remarkable things (%)
Yes	99.8	99.3
No	0.2	0.7
Total	100	100

Source: Field Survey, 2013

Appendix E.2: Ranking of farmers benefits from yam production in Nigeria

Benefits	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
Feed family	86.5	7.3	0.9	0.2	0	31.0	1
Train self	5.7	9.7	3.6	1.4	0	5.4	4
Train children	22.5	58.8	8.3	0.2	0	24.9	2
Acquire more land	2.6	1.7	14.7	5	0.7	5.0	5
Build house	8.8	1.7	21.3	7.8	1.9	8.8	3
Acquire title	0	0.2	0.9	2.1	0.7	0.6	7
Marry more wives	0.5	0.5	2.8	3.8	0.7	1.4	6
Buy cars/motorcycle	0.5	0	0.2	0	0	0.2	8

Source: Field Survey, 2013

Note: 1- 5 denote scores in increasing order of magnitude; the most important was ranked1. These variables did not add up to one hundred because zero percent was excluded from the estimation.

Appendix F: Farmer willingness to expand yam production in Nigeria and hindrances

Appendix F.1: Farmers perception of the constraints of agro-enterprise development in Nigeria

Constraints	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	Weighted average	Rank
Fund	76.8	5.5	2	0.2	0	27.43	1
land	5.2	10	4	0.7	0.2	5.277	5
Access to fertilizers	4.5	12.1	9	1.9	0	6.74	4
High cost of fertilizers	13	14.5	11	2.1	0.7	10.81	2
Unavailability and high cost of planting materials	12.8	8.8	11	2.4	0.5	9.19	3
High cost of labour	1.9	0.2	1	0.2	0	0.85	6
Unavailability of inputs	0.7	0	0	0.5	0	0.34	8
others	1.7	0.2	1	0.5	0	0.837	7

Source: Field Survey, 2013

Note: 1- 5 denote scores in increasing order of magnitude; the most important was ranked 1. These variables did not add up to one hundred because zero percent was excluded from the estimation.

Appendix F.2: Farmer willingness to expand area under yam production in Nigeria

Expand of yam production	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Willing to expand	96.0	97.8	95.5	94.8
Reasons for not willing to expand				
No reason	97.2	98.5	97.0	96.1
Lack of fund	1.4	0.7	1.5	1.9
Unavailability of land	0.2	0	0.8	0
Lack of access to fertilizers	0.7	0.7	0.8	0.6
High cost of fertilizers	0.2	0	0	0.6
Unavailability of seed yam	0.2	0	0	0.6

Source: Field Survey, 2013

Appendix F.3: Ranking of hindrances to expansion of yam production enterprise in Nigeria

Hindrances	1 (%)	2 (%)	3 (%)	4 (%)	Weighted Average	Rank
High cost of planting material	0	0.5	1.9	16.1	7.11	1
Unavailability of planting material	0	0	1.4	3.3	1.74	3
Lack of fund	0	0.2	1.7	16.1	6.99	2
Lack of time	0	0	0	0.2	0.08	6
Have adequate farm	0.2	0.5	0	0.2	0.2	5
No strength to plant more	0.2	0.2	0.2	0.9	0.48	4

Source: Field Survey, 2013

Note: 1- 4 denote scores in increasing order of magnitude; the most important was ranked1. The percentage of the variables did not add up to one hundred because zero score was excluded.

Appendix G: Production variables for yam

Regions	Variables	Mean	Standard deviation	Minimum	Maximum
Nigeria					
	Output (kg)	14,796.94	13,602.14	516.00	75,240.00
	Farm size (ha)	1.51	1.86	0.02	14.50
	Planting material (kg)	2,301.76	2,591.55	38.40	16,000.20
	Fertilizer (kg)	88.17	135.33	0.00	910.00
	Labour (man-days)	363.76	447.70	2.20	3,132.09
	Capital input (depreciated cost-₦)	2,593.40	2,684.77	66.58	23,366.00
Benue					
	Output (kg)	20,151.44	14,698.67	2,320.00	64,940.00
	Farm size (ha)	2.22	2.25	0.22	14.50
	Planting material (kg)	3,517.53	3,279.92	60.00	14,840.00
	Fertilizer (kg)	109.23	131.26	0.00	910.00
	Labour (man-days)	516.19	487.55	44.68	3,132.09
	Capital input (Depreciated cost ₦)	2,870.59	2,714.67	250.00	18,728.00
Enugu					
	Output (kg)	9,771.80	9,840.11	516.00	57,500.00
	Farm size (ha)	0.90	0.95	0.02	6.00
	Planting material (kg)	1,374.33	1,504.89	38.40	9,600.00
	Fertilizer (kg)	119.11	167.79	0.00	900.00
	Labour (man-days)	181.97	221.65	2.20	1,350.40
	Capital input (Depreciated cost ₦)	1,854.71	1,291.48	147.01	8,160.00
Ondo					
	Output (kg)	14,467.58	13813.04	935.00	75,240.00
	Farm size (ha)	1.41	1.88	0.04	12.00
	Planting material (kg)	2,013.42	2,190.19	48.00	16,000.20
	Fertilizer (Kg	36.18	75.71	.00	480.00
	Labour (man-days)	393.10	510.10	12.96	2,756.70
	Capital input (depreciated cost-₦)	3,054.91	3,444.59	66.58	23,366.00

Source: Field Survey 2013

Appendix H: Command for metafrontier analysis using Shazam

* The file parm.txt contains estimated parameters of group frontiers (by column)

* The file sfa#.txt contains n# data observations for group #

* Sections 1 and 3 are problem-specific.

* 1. SET NUMBERS OF PARAMETERS ETC.

gen1 nparms = 21

gen1 ngroups = 3

gen1 n1 = 120

gen1 n2 = 120

```
gen1 n3 = 120

* 2. READ THE ESTIMATED PARAMETERS OF THE GROUP FRONTIERS
smpl 1 nparms
read (parm.txt) parm / rows = nparms cols = ngroups
do # = 1,ngroups
dim b# nparms
copy parm b# / fcols=#;#tcols = 1;1
endo

* 3. READ THE DATA AND CONSTRUCT DATA MATRICES AND VECTORS
gen1 j2 = n1+1
gen1 j3 = n1+n2+1
gen1 k2 = n1+n2
gen1 n = n1+n2+n3
smpl 1 n
genr one = 1
read (sfa1.txt) group ly lx1-lx5 lx11-lx15 lx22-lx25 lx33-lx35 lx44-lx45 lx55
smpl j2 k2
read (sfa2.txt) group ly lx1-lx5 lx11-lx15 lx22-lx25 lx33-lx35 lx44-lx45 lx55
smpl j3 n
read (sfa3.txt) group ly lx1-lx5 lx11-lx15 lx22-lx25 lx33-lx35 lx44-lx45 lx55
smpl 1 n
matrix x =
one|lx1|lx2|lx3|lx4|lx5|lx11|lx12|lx13|lx14|lx15|lx22|lx23|lx24|lx25|lx33|lx34|lx35|lx44|lx45|lx
55
dim x1 n1 nparms x2 n2 nparms x3 n3 nparms
copy x x1 / frows=1;n1 trows=1;n1
copy x x2 / frows=j2;k2 trows=1;n2
copy x x3 / frows=j3;n trows=1;n3
do # = 1,ngroups
matrix yhat# = x#*b#
```

```
endo
matrix b = -(yhat1'|yhat2'|yhat3')'

* 4. OBTAIN AND PRINT PARAMETERS OF THE METAFRONTIER
stat x / means = xbar
matrix c = ((-xbar')|xbar')'
matrix A = (-x)|x
?lp c A b / iter = 5000 primal = bstar
dim beta1 nparms beta2 nparms
gen1 p1 = nparms+1
gen1 p2 = nparms*2
copy bstar beta1 / frows=1;nparms trows=1;nparms
copy bstar beta2 / frows=p1;p2 trows=1;nparms
matrix beta = beta1-beta2
print beta

* 5. OBTAIN AND PRINT TECHNOLOGY GAP RATIOS
do # = 1,ngroups
matrix xbeta# = x#*beta
print xbeta#
matrix dev# = xbeta# - yhat#
print dev#
matrix tgr# = exp(yhat#)/exp(xbeta#)
stat tgr#
print tgr#
endo
* Program to get OLS standard errors by Bootstrapping.
* Run the original regression, save residuals and coefficients.
OLS ly lx1 lx2 lx3 lx4 lx5 lx11 lx12 lx13 lx14 lx15 lx22 lx23 lx24 lx25 lx33 lx34 lx35 lx44
lx45 lx55 / RESID=E PREDICT=YHAT
GEN1 N=360
GEN1 K=21
```

```
GEN1 NREP=1000
* Create space to hold vectors of bootstrapped coefficients.
DIM BET K NREP
* Turn off DO-loop printing or you will get lots of output.
SET NODOECHO
SET NOOUTPUT
SET RANFIX
DO # =1,1000
* Draw a random sample of errors with replacement.
GENR NEWE=SAMP(E)*SQRT(N/(N-K))
* Generate new dependent variable by using NEWE.
GENR Y=YHAT+NEWE
OLS Y lx1 lx2 lx3 lx4 lx5 lx11 lx12 lx13 lx14 lx15 lx22 lx23 lx24 lx25 lx33 lx34 lx35 lx44
lx45 lx55 / COEF=BET:#
ENDO
* Transpose the BETA matrix for use in STAT and PLOT commands.
* This is needed to get the numbers in column order.
MATRIX BET=BET'
SET OUTPUT
* Set the sample size to number of replications.
SAMPLE 1 NREP
* Get the statistics on the replications.
STAT BET
STOP
```

Appendix I: Nigerian yam intercropping systems

Appendix I.1: Number of intercrops for yam in Nigeria

Regions	Nigeria	Benue	Enugu	Ondo
Number of intercrops	108	25	50	57
Maximum number of combined crops	7	5	6	7

Source: Field Survey, 2013

Appendix I.2: Percentage crop combination for yam in Nigeria

Number of crops	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
1	17.8	35.6	10.8	7.8
2	21.7	39.4	11.7	14.4
3	18.8	17.4	15.8	22.4
4	21.7	5.3	27.5	31.2
5	17.3	2.3	31.7	19
6	2.5	0	2.5	4.5
7	0.2	0	0	0.7

Source: Field Survey, 2013

Appendix I.3: Major cropping systems for yam in Nigeria

Cropping system	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Yam	17.8	35.6	10.8	7.7
Yam/Cassava	14.3	36.4	2.5	4.6
Yam/Cassava/Maize	5.4	1.5	7.5	7.2
Yam /Maize	2.5	0.8	4.2	2.6
Yam/Cassava/Okro	1.5	4.5	0	0
Yam/Cassava/Pepper	2.2	3	0	3.3
Yam/ Cassava/Okro/Melon	1	0	5.8	2.6
Yam/ Maize/ Melon/ Okro	1.9	0	5.8	0.7
Yam/Fluted pumpkin	1.5	0	5	0
Yam/Maize/Pepper	2.2	0	0	5.9
Yam/ Pepper	1.9	0.8	0	4
Yam/ Cassava/ Melon /Pepper	1.7	0	0	4.6
Yam/ Cassava/Melon/Maize/Pepper	2	0	0	5.2

Source: Field Survey, 2013

Appendix I.4: Time of planting of yam

Months	Benue (%)	Enugu (%)	Ondo (%)
January	1.5	7.5	2.6
February	3.8	7.5	0.7
March	32.6	26.7	2.6
April	55.3	40	5.2
May	4.5	14.1	0.7
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0.7
October	0	0	15.1
November	0.8	0.9	49
December	1.5	3.3	23.4

Source: Field Survey, 2013

Appendix I.5: Time of planting of major crops in yam enterprise

Month	Cassava (%)	Maize (%)	Okro (%)	Pepper (%)
January	0	0.6	0	1.0
February	1.7	2.4	1.2	2.9
March	14.8	25.4	25	8.8
April	29.2	41.2	34.5	18.6
May	33.5	17.6	19.1	18.6
June	13.9	4.2	8.3	4.9
July	2.5	0.6	1.2	1.0
August	1.7	1.8	3.6	9.8
September	0.8	2.4	2.4	14.7
October	0.4	1.8	2.4	15.7
November	0.8	0	2.4	3.9
December	0.4	1.8	0	

Source: Field Survey, 2013

Appendix I.6: Duration of yam

Number of months	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
5	1.3	0.8	0	2
6	3.5	0	10.3	1.9
7	19	10.6	6.8	35.3
8	38.2	44.7	35.9	34.0
9	29	39.4	29.1	19.6
10	4.8	1.5	9.4	5.2
11	2.5	1.5	5.1	1.3
12	1.7	1.5	3.4	0.7

Source: Field Survey, 2013

Appendix I.7: Time of harvesting

Months	Benue (%)	Enugu (%)	Ondo (%)
January	0	31.7	0.7
February	0	0.8	0
March	0	0.8	0
April	0	0	0.6
May	0	0	1.3
June	0	0	24.4
July	0	0.8	39.4
August	0	1.6	21.8
September	0	2.5	4.6
October	3	1.7	3.9
November	25	29.2	2
December	72	30.8	1.3

Source: Field Survey, 2013

Appendix I.8: Time of harvest of major crops in yam enterprise

Month	Cassava (%)	Maize (%)	Okro (%)	Pepper (%)
January	15.1	1.2	2.4	1.0
February	3.1	0.0	2.4	1.0
March	12.9	0.6	0.0	2.0
April	14.7	0.0	1.2	9.0
May	16.1	2.5	3.6	21.0
June	10.6	26.5	11.9	15.0
July	3.6	0.0	22.6	17.0
August	1.8	19.1	23.8	15.0
September	2.2	5.6	10.7	5.0
October	0.9	0.6	13.1	6.0
November	9.0	2.5	3.6	6.0
December	10.2	1.9	4.8	2.0

Source: Field Survey, 2013

Appendix J: Sources of agricultural, information and the use of information communication technologies in Nigeria

Appendix J.1: Sources of agricultural information in Nigeria

Source	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Fellow farmers	70.3	66.7	85.8	58.3
Relations	16.9	17.5	25.0	8.3
Television	28.6	19.2	32.5	34.2
Extension Agents	36.7	50.8	10.8	48.3
None	3.3	8.3	0.8	0.8
Research Institutes	1.7	0	5.0	0
Traditional leaders	0.3	0	0.8	0

Source: Field Survey, 2013

Appendix J.2: Ranking of sources of agricultural information in Nigeria

Sources	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	Weighted average	Rank
Fellow farmers	59.5	6.4	1.9	0	0	21.92	1
Relatives	5.7	8.1	2.4	0.5	0.2	4.62	4
Television	22	4.7	2.4	0.5	0	9.13	3
Extension Agents	32	3.3	1.4	0.2	0	11.85	2
Research Institutions	2.1	0.2	0.5	0	0	0.85	5
Traditional leaders	0.2	0	0	0	0	0.07	7
No information Source	2.1	0	0	0	0	0.70	6

Source: Field Survey, 2013
Note: 1- 4 denote scores in increasing order of magnitude; the most important was Scored 5. These variables did not add up to one hundred because zero percent was excluded from the estimation.

Appendix J.3: Use of ICTs by Nigerian farmers

ICTs	Use of ICTs	Use of ICTs for agricultural business
Handset	94.5	89.3
Use telephone	0.9	0.7
Use computer	0.7	0
Use internet	0.7	0.2
Use fax	.2	0
Use email	1.2	0.2
Use Google	.7	0.7
Use Facebook	1.9	1.2

Source: Field Survey, 2013

Appendix J.4: Reasons for not using ICTs for Agricultural business

Reasons	Farmers (%)
Lack of knowledge	0.2
No ICTs in communities	0.7
No money to buy ICT	0.9
No contact persons	4.7
Not interested in ICTs	0.7
No reason	92.8

Source: Field Survey, 2013
Appendix K

Appendix K: Awareness, training and use of improved technologies

Appendix k.1.1: Awareness and use of improved yam varieties in Nigeria

Aware (%)	Tries (%)	Use (%)	Discontinued (%)
41.9	36.3	35.5	0.7

Source: Field Survey, 2013

Appendix K.1.2: Awareness, training and use of Yam Minisett Technology in Nigeria

Regions	Aware (%)	Tried (%)	Use (%)	Discontinued (%)	Training (%)
Nigeria	34.7	25.5	22.8	2.9	9.2
Enugu	59.8	51.4	47.7	2.8	3.8
Ondo	13.2	3.7	3.7	0.0	3.9
Benue	36.6	26.9	22.4	6.0	20.7

Source: Field Survey, 2013

Appendix K.2: Training on improved varieties

Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
13.5	36.6	0.8	4.5

Source: Field Survey, 2013

Appendix L: Reasons for non-adoption of improved varieties and Yam Minisett Technology in Nigeria

Appendix L.1: Limitations to use of improved varieties in Nigeria

Limitations	4 (%)	3 (%)	2 (%)	1 (%)	Weighted average	Rank
Improved varieties are expensive	3.8	10	3.6	0.9	5.33	2
Unavailability	21.1	9	4	0.2	11.96	1
Prefer local varieties	1.2	0.5	1.2	0.2	0.89	4
Do not know how to use improved varieties	10.9	0.0	0.0	0.0	4.36	3

Source: Field Survey, 2013
Note: 1- 4 denote scores in increasing order of magnitude; the most important was scored 4. These variables did not add up to one hundred because zero percent was excluded from the estimation.

Appendix L.2: Reasons for non-adoption of YMT

Reasons	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
No reason	24.2	22.2	50	3.9
Lack of knowledge	65.9	62.2	42.4	89
complex	1.9	3	2.3	0.6
time	2.6	3.7	1.5	2.6
expensive	0.5	0.7	0	0.6
lack of fertilizer	1.9	3.7	0.8	1.3
lack fund	1.9	3.7	0.8	1.3
0thers	1.2	0.7	2.3	0.7
Total	100	100	100	100

Source: Field Survey, 2013
Note: The percentage could exceed 100% because of multiple responses

Appendix M: Published paper

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LIMITATIONS TO YAM PRODUCTION ENTERPRISE DEVELOPMENT IN NIGERIA

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ABSTRACT

This paper determines the constraints to yam production enterprise development in Nigeria. A multi-stage random sampling technique was used to extract data from three hundred and sixty yam farmers in Nigeria. Data were analyzed with descriptive statistics. The investigation indicates that high cost of planting material, lack of fund, and unavailability of planting material impede yam production enterprise development in Nigeria. Nigerian yam farmers are poor and resource constrained. Unavailability of financial institutions in the rural areas of Nigeria, the major constraint to loan acquisition by yam farmers, prevents farmers from obtaining loan to purchase sufficient inputs for yam production. Nigerian yam producers adopt the indigenous yam production techniques. They use mainly planting materials from previous harvest. Macro sett is the commonly use type of planting material. The traditional yam production methods encourage the use of excessive and poor quality planting materials for yam production. In Nigeria, yam farmers obtain agricultural information from sources which could be unreliable. This research makes these three key recommendations: establishment of financial institution in the rural areas to increase farmer access to loan; development of an ideal farming system for yam that would increase the availability and affordability of seed yam; also recommended is for Nigerian yam farmers to obtain agricultural information from appropriate sources such as research institutes and extension agents.

Keywords: Limitations, Yam production, Enterprise development

INTRODUCTION

Nigeria is an agrarian economy with over seventy percent of the population engaged in agriculture (Encyclopedia of the Nations, 2015). Despite this, the country still depends heavily on food imports. There is potential for agricultural development in Nigeria (Chinedu & Okoro, 2009). However, this has not been harnessed to develop a sustainable agriculture. Nigeria could be more food secure if its favourable agricultural endowment could be explored and the conditions for farming improved.

Yam is a major staple widely accepted and consumed in Africa. It is important in the diet of people in yam-producing areas (Opara, 2003). Although low in protein and fat, yam has been found to be nutritionally superior to other root and tuber crops (Wanasundera & Ravindran, 1994). It is a highly prized crop in terms of sociocultural significance; evidenced by the annual celebration of New Yam Festival in some yam-producing areas. Yam has greater value than other comparable staples; it is an important source of farm income (Babaleye, 2003) and a major employer of labour in Nigeria (Verter & Bečvařova, 2015). Yam contains pharmacological substances (Lebot, 2009) which are used in the manufacture of drugs.

Nigeria is the leading yam producing country (Food and Agricultural Organization (FAO), 2015). Being a leading yam producer does not imply a higher yield than other yam-producing countries. Currently, Japan has the highest global yam productivity, followed by Papua New Guinea then Tonga (FAO, 2015). Although yam production in Nigeria has risen over time (FAO, 2012), yield has been declining (Ikeh et al., 2012). Increased yam production is due to expansion of land area under yam cultivation.

The traditional yam production techniques practiced in Nigeria are expensive, labour intensive, physically demanding and limit mechanization of yam farming in Nigeria (Authors' observation, 2013; Okoro, 2008; Opara, 2003). Large quantities of inputs, especially planting materials, are required for yam production using traditional methods (O'Sullivan, 2010). Over reliance on traditional farming systems contributes to food insecurity in Nigeria. Farmers usually use poor quality seed yams obtained from last harvest. However, the use of poor quality seed yams has contributed to declining yam productivity. There are no standard storage facilities for yam and this has contributed to significant loss of yam during storage. There is an urgent need to improve the current state of yam farming to enhance yam production. The traditional production techniques for yam in Nigeria are inadequate to meet the demand from the Nigerian population. This project describes yam production in the predominantly yam-growing States of Nigeria. It discloses the perception of farmers on the development of yam production enterprises. It also determines the constraints to yam production enterprise in Nigeria.

MATERIALS AND METHODS

A multi-stage random sampling technique was adopted in collecting cross sectional data from yam farmers in Nigeria. The first stage involves a random selection of three agro-ecological zones of Nigeria. The second stage involves a random selection of three yam-producing States, producing a minimum of 1.2 million metric tonnes of yam per annum. The States include Benue, Enugu and Ondo. The third stage involved random selection of two major yam-producing Local Government Areas (LGAs) from each State. The LGAs selected were Buruku and Katsina-Ala in Benue State, Nkanu-east and Uzo Uwani in Enugu State, and Owo and Ose in Ondo State. A total of three hundred and sixty (360) respondents were selected from Nigeria. Primary data were used for this study. Primary data were collected from the respondents by using a well structure questionnaire and by direct observation. Data collected include resource endowment data (such as availability of inputs, information and credit); resource utilization data (such as labour, land use, planting materials and use of fertilizer); and attitudinal data (such as farmers' responses to issues on yam production). Data were analyzed with descriptive statistics.

RESULTS AND DISCUSSION

Farmer willingness to expand area under yam production in Nigeria

This research suggests that the majority of Nigerian yam farmers are willing to expand the scale of yam production. Table 1 presents farmers responses on willingness to expand area under yam production in Nigeria. Farmers in Benue were more willing to expand yam production.

Table 1: Farmer willingness to expand area under yam production in Nigeria

Expand of yam production	Nigeria (%)	Benue (%)	Enugu (%)	Ondo (%)
Willing to expand	96.0	97.8	95.5	94.8
Reasons for not willing to expand				
Lack of fund	1.4	0.7	1.5	1.9
Unavailability of land	0.2	0	0.8	0
Lack of access to fertilizers	0.7	0.7	0.8	0.6
High cost of fertilizers	0.2	0	0	0.6
Unavailability of seed yam	0.2	0	0	0.6

Source: Field Survey, 2013

Negligible population of the farmers (4%) were reluctant to expand production. The few who were unwilling to expand yam production indicated lack of funds as the main reasons why they were unable to expand yam production in Nigeria.

Hindrances to yam production enterprise development in Nigeria

Table 2 shows the hindrances to yam production enterprise development in Nigeria.

Table 2: Ranking of hindrances to yam production enterprise development in Nigeria

	1(%)	2(%)	3(%)	4(%)	Weighted Average	Rank
High cost of planting material	0	0.5	1.9	16.1	7.11	1
Unavailability of planting material	0	0	1.4	3.3	1.74	3
Lack of fund	0	0.2	1.7	16.1	6.99	2
Lack of time	0	0	0	0.2	0.08	6
Have adequate farm	0.2	0.5	0	0.2	0.2	5
No strength to plant more	0.2	0.2	0.2	0.9	0.48	4

Source: Field Survey, 2013

Note: 1- 4 denote scores in increasing order of magnitude; the most important was scored 4. Ranking is in decreasing order of magnitude; the most severe was ranked 1. The percentage of the variables did not add up to one hundred because zero score was excluded.

It reveals that high cost of planting material, lack of fund and unavailability of planting material are the major constraints to yam enterprise development in these States. Yam farmers are mostly poor and have insufficient funds to purchase the inputs required for yam production. This is consistent with Omojola (2014) who reported that yam production in Osun State of Nigeria is mostly limited by lack of capital, scarcity of planting material and high cost of planting material.

Availability and use of inputs

An assessment of farmer access to farm inputs in Nigeria discloses that most Nigerian yam farmers have difficulties acquiring loans for purchasing farm inputs. Table 3 shows availability and use of inputs in Nigeria. Farmers in Benue State had more difficulties acquiring farm inputs. It was less difficult to access inputs in Ondo State. Most of the yam farmers admitted that they employed sufficient labour for yam production. However, a significant percentage of the farmers used insufficient labour. Benue State had access to labour than other States followed by Enugu then Ondo.

Table 3: Availability and use of inputs

Farmers situation	Nigeria(%)	Benue(%)	Enugu (%)	Ondo(%)
Have difficulty acquiring farm input	76.4	86.7	85.8	56.7
Employ adequate labour	62.5	68.3	60.0	59.2
Use fertilizer	78.6	99.2	90.0	46.7
Have difficulty obtaining loan	66.5	86.7	65.9	50.3
Use adequate planting material	58.5	62.2	53.8	59.4

Source: Field Survey, 2013

The vast majority of yam farmers in Nigeria used fertilizer for yam production. Nevertheless, they used below the recommended rate of fertilizer. Fewer farmers in Ondo used fertilizer for yam production. Although yam is nutrient demanding and thrives on fertile soil, unexpectedly some Nigerian farmers deliberately avoid the use fertilizers for yam production.

Loan acquisition is a serious challenge faced by Nigerian yam farmers. A significant percentage of the farmers had difficulties obtaining loans. It was more difficult to access loans in Benue State. Ondo farmers had less difficulty acquiring farm loans.

Limitations to input acquisition in Nigeria

Distribution of the respondents according to limitations in input challenge is shown in Table 4 below.

Table 4: Limitations to input acquisition in Nigeria

Limitations	Farmers (%)
Lack of fund	46.0
Unavailability of input	20.8
Untimely inputs	2.6
High cost of input	13.3

Source: Field Survey, 2013

Nigerian farmers are poor and lack the funds to acquire sufficient farm inputs. Table 4 highlights the limitations to input acquisition in Nigeria. Approximately 46% of the respondents specified lack of fund as the major constraint to input acquisition in Nigeria. The Table also indicates that unavailability of inputs hinders its acquisition in Nigeria. High cost of input is another limitation to input acquisition. Approximately 13.3% of the respondents indicated it as a constraint to input acquisition in Nigeria.

Few farmers have reported that untimeliness of inputs such as fertilizer and planting materials prevent the use of inputs by yam farmers in Nigeria.

Sources of capital for yam production in Nigeria

The investigation of the sources of capital for yam production in Nigeria reveals that Nigerian yam farmers obtain funds for yam production mainly from non-farm activities. Table 5 highlights the sources of capital for farm activities in Nigeria. The vast majority of the farmers

Table 5: Sources of capital for yam production

Income Sources	Nigeria(%)	Benue(%)	Enugu(%)	Ondo(%)
Non-farm income	97.1	97	94.3	99.4
Bank loan	6.6	6.7	4.1	8.4
Local Saving Scheme	14.1	26.9	5.7	9.7
Loan from friends and relations	24.8	14.2	29.3	30.5
Money lender	1.5	2.2	0	1.9
Loan form cooperative	4.9	0.7	5.7	7.8
Gift	1.5	0	3.3	1.2

Source: Field Survey, 2013; Multiple Responses recorded

(approximately 97%) used non-farm income for yam production. Some yam farmers obtained loans from friends and relations. More Enugu farmers borrowed funds from friends and families. Other farmers obtained loans from local saving schemes. Those who obtained funds from the local saving schemes were more in Benue State. Few Nigerian farmers borrowed money for yam farming from the commercial banks; more farmers in Ondo fall into this category. Farmers in the State had more access to financial institutes and were able to obtain loans from the Banks. Other sources of farm income in Nigeria include cooperatives, money lenders and gifts.

Constraints to loan acquisition in Nigeria

Constraints to loan acquisition in Nigeria is presented in Table 6 below.

Table 6: Constraints to loan acquisition in Nigeria

Problems	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
High interest rate	15.4	3.1	8.3	1.2	0.2	7.8	4
Unavailability of loan	16.1	15.6	9.7	0.9	0	11.6	2
Unavailability of Financial Institution	25.1	14.9	5	0.5	0	13.4	1
Lack of knowledge on how to obtain loan	18.7	9.2	7.3	0.5	0	10.2	3
Reluctant to obtain loan	4	1.2	1.9	0.2	0	2.1	5
Other problems	1.7	0.2	0.2	0	0	0.7	6

Source: Field Survey, 2013

Note: 1- 5 denote scores in increasing order of magnitude; the most important was ranked 1.The percentage of the variables did not add up to one hundred because zero score was excluded.

Table 6 shows the constraints to loan acquisition in Nigeria. Yam farmers are interested to obtain loan. However, lack of financial institutions in the rural areas is the major limitation to loan acquisition by Nigerian yam farmers as it ranks first. Table 6 also indicates that unavailability of loan ranks second. This is another reason why farmers are unable to obtain loan in Nigeria. Ignorance of how to obtain loan ranks third. Many Nigerian yam farmers are ignorant of loan acquisition from the financial institutions; this hinders them from obtaining loans from the Banks.

Ranking of sources of planting material used for yam production in Nigeria

Table 7 shows the ranking of sources of planting material for yam production in Nigeria.

Table 7: Ranking of sources of planting material used for yam production in Nigeria

Sources of planting material	4(%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
Own farm	82.9	9	1.4	0.2	36.16	1
Research institute	0	0.5	1.2	0.5	0.44	5
Market	21.1	31	20.9	0.2	21.94	2
Fellow farmers	10.2	29.1	10.7	0.5	15	3
Extension agents	1.4	0	2.1	0.2	1	4

Source: Field Survey, 2013

Note: 1- 4 denote scores in increasing order of magnitude; the most important was ranked 1. These variables did not add up to one hundred because zero percent was excluded from the estimation.

The main sources of planting material for yam production in Nigeria are own farms, local markets and fellow farmers. Planting materials from these sources often have poor quality and are disease infested. Aighewi et al. (2015) observed that seed yams are subject to contamination with pests and disease pathogens in the traditional yam production system in Nigeria. International Institute of Tropical Agriculture, IITA (2009) observed that the use of such planting material leads to a build-up of disease causing organisms and reduction in yield. Few Nigerian yam farmers obtained planting material from research institutes and ADPs, which are the reliable sources of planting material.

An analysis of the adequacy of planting material used for yam production in Nigeria has shown that most Nigerian yam farmers use insufficient and poor quality planting material obtained mainly from their farms for yam production; this has adverse effect on yam yield. In Nigeria, over 40 percent of the farmers used inadequate planting materials for yam production (see Table 3). The adequacy of planting material differs between regions. Benue has a relatively higher adequacy in the use of planting material while Enugu had the lowest.

Ranking of types of planting material used for yam production in Nigeria

Table 8 shows the ranking of the types of planting material used for yam production in Nigeria.

Table 8: Ranking of types of planting material used for yam production in Nigeria

Types of planting material	4 (%)	3 (%)	2 (%)	1 (%)	Weighted average	Rank
YMT	17.5	3.6	1.2	0	8.32	4
Mini tuber	32.7	5	3.8	0	15.34	3
Milk yam	34.8	6.2	4.7	0.2	16.74	2
Macro sett	51.5	12.1	5.2	0.2	25.29	1

Source: Field Survey, 2013

Note: 1- 4 denote scores in increasing order of magnitude; the most important was ranked 1. The percentage of the variables did not add up to one hundred because zero score was excluded.

It indicated that macro sett was the major type of planting material used for yam production in Nigeria. A significant quantity of planting material is required for yam production using this technique (O'Sullivan, 2010). Seed yam obtained from YMT was the least used type of planting material for yam production in Nigeria. Nigerian yam farmers mainly use macro setts for yam production. This method of yam production requires the use of yam tubers meant for food as planting material. This type of planting material is inappropriate for yam production. It is susceptible to diseases and rot due to exposure of cut yam surface, which could cause low yield of yam.

Constraints to planting material acquisition in Nigeria

Table 9 presents the limitations to planting material acquisition in Nigeria

Table 9: Ranking of the constraints to planting material acquisition

Limitations	4 (%)	3 (%)	2 (%)	1 (%)	Weighted Average	Rank
Costly	16.1	1.9	0.5	0	7.11	1
Unavailability	3.3	1.4	0	0	1.74	3
Lack of fund	16.1	1.7	0.2	0	6.99	2
Lack of time	0.2	0	0	0	0.08	5
Lack of strength	0.9	0.2	0.2	0.2	0.48	4

Source: Field Survey, 2013

The major constraints to planting material acquisition in Nigeria are high cost of planting materials, lack of fund to purchase them and unavailability of planting materials. Planting material for yam production in Nigeria is expensive, this limits its acquisition. Nigerian yam farmers are poor and resource constrained. They lack fund to purchase sufficient planting material for yam production. Other factors preventing yam **Agricultural** farmers from obtaining planting materials include lack the strength and time to purchase seed yams and plant more yams.

Ranking of sources of agricultural information in Nigeria

Table 10 shows the ranking of sources of agricultural information in Nigeria.

Table 10: Ranking of sources of agricultural information in Nigeria

Sources	**5 (%)**	**4 (%)**	**3 (%)**	**2 (%)**	**1 (%)**	**Weighted average**	**Rank**
Fellow farmers	59.5	6.4	1.9	0	0	21.92	1
Relatives	5.7	8.1	2.4	0.5	0.2	4.62	4
Television	22	4.7	2.4	0.5	0	9.13	3
Extension agents	32	3.3	1.4	0.2	0	11.85	2
Research Institutions	2.1	0.2	0.5	0	0	0.85	5
Traditional leaders	0.2	0	0	0	0	0.07	7
No information source	2.1	0	0	0	0	0.70	6

Source: Field Survey, 2013

Note: 1- 4 denote scores in increasing order of magnitude; the most important was scored 5. These variables did not add up to one hundred because zero percent was excluded from the estimation.

There is poor dissemination of agricultural information and technology in Nigeria. Nigerian yam farmers obtain agricultural information mainly from fellow farmers. This confirms Rimi et al (2015), who noted that the major source of agricultural information in Katsina State of Nigeria was fellow farmers. However, this information could be unreliable and have a negative impact on farmer performance. Information is usually altered down the communication line (Talloo, 2007). Therefore, yam farmers are likely to obtain low quality information from other farmers. This could have adverse effect on their performance.

CONCLUSION

Yam production in Nigeria is mainly limited by unavailability and high cost of planting materials and lack of fund. Farmers have insufficient funds to purchase ample inputs for yam production. Nigerian yam farmers lack access to financial institutions. This prevents them from obtaining loans for yam production. Provision of financial support to farmers is crucial in developing the Nigerian yam enterprise. Nigerian yam farmers obtain income for yam production mainly from non-farm activities. They had difficulties acquiring loans and farm inputs. Most yam farmers accepted that they employed adequate labour for yam production. However, significant percentage of the farmers used insufficient labour.

The majority of the farmers also indicated that they used adequate fertilizer for yam production. Nevertheless, the quantity of fertilizer these farmers use for yam production is below the fertilizer requirement for yam production in Nigeria. Increased farmers' access to financial institutions, provision of financial support to farmers and input subsidy would contribute to developing yam production enterprise in Nigeria.

This research suggests that the indigenous yam production method adopted by most farmers in Nigeria is a setback to yam enterprise advancement. Development of an alternative farming system for yam that would increase the availability and affordability of planting materials, boost yam yield and reduce the cost of yam production would contribute to the development of the Nigerian yam enterprise.

Farmers obtain agricultural information mainly from fellow farmers. This source of information could be unreliable. Sourcing agricultural information from reliable sources such as research institutes and extension agents would enhance farmer performance.

RECOMMENDATIONS

1. Establishment of financial institutions in the rural areas of Nigeria to increase farmers' access to loan for farm activities.
2. Subsidizing inputs to increase their affordability.
3. Provision of financial support to farmers to make fund available for yam production.
4. Development of an ideal farming system for yam that would increase the availability and affordability of seed yam.
5. Nigerian yam farmers should be encouraged to obtain information from appropriate sources such as research institutes and extension agents.

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EVALUATION OF YAM-BASED PRODUCTION ENTERPRISES IN NIGERIA

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ABSTRACT

This research investigated yam based production enterprise in Nigeria to identify the ideal farming system for yam. Data were extracted from 360 respondents in selected major yam-producing States in Nigeria. Data were analysed by the use of descriptive statistics and economic analysis. The result of this investigation reveals that yam production is profitable but it requires a large capital outlay. Yam production was more profitable that other comparable crops. There are infinite cropping systems for yam in Nigeria. All the dominant cropping systems for yam are profitable. Yam/maize intercropping system is the most profitable crop system for yam in Nigeria. The key recommendations from this research are increased investment in yam production; adoption of Yam/Maize intercropping system; and the development of an appropriate yam production technique that will reduce the cost of yam and make its production more profitable.

Introduction

The food situation and the conditions of Nigerian farmers are critical. Nigerian food producers are predominantly resource-constrained poor farmers, who are the most food insecure (Otaha, 2013; World Food Programme, 2015). They are unable to produce adequate food for their families (Otaha, 2013). Adoption of appropriate farming technologies and systems can improve farmer performance. This research assessed Nigerian yam production enterprises to identify improved cropping systems for yam. This project illustrated a more profitable yam production system and improved farmer wellbeing. Yam is a significant crop in Nigeria. It is a highly prized crop in the country. It has sociocultural, medicinal, nutritional and economic values. It is nutritionally superior to comparable crops including sweet potato and taro (Wanasundera and Ravindran, 1994). Notwithstanding, yam farmers in Nigeria are performing poorly, in particular there is declining yam yield. Yam production in Nigeria is mainly impeded by high costs, unavailability of appropriate planting materials, and over reliance on labour-intensive indigenous yam production methods. These methods are expensive, encourage the use of low quality planting materials, and inhibit mechanization of yam production. There is a need to embrace an ideal farming system for yam in Nigeria. Mechanization of yam farming would reduce the drudgery of yam production but current production practices and varieties use for yam production limited mechanization possibilities (Opara, 2003). Developing the Nigerian farming system would encourage mechanization. This could increase yield and the profitability of yam production. Assessing yam based production enterprise in Nigeria will lead to the identification of appropriate yam production techniques for a more economically viable yam production. The trend in profitability analysis in Nigeria is usually to determine the economic viability of a particular crop or cropping system in a given region (for example, Asala and Ebukiba, 2016; Ibitoye and Onimisi, 2013). This study evaluated the major cropping systems for yam in Nigeria to identify the most profitable intercrop. It also compared the profitability of the main crops in yam production systems.

Methodology

A multi-stage random sampling technique was used to elicit data from Nigerian yam farmers for yam production. Data were extracted from three hundred and sixty respondents by the use of a well-structured questionnaire and by direct observation. Three yam-producing agroecological zones were randomly selected. Three States producing a minimum of 1.2 million metric tonnes of yam per annum were randomly selected from the zones. The States were Benue, Enugu and Ondo, from different geographical zones. The next stage of sampling involved randomly selecting two major yam-producing Local Government Areas (LGAs) from each State. The LGAs selected were Buruku and Katsina-ala in Benue State, Nkanu-east and Uzo-Uwani in Enugu State, and Owo and Ose in Ondo State. Sixty respondents were randomly selected from each LGA, making a total of three hundred and sixty farmers.Data collected include input and output data for the farm activities. Data were also

collected on prices, and cropping systems. Descriptive statistics were used to describe the different yam production systems.Farm-level economic results were compared using Gross Margin (GM) analysis to determine the profitability of yam, and to evaluate the cropping systems for yam in Nigeria. This analysis used information obtained from the three sampled States to represent the entire country. From the sampling technique used for this project, aggregated data from the States is a good representative of the country. Each yam producing State had equal chance of being selected. There were one hundred and twenty respondents from each State and three hundred and sixty for the country.

Results and Discussion

Cropping systems for yam in Nigeria

Source: Field survey, 2013

Yam is mainly intercropped in Nigeria. There are numerous cropping systems for yam in Nigeria. Table 1 displays the number of intercrops for

Table 1: Number of intercrops for yam in Nigeria

Regions	Nigeria	Benue	Enugu	Ondo
Number of intercrops	108	25	50	57
Maximum number of combined crops	7	5	6	7

Source: Field survey, 2013

Table 2: Percentage crop combination for yam in Nigeria

Number of crops	**Nigeria (%)**	**Benue (%)**	**Enugu (%)**	**Ondo (%)**
1	17.8	35.6	10.8	7.8
2	21.7	39.4	11.7	14.4
3	18.8	17.4	15.8	22.4
4	21.7	5.3	27.5	31.2
5	17.3	2.3	31.7	19
6	2.5	0	2.5	4.5
7	0.2	0	0	0.7

yam in Nigeria. It revealed that there were over 100 cropping systems identified for yam in the country. Ondo State had the highest number of yam intercrops and fewest in Benue State. Table 2 presents the percentage crop combinations for yam in Nigeria. It shows that there are mainly two to four crop combinations for yam in Nigeria. However, some yam farmers practice sole cropping. There are more farmers practicing monocropping in Benue than in other State. Most farmers in the State combine only two crops. The majority of farmers in Ondo had four crop combinations. Yam farmers in Enugu State mainly combine five crops.

Surprisingly, yam alone is the dominant cropping system for yam in Nigeria, especially in Benue State (Table 3). Although, we have earlier reported that yam is mostly intercropped in Nigeria. A further investigation of the various cropping systems indicates that yam alone is the predominant cropping system for yam in Nigeria. This is due to the large number of crop combinations for yam in the country. Yam is primarily intercropped with cassava in Nigeria.

Other major intercrops for yam in Nigeria include Yam/Maize, Cassava/ Yam/ Maize, Yam/Cassava/ Pepper and Yam /Maize/ Pepper (Table 3)

Table 3: Major cropping systems for yam in Nigeria

Cropping system	**Nigeria (%)**	**Benue (%)**	**Enugu (%)**	**Ondo (%)**
Yam only	17.8	35.6	10.8	7.7
Yam/Cassava	14.3	36.4	2.5	4.6
Yam/Cassava/Maize	5.4	1.5	7.5	7.2
Yam /Maize	2.5	0.8	4.2	2.6
Yam/Cassava/Okro	1.5	4.5	0	0
Yam/Cassava/Pepper	2.2	3	0	3.3
Yam/ Cassava/Okro/Melon	1	0	5.8	2.6
Yam/ Maize/ Melon/ Okro	1.9	0	5.8	0.7
Yam/Fluted pumpkin	1.5	0	5	0
Yam/Maize/Pepper	2.2	0	0	5.9
Yam/ Pepper	1.9	0.8	0	4
Yam/ Cassava/ Melon /Pepper	1.7	0	0	4.6
Yam/ Cassava/Melon/Maize/Pepper	2	0	0	5.2

Source: Field survey, 2013

Profitability of selected root and tuber crops

In this investigation, we assume that all commodities produced were sold. An economic evaluation of the major crops in yam production enterprise demonstrates that yam production is more profitable than other comparable crops. However, a large capital outlay is required (Table 4). It has a higher GM than other root and tuber crops. This indicates that it is more profitable than other root and tuber crops. Farmers generate more income per hectare yam production than from other root and tuber crops. However, an economic analysis of the crops based on return per Naira shows that cassava is the most economically viable root and tuber crop. It had a return per Naira of 1.93. This implies that cassava is profitable by returning ₦1.93 for every ₦1 invested. Yam has a return per Naira of 1.82. This shows that it is profitable by returning ₦1.82 for every ₦1 invested.

Table 4: Economic evaluation of selected root and tuber crops

Items	Yam	Cassava	Sweet potato	Cocoyam
Revenue (₦/ha) (A)	901,399	375,296	319,567	314,465
Planting material for yam	72,631	25,715	15,267	58,806
Fertilizer for yam	16,779	10,921	14,379	7,813
Staking material ₦/ha	53,219	-	-	-
Organic manure for yam	17,423	2,587	1,988	23,203
Pesticide for yam	8,127	1,826	2,833	7,614
Herbicide for yam	9,377	1,562	5,636	8,280
Land preparation	69,717	61,618	61,632	62,958
Planting	16,352	10,258	7,165	10,795
Fertilizer application	3,848	4,505	4,330	5,654
Mulching	4,910	-	-	1,167
Staking	32,727	-	-	-
Application of pesticide and herbicide	7,464	4,443	998	3,915
Weeding	91,146	50,569	49,597	34,043
Harvesting	92,738	20,437	39,614	20,190
Variable cost (B)	496,458	194,442	203,439	244,439
GM=A-B	404,941	180,854	116,128	70,026
Return per Naira	1.82	1.93	1.57	1.29

Source: Field survey, 2013
Note: 1 USD = ₦160

Evaluation of the major crops in yam production system

Although yam production in Nigeria is more expensive than other crops, yam production is relatively profitable. An economic evaluation of the major crops in yam production enterprise demonstrates that has a higher GM than the other crops (Table 5). Yam farmers generated more money relative to farm size. Comparing the enterprises on return per Naira indicates that pepper production is most profitable. It had a higher return per Naira (2.10). This signifies a return of ₦2.10 for every ₦1 invested in pepper production. on enterprises

Table 5: Gross margin of major crops in yam production

Items	Yam (₦)	Cassava	Pepper	Maize	Okro	Melon
Revenue (₦/ha) (A)	901,399					
Planting material for yam	72,631	25,715	8,752	8,987	7,777	9,557
Fertilizer for yam	16,779	10,921	10,128	10,995	14,192	7,342
Staking material ₦/ha	53,219	-	-	-	-	-
Organic manure for yam	17,423	2,587	9,245	8,313	8,436	5,648
Pesticide for yam	8,127	1,826	7,763	8,769	8,081	4,609
Herbicide for yam	9,377	1,562	7,155	6,029	7,353	5,020
Land preparation	69,717	61,618	64,778	61,732	63,367	59,573
Planting	16,352	10,258	8,341	9,366	8,575	10,403
Fertilizer application	3,848	4,505	7,070	8,681	6,521	6,540
Mulching	4,910	-	-	-	-	-
Staking	32,727	-	-	-	-	-
Chemical application	7,464	4,443	5,276	18,126	4,553	3,915

Weeding	91,146	50,569	26,025	32,828	29,391	28,099
Harvesting	92,738	20,437	11,808	20,273	12,069	21,037
Variable cost (B)	496,458	194,442	166,342	194,098	170,314	161,744
GM=A-B	404,941	180,854	183,774	101,419	25,966	74,895
Return per Naira	1.82	1.93	2.10	1.52	1.15	1.46

Source: Field survey, 2013

Note: 1 US $ = ₦160

Economic analysis of the major cropping systems for yam in Nigeria

The result of this investigation detects that all the dominant yam cropping systems are profitable (Table 6). Yam /Maize intercrop was the most profitable cropping system. It had the highest Net Return and Return per Naira (2.76). It returns ₦2.27 for every ₦1 invested. Yam/cassava /maize intercrop was the least profitable cropping system. It had the lowest profit and return per Naira (1.75). This signifies a return of ₦1.75 for every ₦1 invested in Yam/Cassava /Maize intercrop. This research also reveals that sole yam is more profitable than Yam/Cassava intercrop. It had a Net Return of 2.65. This indicates that it is profitable by returning ₦2.65 to every ₦1 invested.

Table 6: A comparative economic analysis of major yam cropping systems in Nigeria

	Yam	Yam/Cassava	Yam/Maize	Yam /Cassava/Maize
Revenue Yam	1,225,576	841,534	1,170,267	886,871
Revenue from cassava	-	328,214	-	296,450
Revenue from maize	-	-	326,282	186,925
Total revenue (A)	1,225,576	1,169,749	1,496,549	1,370,246
rent	15,416	15,315	15,124	15,026
Depreciated cost of capital	1,484	4,770	3,554	7,226
Price of planting material	60,625	84,065	83,663	100,282
stakes ₦ /ha	86,813	46,963	82,692	412,134
Fertilizer	0	23,241	19,731	16,778
Organic manure	6,000	0	0	0
Herbicide	12,000	1,980	1,846	5,580
pesticide	0	1,563	0	157,985
Land preparation	62,794.79	91,542	69,717	99,684
Planting	15,953	28,700	20,471	39,065
weeding	101,462	133,492	126,300	155,691
Harvesting	99,875	126,917	118,154	146651
TFC	16,900	20,085	18,678	22,252
TVC	445,523	538,464	522,575	762,930
TC (B)	462,423	558,549	541,254	785,182
profit (A-B)	763,153	611,200	955,296	585,064
Return per Naira	2.65	2.09	2.76	1.75

Source: Field survey, 2013

Note: 1 US $ = ₦160

Conclusion

The study noted the numerous number of possible crop combinations for yam in Nigeria. Yam/Maize is the most profitable cropping system for yam in Nigeria. The research also shows that yam production is profitable but a large capital outlay is required. This shows that farmers will make more profit relative to farm size if they increased investment in yam production. Nigerian farmers have small farms, and so investing in yam production should enable them make more profit and escape poverty. Although cassava has a higher return per naira than yam, since an average Nigerian has small farm, it is advisable for the farmers to invest in yam production for more effective and profitable use of land. Embracing Yam/Maize intercrop and increased investment in yam production can contribute to improving the poverty status in Nigeria. Reduction in the number of crop combinations for yam will contribute to improving the performance of yam farmers. Developing an alternative yam production method that will reduce the cost of yam will make its production more profitable.

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IMPACT OF ADOPTION OF YAM MINISETT TECHNOLOGY ON PERFORMANCE OF

SMALL-HOLDER FARMERS IN NIGERIA: A PROPENSITY SCORE MATCHING

ANALYSIS

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ABSTRACT

There is global food insecurity which could be attributed to poor performance of the agricultural sector in the developing

technologies have been developed and disseminated to farmers. These include Yam Minisett Technology. In spite of this, there is food insecurity and poverty intensification in the country. This raises the questions whether or not farmers are adopting these technologies and the efficacy of these technologies in enhancing farmer performance and alleviating poverty in the country. This research investigates the potential of YMT to improve the performance of yam farmers. The study also evaluates the use of Propensity Score Matching in assessing the impact of a technology on performance/wellbeing.

Keyword: Yam minisett technology, adoption, performance, and Propensity Score Matching

Introduction

Food situation and the conditions of Nigerian farmers are critical. Most previous studies have failed to address the problem of food insecurity in the country due to the use of inappropriate methods. The persistent food insecurity in Nigeria has raised doubts about the potential of new technology to improve farmer performance /wellbeing. There is the need to ascertain whether farmers are adopting new technologies and the efficacy of these technologies in improving farmer performance and reducing poverty. The objectives of this research are to describe the socioeconomic characteristics of Nigerian yam farmers; estimate the technical efficiency of the farmers; ascertain the determinants of adoption of YMT; investigate the role of improved technology on farmer performance enhancement for wellbeing improvement with reference to yam production and Yam Minisett Technology (YMT) in Nigeria; and evaluate the use of Propensity Score Matching (PSM) in assessing the impact of a technology on performance.

Agricultural Research and Development (R&D) is generally believed to be significant in ensuring food security and alleviating global poverty. In order to reduce food insecurity, improved technologies, believed to boost agricultural productivity, have been developed and disseminated (Sanginga, 2015; Arokoyo, 1996), including improved varieties and YMT in Nigeria.

YMT is a rapid seed yam multiplication technique whereby whole-yam tubers containing periderm and cortex parenchyma are cut into small setts of 25-100g and treated for seed yam production (Aighewi et al., 2014). The main idea of YMT is to multiply seed yam for yam production. The traditional methods of yam production require the use of large quantity of yam tubers as planting material (NBS, undated). YMT was developed by NRCRI (Okoro, 2008), with the view to boost yam production by curbing the problem of scarcity of seed yam (making planting material available to farmers at a reduced cost). It reduces the excessive use of yam tubers as planting material. From five to ten percent of harvested yam is required for seed yam production using YMT while from 30 to 50% is required for yam production using indigenous yam production methods (Asiedu et al., 2009). YMT is less complicated and can generate large yams with minimal inputs (Okoro, 2008). It has been reported to produce seed yams up to 900 grams (Ogbonna et al., 2011). Despite this, there is still declining yam productivity (Amujoyegbe & Elemo, 2012). The issue is whether farmers are adopting these new technologies and the significance of the technologies on farm performance and farm family wellbeing.

Inappropriate agricultural policies based on faulty research methods worsen the pre-existing conditions. There have been many studies on adoption of agricultural technologies (e.g. Gbegeh & Akubuilo (2013); Akinola & Owombo (2011); Nchinda et al. (2010); Okoedo-Okojie & Onemolease (2009); Udoh et al. (2008); Agwu et al. (2008); Adegbola & Adekambi (2010); Eyitayo et al (2010). Previous studies on YMT in Nigeria were mainly to ascertain rate of adoption of the technology, determinants of adoption, and profitability of the technology. There are inadequate information on the performance of yam farmers in Nigeria. Few studies evaluated the impact of a technology on production performance and wellbeing (for instance, Adofu et al., 2013). However, the methods used by these previous research to evaluate the impact of technology on performance and wellbeing on production performance can give misleading results since they fail to take into consideration the counterfactual situation of the farmers (that is what the situation would be if technologies were not adopted (Wu et al., 2010, Mendola, 2007). As such, this method gave a biased estimate of the impact of such technologies on farmers' performance/wellbeing. Thus, this method has affected policies on agricultural technology advancement.

Technologies are not randomly assigned to farmers. If they were, then the effect of adopting a technology on their wellbeing would be the income difference between the adopters and non-adopters. The adoption of technology is based on self-selection which is influenced by the socioeconomic characteristics of the farmers. Before an observed change is attributed to the adoption of a particular technology, it is necessary to determine what the situation would be if the technology was not adopted. The observed change could be due to other factors rather than the adoption of the technology. One possible way of eliminating selection bias is the use of Propensity Score Matching (PSM), in which the behaviour of a given adopter is inferred by matching them with an equivalent nonadopter (Wu et al., 2010). The use of Propensity Score Matching (PSM) in assessing the impact of a technology on farmers' wellbeing eliminates the interference of other factors that could contribute to wellbeing. This current study employed Propensity Score Matching, a more appropriate method (Wu et al., 2010; Mendola, 2007), to determine the impact of YMT on yam farmer performance.

Methodology

Cross sectional data was obtained from 360 yam farmers in Benue, Enugu and Ondo. Stochastic frontier production function was used to estimate the TE of the farmers. The impact of adoption of YMT on TE was ascertained using PSM. Before estimating non-parametric propensity score, the first step is to ascertain the determinants of adoption of improved technology by using Probit analysis. Logit and Probit models are standard approaches to measuring binary dependent variables. These two approaches give similar results. Farmers are then grouped based on similarity in conditions that could influence adoption of technology and TE. Adopters and non- adopters of the technology are then regressed based on their performance. This eliminates the interference of other determinants of adoption. T-test was performed to compare the mean technical efficiencies of adopters and non-adopters of YMT before and after PSM. Ttest was also conducted to test the hypothesis that adoption of YMT has a significant effect on farmer performance. The hypothesis that the socioeconomic characteristics of farmers affect the adoption of YMT was tested with Z-test generated from the Probit model.

The Probit/Logit model is expressed implicitly as:

$$Y_i = b_0 + b_i X_i + E \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

where Y_i has the value of either 0 or 1 The effect of a technology is the difference between the performance of farmer adopting a technology (A=1) and not adopting the technology (A=0) expressed as:

$E^T = (Y_i^1 - Y_i^0)$ ……………………………………2

In reality, farmers either do or do not adopt a technology. The performance of a farmer is either Y_i^1or Y_i^0.

The unobserved wellbeing is the counterfactual situation. This is what the situation of the farmers would have been had they not adopted the technology. The observed performance of the farmer can be written as:

$Yi= A Y_i^1 + (1\text{-}A) Y_i^0$ ………………………….. 3

According to Wu et al. (2010), the quantity of interest in the counterfactual framework is the Average Technology Effect (ATE). The ATE for the whole sample is the weighted average of the technology effect for the adopters and non-adopters (Wu et al., 2010). The ATE for the whole sample is the expected effect of the technology across all farmers expressed as:

ATE= P. [E $(Y^1|A=1)$-E $(Y^0 |A=1)$] + (1-P). [E

$(Y^1|A=0)$-E $(Y^0 |A=1)$] … 4 where P is the probability of adopting improved technology (A=1), E $(Y^0 |A=1)$ is the expected value of non- adopters adopting the technology while E $(Y^1|A=0)$ is the expected value of adopters not adopting the technology. The counterfactual states, E $(Y^0 |A=1)$ and E $(Y^1|A=0)$ are unobserved. The counterfactual wellbeing of the farmers should be constructed in estimating the ATE. The ATE for the adopters can be written as:

ATE_A = $(E^T|A=1)$ = E [$(Y^1|A=1]$ –E [$(Y^0|A=1]$ … 5 The problem of self-selection bias is obvious in the above equation as the condition E $[(Y^0|A=1]$ is unobservable. The non-adopters can be used to compare the adopters if the condition E $[(Y^0|A=1] = [(Y^0|A=0]$ is satisfied.

The Average Technology Effect ATE–the expected effect of the technology across all farmers is expressed as:

ATE= P. [E $(Y^1|A=1)$-E $(Y^0 |A=1)$] + (1-P). $[Y^1|A=0)$

- E $(Y^0 |A=1)$] …6

Where P is the probability of adopting improved YMT (A=1), the counterfactual states isE$(Y^0 |A=1)$. The problem of self-selection bias is obvious in the above equation as the condition E $[(Y^0|A=1]$ is unobservable. The non-adopters can be used to compare the adopters if the condition E $[(Y^0|A=1] = [(Y^0|A=0]$ is satisfied.

Translog production function is specified as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k \, logX_{ik} + 0.5 \sum_{k=1}^{5} \sum_{m=1}^{5} b_{km} logX_{ik} \, LogX_{im} + v_i - u_i \quad \text{.....7}$$

Y = Output of yam, X_1 =Land area in hectares, X_2 = Labour in mandays, X_3 = fertilizer used in kg, X_4= seed-yam used in kg, X_5 = depreciated cost of capital, v_i = random error not under the control of the farmer, u_i = captures technical inefficiency relative to stochastic frontier and b_{0-} b_{20} = parameters estimated.

Result and Discussion

Socioeconomic profile of yam farmers

The socioeconomic characteristics of yam farmers in Nigeria are presented in Table 1. Nigerian yam farmers were mostly middle-aged. An average yam farmer in Nigeria was 47 years old. Most yam farmers were in the age range of 40-59 (Table 2).

Males were more involved in yam production in Nigeria than females. Generally, females did not participate actively in yam production in Nigeria. Only 15% of the interviewed yam farmers were female (Tables 1 and 2). Most Nigerian yam farmers have some form of education (Table 2). On average, the farmers had secondary education. Sixteen per cent of the yam farmers in Nigeria had no formal education. Farming is the primary occupation of most Nigerian yam farmers, approximately 95% (Table 2). The majority of the farmers in Nigeria were experienced in yam farming. An average Nigerian yam farmer had farming experience of above 20 years. The majority of farmers in Nigeria had farming experience between 6-15 years. The result of this investigation also shows that most Nigerian farmers are not members of any agricultural organizations (Table 1). Approximately 38% of the yam producers were members of farming associations. An average Nigerian yam farmer has a small farm. Yam producers in Nigeria had a mean farm size of 1.5 hectares. This project discloses that Nigerian yam farmers have poor interaction with extension agents. An average Nigerian has four extension visits per annum. This study also observed that most of the yam farmers in Nigeria were married (Table 2). They have large households. An average Nigerian yam farmer had a household size of eight members. Most yam farmers in Nigeria had household size of between 610 members. This research further reveals that most

Nigerian yam farmers lack access to funds. Over 50 percent of Nigerian yam farmers lack access to credit for yam production (Table 1). Finally, the socioeconomic analysis detects that Nigerian yam farmers are faced with some health issues. Approximately twenty-two percent of the farmers had health challenges (Table 1).

Determinants of adoption of Yam Minisett Technology in Nigeria

This project indicates that YMT adoption is influenced by the socioeconomic status of yam farmers, farm specific, and geographical/ environmental factors. Table 6.3 presents determinants of adoption of YMT in Nigeria. A positive relationship means that increases in the variables would facilitate adoption while a negative sign means that the variables impede adoption. The factors influencing the adoption of YMT in Nigeria include age, education, time of planting, use of fertilizer, number of farm income, access to financial institutions, planting material, capital inputs and extension visits.

Table 3 shows that age is a determinant of the adoption of YMT in Nigeria. It had a positive relationship with adoption and was significant at 1%. This signifies that adoption of YMT increases with age. Older yam farmers in Nigeria are more inclined to adopt YMT. Level of education affects the adoption of YMT in Nigeria. It had a negative impact on YMT adoption and was significant at 1%. This indicates that adoption of YMT decreases with education. Educated yam farmers are less disposed to adopt YMT in Nigeria. Delayed yam planting reduces the probability of YMT adoption in Nigeria. Time of planting had a negative effect on YMT adoption and was significant at 1%. This shows that time of planting moves in opposite direction with YMT adoption. Early planting of yam encourages YMT adoption in Nigeria. The use of fertilizer affects the adoption of YMT in Nigeria. It had a positive coefficient and significant at 1%. The use of fertilizer increases the adoption of YMT. The users of fertilizer were more motivated to adopt YMT in Nigeria. Number of farm income determines the adoption of YMT in Nigeria. It had a negative and significant influence on adoption. Increase in number of income sources decreases the adoption of YMT. Nigerian yam farmers with diverse income generating activities were disinclined to adopt the technology. This result also establishes that access to financial institution influences the adoption of YMT in Nigeria. It had a positive coefficient and was significant at 1%. This shows that access to financial institution encourages the adoption of improved technology. Nigerian yam farmers who had access to financial institutions were more subject to adopting YMT. Quantity of planting material affects the adoption of YMT. Its coefficient was negative and significant at 1%. This shows that the use of more planting material decreases the adoption of YMT. Adopters of YMT were farmers who used less quantity of planting material. The Table also shows that capital input determines the adoption of YMT in Nigeria. It had a negative relationship with adoption. Its coefficient was significant at 1%. This supports that the use of more capital inputs reduces the propensity of yam farmers to adopt YMT. Farmers who used more input for yam production were less inclined to adopt YMT. Lastly, the result supports that extension visit encourages the adoption of YMT. It had a positive and significant effect on YMT adoption. Its coefficient was significant at 1%. This infers that contact with EAs increases the adoption of YMT. Nigerian yam farmers who had contact with EAs were predisposed to adopt YMT technology.

Technical efficiency estimates for yam farmers The TE estimate of yam farmers in Nigeria is high. Table 4 presents the TE estimate of yam farmers in the country. The Table indicates that the majority of yam farmers in Nigeria had efficiency above 80%. The mean, maximum and minimum TE of yam farmers in Nigeria were 0.86, 0.96 and 0.49 respectively. This shows that an average Nigerian yam farmer is 86% efficient. The ideal yam farmer in Nigeria is 96% efficient. The least performing yam farmer in Nigeria 1s 49% efficient.

Impact of Yam Minisett Technology adoption on yam farmer performance

Adoption of YMT has a significant impact on the performance of Nigerian yam farmers. The T-test to compare the mean technical efficiencies of adopters and non-adopters of YMT before and after PSM (Table 5) reveals adopter of YMT outperformed nonadopters. There was no significant difference in the mean TE estimates of adopters and non-adopters before the PSM. However, this was significant after PSM. This implies that increased adoption of YMT increases farmers TE. This justifies the use of PSM to assess the impact of a technology on performance.

Conclusion

Nigerian yam farmers were mostly middle-aged males with large families. On average, the farmers had secondary education. The majority of the farmers in Nigeria were experienced in yam farming. However, they had small farms and limited contact with extension agents. The adoption of YMT is influenced by age, education, time of planting, use of fertilizer, number of farm income, access to financial institutions, planting material, capital inputs and extension visits. This research supports idea that comparing the impact of a technology on performance/wellbeing without considering the counterfactual situation of the technology gives a biased estimate of the impact the technology. The adoption of YMT has the potential to improve farmers' performance in Nigeria. It increases the TE of yam farmers in the country. Therefore, YMT should be disseminated to farmer for increased adoption of the technology and to boost yam production in the country.

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Table 1: Socioeconomic characteristics of yam farmers in Nigeria

Variables	**Nigeria**
Average age (years)	47.2
Gender (% of male farmers)	85.0
Average household size (number of household members)	8.2
Average farming experience (years)	20.7
Average farm size (hectare)	1.5
Extension visit (number of times)	4.1
Average education (years)	9.3
Member of Organization (%)	37.8
Access to credit (%)	46.9
Health issues (%)	21.9

Source: Field Survey, 2013

Table 2: Distribution of socioeconomic characteristics of yam farmers in Nigeria

Gender	
Male	85.0
Female	15.0
Total	100
Household size	
<6	28.3
6-10	53.6
11-15	12.5
>15	5.6
Total	100
Education	
No formal education	16.4
Primary	23.9
Secondary	35.3
Tertiary	24.4
Total	100
Farming Experience	
≤5	11.1
6-15	35.3
16-25	24.7
26-35	13.3
≥36	15.6
Total	100
Primary Occupation	
Farmer	94.6
Civil Servant	0.4
Others	4.8
Total	100

Marital Status	
Single	6.6
Separated and widowed	1
Married	92.5

Source: Field Survey, 2013

Table 3: Determinants of adoption of Yam Minisett Technology in Nigeria

Parameter	coefficient	Std. Error	Z value
Intercept	-1.01	0.07	-13.72***
Gender (male=1, female =0)	-0.03	0.02	-1.30
Age (years)	0.01	0.00	9.55***
Primary occupation(farmers =1, Non farmers=2)	-0.06	0.04	-1.51
Experience in Yam farming (years)	0.00	0.00	1.15
Farm size (hectare)	0.00	0.02	-0.13
Education (years)	-0.02	0.00	-9.60***
Time of planting (months)	-0.02	0.00	-6.61***
Staking (Number)	-0.01	0.02	-0.31
Difficulty acquiring farm input (yes=1, no=0)	-0.02	0.02	-0.98
Use of fertilizer (user=1, non-user=0)	0.08	0.03	3.06***
Distance from market (km)	-0.01	0.03	-0.35
Number of farm income (number of income sources)	-0.02	0.01	-2.05**
Access to financial institution (Yes=1, No=0)	0.18	0.03	5.49***
Quantity of planting material (kg)	0.00	0.00	-11.25***
Labour (man-days)	0.00	0.00	-0.27
Capital input (₦)	0.00	0.00	-13.42***
Extension visit (number of tines)	0.00	0.00	3.43***

Source: Result of Probit analysis

*** and ** are significant at 1 and 5% respectively.

Table 4: Technical efficiency estimates of yam farmers in Nigeria

Mean technical efficiency	= 0.86
Maximum technical efficiency	= 0.96
Minimum technical efficiency	= 0.49

Source: Frontier 4.1 result

Table 5 : Difference in mean technical efficiency

Technical efficiency	Mean	Bias	Standard error	Sig. (2-tailed)
Before propensity score matching				
Non-adopters	0.85	0.00	0.01	
adopters	0.86	0.00	0.01	0.51
After propensity score matching				
Non-adopters	0.82	0.00	0.01	
adopters	0.86	0.00	0.01	0.01

Source: Field Survey, 2013
Bootstrapping at 95% Confidence Interval, bootstrap results are based on 1000 bootstrap samples