IMPACT OF FARM EFFICIENCY ON SORGHUM PRODUCTION IN KADUNA STATE, NIGERIA

BY

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(MSc / AGRIC / 7163 / 2011-12)

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN AGRICULTURAL ECONOMICS

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ZARIA, KADUNA STATE
NIGERIA

JANUARY, 2016

DECLARATION

I hereby declare that this dissertation titled "**Impact of farm Efficiency on sorghum production in Kaduna State, Nigeria"** has been written by me and it is a record of my research work. No part of this work has been presented in any previous application for another Degree or Diploma at any institution. All citations and sources of information are duly acknowledged by means of references.

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CERTIFICATION

This dissertation titled '**Impact of farm Efficiency on sorghum production in Kaduna State, Nigeria',** by Jaafar Sada Mohammed meets the regulations governing the award of the Degree of Master of Science, Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to Almighty Allah (SWT) who created the universe and the creator of all creatures.

ACKNOWLEDGEMENTS

I first of all thank the almighty Allah (SWT) for giving me the opportunity to complete this work successfully. My appreciation goes to my supervisors, namely Dr. M. A. Damisa and Dr. A.A. Hassan for their tremendous guidance and assistance to produce this research dissertation and all the entire staff of the Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.

I am particularly grateful to my father late Alh. Sada Nuhu Paki for his indispensable assistance may his soul rest in *Al-jannatul Firdausi* amin. My profound appreciation goes to my mother, Haj. Maryam Musa Abdullah who I simply refer to as best mother on earth for her tireless endeavour throughout my life.

My appreciation also goes to my uncle Tukur Nuhu for the valuable role he played in making me what I have become in life. May Allah (SWT) reward him *Al-jannatul Ma'awah,*amin. My immense gratitude goes to Baba Usman, Ahmed Dangama, Alh. Kafa, Muhammed Suleiman, Abubakar M. Sahabi and the entire National Health Insurance Scheme staff of the Kaduna State office for their supports and prayers.

I am indeed, grateful to my loved ones such as; Aliyu Khadija, Muhammed Iliya, Asma'u Magaji, Aliyu Sada, Muntari Sada, Prof. Bilkisu Maiha, Dr Salamatu Isa, Khalifa Maikawari and Dr Zainab I. Makarfi. May Allah (SWT) reward you all with *Al-jannatul Na'eem*, amin.

Finally, much gratitude is due to all my good friends, course mates, well-wishers and relatives who could not be mentioned individually. Thank you all.

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Abstract

This study focused at the impact of farm efficiency on sorghum production in Kaduna State, Nigeria. Three villages were randomly selected from three Local Government Areas and 143 sorghum farmers were randomly selected in this area. Primary data were collected from 143 respondents using structured questionnaire. The statistical tools used to analyze the data were descriptive statistics, net farm income, stochastic frontier production function and t-test statistics. The result of the analysis showed that (57%) of the respondents were within the age range of 40-49years, the majority (78%) of the respondent had household size from 1-10 people. The majority of the farmers (69%) had no formal education. Majority of the farmers (73%) had farming experience range from 1-10 years. 93% of the farmers finance their production through personal savings; majority of the farmers (92%) had land size ranging from 1-5 hectares. 75% of the farmers belong to at least one cooperative association while majority 90% of the sorghum farmers had no extension contact. The average costs incurred and revenue obtained per hectare for sorghum were estimated to determine the profitability or otherwise of sorghum production in the study area. The total revenue (TR) was ₦133,653.6 while the total cost (TVC + TFC) was ₦70,937. The net farm income was therefore ₦62,716.6. The average rate of return on investment (return per naira invested) is ₦1.89, indicating that for every ₦1 invested in sorghum production in study area; a profit of 89 kobo was made. Thus, it could be concluded that sorghum production in the study area is profitable. The stochastic frontier production function was estimated for technical efficiency was 0.81. This implies that on the average, output decreased by 19% from the maximum possible level due to inefficiency. The estimated coefficients of all the parameters of production function (seed, fertilizer, labour and agrochemical) were positive and significant at $p<0.01$ and $p<0.10$ and hence play a major role in sorghum production. The constraints identified in were pest and diseases and inadequate capital. It is recommended that agro based industries and non-governmental organization should be encouraged by the local government to support research and production of sorghum productsfor commercial purposes.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Nigeria is the most populous country in Africa with an estimated population of about 160 million (NPC, 2011). Sorghum is the fourth most important world cereals crop following wheat, rice, and maize. It is a staple food in the drier part of Africa, china and India. It is the most widely cultivated crop in the northern guinea savannah zone of Nigeria. The largest growers of sorghum are India (16 million hectares), America (11 million hectares), Nigeria (6 million hectares) and Sudan (2.5 million hectares) (Idrissa, 2010). Total sorghum production in the world exceeds 50 million tonnes, a third of which is from a small area in the developed countries. Average yields are very high on the American continent (> 3.0 t/ha), while they are low (< 1.0 t/ha) in India and Africa. Africa accounts only for a quarter of the world's sorghum production.

Nigeria and Sudan contribute nearly half of the sorghum production in Africa. (Idrissa, 2005). About 50% of the total area devoted to cereal crops in Nigeria is occupied by sorghum. The area estimated at 6.8 million hectares extends northwards from latitude 8^0N to latitude 14^0N. In 1978; the total sorghum production in Nigeria was estimated at 4.8 million tonnes. This figure has risen to about 7.0 million tonnes annually. Consequently, Nigeria becomes the highest sorghum producer in West African sub-region, accounting for 71% of the regional sorghum production for human consumption and has risen from its fifth position in 1995 to the third largest producer of sorghum in the world after USA and India where more than 90% of their sorghum harvest is used for animal feed (Okpeke, 2006).

The level of food insecurity has continued to rise steadily in Nigeria since the 1980s (FAO, 2000). It rose from about 18% in 1986 to about 41% in 2004 (Sanusi *et al*., 2006). Complete eradication or alleviation of poverty is a key imperative development of a country like Nigeria. Poverty is largely situated in rural areas where the poorest people live. For this reason, efforts to reduce poverty have largely targeted rural areas. Theoretically, the rural areas of a region or country lie outside the densely-built up environments of towns, cities and sub-urban villages and their inhabitants are engaged primarily in agriculture as well as the most basic of rudimentary form of secondary and tertiary activities (Adebayo, 1998; and Ariyo, 2011).

Ariyo (2011) asserts that rural development has been placed to the top of the agenda in Nigeria's national development drive. The upsurge of interest in rural development can be attributed to a number of events which had their origin in the colonial heritage and the unanticipated oil boom of the seventies. There were massive rural-urban drift of able-bodiedyoung men and women declining productivity in agriculture, increasing food imports, growing unemployment and the widening gap in welfare terms between the urban and rural areas.

Food crops such as sorghum, rice, maize, millet, cowpea, melon etc are crops that contribute to food security to meet the consumption needs of the household, and as a source for livestock feeds. Their production is therefore important in meeting the food need of the poor rural household in Nigeria. However, an effective management of available resources through an efficient resource allocation pattern will enable a farming household get as much income as possible from its production and consequently

improve its economic access to food required by its members (Mohammed and Omotesho, 2004; Ibrahim *et al*., 2010).

Despite the fact that Kaduna state is one of the major producers of sorghum in Nigeria, the pattern of growth and farm efficiency on sorghum productivity as the production of the crop in the State is not defined (Dalton and Zereyesus, 2012). For instance, Dalton and zereyesus, (2012) and Ibrahim *et al*., (2010) identified accelerated growth in sugarcane between 1983 to 2003 and Tanko *et al*., (2010) identified deccelerative growth in area, production and productivity of rice. Such pattern of growth in area and productivity of sorghum is still not clear.

1.2 Problem Statement

Despite of the relative importance of sorghum in household food consumption very little is commercially processed. Rough estimates suggest less than 3% of Sub-Saharan Africa's sorghum production is used in the formal food and feed industries (Rohrbach, 2003). Sorghum is also a very valuable industrial crop for brewing alcoholic and non-alcoholic drinks as well as in the baking and confectionery industry (Debrah, 1993), this is true in Nigeria. According to NRC (2008), sorghum has great potentials than any other crop. They even postulated that if the twentieth century was the century of wheat, rice and maize, then the twenty-first century could become the century of sorghum. Therefore, to increase sorghum productivity, sound macro and micro-economic farm policies are needed. These require a knowledge of farm efficiency and differences in the productivities of these resources in different farm sizes.

Food crops make significant contributions to food security of rural population by providing a vast array of foods that supply essential nutrients to them (Omonona

and Agoi, 2007). However, few studies have focused on the links between food crops and its impact on household food security. Therefore, the essence of this research work is to evaluate the impact of farm efficiency on sorghum production in Kaduna state.

Based on the foregoing the study attempts to answer the following questions;

(i) What are socioeconomic characteristics of Sorghum producers in the study area?

(ii) How profitable is sorghum productions in the study area?

(iii) How technically, allocatively and economically efficient are the farmers in sorghum production?

(iv) What are the constraints faced by sorghum famers in the study area?

1.3 Objectives of the Study

The broad objective of this study was to examine the impact of farm efficiency on sorghum production in Kaduna state. The specific objectives were to:

(i) describe the socioeconomic characteristics of sorghum producers in the study area;

(ii) estimate the profitability of sorghum production;

(iii) determine technical, allocative and economic efficiencies of sorghum farmers;

(iv) describe the constraint faced by the farmers in the study area.

1.4 Justification of the Study

Sorghum is fast becoming a very important commodity in the food and beverage industries; the industrial demand for sorghum in Nigeria is estimated to be about 200,000 metric tons. The crop is grown in the Southern and Guinea Savannahs and in the Sudan Savannah of Nigeria (USAID, 2008). Increased sorghum production in Nigeria will translate directly into higher consumption, better nutrition and enhanced productivity of the farmers for maximum benefits.

Increasing utilization of sorghum and efficiency on household through development of sorghum food products will improve the livelihoods of the people growing sorghum. Productivity and efficiency studies are very important for the provision of information on how to assess the impact of what the farmers had produced. And increased in the productivity of this product will enhance and translate directly into higher consumption, better nutrition as well as improving their income. The study is essential because it will provide information on sorghum production, efficiency and productivity of farmers in the study area which will enhance product diversification and promote utilization as well as food security of sorghum production in Nigeria.

This study focused on profitability and production efficiency of sorghum among small holder farmers in Kaduna state. This will help farmers and other agencies by identifying problem areas for improvements. Similarly, the study will be useful to the government of Kaduna State, as a basis for rational and empirical policy formulation for sorghum production in the State. Finally, it is hoped that this work will be of assistance to researchers who will identify other areas for further studies on sorghum farming.

1.5 Hypotheses

i. There is no significant difference between costs and revenue in sorghum production

ii. There is no significant relationship between inputs and output in sorghum production in the study

CHAPTER TWO

LITERATURE REVIEW

2.1 Economic Importance of Sorghum

According to Taylor (2003), sorghum and millet are vitally important cereals for the maintenance of food security in Africa. The same notion is supported by FAO (2008) that small grains are the answer to chronic food shortages to rural communities who reside in semi-arid regions especially of the sub Saharan region. This is because of their high levels of adaptation to African conditions (Taylor, 2003). They represent about half the total cereal production on the continent and as such are a major source of protein for the population.

Same conclusions were made in a study that was conducted by Alumira and Rusike (2008) which revealed that new sorghum and millet varieties can reduce the probability of zero yields. Thus, they can make a significant contribution to household food security in drought years (Alumira and Rusike, 2008). However, Alumira and Rusike (2008) argued that changes in varieties alone could not guarantee increased yields from sorghum and millet. Rather they have to be accompanied by improved crop management methods.

Regardless of this, Taylor (2003) argues that sorghum and millets are still under researched compared to other cereals. In view of that, Taylor (2003) advocates that with proper research sorghum and millets could play a more important role and will offer better long-term food security than maize. This is because sorghum, pearl millet and finger millet are indigenous African cereals that, unlike maize and wheat, are well adapted to African semi-arid and sub-tropical agronomic conditions (Taylor 2003). Additional evidence is provided by Taylor (2003) that these grains represent the major

source of dietary energy and protein for some one billion people in the semi-arid tropics. The same considerations were mentioned before by Sorghum presents potential food staple for many of the poorest farm households in semi-arid areas if values are added in order to enhance its quality.

Sorghum (*Sorghum bicolor L.*) is the most extensively grown cereal grain in the country (Aba *et al*., 2004). The crop is environmentally- friendly, requires little or no fertilizers or pesticides and is biodegradable (FAO, 1995). In the savanna and semi – arid regions of Nigeria, millions of people consume sorghum in their daily diets as staple food (Obilana, 1981). These foods are high in energy and are therefore recommended for infants, pregnant and lactating mothers, the elderly and the convalescent (Obilana, 2005). Sorghum is also used as raw material in breweries (Asien and Muts, 1987). About 50% of the total area devoted to cereal crops in Nigeria is occupied by sorghum. The area, estimated at 6.86 million hectares, extends north – wards from latitude 8^0N to latitude 14^0N (Aba et al., 2004). In 1978, the total sorghum production in Nigeria was estimated at 4.8 million tones but the figure has risen to about 7.0 million tons annually (Obilana, 2005). Nigeria is the highest sorghum producer in the West African sub-region, accounting for 71% of the regional total sorghum output. Globally also, the country rose from its fifth position in 1995 to be the third largest producer of sorghum in `the world after the USA and India (FAO, 1995; Obilana, 2005).

2.1.1 Nutritional value of sorghum grain

To understand more about the uses of sorghum grain, it is important to first know about the nutritional value of this crop. Sorghum has excellent chemical and physical properties, which make it a grain of good quality for processing different types of products. Nutritionally, this grain is a source of protein and energy because it supplies

carbohydrates and has more fat than rice and wheat. Additionally, sorghum contains iron, zinc, manganese and copper. Also, its protein structure helps to ensure the quality of various foods: snacks, porridges, flour, and also feed concentrate. Furthermore, it is gluten free and so is consumed by diabetics, and it is a substitute for wheat flour (Hamaker and Bugusu 2002).

According to Joe, Hancock (2011), sorghum grain nutritional value has been subject of myths that limit its consumption in the feed industry: (1) "Sorghum grain has lower content and availability of nutrients than maize:" Compared to maize, sorghum has more mineral content but has a lower level of some amino acids and vitamins (i. e.Arginine, Histidine, Lysine) and higher level of others (i.e. Isolucine, Leucine, Trutophan and Valine). (2) "Sorghum is full of tannins and mycotoxins:" It has been shown that locally grown grains have better quality because of genetically fewer mycotoxins. (3) "Sorghum is not responsive to advanced technology:" The nutritional value of sorghum compared with maize depends on the particle size, thus grinding is very important. A particle size of 500 to 600 microns is recommended when sorghum is used for poultry feed. (4)"Seed grain color is an indication of the nutritional value of sorghum grain:" Pericarp and endosperm colour do not seem to be nutritionally significant. Also, the white sorghum grain plant may be important in marketing and perception of sorghum but it has no nutritional advantages. All these characteristics suggest similarities in nutrients and properties with other grains, which makes sorghum an attractive grain to add value ; however, sorghum is considered an inferior grain, and because of this, its consumption has not increased as has that of other grains in past years (USCP 2010).

2.2 Uses of Sorghum Grain around the World

Around the world, sorghum has been used to prepare many products. For example, consumers buy sorghum paying 14 percent tax on sorghum value added products in South Africa. In Ethiopia, sorghum is consumed as Injera, a fermented pancake that has an attractive texture (Taylor 2007). In Japan, identity-preserved US sorghum grain is used to make snacks, specifically as a substitute for rice. Also, in India it is used as raw material to make bio-ethanol, while in Latin America, it is used mainly as a substitute for corn in the feed industry. More recently, it has been used to substitute for wheat flour in baked products. Primarily, sorghum has four different areas for classifying its value added products: Bio-ethanol, beer, -human food, and animal food. We will start by looking at general aspects of each of these areas. In the ethanol market, corn and sorghum are perfect substitutes. Sorghum can be used in three types of ethanol production: Starch, sugar, and cellulosic, which results in approximately 30 to 35% of US sorghum grain production being used for ethanol purposes.

Second, in Africa, sorghum grain is used to produce opaque beer on a large scale, and the industry is growing in southern, central, and eastern Africa. In fact, beer is one of the few industrialized products in Africa. Sorghum malt is the main ingredient, and it is used in Zimbabwe and South Africa (Taylor 2007).

Third, although sorghum grain has great nutritional properties for humans, its consumption has decreased in urban areas because of the time and effort necessary to prepare sorghum food, and also because of the few marketing techniques to promote its products (Sorghum Checkoff, 2011). While it is used to prepare foods for adults and children, it is not well digested by infants unless it is combined with food that contains

lysine (Anglani, 1998). Clearly, foods prepared with sorghum do not succeed in the market because of consumer bias against it (i.e. inconvenience, unpopular texture, poor shelf-stability). Despite this, sorghum flour is the main sorghum value added product that is increasing its marketability in Africa and is getting importance the last three years in Central America, especially in El Salvador and Nicaragua.

2.3 Food Production Trends in Africa

In the early1960s, Africa was a leading agricultural exporter whereas Asia was faced with serious food shortages. However, by the mid-1960s, Asia had launched the green revolution, which is now supplying 50 million metric tons of grain to the world food supply each year. Africa has taken up the position of Asia and is the one now bearing the impact of the world food problem (Byerlee, 1997).

The food balance sheet in Africa has shifted from positive to negative. For example, between 1970 and 1985, food production grew by 1.5 percent while the population growth was 3 percent. This has in effect led to a decline in per capita food consumption, making Sub-Saharan Africa the only region in the world where average calorific intake has declined over time. The problem of reduced per capita food consumption is evident from of the growing reliance on food imports, food aid and rising poverty. Human population in Africa is expected to double to 1.2 billion by 2020, which will further increase demand for food (Byerlee, 1997). This calls upon researchers and policy makers to unearth new ways of dealing with the threatening food shortage challenge.

The adoption of new technologies designed to enhance farm output and income has received particular attention as a means of accelerating economic development. However, output growth is not only achieved through technological innovation but also

through the efficiency in which such technologies are used. Given the resource constraints faced by many countries in Sub Saharan Africa, improving the productivity of food producers through efficient use of available technologies offers the most viable channel to deal with the problem of food shortages and low unpredictable international food prices.

Feed is the main value added product made with sorghum. Its demand drives production around the world. In fact, 80 percent of total demand for the grain comes from the United States, Japan, Mexico, Argentina, and Venezuela (Checkoff, 2011). Central America also uses this grain for feeding animals but uses locally produced sources. It is popular in part because researchers have shown that sorghum grain has 90 to 95 percent of the feeding value of maize. It is especially favoured to feed swine and poultry. Moreover, recent studies have shown that sorghum can substitute for maize 100 percent without reducing animal performance; however, in broilers' diets, 1 to 2.5 percent fat is required for sorghum to meet maize's nutritional value (Douglas *et al*., 1990).

2.4 Productivity and Efficiency

Productivity and efficiency are two different concepts except under the assumption of constant returns to scale. According to Fried *et al*., (2008), productivity of a producer is the ratio of its output to its inputs. This measure is easy to calculate if a producer uses a single input to produce a single output. But when multiple inputs are used to produce several outputs, the outputs in the numerator and inputs in the denominator have to be combined in some economically sensible fashion, so that productivity remains the ratio of two scalars. Differences in production technology scale of operation, operating efficiency and the operating environment in which production occurs are the most common causes of variations in productivity either across producers or through time.

Technical efficiency of a producer is a comparison between observed and optimal values of its outputs and inputs. This can be done either from the output side or input side. On the output side observed output is compared to potential output obtainable from the inputs while from the input angle observed input levels are compared to minimum potential input required to produce the output. In either perspective, the optimum is defined in terms of production possibilities. It is also possible to define the optimum in terms of the behavioural goal of the producer.

In this case, efficiency is measured by comparing observed and optimum cost, subject to any appropriate constraints on quantities and prices. In these comparisons, the optimum is expressed in value terms and efficiency is allocative. Some authors distinguish other dimensions of efficiency beyond these two (GonzalezVega, 1998; León, 2001; Alpízar, 2007). Gonzalez-Vega (1998), for example, considers five additional categories, describing them in terms of the actions on which production units should embark in order to achieve the greatest possible efficiency:

i) Technological efficiency: to choose the best available technology (production function) to produce each output;

ii) Dynamic efficiency: to promptly absorb innovations in products and processes;

iii) Approach efficiency: to select appropriate technologies according to the nature and magnitude of any challenge faced in the market;

iv) Pure technical efficiency: not to use more inputs than necessary to produce a given amount of output, given the technology;

v) Scale efficiency: to find the correct level of production with the aim of taking advantage of economies of scale; and

vi) Joint-production efficiency: to determine the most attractive combination of output, given the opportunity to generate economies of scope.

It is important to note that the measurement of technical efficiency assumes that the factors of production used are homogeneous. It is not much of a problem if all firms use heterogeneous inputs in fixed proportions. However, if firms are different in the composition of their inputs, according to their quality, then a firm's technical efficiency will reflect both the quality of its inputs and the efficiency in their management. As a result, if technical efficiency is defined with respect to a given set of firms and a given set of factors of production, measured in a specific way, any differences across firms in the quality of the inputs will affect the measure of efficiency (Farrell, 1957)

2.5 Economic Efficiency

Economic efficiency has two components: technical and allocative efficiency. Technical efficiency refers to the ability to avoid wastage either by producing as much output as technology and input usage allow or by using as little input as required by technology and output production. Technical efficiency has, therefore, both an input conserving and output promoting argument. According to Koopmans (1951), a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input required an increase in at least one other input or reduction in at least one output. Therefore, a technically efficient producer could produce the same output with less of at least one input or could use the same input to produce more of at least one output.

Another definition exits which looks at relative technical efficiency. A producer is fully efficient on the basis of available evidence if and only if the performance of other

producers does not show that some inputs or outputs can be improved without worsening some of its other inputs or outputs. With this definition, there is no need for recourse to prices and other assumptions of weights which are supposed to reflect the relative importance of the different inputs and outputs (Cooper *et al.*, 2004). The measurement of technical efficiency is important. According to Alvarez and Arias (2004), technical efficiency reduces production costs and makes a firm more competitive. The allocative efficiency index measures a production unit's ability to choose the input combination that minimizes cost given the best available technology. It is the ratio between the minimum costs if it were technically efficient. Because allocative efficiency implies substituting or intensifying the use of certain inputs based on their prices, inefficiencies may stem from unobserved prices, from incorrectly perceived price or from lack of accurate and timely information.

2.6 Measurement of Efficiency

Efficiency measurements involve a comparison of actual performance with optimal performance located on relevant frontier. Since the true frontier is unknown, an empirical approximation is required. The approximation is normally called a "best practice" frontier. Approximation of the best practice frontier can be done using parametric or non-parametric techniques. Both techniques put emphasis on optimizing behaviour subject to constraints. Berger and Humphrey (1997) identifies at least four different types of approaches (data envelopment analysis, free disposal hull, stochastic frontier approach, and thick frontier approach) that have been employed for determining the best-practice frontier against which relative efficiency scores are measured.

However, there is no agreement on which is the best method. The differences in these methods lies in the differences on the assumptions made on:

1. the functional form of the frontier, be it a parametric or a nonparametric functional form;

2. whether a random error is included; and

3. if there is random error, what probability distribution is assumed for the efficiency scores

Data Envelopment Analysis (DEA) is a Non-parametric technique. It builds a linear piece-wise function from empirical observations of inputs and outputs, without assuming any a priori functional relationship between the inputs and outputs. Efficiency measures are then calculated relative to this surface. Testing of hypothesis is not possible and this method does not suffer multicollinearity and heteroscedasticity. Another non-parametric method of estimation is the Free Disposal Hull (FDH). It is a special case of the DEA model, because it includes only the DEA vertices and the free disposal hull points, interior to these vertices. Thus, the FDH usually generates larger estimates of average efficiency than the DEA. Both approaches allow the variation of efficiency over time and do not impose any a priori functional form to the distribution of inefficiency scores. They do not suffer multicollinearity and heteroscedasticity but testing of hypothesis is not possible.

The Stochastic Frontier Approach (SFA), also referred to as the econometric frontier approach, specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and it allows for random errors. Another parametric approach is the Distribution-Free Approach (DFA), which also designates a functional form for the frontier, except that it assumes that the efficiency of each firm is stable over time, whereas the random error tends to average out to zero over time.

Finally, the Thick Frontier Approach (TFA) specifies a functional form and it assumes that deviations from the predicted performance values from the highest and lowest performance quartiles of the observations (stratified by size class) represent random error, while deviations in predicted performance between the highest and lowest quartiles represent inefficiency (Berger and Humphrey, 1997). Parametric methods are susceptible to misspecification errors. The advantage is that it becomes possible to test hypotheses.

In recent years both parametric and non-parametric methods have become more robust than they were years ago. The exploration of efficiency of small holder farmers using the most recent techniques is left for future research, as for this study; time, data and resource constraints favoured convenience and used DEA.

2.7 Review of Factors Influencing Efficiency

Literature suggests many factors which affect the efficiency of farmers. These are classified into conventional and non-conventional factors. Non-conventional factors capture the impacts of macroeconomic variables such as public investment and agro-ecological variables. Conventional factors are traditional choice variables in the farmers‟ production decision process. According to Frisvold and Ingram (1994), the conventional inputs include labor intensity, fertilizer usage, tractor use intensity and stock of livestock. On the other hand, non-convectional inputs include land quality, irrigation, agricultural research, calorie availability, agricultural export and instability. Deininger and Olinto (2000) and Pender *et al*. (2004) also identified fertilizer, cattle ownership, access to credit, supply of extension, human capital (education, age, and gender of house head), family size and proportions of dependants as explanatory variables to efficiency. The plot level factors such as the size of the farm, tenure,

distance of the field from the residence in one way or another affects productivity (Xu *et al*., 2009).

Ownership of livestock especially oxen is likely to help framers prepare their fields early and also allows them to increase the area of land cultivated. Furthermore livestock acts as buffer zone and improves farmers‟ access to credit and fertilizer markets. In an effort to identify strategies to increase agricultural productivity and reduce land degradation, Pender *et al*., (2004) used econometric analysis on cross sectional data in Uganda. The study findings showed that ownership of livestock (especially oxen), agro-climatic zones, primary sources of income, age of house head, ownership of land and participation in agricultural extension activities positively affected productivity. This study also shows that investments such as irrigation facilities are more likely to improve productivity.

Population density has a bearing on the way farmers employ their inputs. Studies show that farmers in high density populated areas tend to use intensive methods of crop production. For example Frisvold and Ingram (1994) and Pender *et al*., (2004) show that households in more densely populated areas were found to adopt some labour intensive land management practices which enabled them to increase crop production per hectare.

Farm size also affects the productivity. Pender *et al.,* (2004) showed that farm size was negatively related to productivity in Uganda. In Zambia, Brambilla *et al.,* (2009) used cross-sectional post-harvest survey data to investigate the dynamic impacts of cotton marketing reforms on farm output. This study showed that small farms are more efficient. Frisvold and Ingram (1994) also agree that for small fields the production is

normally small but in terms of productivity or production per hectare they perform better than larger plots. Trade performance has some impact on the agricultural productivity. If farmers can access local and export markets, literature shows that productivity can go up because whatever is produced would be bought on the market. Using cross section time series data for 28 sub Saharan African countries, Frisvold and Ingram (1994) estimated an aggregate agricultural production function in an attempt to examine sources of agricultural productivity growth and stagnation. The results showed that the coefficient on agricultural export was positive and statistically significant. However, Pender *et al*., (2004) found little evidence on the impact of access to markets on agricultural intensification and crop productivity. The explanation to this could be that Pender *et al*., (2004) used sectional data while Frisvold and Ingram (1994) used panel data.

Although education as human capital is important for increasing household income, it was not found to be a solution to the problem of low productivity in Uganda (Pender *et al*., 2004). Similar results were reported by Deininger and Olinto (2000) using panel data of the post-harvest survey. However the study which aimed at examining the relatively lackluster performance of the country's agricultural sector following liberalization concluded that education enables farmers to overcome market imperfections as reflected in the fact that more educated farmers demand higher amounts of fertilizer and credit per hectare.

2.8 Related Studies on Efficiency using Parametric Methods

Various studies have been conducted on technical efficiency using the stochastic frontier. For example Siregar and Sumaryanto (2003) determined technical efficiency in Brantas river basin in Indonesia. The research showed that technical efficiency of

soybeans production in the sites was high around 83 per cent. However analysis failed to identify determinants of technical efficiency because none of the parameters in the study was significant.

Amos (2007) looked at the productivity and technical efficiency of small holder cocoa farmers in Nigeria. Farmers were observed to be experiencing increasing returns to scale. The efficiency levels ranged between 0.11 and 0.91 with a mean of 0.72. This indicates that there is plenty of room for farmers to improve their efficiency. The major contributing factors to efficiency were age of farmers, level of the education of household head and family size.

A study conducted in Malawi revealed similar results. Chirwa (2007) focused on the sources of technical efficiency among small scale farmers in southern Malawi.
Econometric results showed that many smallholder maize farmers are technically inefficient, with mean technical efficiency scores of 46 per cent and technical scores as low as 8per cent. The mean efficiency levels were lower but comparable to those obtained in other African countries whose means range from 55 per cent to 79 per cent.
The results also support the hypotheses that technical efficiency increases with the use of hybrid seeds and club membership. One of the variables used for capturing adoption of technology showed that the application of fertilizers does not explain the variations in technical inefficiency. This may imply that most farmers using these technologies use them inappropriately on small land holdings

In examining the technical efficiency of alternative land tenure systems among smallholder farmers, Kuriuki *et al.*, (2008) conducted a study in Kenya to identify

determinants of inefficiency with the objective of exploring land tenure policies that would enhance efficiency in production. The study was based on the understanding that land tenure alone was not enough to indicate the levels of efficiency of individual farms. Other socio economic factors such as gender, education and farm size were expected to be important determinants of efficiency. The study found that parcels with land titles have a higher efficiency level. Other factors such as education status of head, access to fertilizers, and group participation were also found to significantly influence technical efficiency.

2.9 Stochastic Frontier Analysis

The stochastic frontier production function is a method of economic modelling. It has its starting point in the stochastic production frontier models simultaneously introduced by Ogundari (2006), Rahman and Umar (2009), Thomas (2007), Emokaro and Ekunwe (2009) and others which derived from the error model of Aigner *et al*. (1977) and Meeusen and Van den Broeek (1977). The stochastic frontier production function is specified as:

$Y_i = f(x_i.\beta) + e_i$ 1

$e_i = v_i - u_i$ 2

Where:

Y_i = quantity of output of the i^{th} farm

x_i = vector of the inputs used by the i^{th} farm

β = a vector of the parameters to be estimated

e_i = composed error term

v_i = random error outside farmer's control

u_i =technical inefficiency effects

$f(x_i, \beta)$ = a suitable function of the vector

This according to Ogundari (2006), it has been used by many empirical studies, particularly those relating to agriculture in developing countries and also that the functional form meets the requirement of being self-dual (allowing an examination of economic efficiency):

$\ln Y = \beta o + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + (Vi-Ui)$……3

Where,

ln = the natural logarithm

Y = output of sorghum (ha)

βo = constant term

β_1- β_3 = regression coefficients

X_1 = quantity of seed (kg)

X_2 =quantity of fertilizer (kg)

X_3 = total labour used (man days)

X_4 = quantity of agrochemical (litres)

Vi = random variability in the production that cannot be influenced by the farmer.

U_i = deviation from maximum potential output attributable to technically inefficiency.

The inefficiency of production, U_i was modelled in terms of the factors that are assumed to affect the efficiency of production of farmers. Such factors are related to the socio-economic and management variables of the farmers. The determinant of technical inefficiency is defined by:

$U_i = \delta_0 + \delta_1 1nZ_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6$.....4

Where,

U_i = inefficiency effects (profitability)

Z_1 = Age of farmer (years)

Z_2 = Household size (number)

Z_3 = Education (years)

Z_4 = Amount of credit (amount of credit obtained)

Z_5 = Access to extension services (number of times have contact)

Z_6 = farm income (Naira)

δ_0 = constant

δ_1-δ_6 = Parameters to be estimated.

These variables are assumed to influence technical efficiency of the sorghum farmers. The gamma ($\gamma = \sigma^2 \mu / (\sigma 2 \mu + \sigma \nu)$ which is the ratio of the variance of U $\sigma^2 \mu$ to the sigma squared ($\sigma^{2)}$ which is a summation of variances u and v of U and V ($\sigma^2 = \sigma^2 \mu + \sigma^2 \nu$) were also determined.

On the other hand, u_i is a non-negative truncated half normal random variable associated with farm- specific factors which lead to the ith farm not attaining maximum efficiency of production. U_i is associated with technical inefficiency of the farm and ranges between zero and one. U_i follows an independent and identical half-normal distributed N ($0.\delta^2 u$). N represents the number of the farms involved in the cross-sectional survey. According to Bakhsh (2007), stochastic frontier production function model is estimated using the maximum likelihood estimation procedure (MLE).

The stochastic frontier cost function is defined by:

$C = F (Wi, Yi; \alpha) \exp ei \quad i = 1,2 \ldots.n$ ----------5

Where,

C = Represents the minimum cost associated with cocoyam production

W= Vector of input prices

Y = sorghum output

α = Vector of parameters

ei = Composite error term

Using Sheppard's Lemma we obtain

$\frac{\partial C}{\partial Pi} = Xi\ (W, Y; \alpha)$ ---------- 6

This is a system of minimum cost input demand equations (Bravo – Ureta and Evenson, 1994; Xu and Jeffrey, 1995 and Bravo-Ureta and Pinheiro, 1997). Substituting a farm's input prices and quantity of output in equation (6) yields the economically efficient input vector Xc.. With observed levels of output given, the corresponding technically and economically efficient costs of production will be equal to X_{it} P and X_{ie}, respectively. While the actual operating input combination of the farm is Xi P. The three cost measures can then be used to compute the technical (TE) and economic efficiency (EE) indices as follows;

$TE = (X_{it}.\ P) / (X_i.\ P)$ ----------7

$EE = (X_{ie}.\ P) / (X_i.\ P)$ ----------8

The combinations of equations (7) and (8) is used to obtain the allocative efficiency (AE) index following Farell (1957)

$AE = EE / TE = (X_{ie}.\ P) / (X_i.\ P)$ ---------- 9

The efficient production is represented by an index value of 1.0 while the lower values indicate a greater degree of inefficiency. Using the method by Bravo-Ureta and Pinheiro (1997) which was based on the work of Jondrow *et al* (1982), efficiency can then be measured using the adjusted output as shown in equation (10)

$Y^* = f\ (Xi; \beta) – u$ ---------- 10

Where U can be estimated as

$$E\ (\ ui / \varepsilon\ i) = \frac{\sigma\ \lambda}{1 + \lambda^2}\ \frac{f^*\ (\varepsilon i\ \lambda / \sigma\ ) – \Sigma i \lambda}{1 – f^*\ (\varepsilon i\ \lambda\ )} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 11$$

Where

f* (.) and f* (.) are normal density and cumulative distribution functions respectively,

$\lambda = \sigma u / \sigma v$

$\varepsilon = Vi - Ui$ and

Y* is the observed output adjusted for statistical noise

When εi, σ and λ estimates, are replaced in equations (9) and (10), it will provide estimates for U and V. The term V is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g. weather, disease outbreaks, measurements errors, etc. The term U are non negative random variables representing inefficiency in production relative to the stochastic frontier. The random error Vi is assumed to be independently and identically distributed as $N(o, \delta v^2)$ random variables independent of the U is which are assumed to be non-negative truncation of the $N(o, \delta u^2)$ distribution (i.e. half-normal distribution) or have exponential distribution.

2.10 Related Studies on Efficiency using Non Parametric Methods

Non parametric methods of determining efficiency have been used in many countries. For instance, Helfand and Levine (2000) explored the determinants of technical efficiency and the relationship between farm size and efficiency, in the Center-West of Brazil. The efficiency measures were regressed on a set of explanatory variables which included farm size, type of land tenure, composition of output, access to institutions and indicators of technology and input usage. The relationship between farm size and efficiency was found to be non-linear. Efficiency was first falling and then started rising with farm size. The type of land tenure, access to institutions and markets, and modern inputs were found to be important determinants of the differences in efficiency across farms.

Rios and Shively (2005) also looked at the relationship between farm size and efficiency. They focused on the efficiency of smallholder coffee farms in Vietnam on which the two stage analysis approach was used. In the first step, technical and cost efficiency measures are calculated using DEA. In the second step, Tobit regression was used to identify factors correlated with technical and cost inefficiency. Results indicated that small farms were less efficient than large farms and inefficiencies observed on small farms appeared to be related, in part, to the scale of investments in irrigation infrastructure. Shafiq and Rehman (2000) studied the extent of resource inefficiencies in cotton production in Pakistan‟s Punjab. The study identified significant levels of both technical and allocative efficiency. However both the interpretation of the farm level results generated and the projection of the results to a higher level require care because of the technical nature of the agricultural production process.

Fletschner and Zepeda (2002) determined efficiency levels at a higher level. They looked at efficiency at regional and national levels. Three regions were selected to represent distinct production system and social economic conditions. The results indicated high level of technical efficiency across the region but low levels of allocative and scale efficiency. Factors affecting efficiencies included employment opportunities, access to credit, market and extension services.

From the above literature is clear that DEA has gained considerable ground in Agricultural Economics. Most studies using non parametric methods have focused on other agricultural crops but not maize which is an important crop for most African countries. The few studies that have looked at maize only looked at technical efficiency and not allocative efficiency.

2.11 Empirical Studies

2.11.1 Socio-economic characteristics of arable crop producers

Socio-economic characteristics play significant role in the farmers' lives in the sense that they influence willingness to accept changes which contributed significantly in raising farm productivity and ultimately their standard of living. Some of the most commonly used socio-economic variables includes age, sex, marital status, level of education, household size, farm size, farming experience, land acquisition, labour, access to credit, member of cooperative, extension contact and other estimated economic variables like income, output and standard of living.

In the study of Onwueme and Sinha(1999) observed that more than half (58.3%) of the farmers cultivated their cocoyam between May and June, (34.2%) between July and August while only (7.5%) planted between March and April. The reason for planting of cocoyam around May, June, and July is because cocoyam requires enough moisture and rainfall provides adequate water in the soil during this period of the year.

According to Ugbajah and Uzuegbuna (2012) Causative Factors of Decline in Cocoyam Production in Ezeagu Local Government area of Enugu State: Implications for Sustainable Food Security, reported that gender roles in the planting of cocoyam production revealed that39.2% was done by only men in the household and 5% was done by only women. The result also showed that 20% of cocoyam planting was done by men and children together, while 27.5% of the planting was done by everybody in the family. About 6% of them indicated that men and women do the planting while 2.5% indicated that planting was done by children only

According to Emmanuel *et al*. (2006) farmers participating in irrigation project had some type of formal education and not all of them are illiterate. In survey of pigeon pea production systems utilization and marketing in semi-arid lands of Kenya, the average age of farmers in both locations was 46.5 years with over 40% having attended at least 4 years school and average family size was 8.6 people (Mergeai *et al*., 2001). Muhammed-Lawal *et al*. (2009) also reported that 82.73% of the youth in agriculture are male.Chikezie *et al*. (2012) revealed in his findings of factors constraining rural youth involvement in cassava production that majority of the youths in Onu-Imo local government area of Imo State were at the productive age where their energies could be harnessed and utilized for productive venture in agriculture especially cassava production. From his findings 9.17% of the respondents were less than 20 years, 43.33% and 33.33% were between 21–25 years and 26–30 years, respectively, while only 14.17% of the respondents were more than 30 years of age. He also revealed that 81.67% of the respondents were male, while 18.33% were female. According to Adewale *et al*. (2005) gender is no barrier to active involvement in cassava production activities.

Abdullahi *et al.* (2012), which reported that in Ikara Local Government Area of Kaduna State, majority of the sampled respondents were middle aged farmers. . This result suggests that majority of sorghum farmers in the study area are young farmers who are within the age bracket in which people are innovative and active at work (Asiabaka, 1998). Similarly, this findings is in line with Okwoche *et al.* (2012), found that 37.68% of sampled respondents were between 30 and less than 40 years, while 30% of the farmers were between 20 and 30 years. The implication of the foregoing results is that sorghum farming in the study areas has higher patronage among young people who are

energetic enough to withstand the stress involved in the sorghum farm operations and more so that sorghum farming is dominated by men considering the data from these Northern State. The result is also confirmation of Asogwa *et al.* (2012), findings on age, ranging between 31 and less than 40 years is predominant with 42%. Also 32% of the respondents are of the age of between 20 and less than 30 years.

Level of Education of farmers Mustapha *et al.* (2012), shows that most (41.10%) of the respondents had formal education. This implies that the respondents could apprehend the improved technology being disseminated to them. The findings was in agreement with that of Asogwa *et al* (2012), who asserts that most of respondents in study area have formal education (54%0).This result suggests that almost all the respondents are literate enough to give room for effective communication in doing their sorghum farming business in the study area. This is acceptable on the ground that education affects the way farm business is managed as well as overall production (Nkang *et al*., 2009). Educational level plays a good role in adoption of new policy and undertaking risks.

2.11.2 Cost and returns analysis

Cost- return analysis is usually form the basis for farm profitability analysis, it involves itemizing the cost and returns of production and use them to arrive at such estimates as the return to one unit of the resources used, the gross margin, as well as the gross and net returns. Daniel *et al.*,(2010) revealed that farmers incurred an average cost of ₦46, 046.75 per hectare; and within the same period they had an average estimated returns of ₦56, 224.90 per hectare. This implies that the farmers made a profit of ₦10, 178.15 per hectare.

The Gross Ratio (GR) of the farm was 0.54 which showed that 54% of the gross income went for total cost. A ratio less than 1 is always desirable for any farm business. The

lower the ratio the higher the returns on naira invested (Olukosi and Erhabo, 1988). The returns on naira invested in cotton production by the farmers were ₦0.22 that is 22%.

Alam *et al* (2013) average costs and returnsof cotton farmers in the study area. The averagerevenue from cotton output was found to be ₦58, 801.12 per hectare. The total cost incurred in cotton production was ₦37, 629 per hectare.Labour cost has the highest percentage (21%)of the total cost of production. The total variable cost constituted 95% while fixed cost constituted just 5% of the total cost. The enterprisehad an average net farm income of ₦21, 172.12.

The result of the study further revealed thatreturns on Naira invested by farmers in the studyarea was ₦0.56, meaning that a farmer gain 56Kobo in every one naira invested in cotton production. The result of the study clearly indicatedthat cotton production is a profitable venture andso farmers in the study area should be advisedto venture into because it is profitable enterprise.This finding is in conformity with the result ofIbrahim (2008) who conducted a research onthe economics of sole cotton production in Lau Local Government Area of Taraba State andcame out with a similar result (that is, returns on investment of ₦0.76

2.11.3 Technical, allocative and economic efficiency

2.11.3.1 *Technical Efficiency*

By applying their model of technical inefficiency effects using panel data on Indian paddy rice producers, Battese and Coelli (1995) found a positive relationship between the degree of inefficiency and the producer's age, and a negative relationship between the degree of inefficiency and the educational level of the producer. Coelli and Battese (1996) used the same approach to analyse the factors affecting the technical inefficiency

of Indian farmers, and found the mean technical efficiency levels to be 0.74 and 0.71, respectively, for the villages of Aurelle, Kanzara and Shirapur. They also found a negative correlation between technical inefficiency and variables such as farm size and the level of education and age of the farmer.

By using the trans logarithmic stochastic frontier production function in which inefficiency effects are a function of socioeconomic variables, Ajibefun *et al*. (1996) obtained technical indicators whose average was 82%. They found positive correlations between the degree of technical inefficiency and the farmer's age, farm size and proportion of hired labour used, and a negative correlation between the degree of technical inefficiency and the producer's experience. Lyubov and Jensen (1998) used the same approach as Ajibefun *et al*. (1996) to analyse the technical efficiency of grain production in the Ukraine from 1989 to 1991. Out of the 80 farms considered, they found that variables such as the number of farm workers per hectare, the proportion of active household members engaged in non-agricultural activities, and the distance between the farm and the nearest city, have a negative impact on technical inefficiency.

Farrell (1957) defines allocative efficiency as the ability to choose optimal input levels given factor prices. According to Kalarijan and Shand (1999), the willingness and ability of an economic unit to equate its specific marginal value product is referred to as allocative efficiency. In effect, allocative efficiency refers to the adjustment of inputs and outputs to reflect relative prices (price efficiency) under a given technology (Ellis, 1988).

Unlike technical efficiency concept that only consider the process of production, allocative efficiency concepts pertain to the idea that society is concerned with not only

how an output is produced, but also with what outputs and balance of output are produced (Hensher, 2001).

2.11.3.2 *Allocative Efficiency*

A firm is said to have realized allocative efficiency if it is operating with the optimal combination of inputs given input prices. The traditional approachesto measuring allocative efficiency require input prices (Atkinson andCornwell, 1994; Greene, 1997; Kumbhakar, 1991; Kumbhakar; Oum and Zhang, 1995and Tsionas, 2005) which arehardly available in reality. This explains why empirical studies of allocative efficiency are highly concentrated on certain industries, particularly banking, because information on input price can be readily obtained for these industries.

Recently, more attempts to measure allocative efficiency have been advanced. For example given incomplete input price data information,Kuosmanen and Post (2001)put forward a methodology to derive the upper and lower bounds ofoverall efficiency. Their technique makes an additional assumption that prices are within a convex polyhedral cone.

Kuosmanen *et al*. (2006)continue by taking advantage of the law of one price, which is theoretically asserted to hold in the competitive market. The authors, while acknowledging that the input price vector is often not observed, consider the whole price domain instead of separate single input price vectors. The derived domain includes relative price restrictions, which allow them to obtain an upper bound of efficiency via maximization in terms of input prices that are endogenously chosen from the domain.Camanho and Dyson (2005)and laterJahanshahloo *et al*. (2008) have developed

ways to measure upper and lower bounds for allocative efficiency when some information of input prices is known.

In his seminal paper,Farrell (1957)used the concept of efficiency postulated byKoopmans (1951)and the radialtype of efficiency measure considered by Debreu (1951)to introduce the foundation for efficiency analysis. Hedifferentiated between technical and allocative efficiencies. A firm is technically efficient if it uses the minimal possiblecombination of inputs for producing a certain output (input orientation). Allocative efficiency, or as Farrell called itprice efficiency, refers to the ability of a firm to choose the optimal combination of inputs given input prices. If a firm has realized both technical and allocative efficiency, it is then cost efficient (overall efficient).

2.11.4 Production constraints faced by small holder farmer

Research finding on the constraints to the effective performance of agricultural and rural development project revealed that, most past policies, strategies and interventions failed to achieve their objectives as a result of poor design (Tomori *et al*., 2005). In Nigeria, most of those policies were not successful due to "top down" policy in which development are forced on people regardless of their felt needs (Ijere 1992). Other factors that militate against project implementation (Wallace, 1979) included lack of understanding the socio-economic and socio cultural and religious factors of the beneficiary's communities. Arokoyo (1995) opined that lack of understanding of the socio-economic and socio-cultural elements of the communities or participants by the programme implementers which are lack of appropriate institutional framework and linkages between the government agencies and research institutes charged with the responsibilities. Morardet *et al.* (2005) identified inappropriate technology as hindrance in the transfer of many technologies to farmers practicing irrigation. These factors

according to them; land possession, village-family structure and income were the most important.

Ugbajah and Uzuegbuna (2012) revealed the four major problems, namely logistic, agronomic, marketing and socio-cultural problems should be remedied by the collective effort of the government, extension agents and the farmers. Unavailability of improved processing facilities, poor funding and lack of production inputs, Lack of improved cultivars lead to the continued use of low–yielding local cultivars as planting materials.

The most common rice plant diseases found in Nigeria include blast, which can be severe in drought-prone rainfed systems, and rice yellow mottle virus and leaf scald in irrigated and more humid areas (Longtau 2003a). Common pests include birds and rodents. Labour: its high cost and scarcity at peaks of farm work during the farming season was also a major constraint reported. The labour problems perhaps explain why respondents cultivate small lowland rice plots The results on the prominence of pests and diseases infestation of rice farms especially for the lowland rice farms agrees with Abdullahi (1980) that the continuous moisture of the lowland fadama farms provides favourable conditions for disease agents such as fungi and bacteria, particularly on cereals like maize and vegetables.

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

The study was conducted in Kaduna State. The State lies in North-West of Nigeria Kaduna State is located between latitude 09^0N and 11^0N and between longitude 06^0E and 08^0E of the Greenwich meridian. The state has a projected population of 7,669,889 million people in 2014 going by a population growth rate of 3.2% per annum of the 2006 population census. It has an estimated cultivated land area of about 45,786km^2. The State experiences both wet and dry seasons with the wet season commencing in the month of April in the southern part of the State and between May and June in the Northern region. The dry season extends from October to April and is marked by dry harmattan winds. The annual rainfall varies between 1,107mm in Samaru to 1,286mm in Kaduna. Kaduna State shares common boundaries with Katsina, Kano to the north, Nassarawa to the south, Federal Capital Territory, Niger to the west and Plateau to the east. The entire land structure consists of an undulating Plateau with major rivers in the State including River Kaduna, River Wonderful in Kafanchan, River Gurara. The State extends from the tropical grassland known as Guinea Savannah to the Sudan Savannah in the North. The grassland is a vast region covering the Southern part of the State. The prevailing vegetation of tall grass and big trees are of economic importance during both the wet and dry seasons. There are 57 languages spoken as first languages in Kaduna State. Gbari and Hausa are major languages; most other languages are small and endangered minority languages, due to the influence of Hausa. Kaduna State provides the meeting point of the earliest histories of Nigeria. It is the home of Nok which gave its name to the oldest culture of Nigeria – the Nok culture (Kaduna State Official Website, 2013)

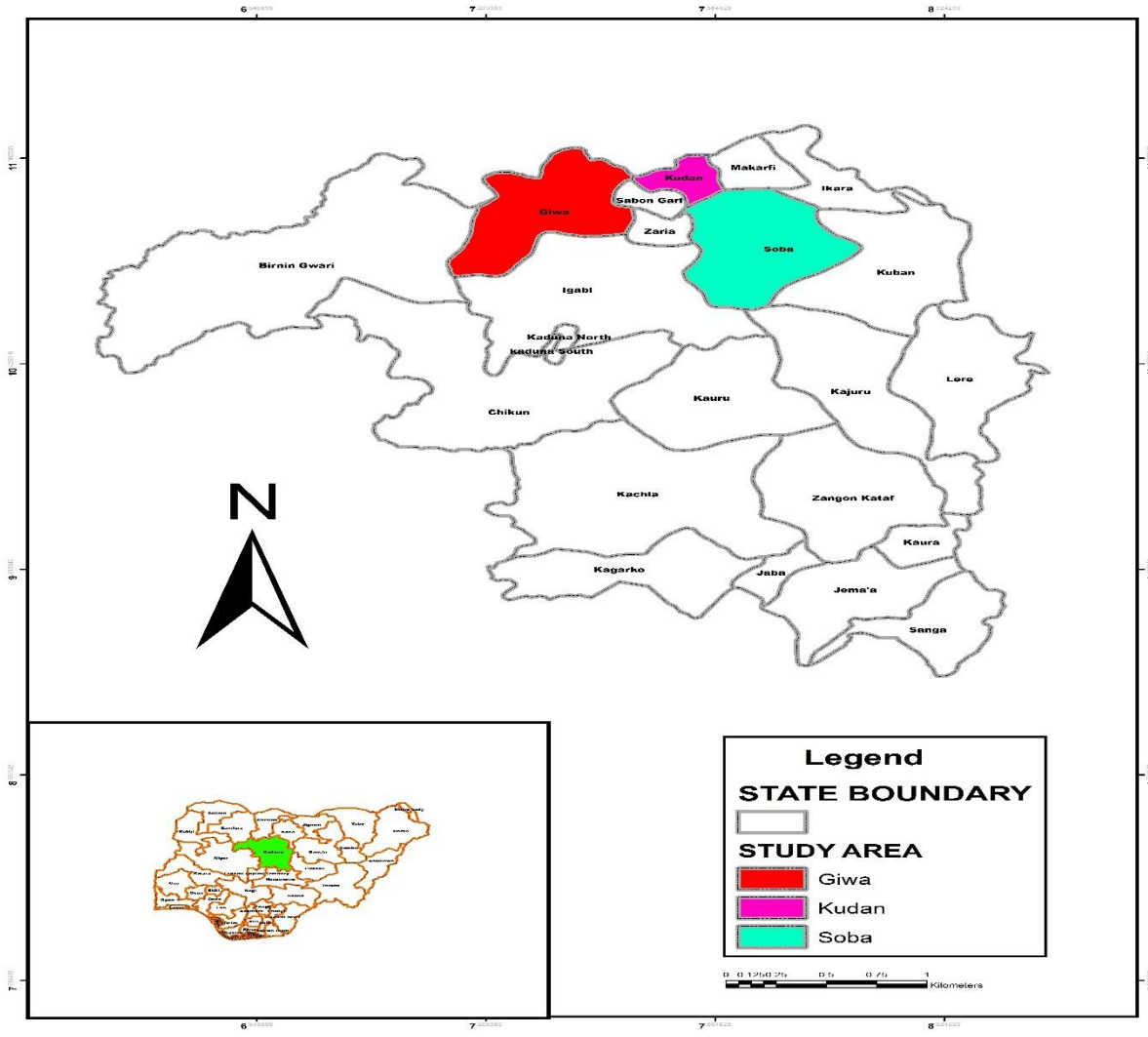

Figure 1: Map of Kaduna State Showing the Study Area

3.2 Sampling procedure

A combination of purposive and random sampling techniques was used to select respondents for this study. The first stage involved a purposive selection of the three (3) local governments based on predominance of sorghum production among the farmers. Secondly, 9 villages was purposively selected. Three from each local government area based on their intensity of sorghum production. Finally, a simple random sampling was employed in selecting farmers from each of the villages. Ten percent (10%) of the

sample frame (1430) was used as the sample size. In all, 143 farmers was randomly selected.

Table 2: population and sample size of farmers

LGAs	Villages	Sample frame	Sample size (10%)
Giwa	Yakawada	430	43
Soba	Soba	690	69
Kudan	M/Danja	310	31
Total		**1430**	**143**

3.3 Data Collection

Primary data was used for this study. These were collected with the aid of structured questionnaire. Information were collected on (a) farmer's socio-economic characteristics such as age, gender, household size, educational status, farming experience, amount of credit received, numbers of extension contact, years spent on the cooperative, farm size, income. (b) Constraints faced by the farmers. (c) costs and total return to the farmers

3.4 Analytical Techniques

The tools of analysis used include: Descriptive statistics, Net farm income, Stochastic production frontier model

3.4.1 Descriptive statistics

Descriptive statistics was used to achieve objectives (i)and (vii) of the study. It involves the use of measures of central tendency such as mean, frequency distribution and percentages to describe the socioeconomic characteristics and constraint confronting the sorghum production.

3.4.2 Net Farm Income

The Net Farm Income (NFI) was employed to achieve objective two (ii). It was used to estimate the cost and return of sorghum production. The formula for net farm income was stated as follows.

NFI= TR-TC……..…….16

Where

NFI= net farm income

TR= total revenue

TC= total cost of production

TC= TVC+TFC

3.4.3 Stochastic production frontier analysis.

The stochastic production function was used to achieve objective iv. The stochastic production function is written as:

$Y_i = f(x_i.\beta) + e_i$ 17

$e_i = v_i - u_i$ 18

Where:

Y_i = quantity of output of the i^{th} farm

x_i = vector of the inputs used by the i^{th} farm

β = a vector of the parameters to be estimated

e_i = composed error term

v_i = random error outside farmer's control

u_i =technical inefficiency effects

$$\ln Y = \beta o + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + (Vi - Ui) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 19$$

Where,

ln = the natural logarithm

Y = output of sorghum (ha)

βo = constant term

$\beta_1 - \beta_3$ = regression coefficients

X_1 = quantity of seed (kg)

X_2 =quantity of fertilizer (kg)

X_3 = total labour used (man days)

X_4 = agrochemical (litres)

Vi = random variability in the production that cannot be influenced by the farmer.

U_i = deviation from maximum potential output attributable to technically inefficiency.

$$U_i = \delta_0 + \delta_1 1 n Z_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 20$$

Where

U_i = inefficiency effects

Z_1 = age of farmer (years)

Z_2 = household size (number)

Z_3 = formal education (years)

Z_4 = amount of credit (amount of credit obtained)

Z_5 = access to extension services (number of times have contact)

Z_6 = farm income (Naira)

δ_0 = constant

$\delta_1 - \delta_6$ = Parameters to be estimated.

$C = F(W_i, Y_i; \alpha) \exp ei \; i = 1,2 \ldots n$ ----------21

Where,

C = Represents the minimum cost associated with sorghum production

W= Vector of input prices

Y = Sorghum output

α = Vector of parameters

ei = Composite error term

$\ln C = \beta o + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + (Vi+Ui)$……..……22

Where,

ln = the natural logarithm

lnC = cost of sorghum output (₦)

βo = constant term

$\beta_1 - \beta_3$ = regression coefficients

X_1 = cost of seed (₦)

X_2 =cost of fertilizer (₦)

X_3 = cost of labour (₦)

X_4 = cost of agrochemical (₦)

Vi = random variability in the production that cannot be influenced by the farmer.

U_i = deviation from maximum potential output attributable to technically inefficiency.

$U_i = \delta_0 + \delta_1 1nZ_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6$.....23

Where

U_i = inefficiency effects

Z_1 = age of farmer (years)

Z_2 = household size (number)

Z_3 = formal education (years)

Z_4 = amount of credit (amount of credit obtained)

Z_5 = access to extension services (number of times have contact)

Z_6 = farm income (Naira)

δ_0 = constant

3.4.4 t-test Statistic

The t-test statistics was employed to achieve objectives iv and v of the study and it is presented as follows:

$$t = \frac{(\bar{X}_{1-}\bar{X}_2)}{\frac{\sqrt{S_{1+}^2 S_2^2}}{n_{1+}n_2}}$$

Where:

t = Calculated t value

$\bar{X}_1$ = Mean value of respondents one

$\bar{X}_2$ =Mean value of respondents two

S_1 = Standard deviation of respondents one

S_2 = Standard deviation of respondents two

n_1 = Sample size of respondents one

n_2 = Sample size of respondents two

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Sorghum Farmers

4.1.1 Age distribution of sorghum farmers

The result in Table 1 revealed that 57% of sorghum farmers were within the age range of 40-49 years. The average age of sorghum farmers was found to be approximately 44 years with minimum of 20 years and maximum of 59 years. This implies that, the farmers are strong, agile, and active and can participate adequately in farming activities. Age is expected to have negative influence on the respondent's participation in sorghum production that is why younger farmers are more active in the production of this crop. This agrees with the findings of Maurice (2004) and Yusuf (2005), this age can influence the adoption of improved agricultural practices. And the findings are also consistent with those of Nwanko *et al.* (2009) and Institute for Agricultural Research (2001), reported that the most active farmers' age group engaged in agricultural production is within 31- 50 years.

Table 1: Age distribution of sorghum farmers

Age (years)	Frequency	Percentage
20-29	13	9.1
30-39	43	30.1
40-49	81	56.6
50-59	6	4.2
Total	143	100
Mean	**44**	

4.1.2 Household size of sorghum farmers

Table 2 show the distribution of sorghum farmers by household size. Majority of the farmers 78% had household size that ranged from 1-10 persons in their family average of 11 persons. The maximum family size observed was 40 persons with a minimum of 1 person. This implies that the farmers in the study area might have advantage of family labour availability if many household members participate in farms. However, the implication of large household size is that it will increase household consumption expenditure which would compete with production for limited financial resources within the household. According to Okoruwa and Ogundele (2006) large family size does not necessarily translate to higher use of family labour because some of the young able bodied family member may prefer other jobs than farming. This finding is also in line with Solomon (2008) and Banmeke (2003), which indicates that large household size assist more on farm and other household activities.

Table 2: Distribution of sorghum farmers according to their household size

Household size (number)	Frequency	Percentage
1-10	111	77.6
11-20	21	14.7
21-30	11	7.7
Total	143	100
Mean	**11**	

4.1.3 Educational level of sorghum farmers

The result in Table 3 revealed that 69% of sorghum farmers had no formal education. Literacy is believed to have a positive implication on efficient use of productive resources and adoption of farm innovation. This indicates that the farmers' educational level is low. This finding is at variance with Amaza (2000), education has a positive and significant impact on farmers' efficiency in production. Thus, literacy level will greatly influence the decision making and adoption of innovation by farmers, which may bring about increase in productivity.

Table 3: Distribution of sorghum farmers according to their level of education

Education (years)	Frequency	Percentage
No formal education	98	68.5
Primary education	24	16.8
Secondary education	11	7.7
Tertiary education	10	7.0
Total	**143**	**100**

4.1.4 Farming experience of sorghum farmers

The experience of the majority of the surveyed farmers in sorghum producers show that 73% of sorghum farmers had 1-10 years of experience with an average of 12 years. The maximum farming experience observed was 50 years with a minimum of 1 year. The farming experience shows that farmers will be able to make sound decisions as regards resources allocation and management of their farms. This findings is in line with Ajani (2000) on productivity in food farming in northern area of Oyo State revealed that year of farming experience increased agricultural productivity among farming households in Nigeria.

Table 4: Distribution of sorghum farmers according to farming experience

Farming Experience	Frequency	Percentage
1-10	105	73.4
11-20	30	21.0
21-30	8	5.6
Total	143	100
Mean	**12**	

4.1.5 Credit obtained by sorghum farmers

The results in Table 7 revealed that the majority 93% of farmers had no access to credit to finance their sorghum production activities while about 7% had access to credits. This implies that the farmers were using their personal saving to purchase farm inputs and adopt farm innovation. This low access to credit could be attributed to the fact that government seldom grants financial credit to large numbers of farmer. Ekong (2003) asserts that credit is a very strong factor that is needed to acquire or develop any enterprise; its availability could determine the extent of production capacity.

Table 5: Distribution of sorghum farmers according to credit obtained.

Variable	Frequency	Percentage
No access to credit	132	92.8
Formal source	11	7.2
Total	**143**	**100**

4.1.6 Distribution of sorghum farmers based on farm size

The result in Table 6 revealed that majority 92.3% of sorghum farmers have farm size ranging from 1-5 hectares with an average of 2 hectares. This show that majority of the farmers have small farm sizes and will not be able to enjoy economy of scale in production, similarly, small farm sizes is an impedent to agricultural mechaniztion because using farm machineries like tractor will be difficult. Small farm sizes might be as a result of the fact that most of the farmers got their land through inheritance.

Positive relationship has been established between farm size and improvement in households' income (Jayne *et al*., 2005;Deininger, 2003). The larger the farm size of the household, the higher the expected level of food production.

Table 6: Distribution of sorghum farmer according to their farm size

Farm size (hectares)	Frequency	Percentage
1-5	132	92.3
6-10	7	4.9
>11	4	2.8
Total	143	100
Mean	**2**	

4.1.7 Membership of cooperative society

The result in Table 8 revealed that (25%) of sorghum farmers do not participate in any cooperative association while those who were members of cooperative society constituted 75% of the farmers with the minimum and maximum years of membership of 0 and 15, respectively. The average years of membership of cooperative society was 5 years.

This implies that farmers had opportunity of interacting with other farmers to enhance diffusion of innovations among the farmers. This finding is in line with Odebiyi (2010) that cooperative groups ensure that their members derive benefits from the groups such as they could not derive individually. According to Idiong *et al*. (2007), membership of cooperative affords the farmers opportunities of sharing information on modern sorghum practices.

Table 7: Distribution of sorghum farmers based on cooperative association

Cooperative association	Frequency	Percentage
Non members	33	24.6
1-5 years	73	54.5
6-10 years	24	17.9
11-15 years	4	3.0
Total	134	100
Mean	**5**	

4.1.8 Numbers of extension visits

The ultimate aim of extension services is to enhance farmers' ability to efficiently utilize resources through the adoption of new and improved methods used in rice production instead of using traditional methods which are inefficient, resulting to low yield. The distribution of the sampled farmers based on numbers of extension visit is presented in Table 8.

The result in Table 8 revealed that 90% of sorghum farmers in the study area had no contact to extension service while 10% had contact to extension service with average of 1 times per year. This implies that there is low extension-farmers ratio in the study area. According to Obwona (2000), extension service is very essential to the improvement of farm productivity and efficiency among farmers

Table 8: Distribution of sorghum farmers according to extension visit

Extension Contact (Numbers)	Frequency	Percentage
No contact	121	90.3
1-3	9	6.7
4-6	4	3.0
Total	134	100
Mean	**1**	

4.2 Profitability of Sorghum Production in the Study Area

4.2.1 Cost of sorghum production in the study area.

Sorghum seed used by the farmers in the study area were mainly unimproved seeds taken from the previous harvest. The quantity of sorghum seed was 37.96 kg/ha with an average market price of ₦120 per kg was used and this constitutes 7.4% of the total cost of production. The quantity of fertilizer was 319.64 kg/ha with an average market price of ₦100 per kg was used and this constitutes 62.7% of the total cost of production.

Labour costs consisted of cost of land preparation, planting, fertilizer application, weeding, replacement and harvesting. The family labour was computed on the basis of opportunity cost in man-days. The wage rate varied according to farm operation performed. An average wage rate of ₦400 per man-day was used, giving the average labour cost per hectare to be ₦26,200. The quantity of agrochemical used was 28.58 litres/ha with an average market price of ₦800 per litre was used and this constitutes 5.6% of the total cost of production while the total cost of fixed inputs (cost of renting land and depreciation of tools) incurred on sorghum production was ₦6113 and this constitute 12% of the total fixed cost.This however, contradicts the recommended rates

per hectare for seed (20kg), fertilizer NPK 15:15:15 (200kg), (NAERLS, 2013), and the average sorghum yield of (4 tonnes/ha) (Idowu-agida*et. al.*, 2010). This implies that sorghum farmers in the study area are over-utilizing their resources to produce less than the potential yield per hectare.

4.2.2 Returns to investment in sorghum production

Results presented in Table 9 indicated that the total revenue (TR) was ₦133,653.6/ha while the total cost (TVC+TFC) was ₦70,937/ha. The net farm income was therefore ₦62,716.6/ha. The average rate of returns on investment (return per naira invested) was ₦1.89, indicating that for every ₦1 invested in sorghum production in the study area, a profit of 89 kobo was made. Thus, it could be concluded that sorghum production in the study area was economically viable. This finding is similar to that of Okoye *et al.*, (2009) in Determinants of labour productivity on small-holder sorghum farms in Anambra State, Nigeria, observed that sorghum production is profitable by returning ₦1.80 to every ₦1.00 spent.

Table 9: Average costs and returns per hectare of sorghum production

Variables	Values/ha (₦)	% Contribution
A. Variable cost		
i seed (kg)	3,796	5.4
ii fertilizer (kg)	31,964	45.1
iii labour (man-days)	26,200	36.9
iv agrochemical (kg)	2,864	4.0
Total variable cost (i + ii + iii + iv)	64,824	
B. Fixed costs		
i Cost of renting land	4813	6.8
ii Depreciation of tools (hoe and cutlass)	1300	1.8
Total fixed cost= (i + ii)	6,113	
C. Total cost	70,937	100
D. Total Revenue	133,653.6	
E. Net Farm Income (NFI)= (D -C)	62,716.6	
F Return per Naira Invested (D/C)	1.89	

Test of Hypothesis I

The null hypothesis (H_o) which stated that there is no significant difference between costs and revenue in sorghum production in the study area was tested using the result of a t-test presented in Table 10. From the result in the Table 16, an average cost was 9302.62 and average return was 23460.29. The calculated t-value was 9.04 and exceeds the critical value (t-critical two tail) of 1.99, therefore $H_o$is rejected at 5% level of significance. The result of the analysis indicates that sorghum production is profitable in the study area.

Table 10: The result of t-test showing significant differences between costs and return in sorghum production.

Variable	Average cost	Average return
Mean	9302.62	23460.29
Standard deviation	116386.39	28867975.34
Observations	220	220
Pearson Correlation	0.76	
Hypothesized Mean Difference	0	
Df	219	
t Stat	-9.04	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.66	
P(T<=t) two-tail	0.00	
t Critical two-tail	1.99*	

*P<0.05

4.3 Efficiency of Sorghum Production

4.3.1 Estimated technical efficiency of sorghum farmers

The model specified was estimated by the maximum likelihood (ML) method using FRONTIER 4.1 software developed by Coelli (1995). The ML estimates and inefficiency determinants of the specified frontier are presented in Table 11. The study revealed that the generalized log likelihood function was -181.569. The log likelihood function implies that inefficiency exist in the data set. The log likelihood ratio value represents the value that maximizes the joint densities in the estimated model. Thus, the functional form that is, Cobb-Douglas used in this estimation is an adequate

representation of the data. The value of gamma (γ) is estimated to be 0.89 and it was highly significant at ($p<0.01$) level of probability. This is consistent with the theory that true γ-value should be greater than zero. This implies that 89% of random variation in the yield of the farmers was due to the farmers' inefficiency in their respective sites and not as a result of random variability. Since these factors are under the control of the farmer, reducing the influence of the effect of γ will greatly enhance the technical efficiency of the farmers and improve their yield. The value of sigma squared ($\boldsymbol{\sigma^2}$) was significantly different from zero level of probability. This indicates a good fit and correctness of the specified distributional assumptions of the composite error terms while the gamma γ indicates the systematic influences that are unexplained by the production function and the dominant sources of random error. This means that the inefficiency effects make significant contribution to the technical inefficiencies of sorghum farmers.

However, the estimated coefficients of all the parameters of production function (seed, fertilizer, labour and agrochemical) were positive and significant at 1% and 10% level of probability and hence play a major role in sorghum production in the study area except fertilizer which is negative and statistically not significant. The average technical efficiency for the farmers was 0.81 implying that, on the average, the respondents are able to obtain 81% of potential output from a given mixture of production inputs. Thus, in a short run, there is minimal scope (19%) of increasing the efficiency, by adopting the technology and techniques used by the best sorghum farmer.

The estimated coefficient for seed was 0.590 which is positive and statistically significant at 1% level. The estimated 0.501 elasticity of seed implies that increasing

seed by 1% will increase sorghum output by less than 1% which means, all things being equal the output is inelastic to changes in the quantity of seed used. The significance of seed quantity is however, due to the fact that seed determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance. This is in line with the findings of Shehu *et al* (2010) who observed that the estimated coefficient of seed and labour inputs were positive as expected and significant at 1% level which implies that the more seed is applied and the more labour employed the better the output of sorghum.

Table 11: Results of Maximum Likelihood Estimates of Stochastic Frontier Production Function of Sorghum Production

Variables	Parameters	Coefficients	Std. error	T-Value
Constant	β_0	6.327	0.354	17.859***
Seed	β_1	0.590	0.173	3.470***
Fertilizer	β_2	-0.187	0.152	-1.235
Labour	β_3	0.237	0.068	3.496***
Agrochemical	β_4	0.194	0.115	1.680*
Inefficiency variable				
Constant	Z_0	0.475	0.908	0.052
Age	Z_1	-0.003	0.017	-0.152
Household size	Z_2	-0.032	0.028	-1.115
Education	Z_3	0.0011	0.0701	0.016
Farming experience	Z_4	0.076	0.105	0.720
Extension contact	Z_5	-0.025	0.014	-1.793*
Cooperative association	Z_6	-0.312	0.128	-2.438**
Farm size	Z_7	-0.027	0.041	0.663

Diagnostic Statistic

Sigma-square	(σ^2)	0.745	0.041	1.761*
Gamma	**(γ)**	0.896	0.274	3.270***
Log likelihood function	*L/f*	-181.569		
LR test	5.804			
Total number of observation	143			
Mean efficiency	0.81			

***p<0.01, ** p<0.05and *p<0.1

The estimated coefficient for fertilizer was -0.187 which is negative and statistically not significant. This implies that a unit increase in fertilizer will to decrease in sorghum output by 18.7%. Farmers might have over-utilized fertilizer input which result to insignificant variable in sorghum production. This study is at variance with the findings of Maurice (2004) and Oladiebo and Fajuyigbe (2007) who opined that fertilizer is a major land augmenting input because it improves the quality of land by raising yields per hectare.

The coefficient of labour was 0.237 which is positive and statistically significant at 1% level. This shows that labour is an important variable in sorghum farming in the study area. This is in line with several studies by Umoh (2006) and Okike (2000) which show the importance of labour in farming, particularly in developing countries where mechanization is rare on small scale farms. In the study area, human power plays a crucial role in virtually all farming activities. This situation has variously been attributed to the practice of split-plot cropping on small scattered land holdings and lack of affordable equipment (Umoh, 2006).

The estimated coefficient of agrochemical was 0.194 which is positive and statistically significant at 10% level of probability. This implies that an increase in agrochemical to a certain level will increase sorghum output by 19.4%. This study is in agreement with the findings of Maurice (2004).

The estimated result of the inefficiency model is contained in Table 11. Generally, a negative sign on a parameter means that the variable reduces technical inefficiency, while a positive sign increases technical inefficiency. The results show that all the technical inefficiency variable except extension contact and membership of cooperative society were not statistically different from zero.

The estimated coefficient of membership of cooperative association has a negative sign related to inefficiency and statistically significant at 5% level of probability. The effect of this result is that most of the sorghum farmers in the study area do enjoy the assumed benefits accrued to co-operative societies through pooling of resources together for a better expansion, efficiency and effective management of resources and for profit maximization. On the other hand it affords the farmers the opportunity of sharing information on modern sorghum practices by interacting with other farmers. Ekong (2003) and Ajayi (2002) Stated that membership of cooperative societies has advantages of accessibility to micro-credit, input subsidy and also as avenue in cross breeding ideas and information. This result is also in line with the finding of Idiong *et al*. (2007) who found that membership of cooperative afford the farmers the opportunity of sharing information on modern rice practices. They noted that membership of

cooperatives was negative and implies improvement in technical efficiency of the farmers.

The coefficient of extension contact was negative and significant at 10% level. This means that an increase in extension contact will lead to increase in technical efficiency. This finding is in line with the study of Ajani (2000) who observed that extension contact enhance farm productivity and efficiency in his study of resources productivity in food crop farming in Northern area of Oyo State, Nigeria.

4.3.2 Estimated Stochastic Frontier Cost Functions

The Maximum Likelihood (ML) estimates of the stochastic frontier cost parameters for sorghum are presented in Table 12. For the cost function, the sigma ($\sigma^2 = 0.30$) and the gamma ($\gamma=0.71$) are quite high and highly significant at 1% level of probability. The high and significant value of the sigma square (σ^2) indicate the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005). The gamma ($\gamma = 0.71$) shows that 71% of the variability in the output of sorghum farmers that are unexplained by the function is due to allocative inefficiency.

The results of stochastic frontier cost function for sorghum are shown in Table 12. The estimated coefficients of the parameters of the cost function are positive except that of agrochemical which is negative. The cost variables seed, fertilizer and labour are significant at 1% level while agrochemical is not significantly different from zero.

The coefficient of the cost of seed was positive and statistically significant at 1%. This implies that seed are important in crop production in sorghum farms. This indicating that if there is an increase in cost of seed, the total cost of production will increase. The result of this research agrees with the findings of Ogundari *et al* (2006) where they

reported direct effect of seed on cost of production in their study on economies of scale and cost efficiency in small scale maize production in Nigeria.

The coefficient of the cost of fertilizer was positive and statistically significant at 1%. This implies that fertilizer is important in crop production in sorghum farms. This indicating that if there is an increase in cost of fertilizer the total cost of production will increase. The result of this research agrees with the findings of Ogundari *et al* (2006) where they reported direct effect of fertilizer on cost of production in their study on economies of scale and cost efficiency in small scale maize production in Nigeria.

The estimated coefficient of the variable labur was positively signed and statistically significant at 1% level indicating that if there is an increase in labour cost the total cost of sorghum production will increase. The result of this research also agrees with the findings of Ogundari *et al* (2006) where they reported direct effect of labour cost on cost of rice production in their study on economies of scale and cost efficiency in small scale rice production in Nigeria.

Table 12: Maximum Likelihood Estimates Results of Frontier Production Function (Allocative Efficiency) of Sorghum production

Variables	Parameters	Coefficients	Std. error	T-Value
Production Function				
Constant	β_0	8.493	0.429	19.752***
Cost of Seed	β_1	0.116	0.041	2.823***
Cost of Fertilizer	β_2	0.038	0.125	3.024***
Cost of Agrochemical	β_3	-0.009	0.025	-0.341
Labour	β_4	0.223	0.071	3.150***
Inefficiency variable				
Constant	Z_0	0.284	0.595	0.477
Age	Z_1	-0.031	0.018	-1.697*
Household size	Z_2	0.673	0.027	2.454**
Education	Z_3	-0.167	0.101	-1.643
Farming experience	Z_4	-0.004	0.016	-0.249
Cooperative association	Z_5	0.074	0.240	0.307
Extension contact	Z_6	0.070	0.037	1.889*
Amount of credit borrowed	Z_7	-0.34E-05	0.62E-05	-0.551
Diagnostic Statistic				
Sigma-square	$(\boldsymbol{\sigma^2})$	0.301	0.128	2.355***
Gamma	**(γ)**	0.7065	0.164	4.309***
Log likelihood function	*L/f*	-67.789		
LR test	44.707			
Total number of	143			

observation	
Mean efficiency	0.76

***p<0.01, ** p<0.05and *p<0.1

The factors influencing allocative efficiency of sorghum farmers in the study area are age of the farmer, household size, level of education, farming experience, cooperative association, extension contact and credit accessibility.

The results shows that age, household size, and extension contact were statistically significant at 10%, 5% and 10% level of probability respectively while education, farming experience, cooperative and credit were not significant.

The coefficient for age was negatively signed and significant at 10% probability level, this implies that increase in age will result in allocative inefficiency because most of the respondents were aged and would tend to misallocate their resources. This was also reported by Idiong (2005) and Hussain *et al*. (1984).

The estimated coefficient of household size has a positive sign and statistically significant at 5% level of probability. This indicates that increase in household size of the farmer increase allocative inefficiency and would tend to misallocate their resources.

The coefficient for extension contact was negatively signed and significant at 10% probability level, this implies that increase in extension contact will result in allocative inefficiency and consequently tend to allocate their resources efficiently because of the training received from the extension officer.

4.3.3 Distribution of respondents according to technical, allocative and economic efficiencies of sorghum farmers in the study area.

4.3.3.1 Distribution of sorghum farmers according to technical efficiency estimates

The frequency distribution of the technical efficiency estimates for sorghum farmers in the study area as obtained from the stochastic frontier model is presented in Table 13. It was observed from the study that 83% of the farmers had technical efficiency (TE) of 0.81 and above while 17% of the farmers operated at less than 0.8 technical efficiency levels. The farmer with the best and least practice had technical efficiencies of 0.84 and 0.24 respectively. This implies that on the average, output fell by 16% from the maximum possible level attainable due to inefficiency. Also, 81% of the farmers were estimated to have technical efficiency exceeding 0.8, indicating there were some 17% technical inefficient farmers in the study area.

The study also suggest that for the average farmer in the study area to achieve technical efficiency of his most efficient counterpart, he could realize about 23 percent (1-0.81/0.84*100) cost savings while on the other hand, the least technically efficient farmers will have about 91 percent (1-0.24/0.84*100) cost savings to become the most efficient farmer.

4.3.3.2 Distribution of sorghum farmers according to allocative efficiency estimates

The Maximum Likelihood (ML) estimates of the stochastic frontier cost function for sorghum are presented in Table 12. The sigma (σ^2= 0.76) and the gamma (γ=0.006) are quite high and highly significant at 1.0% level of probability. The high and significant value of the sigma square (σ^2) indicate the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005). The

gamma ($\gamma = 0.006$) shows that 0.6% of the variability in the output of sorghum farmers that are unexplained by the function is due to allocative inefficiency.

The allocative efficiency estimates presented in Table 13, indicate that it ranged from 0.20 to 1.00; the mean allocative efficiency was 0.71. The result indicates that average sorghum farmer in the state would enjoy cost saving of about 29.3 (1-0.71/0.99*100) percent if he or she attains the level of the most efficient farmer among the respondents. The most allocatively inefficient farmer will have an efficiency gain of 87.8 (1-0.13/0.99*100) percent in sorghum production if he or she is to attain the efficiency level of most allocatively efficient farmer in the state. This finding is in line with Okoye, (2005) who observed that the mostallocatively inefficient farmerwill have an efficiency gain of 89.6 percent in sorghum production if he or she is to attain the efficiency level of most allocatively efficient farmer in the state

4.3.3.3 Distribution of sorghum farmers according to economic efficiency estimates

The frequency distribution of the economic efficiency estimates for sorghum farmers in the study area as obtained from the stochastic frontier model is presented in Table 13. It was observed from the study that 15% of the farmers had economic efficiency (EE) of 0.81 and above while 85% of the farmers operate at less than 0.8 efficiency level. The mean economic efficiency of the 143 sampled farmers in the study area was 0.58. The farmer with the best and least practice had economic efficiencies of 0.91 and 0.12 respectively. This implies that on the average, output fall by 42% from the maximum possible level due to inefficiency. Also 9% of the farmers were estimated to have economic efficiency exceeding 0.8, indicating there are some 20% economic inefficient farmers in the study area.The study also suggest that for the average farmer in the study area to achieve economic efficiency of his most efficient counterpart, he could realize

about 47 percent (1-0.57/0.91*100) cost savings while on the other hand, the least technically efficient farmers will have about 97 percent (1-0.12/0.91*100) cost savings to become the most efficient farmer. However, the average economic efficiency of the sorghum farmers was 57 percent. This indicates that sorghum farms were fairly economically efficient.

Table 13: Frequency Distribution of Technical, Allocative and Economic Estimates from the Stochastic Frontier Model

Efficiency Level	Technical Frequency	%	Allocative Frequency	%	Economic Frequency	%
< 0.2	0	0	11	8.87	12	9.68
0.21-0.40	3	2.42	8	6.46	21	16.94
0.41-0.60	4	3.23	41	33.06	41	33.06
0.61-0.80	14	11.29	28	22.58	39	31.45
0.81-1.00	103	83.06	36	29.03	11	8.87
Total	124	100	124	100	124	100
Minimum	0.24		0.13		0.12	
Maximum	0.84		0.99		0.91	
Mean	0.81		0.71		0.57	

Test of Hypothesis II

The hypothesis which stated that there is no significant differences between inputs and output in sorghum production was tested using F-test statistic. The estimated F-value was 64.321 with a P-value of 0.001 which is greater than 0.01. In other words, the test is significant at 1% probability level. This implies that there is significant relationship between the physical inputs and output of sorghum production. The null hypothesis is therefore rejected and the alternative hypothesis accepted.

Table.14: Hypothesis Testing for Input and Output

Hypothesis		Df	F-value	Significant
Hypothesis	F-test	219	64.321	0.001

Note: ***=Significant at 1% Level. $\mathbf{H_o}$ =Null Hypothesis.$\mathbf{H_1}$= Alternative Hypothesis.

4.4 Constraints Faced by Sorghum Farmers in the Study Area

The problems faced by sorghum farmers in the study area were ranked according to their magnitude as stated by the farmers (Table 15). The problem of pest and disease was the most severe constraint of sorghum producers with about 92% of the respondent attesting to this fact. Pest and disease were responsible for pre-harvest and post-harvest losses by sorghum producers.

The finding revealed 62% of the sorghum farmers indicated inadequacy of capital and credit facilities which rank second. This affects sorghum production in the study area, because the meager savings the farmers might have made or the funds generated from relatives is not sufficient to satisfy various activities in sorghum production. Most of the farmers also complained of not having enough money to purchase chemicals to combat these diseases, although the economic advantage of spraying could lead to increase yield thereby justify the costs they invested.

The result also revealed that 52% of the sorghum farmer indicate short of labour as constraints in the study area. According to the farmers, during active period of production-every household would have been engaged in his family farm work. The demand for labour is normally very high and expensive during the peak period of land

clearing, ridging, harvesting, processing and weeding, these led to labour shortage in sorghum farming in the study area .

High cost of fertilizer rank fourth as perceived to be least serious constraint with about 22% of the farmers attesting to this fact. According to the respondents fertilizer is made available when farmers are far into the production period, sometimes at the middle of the raining season.

Table 15: constraints associated with sorghum production

Variable	***Frequency**	**Percentage**	**Rank**
Pest and disease	129	90.2	1st
Lack/Inadequate capital	89	62.2	2nd
Labour shortage	75	52.4	3rd
Hight cost of fertilizer	32	22.4	4th
Total	325		

***** Multiple response was allowed

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study looked at impact of farm efficiency on sorghum productivity and it's implication on the household food security in Kaduna State, Nigeria. Three villages were randomly selected from three Local Government Areas and 143 sorghum farmers were selected in this area, and to achieve this, the study came up with seven main objectives. These were to: describe the socio-economic characteristics of sorghum farmers in the study area, estimate the food security status of sorghum farmers, and determine the technical efficiency of the sorghum farmers, impact of efficiency on productivity, impact of efficiency on food security of sorghum farmers and to describe the constraints faced by sorghum farmers in the study area. The primary data were collected from 143 respondents using structured questionnaire. The statistical tools used to analyze the data were descriptive statistics, net farm income, stochastic frontier production function and t-test statistics.

The result of the analysis shows about 57% of the respondents were within the age range of 40-49years, the majority 78% household size ranged from 1-10 people. The majority of the farmers 69% had no formal education. Majority of the farmers 73% had farming experience range from 1-10 years. About 93% of the farmers finance their production through personal savings; majority of the farmers 92% had land size ranging from 1-5 hectares. However, 75% of the farmers belong to one cooperative association or more while majority 90% of the sorghum farmers do not have contact with extension contact.

The average costs incurred and revenue obtained per hectare for sorghum were estimated to determine the profitability or otherwise of sorghum production in the study

area. The total revenue (TR) was ₦133,653.6 while the total cost (TVC + TFC) was ₦50,957. The net farm income was therefore ₦82,696.6. The average rate of return on investment (return per naira invested) is ₦1.69, indicating that for every ₦1 invested in sorghum production in study area; a profit of ₦1.69 kobo was made. Thus, it could be concluded that sorghum production in the study area is profitable.

The stochastic frontier production function was estimated for technical efficiency. It was observed from the study that the mean technical efficiency for the 134 sampled farmers in the study area was 0.81. This implies that on the average, output fall by 19% from the maximum possible level due to inefficiency. The estimated coefficients of all the parameters of production function (seed, fertilizer, labour and agrochemical) were positive and significant at 1% and 10% level of probability and hence play a major role in sorghum production in the study area except fertilizer which is not negative and statistically not significant.

Finally, among the constraints identified in the study area, the majority of the respondent attested to the fact that pest and diseases and inadequate capital were major constraints faced.

5.2 Conclusion

Based on the findings of this study, sorghum production in the study area is profitable by returning89 kobo to every ₦1.00 spent. Given that sorghum is an important staple food in Nigeria, any attempt to increase its productivity would be a right step towards the resolution of food crises. Apart from ensuring a food stability, increased sorghum production will provide more employment opportunities for the unemployed citizens' long term in the country. This is in view of the importance of sorghum in household food demand.The implication of the study is that technical and allocative efficiency in farm production among the farmers could be increased by 197 and 24%, respectively

through better use of available resources given the current state of technology. This can be achieved through improved farmer-specificfactors. These results call for policies aimed at encouraging new entrants especially the youths who are agile and stronger to grow sorghum and the experienced ones to remain in farming.

5.3 Contribution of the Study to Knowledge

1. The study revealed that sorghum production in the study area is profitable with net farm income of ₦62,716.6.
2. The study revealed that sorghum farmers in the study area achieved technical efficiency of 81 percent.

5.4 Recommendations

From the findings of this study, the following recommendations are made:

i. Since cooperative membership was a significantly determinant of technical efficiency, sorghum farmers should join cooperative societies, so as to be able to benefit from the government and non-governmental organization through increased credit access, input supply and farm advisory services.

ii. The most severe problems encountered in sorghum production are pest and disease. This constraint constitutes serious impediments to sorghum production and need to be addressed adequately before sorghum production can be improved in the study area. It is recommended that agro based industries and non-governmental organization should be encouraged by the local government to support research and production of sorghum products for commercial purposes.

iii. Majority of the farmers financed their production through personal savings and relatives which are mostly not adequate for appreciable production. Agricultural

loan facilities should be made accessible to sorghum producers to ensure timely and adequate utilization of agricultural inputs for improvement in farm production efficiency.

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DEPARTMENT OF AG
RICULTURAL ECONOMICS AND RURAL SOCIOLOGY, FACULTY OF AGRICULTURE, AHMADU BELLO UNIVERSITY, ZARIA.

Dear Respondent,
This questionnaire will be used by a student in the above named department. Please provide the necessary information required in the questionnaire. All information will be treated with utmost confidentiality and will strictly be used for academic purposes.
Thanks for your cooperation.

FARMERS RESEARCH QUESTIONNAIRE

SOCIO –ECONOMICS CHARATERISTICS

1. Name of farmer……

2. Gender: Male ( ) Female ( )

3. Age (years)……

4. Marital status: Married ( ) Single ( )

5. Highest level of Education:

(a) No Formal Education ( ) (b) Primary school Education ( ) (c) Secondary School

Education ( ) (d) Tertiary Education ( )

6. Family Size (All the number of the people depending on you for living)…….

(a) No of Adult Male ( ) (b) No of Adult female ( ) (c) Children >15yrs ( ) (d) Children <15yrs ( )

7. How long have you been in sorghum farming? (Yearsof experience)……

8. Do you belong to any co-operative/Association? Yes ( ) No ( )

9. If yes, (Years of participation) ----------

10. What benefit did you derive as a member?

11. What is your major source of capital for sorghum farming?

A .Personal savings ( ) b. Friends and family ( ) c. Gift ( ), d. borrow ( )

12. If you borrow, what were the sources of the credit?

a. commercial bank( ) b. Bank of Agriculture ( ) c. Cooperative Society ( )

d. Money Lenders ( ) e. Friends and Family ( ) f. Others (specify)……

13. How much did you borrow to finance last production? (Fill for the source you indicated in Q .12)

SOURCE OF LOAN	AMOUNT(₦)	INTERST RATE (%)
Commercial Bank		
Bank of Agriculture		
Cooperative Societies		
Money Lenders		
Friends And Family		
Others (Specify)		

14. Have you been visited by an extension agent? Yes ( ) No ( )

15. If Yes, How many times in last one year?

16. Did you visit an extension agent last year? Yes ( ) No ( )

17. If Yes, How many times in last one year?

18. What activities did the agent teach you? .....

19. Of what benefit were the techniques learnt to you to the success of your farm? .....

..

20. Have you been trained on sorghum farming? Yes ( ) No ( )

21. If Yes, which organization conducted the training?

22. Was the training beneficial to you?

a. Not beneficial ( ) b. somehow beneficial ( ) c. beneficial ( ) d. very beneficial ( )

Inputs variable

(1) Farm size (Ha)

(1) How many sorghum farm plots do you have? ..... Indicate and the size in the table below.

(ii). How did you acquire your land? *(Tick below)*

Plot	**Plot size (ha)**	**Mode of Acquisition**				
		(a) Inheritance	(b) Lease	(c) Borrowed	(d) Gift	(e) Purchased
1						
2						
3						

(iii). How much does it cost to rent one Hectare of land per season in your village?

....……..... Naira

(iv). Do you plant sorghum sole or as mixed cropping?

(v). If mixed, with what crops do you plant with sorghum?

Variable inputs (Last production Cycle)

(ii)Seed (Kg)

Plot No	Quantity of Seed(Kg)	Cost (₦)	Quantity of seed (kg) for other crops	Cost (₦)
1				
2				
3				

(iii).Fertilizer.

Plot No	Fertilizer type	Quantity(Kg) for sorghum	Cost(₦)	Quantity(Kg) for other crop	Cost(₦)
1					
2					
3					

(iv).Agrochemical.

Plot No	Agrochemical type	Quantity(litres) for sorghum	Cost(₦)	Quantity(litres) for other crop	Cost(₦)
1					
2					
3					

Labour input

(i) Land preparation

Plot No	Labour for sorghum			Labour for other crops		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)
1						
2						
3						

(ii) Planting

Plot No	Labour for sorghum			Labour for other crops		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)
1						
2						
3						

(iii) Fertilizer Application

Plot No	Labour for sorghum			Labour for other crops		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)
1						
2						
3						

(iv) First Weeding

Plot No	Labour for sorghum			Labour for other crops		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost(₦)
1						
2						
3						

(v) Second Weeding

Plot No	Labour for sorghum			Labour for other crops		
	No of people	No of Hours	Cost(₦)	No of people	No of Hours	Cost (₦)
1						
2						
3						

(v) Harvesting

Plot No	Labour for sorghum			Labour for other crops		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)
1						
2						
3						

Information on sorghum output and other crops

Plot No	No. of output of sorghum produced(Kg)	Total Qty sold	Price/Unit	Plot No	No. of output of other crops produced(Kg)	Total Qty sold	Price/Unit
1				1			
2				2			
3				3			

1. In which months are you food surplus?

2. In which months is your household food secured?

3. In which months does your household face food shortage?

4. In which months does your household rely on food purchase for feeding?

5. Give the months when food prices are highest

6. Estimate how much you spend on food purchase

Household expenses (Last year cropping season)

Items	Amount (N)/week	Amount (N)/month
1. Food		
2. Rent		
3. Clothing		
4. Housing maintenance.		
5. Light/electric power		
6. Fuel		
7. Pharmaceutical products		
8. Hospital care		
9. Schooling		
10. Community levy/contribution		
11. Financial assistance/ monetary gifts (present)		
12. Travels		
13. Contributions to associations and groups		
14. Others (pls. specify)		

On-farm and off-farm income (*Provide estimation*)

Source	crop	Amount (N)
1. sorghum income	Value of soghum sold	
2. Income derived from other produce	1= Maize	
	2= Cowpea	
	3= Rice	
	4= Vegetable	
	5= Millet	
	6= Others (Specify)	

Constraints of Sorghum Production

S/n	Constraints
1	
2	
3	
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Suggest possible ways of solving the problems

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Thanks for your Attention