PROFITABILITY AND EFFICIENCY OF SORGHUM PRODUCTION IN FUNAKAYE, BALANGA AND YAMALTU DEBA LOCAL GOVERNMENT AREAS OF GOMBE STATE, NIGERIA

BY

Simon Eli TUGGA

P16AGAE8012

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

DEPARTMENT OF AGRICULTURAL ECONOMICS,
FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY,
ZARIA, KADUNA STATE,
NIGERIA

FEBRUARY, 2021

DECLARATION

I hereby declare that this dissertation entitled "**Profitability and Efficiency of Sorghum Production in Funakaye, Balanga and YamaltuDeba Local Government Areas of Gombe State, Nigeria"** has been written by me in the Department of Agricultural Economics and it is a record of my own research work. The information derived from the literature had been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

Simon Eli TUGGA **Date**

(Student)

CERTIFICATION

The dissertation titled **Profitability and Efficiency of Sorghum Production in Funakaye, Balanga and YamaltuDeba Local Government Areas of Gombe State, Nigeria** carried out by **Simon Eli TUGGA,** meets the regulations governing the award of the Degree of Masters of Science (MSc) in Agricultural Economics of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

_____ _____

Dr. A. A. Hassan **Date**

Chairman, Supervisory committee

_____ _____

Dr. O. A. Ojeleye **Date**

Member Supervisory committee

_____ _____

Dr. A. A. Hassan **Date**

Head of Department
Agricultural Economics
Ahmadu Bello University, Zaria

_____ _____

Prof. S. Abdullahi **Date**

Dean, School of Postgraduate Studies
Ahmadu Bello University, Zaria

DEDICATION

This work is dedicated to my family in view of the moral support I received all through the period of my academic pursuit.

ACKNOWLEDGEMENTS

I specially express my deep appreciation and sincere gratitude to my supervisors Dr. A. A. Hassan (H. O. D) and Dr. O. A. Ojeleye for their invaluable assistance, close supervision, constructive criticisms, suggestion and pieces of advice that aided the completion of this research work. God bless them all.

My appreciation also goes to my lecturers in the Department, Prof. Ben Ahmed, Prof. M .G .Maiangwa, Dr. O. O. Ugbabe, Dr. O. Yusuf, Dr. Y. U. Oladimeji (PG Coordinator), Mr Abel Gomina, Mal Abdulrahman Sanniamong others, for imparting me with knowledge and discipline for the task ahead. God bless you all.

My profound appreciation goes to my mother, Mrs Monica .E. Tugga who I simply refer to as best mother on earth for her tireless endeavours throughout my life. I also express my sincere gratitude and appreciation to my brother DR. Samuel EliTugga for his advice and for the valuable role he played in making this programme a success, may God continue to reward him. My appreciation also goes to my siblings and sister in-law and the entire family members for their Prayers and Support.

However, I cannot forget my able friends who have contributed in one way or the other to my stay in school. Therefore, it is my pleasure to acknowledge all my wonderful friends and colleagues, God bless you all.

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ABSTRACT

The study focused on profitability and efficiency of sorghum production in Funakaye, Balanga and YamaltuDeba Local Government Areas of Gombe State, Nigeria.Primary data was used for the study. Data were collected with the aid of structured questionnaire administered to Two hundred and thirty four (234) sorghum farmers in the study area. The data were analyzed using descriptive statistics, gross margin and stochastic frontier for both production and cost function. The results of the socio-economic characteristics of the farmers showed that the mean age of the farmers was 40 years and average years of farming experience was 16 years. The results also showed that majority of the farmers (86 percent) were not registered with a cooperative. About 12 percent of these farmers had no formal education. The average household size of the farmers was 9 persons per household. Also 80.3 percent of the farmers had no access to credit. The result shows that sorghum production is profitable with a gross margin of ₦187,758 and the return per naira invested was ₦2.12 indicating that for every ₦1 invested in sorghum production a profit of 1.12 Kobo will be made. The mean technical and allocative efficiencies in sorghum production were 0.63 and 0.65 respectively.The estimated coefficients of all the parameters of production function (farm size, fertilizer, manure and herbicides) were positive and significant while (pesticides and labour) were negative at $p<0.01$, $p<0.05$ and $p<0.1$ levels of probabilities respectively. Results of the factors influencing technical efficiency in sorghum production showed that age, farming experience; years of cooperative membership and access to credit were negative and statistically significant at $p<0.01$, while extension visit and household size were negative and statistically significant at$p<0.05$ level. The factors that significantly influence allocative efficiency were Age, educational level, household size, farming experience, years of cooperative membership and access to credit.Major constraints to sorghum production were high cost of fertilizer, inadequate capital, and high cost of labour. Itwas concluded that sorghum production was profitable with gross margin of ₦187, 758 and with ₦2.12 return per naira invested, it was also concluded that 92 percent of random variation in the yield of sorghum farmers was due to the farmers' inefficiency in their respective sites. It was recommended that farmers should adopt the recommended rate of fertilizer application so as to be more efficient. It was also recommended that farmers should be encouraged to join cooperative societies in other to enhance their farming skills.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Agriculture plays a significant role in the Nigerianeconomy;basically it provides employment opportunities for the teeming population and contributes to the growth of the economy. Despite these however, the sector is thus characterized by poor yields, low level of inputs and limited land under cultivation (Izuchukwu, 2011). Nigeria is facing two key gaps in agriculture today, these are inability to meet domestic requirements and export at quality level required for market success due to inefficient system for setting and enforcing food quality standards, as well as poor knowledge of target markets (Federal Ministry of Agriculture and Rural Development FMARD, 2016).The production and socio-economic characteristics of the farmers, inconsistent government policies, the poor infrastructural base, all interact and affect the agricultural sector, resulting in low production, high price of food items and inflation. If Nigeria is ready to go back to agriculture, the problem of poverty, hunger and malnutrition could be alleviated.Adequate production of most Nigeria staple crops such as sorghum which is consumed in many parts of the country, will contribute positively to the agricultural sector.

Sorghum(*Sorghum bicolor* (L)) is a widely grown cereal grain in the country (Mohammed, 2016). It constitutes the main food grain for over 750 million people who live in the semi-arid tropics of Africa, Asia, and Latin America (Food Security Department FSD, 2015).Sorghum has a unique property that makes it well suited for food uses. Sorghum is one of the most drought tolerant cereal crops currently under cultivation. It offers farmers the ability to reduce costs on irrigation and other on-farm expenses. Sorghum requires an average temperature of at least 20 ^{0}C to produce maximum yield. In general, it is a very competitive crop and does well

in competing with weeds in narrow rows (Food and Agricultural Organization Statistics FAOSTAT, 2018). Its growth habit is similar to that of maize. It has a waxy coating on its leaves and stems which helps to keep water in the plant even in intense heat. Sorghum is valued for its grain, stalks and leaves. Many people in the United State are familiar with sorghum for the syrup made from the sweet juice in stalks of certain sorghum varieties or for the use of sorghum in silage or for pastures. 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 animal feeds. Their production is therefore important in meeting the food need of the poor rural household in Nigeria (Sani and Oladimeji, 2017).

Millions of people consume sorghum in their daily diets as staple foods; these foods are high in energy and nutrition and are therefore recommended for the infants, pregnant and lactating mothers. Sorghum is an environmentally-friendly food and industrial grain in Nigeria. Development of commercial sorghum offers substantial benefits to Nigerian farmers and national food security. Nigeria is second after the United State of America in sorghum cultivation (United State Department of Agriculture, USDA, 2017).

The largest groups of producers are small-scale subsistence farmers with minimal access to production inputs such as fertilizer, pesticides, improved seeds (hybrids or varieties), and inadequate technical know-how; The lack of initial processing facilities, has undermine the marketability of sorghum for both local consumption and for export, and even when they are available, the quality of the grain is sometimes unattractive, and when purchased, are underpriced (Ogidi and Abah, 2012).Many sorghum farmers sell their farm produce at give-awayprices regardless of the cost of production. They do this in order to meet some pressing needs of their families; thusthey hardly break-even not to talk of making profit (Vihi, Ngu-uma, and Oma, 2019).

Improving the productivity of smallholder sorghum farmers is important for economic development because smallholder farmers provide a source of employment and a more equitable distribution of income(Momoh, 2016); Productivity without efficiency is usually very expensive and lack of efficiency among sorghum farmers,affects sorghum production.

1.2 Statement of the Problem

World sorghum production is forecast at 59.34 million metric tonnes in 2017/18 (USDA, 2017). According to Mohammed, (2016) the production of the commodity is not given due consideration despite its importance in Nigeria.This can be seen in the decline in output of sorghum. According to Pre-harvest Assessment Mission in Nigeria carried out in October, 2017 by Comité Inter-Etats pour la Luttecontre la Sécheresse au Sahel "Interstate Committee for Drought Control in the Sahel" (CILSS), Food and Agriculture Organization of United Nations (FAO) and National Agricultural Extension and Research Liaisons Services (NAERLS) it was reported that the estimated output of Sorghum in 2017 with a 5-year average (2012-2016), indicated that the outputs of sorghum decreased by 16.26 percent, the total output of sorghum in 2016 was 6461.299 Mt but it decreased to 6298.15 Mt in 2017. This amounts to a decrease of 2.53 Percent

Generally, the decrease in the output of sorghum crop in 2017 compared with the 5-year average (2012-2016) may be attributed to so many things that have intensified within the last five years. First, the destabilization and displacement of farmers in the northeastern Nigeria by Boko Haram increased within the last five years in North Eastern States which Gombe state is not an exception. Second, communal clash arising from land disputes across the country is a factor. Third, the impact of climate change on crops and other associated exogenous variables like flooding that displaced and damaged properties including farm lands.

Sorghum remains a valuable source of livelihood of the people in the area. Despite the fact that Gombe State is one of the major producers of Sorghum in Nigeria, sorghum still remains below its yield potential; the average grain yield of sorghum farmers' in the study area is estimated little below 1000 kg ha−1 because of the huge inefficiency gap that exist in sorghum production.Others factors that affect the viability and profitabilityof sorghum production are not easily known to the sorghum farmers. The small holder farmers are generallyless knowledgeable and take these factors for granted. Hence the need to research andanalyse the profitability of sorghum production and establish the factors that affect its profitability becomes even more compelling.

Moreover, findings by Aduba, Mohammed, Jilasaya, and Ozumba (2013), has shown that high cost of labour, inadequate fund, lack of access to extension services and lack of improved seeds were some of the problem affecting sorghum production. It is also reported that efficiency determinants such as level of education, farming experience and membership of cooperative societies also affects sorghum production in Gombe State (Sani and Oladimeji, 2017). Therefore, to increase sorghum productivity, there is a need to understand the efficiency of production, since increase productivity is directly related to production efficiency, it is necessary to raiseproductivity of the farmers by helping them to reduce their technical inefficiencies.It is against this backdrop; that the following research questions were addressed in this study.

i) what are the socioeconomic characteristics of the sorghum farmers?
ii) how profitable is sorghum production?
iii) how technically, allocative and economically efficient are sorghum farmers?
iv) whatare the factors influencing technical, allocative and economic efficiency in sorghum production?
v) what are the constraints to sorghum production?

1.3 Objectives of the Study

The broad objective is to determine the profitability and efficiency of sorghum production in Funakaye, Balanga and YamaltuDeba LGAs of Gombe State, Nigeria. The specific objectives were to;

i) describe the socioeconomic characteristics of sorghum farmers.
ii) determine the profitability of sorghum production.
iii) determine the technical, allocative and economic efficiency of sorghum farmers.
iv) determine the factors influencing the technical, allocative and economic efficiency of sorghum farmers.
v) identify and describe the constraints to sorghum production.

1.4 Justification of the study

Efficiency is an important factor in productivity growth,in an economy where resources are scarce and opportunity for new technologies is inadequate(Mohammed, 2016). It is possible to demonstrate the possibility of raising productivity by improving efficiency without increasing the resource base or developing new technology. Measurement of the extent and determinants of efficiency indicates which aspects of farm characteristics can be addressed by public investment to improve efficiency. Therefore it is important to identify and examine the socio-economic attributes of sorghum farmers, production constraints, and resources use and utilization pattern so as to determine their effects on sorghum profitability and production efficiency. For the inefficient farms, the causes of inefficiency may be either inappropriate scale or misallocation of resources. This study is important as it will help determining whether or not farm input is an issue in the production of sorghum in the study area. It will attempt to equally identify ways of responding to some of the challenges faced by sorghum farmers and profer solution-based data to smallholder sorghum farmers in Gombe State.

Moreover, findings from this study will be of assistance in providing a comprehensive analysis of the major benefit to the farmers, and stakeholders in the agricultural industry and institutions, as it will help highlight those variables that could be better managed to improve productivity and production efficiency in sorghum farming. The study will also guide policy makers and researchers in conducting researches for improving the production of sorghum in Nigeria(Sani *et al;* 2017). It will also help policy makers in making policies for the improvement of the welfare of sorghum farmers, which will give room for the expansion of sorghum production, increased employment and the overall economic growth of the nation.

Furthermore, the research will serve as a "spring-board" for further research by public and private institutions particularly on the aspects not covered in this study. The outcome of the study will also provide information on the profitability of sorghum production so that investors, donor agencies, non- governmental organizations (NGOs), development partners and private companies wishing to invest and sponsor intervention programs that will help improve on the production efficiency of sorghum farming decisions in the study area.

1.5 Research Hypothesis

The hypotheses that was tested in this study:

i. There is no significant relationship between socio-economic characteristics and technicalefficiency in sorghum production in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1Conceptual Framework

2.1.1 Concept of productivity in agriculture

The ultimate objective or the interest of economist in productivity should be to find ways of increasing output per unit of input, and of attaining desirable inter-firm, intra-firm, and inter-sector transfer of production resources, thereby providing the means of raising the standard of living. A meaningful assessment of productivity depends upon a clear and precise definition of inputs in such a way that their movements over time are not equal. Determining which inputs and outputs are consistent with the particular concept of productivity in question is important. Sometimes one is faced with separate and distinct conditions when measuring labour, capital, or land productivity International Food Policy Research Institute (IFPRI, 2013). In other words, "resource productivity" may be defined in terms of an individual resource input or in terms of a combination of such inputs. Maximum resource productivity implies obtaining the maximum possible output from the minimum possible set of inputs. A change in productivity overtime will depend upon changes in the types and quantities of inputs. The basic concepts in productivity measurement are Average Product (AP), Marginal Product (MP), Marginal Rate of Substitution (MRS), Elasticity of Production (E.P) and Returns to Scale (RTS). The average product of an input is total product divided by the amount of the input used to produce this output. Thus average product is the output-input ratio for each level of output and the corresponding volume of input. The marginal product of an input is the addition to total product attributable to the addition of one unit of variable input to the production process, the fixed input remaining unchanged. The marginal rate of substitution measures the reduction in one input per unit increase in the other that is just sufficient to maintain a constant level of

output. We can establish the rate of return in three main ways as discussed in orthodox economic theory. The first of these returns is the case of constant returns. This states that each additional unit of input results in a constant rate of increase in output. The second of these rates of return is that of increasing returns. This states that each additional input of productive resources results in a larger increase in product than the preceding unit. The last of the three returns is the case of decreasing and/or diminishing returns.

2.1.2 Input and output relations in a production process

The production process is one whereby some goods and services, called inputs are transformed into other goods and services, called output. In agriculture, the physical inputs are usually land, labour, capital, management and of recent water resources.

2.1.3 Productivity and Efficiency

Productivity and efficiency are two different concepts except under the assumption of constant returns to scale. According to Hassan (2014),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.

2.1.4 Measurement of production efficiency in agriculture

In order to assess farm efficiency in production economics, complementary observations of the operator's behaviour can be modelled, depending on the research question and data availability (Okoruwa and Ogundele, 2008; Mohammed, 2016). The operator theoretically behaves as a profit-maximizer or cost-minimizer when choosing the optimal bundle for the farming process. Efficiency measures provide an indicator of performance. In conformity with micro-economic theory, production processes are technical relations of employed inputs to maximum attainable output. To prevent waste of resources, efficiency is of great importance for every sector of the economy. Mohammed, 2016 defined efficiency as the quantity of output (Y) per unit of input (X) used in the production process. According to (Tim,2012; Jimjel, 2014), there are three types of efficiencies; these are technical, allocative and economic (or cost) efficiency.

(i) Technical efficiency. It reflects the ability of a firm to choose an optimal set of inputs. Omotosho*et al;* (2013) point out that technical inefficiency arises when actual or observed output from a given input mix is less than the maximum possible. Okoruwa and Ogundele (2008) maintained that the technical efficiency of a firm is characterized by the relationship between observed (actual) production and some ideal or potential production. The measurement of firm specific technical efficiency is based upon deviation of observed output from the best production or efficient production frontier. Accordingly, if a firm's production point lies on the frontier, the firm is perfectly efficient. If it lies below the frontier, it is technically inefficient, with the ratio of the actual to the potential defining the level of efficiency of the firm/farm (Okoruwa and Ogundele, 2008). Technical efficiency improves in any of the following situations:

(a) Where it is possible for a firm to produce with the given know-how, a large amount of output from the same inputs or

(b) The same output with less of one or more inputs without increasing the amount of other inputs (Yusuf and Adenegan, 2007).

(ii)Allocative efficiency (AE) is the ability of a firm to choose optimal input levels for a given factor price (Ogundari and Ojo, 2006, Okoruwa and Ogundele, 2008). It is the ability to choose the level of input that maximizes profit given factor prices. According to Haruna*et al. (*2008), allocative efficiency is the extent to which farmers make efficient decisions by using input up to the level at which their marginal contribution to production value is equal to the cost of the factor or input. Allocative efficiency is achieved at the point when the marginal value product (MVP) equal the marginal factor cost (MFC).

(iii) **Economic efficiency** (EE) also referred to as the overall performance measure and is equal to the product of TE and AE (That is, EE = TE X AE). An economically efficient input/output combination would be both on the production frontier and the expansion path (Ogundari and Ojo, 2006). Economic efficiency is concerned with the relativity of value of unit output to unit cost of resources used in production. It exists when the marginal value product (MVP) is not different from the marginal factor cost (MFC) (where MVP=MFC). In other words, to achieve economic efficiency, the ratio of MVP and MFC must be equal to one. It occurs when a firm chooses resources and enterprises in such a way as to attain an economic optimum, so as to achieve maximum profit. Economic efficiency, however, depends on market forces, which in turn, are influenced by the sectorial and marketing policies of government (Nwachukwu and Onyenweaku, 2007). Maximum efficiency of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output (Umoh, 2006).

2.1.5 Profitability concept in agriculture

Profit maximization is one of the important goals of farm business. Profit is generally described as the differences between total revenue and total cost. The total revenue is the product of output sold and the unit price. Farm budgeting technique is one of the simplest and oldest tools of analysis in farm management and production economics studies. Net farm income technique is more applicable where the fixed cost of production is not negligible (Babangida, 2016).

2.1.6 Production efficiency in agriculture

The production efficiency of a farm/firm refers to its success in producing as large amount of output as possible given a set of inputs. It is the use of resources in such a way as to maximize the production of goods and services (Olukosi and Erhabo, 2008; Vihi 2019). The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike. It is no surprise; therefore, that considerable effort has been devoted to the analysis of farm production efficiency in developing countries (Tanko and Opara, 2010). An underlying premise behind much of this work is that if farmers were not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output (Belbase and Grabowski, 2005). Optimal productivity of resources implies an efficient utilization of resources in the production process.

2.1.7 Sorghum Crop

Sorghum (*Sorghum bicolor* L.) is a staple food crop for millions of poor in the semi-arid tropics (SAT) and is adapted to a wide range of environmental conditions. Sorghum is a cereal of remarkable genetic variability; more than 30,000 varieties are present in the world (Clara, 2019). It‘s a thermophilic (26-40 ^{0}C), drought-resistant plant, which grow slowly at 16-20 ^{0}C and stops growing under; cultivated sorghums are annual or weak perennials and are

essentially non rhizomatous, the roots continue to live and support the plant. Meanwhile sorghum can be grown successfully on a wide range of soils. It tolerates ph range from 5.5 to 8.5 and also some degree of salinity, alkalinity and poor drainage. Sorghum is a warm short cycle annual crop, adapted to withstand higher average temperatures than other cereal crops (Clara *et al*; 2019), Sorghum as a crop originated as far back as 3,000 years ago. The selection in those early times was for grain more than for forage. However, selection for forage varieties has been occurring for the last hundred years. Forage sorghums are similar to grain but are taller and have higher forage quality (Newmann*et al*., 2010). It is generally, although not universally, considered to have first been domesticated in North Africa, possibly in the Nile or Ethiopian regions as recently as 1000 BC (Kimber, 2000). Today, sorghum is cultivated across the world in the warmer climatic areas. It is quantitatively the world‘s fifth largest most important cereal grain, after wheat, maize, rice and barley Food and Agricultural Organization (FAO, 2003; Clara, 2019).

2.1.8 Sorghum production in Nigeria

Nigeria’s agricultural production of sorghum leaped to the second place, now trailing only the United States in annual production. Data obtained from the United States Department of Agriculture (USDA) forecasts world sorghum production at 59.34 million metric tonnes for 2017/2018. Of this number, USA’s output is projected to reach 8.4m metric tonnes while Nigeria is second with 6.4m metric tonnes, Mexico comes in the third position with 6.0m metric tonnes

2.1.9 Sorghum consumption

Sorghum is used as human food, animal feed, and in the production of alcohol and other industrial products. The larger proportion which is estimated to account for about 55 percent of the annual total production is used for human food (Kumar *et al.*, 2011). There is an increasing trend of sorghum consumption as human food, which was earlier reported to be about

35percent of total annual production (Diko*et al*., 2006; clara., 2019). Sorghum is assumed to be a staple food for most people in Africa, Asia and Latin America (Ejeta and Grenier, 2005; Henley, 2010).

2.1.10 Uses of sorghum:

Sorghum is an important food security crop particularly for the growers, consuming over 87 percent of what they produce. Moreover, anti-nutritional factors phytates and tannis which can reduce bioavailability of proteins, starch and minerals have been reported in sorghum (Mugula 2010). Sorghum grain is traditionally used as main ingredient in different food products such as *Enjer* ,*Nifro* , *genfo*(porridge), *Kitta*(flat bread from unfermented dough),*Kollo*(rosted grain), bread and weaning foods. It is consumed by all age classes. Children start consuming sorghum in the form of thin porridge and soup. The best grain for the preparation of such food stuffs is the bold and creamy white colored sorghum grains. Traditional homemade beverages are also prepared from sorghum, including *Areke*, *Bordie* and *Tella*. Generally, creamy white, yellow and red grain types are used for making Injera and other food recipes. The brown and chalky white color groups with high polyphenol content are mostly preferred to make local beverages. Sorghum is the second most important crop for *Enjera*quality next to teff. The stalk is also used for animal feed, for construction of houses and fences and as fuel. The current average annual per-capita consumption is estimated to be about 40Kg. Owing to its drought resistance, sorghum promises to be a food security crop in many parts of the country.

2.1.11 Sorghum adaptation to environmental conditions

As a warm-season crop (photosynthetic pathway), it is a short-day annual grass, growing best under relatively high temperatures and under sunny conditions (Newmann*et al*., 2010). The species are native to tropical and sub-tropical regions of all continents in addition to the South - west pacific sorghum is similar to corn (maize) in its early stages, with corn-like leaves and stalks but varies considerably from it in later stages. The inflorescence and grain is a panicle,

characterized by spikelet‘s borne in pairs. It has more shots than corn and produces several head bearing culms from the nodes. It has more extensively branched root system, waxy coating on leaves and stems which helps to retain water even under intense heat and these number of morphological physiological characteristics contribute to its adaptation to dry condition. Hence it is widely grown in different ecological zones of Nigeria and equally grows on a wide range of soils: sandy, loamy, sandy-loamy, saline, and alkaline soils with a pH range of 4.0 to 8.5

2.1.12 Sorghum breeding and selection

In Nigeria, the most common land races of sorghum are: Kaura, Fara-fara and Guinea. They are variously tolerant to striga (a parasitic weed) in all the Savannah zones and are agronomical alike (Ogbonna, 2007). Improvement by breeding started in 1956 in Nigeria, however, years of selection at the Inst itute of Agricultural Research (IAR), Samaru Nigeria have resulted in the development and release of sorghum varieties suited to specific ecological zone. Some of the improved varieties are; SAMSORG-3 and SAMSORG-40 (Sudan savannah ecology) SAMSORG-13 and SAMSORG-24 (Northern Guinea Savannah Ecology), and SAMSORG-17 and SAMSORG-16 (Southern Guinea Ecology) among others. Sorghums in general can be classified into two types: Forage types (mainly for forage or animal feed) and grain types (mainly for human consumption). The forage sorghums are further grouped into four types: (a) hybrid forage sorghum, (b) sudan grass, (c) sorghum x sudan hybrids (also known as sudan hybrids), and (d) sweet sorghum. The latter is used mainly for molasses but more recently for biofuel production as well (Newmann*et al.*, 2010).

2.1.13 Sorghum processing and utilization

2.1.13.1 Processing

Sorghum is the most amenable cereal grain to different processing technologies including: primary, secondary and tertiary methods (Sani, Haruna and Sirajo, 2013). Primary processing

involves: fermentation, malting, wet and dry milling, boiling roasting and popping. Secondary processing involves; brewing, beverage and drinks production, baking and confectionary making, steaming, extrusion (for paste and noodles), while tertiary processing involve; composite flours (mixing of cereal/cereal flours, cereal/legume flours, cereal/cassava flours), bio-fortification and chemical fortification additives. The different processing levels and there technologies are achieved using different agro-industrial equipment and machineries. These result in diversified end product for foods, feeds, beverages, alcoholic and non-alcoholic drinks.

2.1.13.2 Utilization

The uses of sorghum in Nigeria can be group into two: traditional and industrial. The traditional uses include a variety of traditional foods, beverages and drinks while its non-food traditional uses include: thatching of roots and fencing of compounds. Sorghum consumption for food is mainly in the form of flour or paste processed into two main dishes: OGI or AKAMU, a thin porridge and TUWO, tick porridge. Other dishes that are sometimes made from sorghum include a number of deep fried snacks and steamed dumplings. Of all the cereal crops, sorghum contributes about 50 percent of the calories in Nigeria generally and about 73 percent in the savannah regions of the country in particular (Taylor, 2003). Sorghum foods are also high in minerals, vitamins and some essential amino acids which are further enhance through bio-fortification thus, making them superior to other cereal foods. They contribute more energy and digestible protein in the diet of the majority of the people in sub-Saharan regions than those obtained from root and tuber crops (Sani, Haruna and Sirajo, 2013). In addition, its polyphenol (mostly Tanin) contents are used as antioxidant just as the slow digestibility of sorghum starch and protein makes its food useful in diabetic treatments.

2.1.14 Importance of Sorghum Crop to Nigeria

According to Taylor (2003), sorghum is 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 12 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 (2005) which revealed that new sorghum 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, 2005). However, Alumira and Rusike (2005) argued that changes in varieties alone could not guarantee increased yields from sorghum. Rather they have to be accompanied by improved crop management methods. Regardless of this, Taylor (2003) argues that sorghum is still under researched compared to other cereals. In view of that, Taylor (2003) advocates that with proper research sorghum could play a more important role and will offer better long-term food security than maize. This is because sorghum is 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. According to Sani(2013), sorghum is one of the most important staple food crops in Nigeria and its production surpasses all other crops and in the Nigerian savannah zone is grown on an estimated area of 4.5 million hectares with annual production output of about 6 million tons. Sorghum is a very valuable industrial crop for brewing alcoholic and non-

alcoholic drinks as well as in the baking and confectionery industries in Nigeria. According to Sani *et al* (2013), sorghum has greater untapped potentials than any other crop. It 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. So of all the cereal crops, sorghum contributes about 50 percent of the calories in Nigeria generally and about 73 percent in the savannah regions of the country in particular (Sani *et al.,* 2013).

The potential for sorghum to be the driver of economic development in Africa especially Nigeria cannot be over emphasized.

2.1.15 Nutritional Value of Sorghum Grain

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 colour 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.

2.1.16 Uses of Sorghum Grain in Nigeria

Sorghum is used in foods, such as porridge, bread, pastries, couscous, and beverages. In Nigeria, sorghum is mainly consumed as tuwo (local paste) and local beverages. Around the world, it is also used for the production of malt drinks, lagers, other beverages and confectioneries as well as in the livestock feeds industry. It can also be used as a gluten-free replacement for wheat, but due to the lack of gluten, sorghum bread is generally unleavened. Today, breeding has resulted in better nutritional value of sorghum and better flavor (Tonukari, 2012). 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. 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 percent 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. 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. Ultimately, 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. Central America also uses this grain for feeding animals but uses locally produced sources

2.2. Theoretical framework

2.2.1 Theory of production(DorfmanRobert, 2016)

The theory involves some of the most fundamental principles of economics. These include the relationship between input and ouput. The various decisions a farm makes about its productive activities can be classified into three layers of increasing complexity. The first layer includes decisions about methods of producing a given quantity of the output in a plant of given size and equipment. It involves the problem of what is called short-run cost minimization. The second layer, including the determination of the most profitable quantities of products to produce in any given plant, deals with what is called short-run profit maximization. The third layer, concerning the determination of the most profitable size and equipment of plant, relates to what is called long-run profit maximization. No matter how much crop a farm produces, it endeavours to produce it as cheaply as possible. Taking the quality of the crop and the prices of the productive factors as given, which is the usual situation, the farm task is to determine the cheapest combination of farm inputs that can produce the desired output. This task is best understood in terms of what is called the Production function (DorfmanRobert, 2016), an equation that expresses the relationship between the quantities of inputs used and the amount of output obtained. It states the amount of product that can be obtained from each and every

combination of factors. This relationship can be writtenas $\boldsymbol{y = f(X1, X2 \ldots\ldots, Xn; K1, K2, \ldots, Kn)}$.

Here, *y* denotes the quantity of output. The farm is presumed to use *n* variable factors of production that is, factors like seed, and fertilizer, the quantities of which can be increased or decreased. In the formula the quantity of the first variable factor is denoted by X_1 and so on. The available quantity of the first fixed factor is indicated in the formal by k_1 and so on. The entire formula expresses the amount of output that results when specified quantities of factors are employed. It must be noted that though the quantities of the factors determine the quantity of output, the reverse is not true, and as a general rule there will be many combinations of productive factors that could be used to produce the same output. Finding the cheapest of these is the problem of cost minimization.

2.2.2 Profitability theory

The principal target for all economic ventures is to reach possible maximum revenues. Fulfillment of maximum earnings is the indicator of efficient production operation. However, producers suffering limited resources and budgets may focus on minimization of cost rather than profit maximization, and determine the size of theirproduction to cope with such option **(**Amin and Dahlia, 2015)

2.2.2.1 ManagerialEfficiency Theory of Profit

According to RajibkumarSanyal, **(**2019), this theory recognizes that some farms are more efficient than others in terms of management of productive inputs and successfully gets the maximum output required. Farms with average level of efficiency earns average rate of return. Farms with higher managerial skills and production efficiency are required to make more profit than farmers with high rate of inefficiency.

2.2.2.2 Risk and Uncertainty Bearing Theory of Profit:

According to RajibkumarSanyal, **(**2019), this theory explains that profits are a necessary reward of the farmer for bearing risk and uncertainty in a changing economy or weather conditions. So this is functional theory of profits. Profits arise as a result of uncertainty of future. Farmers have to undertake the work of production under conditions of uncertainty. In advance they have to make estimates of the future conditions regarding demand for the product and other factors which affect price and costs. In view of their estimates and anticipations, they make contract with the suppliers of factors of production in advance at fixed rates of remuneration. They realize the value of output produced by the hired factors after it has been produced and sold in the market. But a good deal of time is spent in the process of producing and selling the product. But between the times of contracts and sale of output many changes may take place which may upset anticipations for good or for worse and thereby give rise to profits, positive and negative. Now if the conditions prevailing at the time of the sale of output could be known or predicted when the farmers enter into contractual relationships with the factors of production about their rates of remuneration, there would have been no uncertainty and, therefore, no profits. Thus uncertainty, that is, ignorance about the future conditions of demand and supply, is the cause of profits. It should be noted that positive profits accrue to those farmers who make correct estimate of the future or whose anticipations prove to be correct. Those whose anticipations prove to be incorrect will have to suffer losses

2.3 Analytical framework

2.3.1 Costs and return 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 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 percent of the gross income went for total cost. Jimjel (2015) examined the cost and return of sorghum production in Adamawa state .CACP cost analysis was use to analyze the data and the results reveals that sorghum is a profitable enterprise with gross margin and net return of ₦89,430.30 and ₦61,926.30 with cost-benefit ratio of 1.7.

Mohammed,(2016) in his work using stochasticfrontier production function estimated that the mean technical efficiency of sorghum farmers 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.

2.3.2Stochastic frontier analysis

The stochastic frontier production model is estimated using the maximum-likelihood estimation (MLE) procedure (Bakhsh, 2007). 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) adopted by Sani and Oladimeji (2017). The stochastic frontier production function is specified as:

$$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + V_i - U_i$$

Where

Y = quantity of output of the ith farm

X_1 = land (hectare)

X_2 = total labour (man-days)

X_3= fertilizer input (kg)

X_4= quantity of seeds used (kg)

X_5= herbicide (liters)

X_6= pesticide (liters)

X_7= Manure (Kg)

β_1 - β_6= regression coefficients

V_i = A random variable in production which accounts for the random variation is output by factors beyond the control of farmers.

U_1 = random variable called technical inefficiency effects

β_o = intercept

The inefficiency of production, Ui 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:

$$Ui = \beta o + \beta 1Z1 + \beta 2Z2 + \beta 3Z3 + \beta 4Z4 + +\beta 5Z5 + \beta 6Z6 + \beta 7Z7 + \beta 8Z8 + \beta 9Z9 + Ei$$

Where,

Ui = inefficiency effects

Z_1 = age (in years)

Z_2 = Educational Level(No formal education=0, primary=1, secondary=2, tertiary=3, Arabic=4, Adult=5)

Z_3 = amount of loan obtained in Naira(₦)

Z_4 = Household size.

Z_5 = Years of participation in cooperative activities.

Z_6 = Number of visits made by extension agent to the farmer in the year.

Z_7 = Number of years engaged in sorghum farming.

Z_8 = marital status (dummy; married=1, single=2, Divorce=3)

Z_9 = Sex of farmer (dummy; male=1, female=2)

$\beta 1 - \beta 9$ = parameters to be estimated

βo = intercept

Ei = error term

2.3.3 Data envelopment analysis (DEA)

Data envelopment analysis (DEA) involves the use of linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data. Efficiency measures are then calculated relative to this surface. Comprehensive reviews of the methodology arc presented by Seiford and Thrall (1990), Lovell (1993), Ali and Seiford (1993), Lovell (1991), Charnes et al., (1995) and Seiford (1996).

The piece-wise-linear convex hull approach to frontier estimation, proposed by Farrell (1957), was considered by only a few authors in the two decades following Farrell's paper. Boles (1966) and Afriat (1972) suggested mathematical programming methods which could achieve the task, but the method did not receive wide attention until the paper by Charnes, Cooper and Rhodes (1978), in which the term data envelopment analysis(DEA) was first used. Since then there has been a large number of papers which have extended and applied the DEA methodology.

Charnes Cooper and Rhodes (1978) proposed a model which had an input orientation and assumed constant returns to scale (CRS). Subsequent papers have considered alternative sets of assumptions, such as Banker, Charnes and Cooper (1984) in which a variable returns to scale (VRS) model is proposed.

2.3.4Gross Margin Analysis

Gross margin analysis forms an alternative basis for farm profitability analysis. It involves accurate collection of different costs of variable inputs and the gross income obtained from a particular enterprise (Bernard, 2003). Essentially, gross margin is a budgeting tool needed to estimate total variable cost of production and revenue. Gross margin is the difference between gross income and total variable cost. Normally, gross margin analysis is used to test the effects of changes that do not alter the fixed cost of production, especially the cost of land and other durable factors. It is used to determine the potential profitability and effect on farmer's farm income. It has the advantage of being simple as well as useful in the analysis of the profitability of small farms that have small fixed costs (Vihi; *et al* 2019).

Gross margin model is expressed as follows:

GM = TR – TVC

Where:

GM = Gross margin (N/ha)

TR = Total revenue or total value of output from the sorghum enterprise (N/ha). It is

The product of average output per hectare multiplied by the market price.

TVC = Total variable cost or the costs that are specific in producing (sorghum) output (N/ha). TVC varies according to output and are incurred on variable inputs. This includes cost of inputs like seeds, fertilizer, and harvesting, processing, labour cost (hired/family).

2.3.5 Measurement of variables used for technical, allocative and economic efficiency of sorghum

i. **Age:** This variable was measured as the chronological years of the farmers. The variable is expected to be positively or negatively related with technical efficiency. The reason is that as farmers advance in age, inefficiency in resource use decreases, while technical efficiency increases and vice versa

ii. **Sex of farmer**: This variable was measured as dummy (male=0, female=1). The variable is expected to be negatively related with technical inefficiency.

iii. **Household size**: This variable was measured as the number of persons in the household. This variable is could be both positively and negatively related with technical efficiency. The reason for negative relationship with technical inefficiency could be due to the fact that the more the number of people in a household the more likely their contribution to family labour. It may affect technical inefficiency positively, as increased household size increases the financial burden on the household head thus, reducing the cash surplus for farm needs and expansion.

iv. **Educational Level**: This variable was measured based on the level of education attained by a farmer. The variable is expected to be positively related with technical efficiency. The reason is that education encourages adoption of better management systems and promotes consciousness to maximize the full benefits of resource use. It also propels farmers to adopt new innovations.

v. **Farming experience:** This variable was measured as the number of years a farmer is involved in sorghum production. The variable is expected to be positively related with technical efficiency. The reason is that the more the number of years engaged in sorghum production, the more the technical know-how a farmer acquires.

vi. **Cooperative society membership**: This variable was measured as the number of years of participation in cooperative society. The variable is expected to be negatively related with technical inefficiency. The reason is that, membership of cooperative society facilitates access to markets as well as greater chances of financial assistance from institutional sources of credit necessary for increased efficiency.

vii. **Access to credit**: This variable was measured as whether the farmer obtained credit or not in the year. The variable is expected to be negatively related with technical inefficiency.

The reason is that credit may alleviate seasonal needs for working capital and could lead to increase in crop area.

viii. **Extension visits**: This variable was measured as the number of visits by extension agent to the farmer within the year. The variable is expected to be positively related with technical inefficiency. The reason is that increased contact with extension agents will lead to more knowledge on improved production technologies that could have strong influence on farm output.

ix. **Quantity of fertilizer used**: This variable was measured in kilogram per hectare as the amount of synthetic chemical used to enhance soil fertility. The variable is expected to be positively related with allocative efficiency. The reason is that it helps in increasing farmers‟ output if well managed.

x. **Labour:** This variable was measured as the number of hours per day engaged by both family and hired labourers. The variable is expected to be positively related with allocative efficiency. The reason is that it helps to boost farmers‟ output if judiciously managed.

xi. **Quantity of seed planted**: This variable was measured in kilogram per hectare as the amount of seed planted. The variable is expected to be positively related with allocative efficiency if applied at the recommended rate. The reason is that it helps in good crop establishment which affect farmers output.

xii. **Quantity of agro-chemical used**: This variable was measured as the amount of pesticide and herbicides (liters per hectare) used. The variable is expected to be positively related with allocative efficiency if applied at the recommended rate, if otherwise, it could positively relate with inefficiency. The reason is that it helps in healthy crop establishment and development necessary for increased output.

xiii. **Farm output**: This variable was measured in kilogram per hectare as the total output obtained by the farmer. The variable is expected to be positively related with allocative efficiency if the yield is good and negative if otherwise.

xiv. **Cost of production**: This variable was measured in naira to include costs such as seed, fertilizer, agrochemical, land (if rented) and depreciation. The variable is expected to be negatively related with allocative efficiency if the cost of production is high and positively related if the cost of production is low. The reason is that the cost of production affects the whole revenue profile of the farmer.

2.4 Empirical framework

Stochastic frontier approaches have found wide acceptance within the agricultural economics literature because of their consistency with theory and relative ease of estimation. The measurement of efficiency (technical, allocative and economic) has remained anarea of important research, both in the developing and developed countries, where resources are scarce and opportunities for developing and adopting better technologies are dwindling(Kibaara, 2005).

Sani and Oladimeji, (2017) worked on Determinantsof Technical Efficiency among Sorghum Farmers under Agricultural Transformation AgendainGombeState, Nigeria.Stochastic production frontier model was employed in the analysis of the data. The study revealed that sorghum farmers achieved technical efficiency of 83 percent. The determinants of technical efficiency include: seed, fertilizer and labour. Therefore, timely distribution of input especially fertilizer and seed should be done to enhance sorghum production. The inefficiency determinants were level of education, farming experience and membership of cooperative societies. Cooperative membership was the most significant determinant of inefficiency; hence, participation of rural households' in cooperative societies may be necessary for them to be able to pool their resources and to provide services (purchase of quality inputs in bulk). Besides, agencies of government such as the National Directorate of Employment should train rural households on small scale enterprises.

Mohamed, Bushara, and Aisha (2016) used stochastic frontier to estimate production efficiency in measuring production efficiency of sorghum small farmers in Rahad Agricultural Scheme Season (2011-2012) Sudan. The results showed that most estimated parameters of efficiency of stochastic frontier model for sorghum production of small farmers has expected signs. The mean production efficiency was 78 percent for sorghum crop. This means that tenants could increase their output by 22 percentthrough a better use of available resources. The improved seed and the insufficient number of irrigation and market factors (packaging-transportation-storage has significant impact on sorghum predation of small farmers in Rahad Scheme. Sowing date, location of the farm, experience of growing sorghum, harvesting operations and agricultural income had no significant impact on sorghum production. Working time in the field had a positive sign. This indicates that increase working time in the field would increase the yield. Tenants in age group of (25-35) years had the highest production efficiency and oldest tenants had the lowest production efficiency. The study recommended the improvement of education level of farmers, increasing the working time in field.

Adam, Ahmed,Kuhlmann,and Elamin,in their work onAnalysis of Factors Affecting Sorghum Production in the Gezira Scheme Sudan and Implications on the Household Food Security (2005).Stochastic frontier production function was estimated using a sample of 100 tenants in the Gezira Scheme. The results show that credit, capital, hired labor, fertilizer and irrigation have a significant positive effect in sorghum production levels, while sorghum area shows a negative and significant effect. An average of technical efficiency of 67 percent for sorghum production is found, implying that room to increase sorghum yield through the better use of the tenants available resources is exist. Size of holding, education level, tenants experience, household size, contact with extension agents and farm location are significant in explaining tenants' technical inefficiency.

Abba (2012) in his work on Technical Efficiencyof Sorghum Production in Hong Local Government Areaof Adamawa State, Nigeriausing the stochastic frontier production function which incorporates a model of inefficiency effects. Farm level data were collected from a sample of 100 sorghum farmers in Hong local government area of Adamawa state using structured questionnaires. The empirical result shows that land, seed, and fertilizer were the major factors that influence changes in sorghum output. Farm specific variables such as education, extension contact and household size were found to have significant effects on the technical inefficiency among the sorghum producers. The technical efficiency of farmers varied from 0.1562 to0.9214 with a mean technical efficiency of 0.7262. The implication of the study is that efficiency in sorghum production among the farmers could be increased by 28percent through better use of land, seed and fertilizer in the short term given the prevailing state of technology. This could be achieved through policy interventions by the government in terms of better access to land, improved seed and fertilizer .The inefficiency effect also shows that improved farmer's educational levels through better education and literacy campaigns would help tremendously to increase efficiency.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3. 1 Description of the Study Area

The studywas conducted in Funakaye, Balanga and YamaltuDeba Local Government Areas ofGombe State, Nigeria.

Funakaye Local Government Area of Gombe State has a land mass of 1,415 km^2 and a population of 236,087 at the 2006 population census with a projected population of 434,067 in 2020 at an annual growth rate of 4.35 percent.Its headquarters are in the town of Bajoga. Funakaye is bounded in the east by the Gongola River and lakeDadin Kowa. Funakaye lies on 10° 51'N11°26'E. It is made up of predominantly Fulani and other minorities. The religion mostly practice is Islam and Agriculture is their major source of occupation.The LGA is blessed with abundant agricultural land and was estimated that sixty-five (65 percent) of the total land area is cultivable.

Balanga Local Government Area of GombeState has a land mass of 1,626 km^2 and a population 212,549 at the 2006 population census with a projected population of 390,790 in 2020 at an annual growth rate of 4.35 percent. The LGA is bordering Adamawa State. Balanga lies on 9° 58'N 11°41'E. It's headquarter are in the town of tallase. 45 percent of the populations aremuslims and the major speaking language is Waja. Agriculture is their major source of occupation. The LGA is blessed with abundant agricultural land.

YamaltuDeba Local Government Area of Gombe State has a land mass of 1,981 km^2 and a population 255,248 at the 2006 population census with a projected population of 469,296 in 2020 at an annual growth rate of 4.35 percent.

The LGA is bordering southern part of LakeDadin Kowa. It lies on 10° 13'N 11°23'E. It's headquarter are in the town of Deba. 45 percent of the populations areMuslims; it is inhabited by mainly Tera and Fulani people. Agriculture is their major source of occupation. The LGA is blessed with abundant agricultural land.



Fig 1; Map of Gombe State

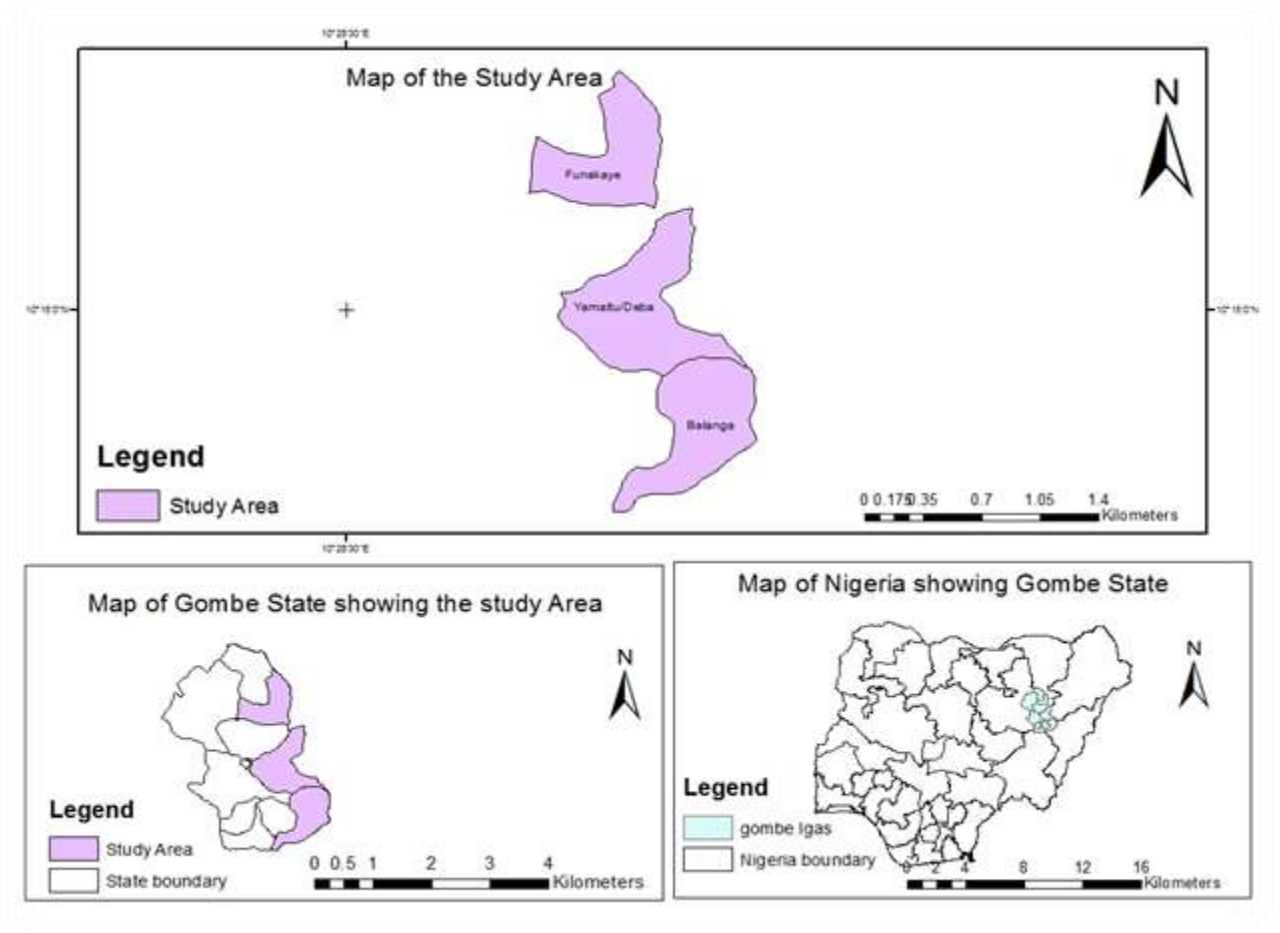


Fig 2; Map of Gombe State, Nigeria showing the study areas

3.2 Sampling Procedure and Sample size

A multi-stage sampling procedurewas used to select the respondents. The first stage involves the random selection of three Local Government Areas (LGAs) from the 11 Local Government Areas in Gombe State.Secondly, 2 villages each (Bajoga, Tongo, Talasse, Balanga, Dassa and Kuri) were randomly selected from each LGA given a total of six (6) villages (Table1).The last stage involves using a Slovia formula adopted by Abdulrahman and Oladimeji(2017) for calculating sample sizebased on the assumption of 5 percent expected margin of error, 95 percent confidence interval and applying the finite population correction factor.Expressed as

$$S = \frac{N}{1+N(e)^2} \quad \text{..... (1)}$$

Where
N= sample frame
e = level of significance desired
1= constant
S= sample size
A simple random sampling was employed in selecting respondents from each of the villages. Fourty two percent (42percent) of the sample frame (555) was used as the sample size. In all, 234 farmers were randomly selected using balloting method.

$$S_Z = \frac{555}{1 + 555(0.05)^2}$$

$$S_Z = \frac{555}{2.39}$$

$S_Z = 232$

$$\frac{232}{555} \times 100 = 42\text{percent}$$

Table 1 Selected LGAs and Sample size of farmers

LGAs	Villages	Sample frame	Samplesize 42 percent
Funakaye	Bajoga	119	50
	Tongo	85	36
Balanga	Talasse	70	29
	Balanga	80	34
YamaltuDeba	Dasa	125	53
	Kuri	76	32
Total		555	234

Source: GombeState Agricultural Development Programme (GSADP, 2017)

3.3 Data Collection

Primary data was used for this study; the primary data pertaining to this study was collected using structured questionnaire. To facilitate the collection of the data, the services of enumeratorswas engaged. The data collected include:socio-economic characteristics of the sorghum farmers, such as age, sex, educational level, household size, farming experience, marital status, access to credit, membership of cooperative societies and contact with extension agents.

Farm production information which included: farm size, hired and familylabour used, fertilizer used, quantity of agrochemicals used, quantity of seed used, farm output, farm input costs, prices of output, and constraints to sorghum production was also collected.

3.4 Analytical Techniques

3.4.1 Descriptive Statistics:

Descriptive statistics such as percentages, frequency, standard deviation, and arithmetic means was used to achieve objective (i) and (v)

3.4. 2 Gross Margin Model

This was used to achieve objective (ii) of the study.Gross margin analysis is by definition the difference between the gross farm income and total variable cost.Shalma, (2014) summarized the usefulness of gross margin as being easy to compute and interpret, highly applicable to subsistence system of farming involving small fixed capital component, useful where the same capital items are used in many different enterprises in a given farm, used to determine net farm income, serves as a guide to the selection of enterprises by comparing their margins, helps the farm manager to critically examine the variable cost components in production and helps in building partial budgets for the farm. Normally, gross margin analysis is used to test the effects of changes that do not alter the fixed cost of production, especially the cost of land and other

durable factors. It is used to determine the potential profitability and effect on farmer's farm income. It has the advantage of being simple as well as useful in the analysis of the profitability of small farms that have small fixed costs (Samm, 2009). The gross margin analysis will be used to measure the profitability of sorghum producers in the study area. The model is specified as thus:

$$GM = TR - TVC \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..\dots\dots\dots\dots.(2)$$

Where:

GM = Gross margin (Naira)

TR = Total revenue (Naira)

TVC = Total variable cost (Naira)

RNI= TR/TVC………………………………………………………………………. (3)

Where

RNI= Return per naira invested

3.4.3Stochastic Frontier Model Specifications

The stochastic frontier model was used to achieve objectives (iii) of the study. The stochastic frontier as an economic method of efficiency measurement in production systems is built around the premise that a production system is bounded by a set of smooth and continuously differential concave production transformation functions for which the frontier offers the limit to the range of all production possibilities. This approach was taken up by Aigner and others which subsequently resulted in the development of this method in econometric studies .The model is explicitly expressed as:

$$Ln\ Y = b_o + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 lnX_4 + b_5 LnX_5 + b_6 LnX_6 + b_7 LnX_7 + V_i - U_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Where:

Y= output of sorghum (kilogram)

X_1 = farm size(hectare)

X_2 = seed (kg)

X_3= fertilizer input (kg)

X_4= manure (kg)

X_5= herbicide (liters)

X_6= pesticides (liters)

X_7= labour (man-day)

β_1–β_7= regression coefficients

V_i = A random variable in production which accounts for the random variation is output by factors beyond the control of farmers.

U_1 = random variable called technical inefficiency effects

β_o = intercept

The model was estimated by maximum likelihood estimation (MLE) technique available in the computer program called frontier version 4.1 developed by Coelli (1996), adopted byKusse; Jema, and Bosena, (2018).

Hence, TE = $Ya/Y\wedge = \frac{actual\ \ output}{frontier\ \ output}$

This is the technical efficiency (TE) which is defined as the ratio of observed output or the actual output to maximum feasible output which is called frontier output.

When TE = 1, it shows that a farmer obtains maximum feasible output, while if TE<1 means a shortfall of the observed output to the frontier output.

3.4.4 Stochastic frontier cost function.

The stochastic frontier cost function is a Cobb-Douglas functional form was used to estimate the allocative efficiencies (AE) of sorghum farmers. It is specified as follows:

$$lnCi = ln\beta_o + \beta_1 lnP_1 + \beta_2 lnP_2 + \beta_3 lnP_3 + \beta_4 lnP_4 + \beta_5 lnP_5 + \beta_6 lnP_6 + \beta_7 lnP_7 + V_i + U_i \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. \ldots \ldots \ldots \ldots \ldots (5)$$

Where:

Ci = Total production cost of the sorghum farmer (naira)

P_1 = Cost of land (naira)

P_2 = Cost of seed(naira)

P_3= Cost of fertilizer input (naira)

P_4= Cost of manure(naira)

P_5= Cost of herbicide (naira)

P_6= Cost of pesticides (naira)

P_7= Cost of labour (naira)

$\beta_1 – \beta_7$= estimated coefficients

V_i = A random variable in production which accounts for the random variation is output by factors beyond the control of farmers such as Weather and diseases

U_1 = random variable called technical inefficiency effects due to farmers socioeconomic characteristics such as age, years spent in school and farm size.

However, because inefficiency is assumed to always increase costs, error components have positive signs (Coelli*et al*., 2002, Babangida, 2016).

3.4.5The economic efficiency function

This is the product of technical efficiency (TE) and allocative efficiency (AE) of the individual sorghum farmer. Therefore the economic efficiency is given as;

$$EE = TE \times AE \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots \ldots \ldots \ldots \ldots \ldots . (6)$$

$$AE = \frac{EE}{TE} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots (7)$$

$$TE = \frac{EE}{AE} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots (8)$$

3.4.6 Technical inefficiency model.

Apart from determining the farmer's technical efficiency in sorghum production, this study also identify the factors influencing technical efficiency i.e. objective (iv). The model is specified as follows;

$$Ui = \beta o + \beta 1W1 + \beta 2W2 + \beta 3W3 + \beta 4W4 + +\beta 5W5 + \beta 6W6 + \beta 7W7 + \beta 8W8 + \beta 9W9 + Ui \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . \ldots \ldots . (9)$$

Where Ui = Technical inefficiency of the farmer

W_1 = age(in years)

W_2 = Sex of farmer (male=1, female=0)

W_3 = Marital status (single=0, widowed=1, divorced=2, married=3)

W_4 = Educational Level (No formal education=0, primary=1, secondary=2, tertiary=3)

W_5 = Household size (Number of persons)

W_6 = Number of years engaged in sorghum farming (Years)

W_7 = Years of participation in cooperative activities (years)

W_8 =Access to credit (Yes=1, No=2)

W_9= Number of visits/contact made by extension agent to the farmer in the year.

$\beta 1 - \beta 9$ = parameters to be estimated

βo = intercept

Ui = error term

3. 4.7*A priori* Expectations

The following are the *a priori* expectations of the factors influencing the technical, allocative and economic efficiency of the farmers.

Z_1 = Age is expected to bepositive or negative

Z_2 = Education is expected to bepositive

Z_3 = Access to credit is expected to be positive

Z_4 = Household size; this variable is expected be negative or positive

Z_5 = Cooperative membership; this variable is expected to be positive

Z_6 = Extension contacts; this variable is expected be positive

Z_7 = Farming experience; this variable is expected to be positive

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic characteristics of Sorghum Farmers

The socioeconomic characteristics of sorghum farmers that were analyzed using descriptive statistic include age, sex, marital status, educational level, household size, number of years engaged in sorghum farming, years of participation in cooperative societies, access to credit and extension contact.

4.1.1 Age of sorghum farmers

Table 1: Age distribution of sorghum farmers

Age(Years)	Frequency	Percentage
20-29	36	15.00
30-39	69	30.00
40-49	80	34.00
50-59	38	16.00
60-69	10	4.00
70-79	1	1.00
Total	234	100.00
Mean	40	

The result in Table 1 revealed that 34 percent of sorghum farmers were within the age range of 40-49 years. The average age of sorghum farmers was found to be approximately 40 years within the active age of between 26– 60 years with the standard deviation of 10.5 and the coefficient of variation is 26.3 percent which is low. It implies that the age of sorghum farmers in the area are close to the average mean age of the farmers, it agrees with the findings of

Oladimeji, Damisa, Abdulsalam, and Omokore (2014), that most farmers are within their active years and can make positive contribution to agricultural production. This finding is also similar to that of Oladimeji and Ajao, (2014),Adegboye (2011),which observed that modal age of 41-50 years constitute a reasonable proportion of the cereal farmers in Nigeria and should be more flexible to new ideas and risk; hence they are expected to adopt innovations more readily than older farmers.

4.1.2 Level of educationof the farmers

Table 2: Distribution of sorghum farmers according to their level of education

Education	Frequency	Percentage
No formal Education	108	48.00
Primary Education	40	17.00
Secondary Education	45	19.00
Tertiary Education	42	18.00
Total	234	100.00

The result in Table 2 shows that 48percent of the farmers had no formal education, 17percent of the respondent had only primary education, 19 percent had secondary education and 18 percent had tertiary education. It implies that sorghum farmers in the study area had one form of formal education or the other.Education is an important socio-economic factor that influences farmer's decision making because of its influence of farmers' awareness, perception and adoption of innovations that can bring about increase in productivity.Adeyemo (2010) revealed that education will obviously improve the efficiency of farmers as it will enable them to access improved technologies and select the best available ones, thereby increasing their output level.

4.1.3 Household size of the farmers

Table 3: Distribution of farmers according to householdsize

Household size	Frequency	Percentage
1-5	44	19.00
6-10	82	35.00
11-15	56	24.00
16-20	35	15.00
21-25	10	4.00
26-30	7	3.00
Total	234	100.00
Mean	12	

Table 3 shows the distribution of sorghum farmers by household size. 35 percent of the farmershad household size that ranged from 6-10 persons and 24 percent had household size of 11-15 persons in their family with average of 12 persons. 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 Babangida (2016),there is a positive and significant relationship between household size and farmers' efficiency in production. However, the absolute number of people in a certain family cannot be used to justify the potential for productive farm. It also agrees with Mohammed (2016), findings that 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.

4.1.4 Farming Experience of the farmers

Table 4: Distribution of farmers according to farming experience

Farming Experience	Frequency	Percentage
1-10	89	38.00
11-20	86	37.00
21-30	42	18.00
31-40	15	6.00
41-50	2	1.00
Total	234	100.00
Mean	16	

The result in table 4 shows the distribution of sorghum farmers based on years of farming experience. The result shows that 38 percent of sorghum farmers in the study area had experience in the sorghum production from 1-10 years, 37 percent had been producing sorghum for 11- 20years. The coefficient of variation is 63 percent; it implies that there is a wide variation among the sorghum farmers in the study area in terms of farming experience. Years of farming experience is an important factor that influences production efficiency among farming households. Farmers with more years of farming experience have been observed to have higher farm output than those with lesser years of farming experience. This agrees with the findings of Izeko and Olumeze (2012). As one gets proficient in the methods of production, optimal allocation of resources is expected to be achieved. Farming experience was expected to influence farm production efficiencies because of accumulation of skills noted that the longer a person stays on a particular job, the better his job performance tends to be (Oladimeji and Abdulsalam, 2013; Adebayo, 2006).

4.1.5 Sex of the farmers

Table 5: Distributions of farmers according to sex

Sex	Frequency	Percentage
Male	213	91.00
Female	21	9.00
Total	234	100.00

Table 5 shows the sex distribution of the sorghum farmers.The table reveals that majority of the sorghum farmers were male representing 91 percent of the sampled farmers while 9 percent werefemales. This implies that sorghum production is dominated by male and this can be attributed to cultural and religious believes prevailing in the study area where females are hardly allowed to go into farming activities.Onuk, Ogara, Yahaya and Nannim (2010), also pointed out that this can also be attributed to the fact that men always have more right to land as a productive resource than women.

4.1 6 Membership of cooperative society of farmers

Table 6: Distribution of farmers according to membership of cooperative society

Membership	Frequency	Percentage
Non	202	86.00
Yes	32	14.00
Total	234	100.00

The result in Table 6 reveals that 86 percent of sorghum farmers do not participate in any cooperative association while those who were members of cooperative society constituted 14 percent of the farmers with the minimum and maximum years of membership of 1 and 20 respectively. According to Idiong*et al*; (2007), membership of cooperative affords the farmers opportunities of sharing information on modern sorghum practices.

4.1.7 Years of membership of farmers in cooperative society

Table 7: Distribution of farmers according to years spent in cooperative society

Years spent in cooperative society	Frequency	Percentage
1-5	20	63.00
6-10	9	28.00
11-15	1	3.00
16-20	2	6.00
Total	32	100.00
Mean	5.6	

The average years of membership of cooperative society was approximately 6 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. Hassan (2014), observed that membership of association was positively related to technical efficiency, and resulted in increase in output.

4.1.8 Farm sizeof the farmers

Table 8: Distribution of farmers according to farm size

Farm size (ha)	Frequency	Percentage
1-5	173	74.00
6-10	54	23.00
11-15	7	3.00
Total	234	100.00
Mean	4.53	

The result in Table 8 reveals that majority (74 percent) of sorghum farmers have farm size ranging from 1-5 hectares with an average of 4.5 hectares. This show that majority of the farmers have small farm sizes and will not be able to enjoy economics of scale in production. Consequently, small farm size is an impendent to agricultural mechanization 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. This in line with studies of Oladimeji*et a;*(2016), on melon production in Kwara State; Sidi*et al;*(2014), on sesame production in Yobe State and Oladimeji and Abdulsalam(2013), on rice production in Kwara State of Nigeria.

4.1.9 Marital Status of farmers

Table 9: Distribution of farmers according to marital status

Marital status	Frequency	Percentage
Single	6	3.00
Married	225	96.00
Divorced	3	1.00
Widowed	0	0.00
Total	234	100.00

The result in Table 9 shows the distribution of Sorghum farmers based on their marital status. 96 percent of the sorghum farmers were married. The result shows that 6 percent of the respondents were single, and 1 percent was divorced. Babangida (2016), in his study on profitability and production efficiency in cotton production in North- West Nigeria revealed that the co efficient of marital status was negative and not significant.

4.1.10 Extension contact of farmers

Table 10: Distribution of farmers according to number of extension contact

Extension contact (Numbers)	Frequency	Percentage
No Contact	204	87.00
1-5	27	12.00
6-10	3	1.00
Total	234	100.00
Mean	3	

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 sorghum production instead of using traditional methods which are inefficient, resulting to low yield. The result in Table 9 reveals that 87 percent of sorghum farmers in the study area had no contact withextension service. 13 percent had contact with extension service with average of 3 times per year. This implies that there is low extension - farmerscontactin the study area. It is expected that extension services should enhance sorghum farmers' ability to efficiently utilize resources through the adoption of improved methods used in sorghum production in the study area (Sani and Oladimeji, 2017).

4.1.11 Access to credit of farmers

Table 11: Distribution of farmers according toaccess to credit

Access to Credit (₦)	Frequency	Percentage
No access	188	80.3
Formal source	16	6.8
Friends and family	22	9.4
Money lenders	8	3.4
Total	234	100
Mean	1.36	

The result in Table 11 shows that about 80 percent of the farmers financed their sorghum production from personal savings, 6.8 percent sourced their credit through formal sources. 9.4 sourced their credit through informal source like family and friends, while 3.4 sourced credits from money lenders. The low access to credit could be attributed to the fact that government rarely grants financial credit to farmer. Sani and Oladimeji (2017), in their studies on determinant of technical efficiency among sorghum farmers under the Agricultural Transformation Agenda in GombeState, asserted 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.Similarly, Hassan (2014) reported a positive relationship between credit and technical efficiency. This implies that farmers who have access to credit tended to be more efficient in production.

4.1.12 Land acquisition of farmers

Table 12: Distribution of farmers according to land acquisition

Land acquisition	Frequency	Percentage
Inheritance	174	74.00
Lease	16	7.00
Borrowed	12	5.00
Gift	8	4.00
Purchased	24	10.00
Total	234	100.00

Land is one of the most important resources for sorghum production. The result shown in Table 12 reveals that 74 percent of the sorghum farmers acquired their land through inheritance, 7 percent acquired theirs through leasing, 5 percent through borrowing, 4 percent through gift, while the remaining 10 percent acquired land by purchase. The reason for the result was due to the nature of land tenure system and inheritance characteristic of the respondents in the study area.

4.2 Measurement of profitability in Sorghum production

4.2.1 Gross Margin

Gross margin analysis was carried out so as to determine the level of profit associated with sorghum production in the study area. The result is presented in Table 13.

Table 13: Average cost and return per hectare of sorghum production

Variable	Value (₦)	Unit price(₦)	Percentage
a. Total Revenue(TR)	354,946.6		
b. Variable Costs			
i. Seed (kg)	4,882	120/kg	2.9
ii. Fertilizer (kg)	48,114	6,900/bag	28.8
iii. Agrochemical (litre)	12,264	1600/litre	7.3
iv. Labour (man-days)	101,928.6		61
c. Total Variable cost(TVC)	167,188.6		100
e. Gross Margin(TR-TVC)	187,758		
d. Return to Naira invested (TR/TVC)	2.12		

The analysis revealed total revenue (TR) of ₦354,946.6 per hectare and a total variable cost of (TVC) production ₦ 167,188.6 per hectare thus, the gross margin realized is ₦187,758. This shows that sorghum production in the study area is profitable to the tune of ₦187,758 per hectare. The total cost of production consists of the costs of fertilizer, seed, agrochemicals, labour. Among the variable costs recorded by the sorghum producers, labour recorded the highest with a cost of ₦101,928.6 representing 61 percent of the total cost of production per hectare. This was followed by fertilizer with a cost of ₦48,114 representing 28.8 percent. From the result, it shows that more profit will be made in sorghum production if the cost of labour and fertilizer is reduced.

Findings by Vihi, Ngu-uma, and Oma (2019) have shown that sorghum production in Riyom Local Government Area of Plateau State Nigeria is profitable with a gross margin of ₦56,500.40 per hectare.

4.2.2 Return to investment in sorghum production (RNI)

Table 13 further shows the average rate of return on investment per hectare (return per naira invested per hectare) was ₦2.12, indicating that for every ₦1 invested in sorghum production a profit of 1.12 kobo was made as profit. Thus, it could be said that sorghum production in the study area though on a small scale, was profitable.

4.3 Estimation of Technical, Allocative and Economic Efficiency of Sorghum Farmers

4.3.1Technical Efficiency of Sorghum Farmers (input-output relationship)

The model specified was estimated by the maximum likelihood (ML) method using frontier version 4.1 software developed by Coelli (1996) and adopted by Sani and Oladimeji (2017). The ML estimates and inefficiency determinants of the specified frontier are presented in Table 14.

Table 14: Estimation of maximum likelihood of production function

Variable	Parameter	Coefficient	Standard-error	T-value
Efficiency model				
Constant	β_0	9.5429	1.6365	5.831
Farm Size	β_1	0.0004	0.0002	1.904*
Seed	β_2	0.0001	0.0004	0.313
Fertilizer	β_3	0.0015	0.0002	8.693***
Manure	β_4	0.0007	0.0002	4.049***
Herbicide	β_5	0.0018	0.0003	7.196***
Pesticide	β_6	-0.0004	0.0003	-1.504
Labour	β_7	-0.0014	0.0004	-3.834***
inefficiency model				
Constant	W_0	-16.3310	4.5378	-3.599
Age	W_1	-3.0107	0.4736	-6.357***
Sex	W_2	-20.7531	1.6947	-12.246***
Marital status	W_3	-5.6741	1.5047	-3.771***
Educational Level	W_4	-4.7032	2.9180	-1.612
Household size	W_5	-3.5926	1.2849	-2.796**
Farming experience	W_6	-6.2054	1.4592	-4.253***
Years of membership	W_7	-6.7248	1.1440	-5.878***
Access to credit	W_8	-30.306	2.822	-10.739***
Extension visit	W_9	-30.428	3.228	-9.426**
Diagnostic statistics				
Sigma-squared	δ^2	5.1620	1.0001	5.162***
Gamma	Γ	0.9200	0.1133	8.827***
Loglikelihood function	*LIF*	-168.466		
LR test	*LR*	60.233		
Mean Efficiency		0.63		

Note: ***, ** and * significant at 1 percent, 5 percent and 10 percent levels of probability

The study revealed that the generalized log likelihood function was -168.466. 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 92 percent 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 92 percent 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 (σ^2) was also highly significant at $p<0.01$. 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 the parameters of production function (farm size, fertilizer, manure and herbicides) were positive while (pesticides and labour) were negative. Fertilizer, manure, herbicides and labourwere significant at$p<0.01$while land is significant at $p<0.1$. Seed was not statistically significant which is contrary to the findings ofSani and Oladimeji (2017), and Mohammed (2016), who found out that seed, was statistically significant in sorghum production. The non – conformity of the seeds to *a priori* expectation could be due to the fact that most farmers recycle their old seeds.In order to have good emergence count,farmers used more seeds than required to make allowance for non-viable seeds;if correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance (Mohammed, 2016).This variable is however not significant. This is in line with the findings of Ojehomon,Adewumi and Omotesho (2013), on determinant of technical efficiency of new rice for Africa (NERICA) production: a gender approach; who found out that seed was not significant in rice production. Similarly, Pesticides was not significant and therefore do not take part in sorghum production.

The mean technical efficiency for the farmers was 0.63 implying that, on the average, the respondents are able to obtain 63 percent of potential output from a given mixtures of production inputs. Thus, in a short run, there is minimal scope 37percent of increasing the efficiency, by adopting the technology and techniques used by the best sorghum farmer.

The estimated coefficient for farm size was 0.0004 which is positive and statistically significant atp<0.1 and has the expected positive sign, which is in conformity to *a priori*expectation. The significance of farm size is that it is one of the major factors of production. This implies that a unit increase in farm size will increase sorghum output by 0.04 percent.The coefficient of herbicides was 0.0018 which was positive and statistically significant at p<0.01 and has the expected positive sign, which is in conformity to *a priori* expectation. This shows the importance of optimal application of herbicide in sorghum farming in the study area. This is in line with the study by Umoh (2006), which show the importance of optimal agro-chemical usage in farming particularly in developing countries where most farmers operate on small-scale farms. This implies that a unit increase in quantity of herbicides used will increase sorghum output by 0.18percent because weeds will be destroyed and there will not be competition for air, water and space with sorghum crop.

The estimated coefficient for fertilizer was 0.0015 which is positive and statistically significant at p<0.01. This implies that a unit increase in fertilizer will increase sorghum output by 0.15percent. Fertilizer is a major land augmenting input because it improves the quality of land by raising yields per hectare. This study is in agreement with the findings ofOladiebo and Fajuyigbe, (2007); Sani and Oladimeji, (2017).The coefficient of manure was 0.0007 which is positive and significant at p<0.01; this implies that a unit increase in manure will increase output of sorghum by 0.07percent. The coefficient of labour was -0.004 which is negative and

statistically significant at p<0.01. The negative sign of labour indicates that farmers might have over-utilized labour input this implies that a unit increase in labour will decrease sorghum output by 0.14percent. This shows that labour is an important variable in sorghum farming in the study area. This is also agrees with the study 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).

Table 14 further shows the factors influencing technical efficiency of sorghum production. Generally, a negative sign on a parameter means that the variable reduces technical inefficiency and increases technical efficiency while a positive sign increases technical inefficiency and reduces technical efficiency.

The coefficient of age was negative and statistically significant at p<0.01, implying that an increase in age, decreases technical inefficiency. This is similar to the findings of Neba*et al;* (2010), Gul *et al;* (2009), and Kouser*et al;* (2010) who found age to be negatively related to technical inefficiency. The possible reason given may be due to the fact that as the farmers advanced in age, the farmers becomes more experienced in sorghum production making inefficiency in resource use to decrease while technical efficiency increases. This finding is also contrary to the findings of Jema and Bosena (2018), who found age to be positively related to technical inefficiency.

The coefficient of household size was negative and statistically significant at p<0.05, implying that an increase in household size will lead to an increase in technical efficiency. Household size is an important variable because sorghum production is a labor-intensive activity, In this regard; the effect of household size on technical inefficiency cannot be overemphasized. The

result is in accordance to *a priori* expectation that those households having large household size are less inefficient than households having small household size. Family labour is the main input in crop production. As the farmer has a large household size, he would manage crop plots on time and may be able to use appropriate input combinations. The result is similar to the findings Essa (2011) but contrary to the findings of Hailemarim (2015).

The coefficient of farming experience was negative and statistically significant at $p<0.01$. This shows that it increases technical efficiency and decreases technical inefficiency; in a study on estimating technical efficiency of cotton production in Yendi Municipality, northern Ghana. Adzwala*et al;* (2013), found that the coefficient of farmers experience was negative and significant at $p<0.05$ implying that farmer cultivating cotton for longer years were less technically inefficient.

The coefficient of years of cooperative membership was negative and statistically significant at $p<0.01$. This shows that cooperative membership increases technical efficiency. Agricultural cooperatives enhance farmers' efficiency through easy access to productive inputs and facilitating more extension visits thereby helping them adopt new innovations. This is similar to findings of Abate; Francesconi and Getnet (2013), in their work on Impact of agricultural cooperatives on smallholders, technical efficiency in Ethiopia; found out that farmer that spent more years in cooperative association are more technically efficient.

The coefficient of access to credit was negative and statistically significant at $p<0.01$. This is in accordance with *a priori* expectation because credit is believed to increase crop area, more input application and more yields Mohammed (2016), It must however be noted that for access to credit to positively affect technical efficiency, the credit has to properly managed and sound agronomic practices has to be adopted (Adejoh, 2010).

The coefficient of extension visit was negative and statistically significant at $p<0.05$. This implies that a frequent visit facilitates the flow of new ideas between the extension agent and sorghum farmer's thereby giving room for improvement in farm efficiency. This result is in line with the results of Musa (2013), and Hailemaraim (2015), this finding is also similar to the findings of Jema and Bosena (2018) in their work on technical efficiency of sorghum production in Konso district southern Ethiopia who found a negative relationship between level of inefficiency and extension service.

4.3.2 Allocative efficiency (cost efficiency) of sorghum farmers

The Maximum Likelihood (ML) estimates of the stochastic frontier cost parameters for sorghum are presented in Table 15. For the cost function, the sigma (δ^2= 0.79) are quite high and very low for the gamma (γ=0.1164) and highly significant at $p<0.01$ of probability. The high and significant value of sigma square (δ^2) indicated the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005; Babangida, 2016). The gamma (γ = 0.1164) shows that 11.64 percent 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 15.

Table 15: Estimation of maximum likelihood of allocative efficiency (cost efficiency)

Variable	Parameter	Coefficient	standard-error	t-value
Efficiency model				
Constant	β_0	-36.675	9.610	-3.816
Farm size	β_1	0.0317	0.0108	2.939***
Seed	β_2	0.0657	0.0354	1.855*
Fertilizer	β_3	0.0805	0.0438	1.836*
Manure	β_4	-0.0341	0.0110	-3.092***
Herbicide	β_5	0.0510	0.0552	0.925
Pesticide	β_6	0.0061	0.0360	0.168
Labour	β_7	0.0414	0.0713	0.580
inefficiency model				
Constant	W_0	8.7822	3.3967	2.586
Age	W_1	-0.7397	0.3913	-1.890*
Sex	W_2	1.0787	4.7546	0.227
Marital status	W_3	0.8725	3.8762	0.225
Educational Level	W_4	-12.0843	6.2764	-1.925*
Household size	W_5	-10.9039	2.9930	-3.643***
Farming experience	W_6	-3.4982	2.0023	-1.747*
Years of membership	W_7	-0.3618	1.1489	-0.315
Access to credit	W_8	3.924	2.009	1.953*
Extension Contact	W_9	-3.6159	17.3114	-0.209
Diagnostic statistics				
Sigma-squared	δ^2	7.9070	1.0591	7.466***
Gamma	Γ	0.1164	0.0107	10.883***
Log likelihood function	LIF	-1488.63		
LR Test	LR	19.7017		
Mean Efficiency		0.65		

Note: ***, ** and * significant at 1 percent, 5 percent and 10 percent levels of probability

The estimated coefficients of the parameters of the cost function are positive except that of manure which is negative. Farm size and manure are significant at $p<0.01$ whilethe cost of variable seeds and fertilizer are significant atp<0.1. The cost of labour, herbicides and pesticides are not statisticallysignificant.

Farm size was positive and statistically significant at $p<0.01$. This indicating that if there is an increase in cost of farm size, the total cost of sorghum production will increase.

The coefficient of the cost of seed was positive and statistically significant at $p<0.1$. This implies that seed are important in crop production in sorghum farms. This is 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 Mohammed (2016), where he reported direct effect of seed on cost of production in his study on impact of farm efficiency on sorghum production in Kaduna State.

The coefficient of the cost of fertilizer was positive and statistically significant at $p<0.1$. 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 also agrees with the findings of Mohammed (2016).

. The coefficient of the cost of manure was negative and statistically significant at $p<0.01$. This indicating that if there is an increase in the cost of manure, the total cost of sorghum production will decrease. From the result in Table 15, it shows that the cost of production is influenced by the prices of input applied.

Table 15 further shows the factors influencing allocative efficiency of sorghum farmers in the study area which are age of the farmer, household size, level of education, farming experience, and access to credit.

The coefficient of age was negatively signed and significant at $p<0.1$, 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 Mohammed (2016)

The coefficient for educational level of farmers was negative and statistically significant at $p<0.1$. Education raises the technical competence of an entrepreneur and enables the entrepreneur to cope with the complexities associated with adoption of improved technologies Educated household heads may better understand and process information provided by different sources regarding new investments thereby reducing their allocative inefficiency. This is similar to the findings of Babangida (2016) in his work on Profitability and production efficiency in cotton production in North-west Nigeria.

The coefficient of household size is negative and is statistically significant at $p<0.01$. This shows that it increase allocative efficiency, and decrease allocative inefficiency. This is because the household size is a determinant factor in labour availability which is very crucial in sorghum production. Thus, decreasing allocative inefficiency

The coefficient of farming experience was negative and statistically significant at $p<0.1$. This shows that it increase allocative efficiency and decreases allocative inefficiency. This is perhaps due to their ability to draw on past experience and apply to their present farming conditions.

The coefficient of access to credit was positive and statistically significant at $p<0.1$. According to the result since access to credit is positive, allocative inefficiency will increase. This is contrary to *a priori* expectation that access to credit should have positively affected allocative efficiency, or reduces allocative inefficiency. The result might be explained probably due to the fact that the credit obtained was not judiciously allocated in the cotton production process. The credit might have been diverted to other nonfarm household expenditure including marrying additional wives or payment of children school fees. This confirm to the assertion of Adejoh (2010) in his study on production efficiency and profitability of yam production in Ijumu local government area of Kogi State, Nigeria that access to credit per see does not

influence allocative efficiency but the proper management of the credit facility as well as application of sound agronomic practices. Another probable reason for the result might be that the interest rate on the credit was high or the credit was not given on time for the farmers to use during the cropping season. This is also similar to the findings of Shah *et al.*, (2008),in their study on impact of agricultural credit on farm productivity and income of farmers in mountainous agriculture in northern Pakistan. Their study revealed that for institutional credit to be more effective in increasing farmers' productivity, the institutional credit should be of low interest rate, procedures of advancing loan should be made simple to peasant farmers and credit should be made available on time.

4.3.3Frequency distribution of technical, allocative and economic efficiency estimates of sorghum farmers

4.3.3.1 Frequency distribution of technical efficiency estimates of sorghum farmers

Table 16: Distribution of technical efficiency estimates of sorghum farmers

Technical efficiency	Frequency	Percentage
0.20-0.29	10	4.3
0.30-0.39	30	12.8
0.40-0.49	19	8.1
0.50-0.59	35	15.0
0.60-0.69	45	19.2
0.70-0.79	45	19.2
0.80-0.89	35	15.0
0.90-0.99	14	6.0
Average	0.62	
Maximum	0.97	
Minimum	0.20	

The result in Table 16 shows the frequency distribution of technical efficiency indices of sorghum farmers as obtained from the stochastic frontier model.It was observed from the study that the average technical efficiency level is 0.62 ranging from 0.20 to 0.99. The technical efficiency index ranged from a minimum of 0.20 to a maximum of 0.97 for sorghum farmers. This implies that sorghum farmers have the potentials to improve their production efficiency

technically using existing technology by 36 percent (because of the average of 0.62). This also implies that on the average, output fall by 36 percent from the maximum possible level due to inefficiency. From the result 59.4percent of the farmers had technical efficiency (TE) 0.62 and above while 40.6 percent of the farmers operated at less than 0.62 technical efficiency levels.The results also suggest that for the average farmer in the study area to achieve technical efficiency of his most efficient counterpart, he could realize about 36 percent (1 – 0.62/0.97x100) cost savings. A similar calculation for the most technically inefficient farmer reveals cost savings of 79.38 percent in sorghum production if he or she is to attain the efficiency level of most technically efficient farmer [1-(0.20/0.97)*100]

4.3.3.2 Frequency distribution of allocative efficiency estimates of sorghum farmers

Table 17: Distribution of allocative efficiency estimates of sorghum farmers

Allocative efficiency	Frequency	Percentage
0.10-0.19	3	1
0.20-0.29	13	5
0.30-0.39	25	11
0.40-0.49	27	12
0.50-0.59	25	11
0.60-0.69	42	18
0.70-0.79	39	16
0.80-0.89	40	17
0.90-0.99	20	9
Average	0.61	
Maximum	0.97	
Minimum	0.10	

The allocative efficiency estimates presented in Table 17, indicate that it ranged from 0.10 - 0.99. The allocative efficiency index ranged from a minimum of 0.10 to a maximum of 0.97 with average of 0.61. These implied that if the average sorghum farmer were to achieve allocative efficiency of their most efficient counterpart, then the average farmer could realize 37 percent cost savings [1-(0.61/0.97)*100] A similar calculation for the most allocative inefficient farmer reveals cost savings of 89.7 percent in sorghum production if he or she is to

attain the efficiency level of most allocative efficient farmer [1-(0.10/0.97)*100] This finding is in line with Mohammed (2016), who observed that the most allocative inefficient sorghum farmer will have an efficiency gain of 87.8 percent in sorghum production if he or she is to attain the efficiency level of most allocative efficient farmer. It is evident from these results that allocative inefficiency constitute a more serious problem than technical inefficiency by comparing the level the average and least efficient farmers have to attain to reach the level of the most efficient farmer.

4.3.3.3 Frequency distribution of economic efficiency estimates of sorghum farmers

Table 18: distribution of economic efficiency estimates of sorghum farmers

Economic efficiency	Frequency	Percentage
0.00-0.10	8	3.4
0.10-0.19	33	14
0.20-0.29	37	15.8
0.30-0.39	51	21.8
0.40-0.49	45	19.2
0.50-0.59	29	12.4
0.60-0.69	17	7.3
0.70-0.79	10	4.3
0.80-0.89	2	0.9
0.90-0.99	2	0.9
Average	0.39	
Maximum	0.91	
Minimum	0.05	

The stochastic frontier production function and cost functions were used to estimate the economic efficiencies indices of the farmers in the study area. Economic efficiency indices were estimated as the product of technical and allocative efficiency indices. 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 18. The combined multiplicative effect of technical and allocative efficiency shows that the average economic efficiency indices for the sampled farmers were 0.39 with a minimum of 0.05 and a maximum of 0.91. It was observed from the study that 66.8 percent of the farmers had economic

efficiency (EE) of 0.39 and above while 33.2 percent of the farmers operate at less than 0.39 efficiency level. This implies that on the average, output fall by 39 percent from the maximum possible level due to economic inefficiency. 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 57 percent (1 – 0.39/0.91x100) cost saving while on the other hand, the least economic efficient farmers will have about 94.5 percent (1 – 0.05/0.91x100) cost saving to become the most efficient farmer.

4.3.4 Disaggregation of the farmer's efficiency in relation to the significant socio-economic variables

Disaggregation further explains the relationship between average efficiency and some significant socio-economic variables characterizing sorghum farmers.

4.3.4.1 Average efficiency and age of sorghum farmers

The result in Table 19 shows that efficiency seemed to be quite stable among the age groups, as there was relatively insignificant difference in their average technical efficiencies but from age 50-59 the average technical efficiency (TE) of sorghum farmers increased slightly, suggesting that older farmers were more efficient. This is similar to the findings ofAdzawla (2013), who found that older farmers were more efficient.For the average allocative efficiency (AE), farmers at the age of 50-59 years is 0.63 implying that farmers at this age are not minimizing cost compared to the farmers at the age of 20-29 years this could be due to the fact that older farmers spend more on labour compared to the younger farmers and as result are not minimizing cost.

Table 19: Average efficiency distribution and age of sorghum farmers

Age of sorghum farmers	Average TE	Average AE	Average EE
20-29	0.59	0.70	0.42
30-39	0.60	0.60	0.38
40-49	0.60	0.61	0.39
50-59	0.63	0.60	0.37

4.3.4.2 Average efficiency and household size of sorghum farmers

Table 20 shows generally, technical efficiency increased with increasing household size. Farmers with household size of between 26 and 30 had the highest average technical efficiency of 0.69 and allocative efficiency of 0.74, this suggests that as the number of people in a household increases, a pool of family labour becomes available and this leads to specialization thereby increasing technical efficiency. The result also suggests that due to high number of the household size which leads to specialization, it helps the household in reducing the cost of labour thereby minimizing cost and maximizing profit.

Table 20: Average efficiency distribution and household size of sorghum farmers

Household size of sorghum farmers	Average TE	Average AE	Average EE
1-5	0.63	0.70	0.43
6-10	0.63	0.62	0.41
11-15	0.64	0.62	0.40
16-20	0.62	0.40	0.42
21-25	0.68	0.59	0.36
26-30	0.69	0.74	0.26

4.3.4.3 Average efficiency and years of cooperative membership of sorghum farmers

The result in Table 21 indicates that efficiency was highest among farmers with between 6-10 and 11-15 years of cooperative membership (0.68), followed by those with between 6 and 10 years of cooperative membership (0.65). The result suggests that with more years in cooperative membership, TE will increase because membership of cooperative affords the farmers opportunities of sharing information on modern sorghum practices.Also Average allocative efficiency (AE) which is 0.76 shows that farmers with 11-15 years of cooperative membership are minimizing cost this could be due to fact that with more years spent in cooperative society, more knowledge is acquired on how to allocate input at an optimal level giving a price factor.

Table 21: Average efficiency distribution and years of cooperative membership of sorghum farmers

Years of cooperative membership	**Average TE**	**Average AE**	**Average EE**
1-5	0.65	0.63	0.40
6-10	0.68	0.55	0.39
11-15	0.68	0.76	0.51

4.3.5 Disaggregation of the farmer's efficiency in relation to the significant input variables

Disaggregation further explains the relationship between average efficiency and some significant socio-economic variables characterizing sorghum farmers.

4.3.5.1 Average efficiency and farm size of sorghum farmers

Table 22: Average efficiency distribution and farm size of sorghum farmers

Farm size (ha)	Average TE	Average AE	Average EE
1-5	0.62	0.62	0.38
6-10	0.64	0.59	0.39
11-15	0.72	0.63	0.46

Table 22 shows the average efficiency distribution of sorghum farmers based on farm size. From the results, farmers who had relatively large farms size between 11- 15 had greater technical efficiency (0.72) than those who had smaller farms size. The average allocative AE is 0.63 for farmers with 11-15ha which is high, and economic efficiency varies based on the farm size. The implication of this result is that with increase in farm size, TE also increases. And AE which is 0.63 imply that they are minimizing cost due to the fact that with increase in farm size, more inputs will be purchased at a discount rate because farmers are buying in bulk. This findings is similar to the findings of Adwazla and Donkoh (2013), they found out that that farmers' who had farm size (2 acres) had greater efficiency (0.93) than those who had smaller farms (1 acre).

4.3.5.2 Average efficiency and quantity of fertilizer used by sorghum farmers

Table 23: Average efficiency distribution and quantity of fertilizer used by sorghum farmers

Fertilizer quantity (kg)	Average TE	Average AE	Average EE
25-50	0.62	0.62	0.38
50-75	0.65	0.64	0.41
75-100	0.61	0.62	0.39
100-125	0.60	0.58	0.35

Table 23 shows the average efficiency distribution of sorghum farmers based on quantity of fertilizer used by sorghum farmers. From the results, farmers who had higher quantity100-125 had lesser technical efficiency (0.60) than those who had smaller quantity. The average allocative AE is (0.58) which is low compared to farmers with TE of 0.61, and economic efficiency varies based on the quantity used, from 25-50 kg, the average TE increased but will more application it decreases. The implication of this result is that with increase quantity of fertilizer, TE will also decrease; this could be as a result of the fact that farmers did not really follow the recommended rate of fertilizer application. Also the average AE (0.58) shows that farmers with farm size of 11-15ha are not minimizing cost due to the fact that they applied more fertilizer at a high price.

4.3.5.3 Average efficiency and quantity of herbicides used by sorghum farmers

Table 24: Average efficiency distribution and quantity of herbicides used by sorghum farmers

Herbicides (L)	Average TE	Average AE	Average EE
1-5	0.62	0.61	0.38
6-10	0.65	0.64	0.40
10-15	0.66	0.57	0.38

Table 24 shows the average efficiency distribution of sorghum farmers based on quantity of herbicides used by sorghum farmers. From the results, farmers who had higher quantity >10 had greater technical efficiency (0.66) farmers that used from 1-5 L had lesser technical efficiency (0.62). The average allocative and economic efficiency varies based on the quantity used. The implication of this result is that with increase quantity of herbicides, TE will also increase.

4.5Constraints to sorghum Production

Table 25: Constraint to sorghum farming

Variables	Frequency	Percentage	Rank
Cost of Fertilizer	188	80	1st
Inadequate capital	178	76	2nd
Cost of labour	121	51	3rd
Inadequate improved seed	108	46	4th
Pest and diseases	85	36	5th
Weed infestation	84	35	6th
Inadequate extension workers	71	30	7th
Inadequate storage facilities	30	12.8	8th

The problems faced by sorghum farmers in the study area were ranked according to their magnitude as stated by the farmers (Table 25). The problem of fertilizer cost was the most severe constraint of sorghum production with about 80 percent of the farmers attesting to this fact.Fertilizer is an important input in crop production been that it replenishes the fertility of the soil. However it is not extensively used in the study area due to its high price; this makes most farmers not being able to meet up with the recommended level of application of the input,this result in yield generally beinglow. 76 percent of the sorghum farmers indicated inadequacy of capital and credit facilities which rank second, affects sorghum production in the study area, because the savings the farmers might have made or the funds generated from personal savings is not sufficient to satisfy various activities in sorghum production. Most of the farmers also complained of not having enough money to purchase farm inputs.

The result also revealed that 51 percent of the sorghum farmers indicate cost 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;and these led to high cost of labour in sorghum farming in the study area.

About 46 percent of sorghum farmers indicated inadequate improved seed is also one of the constraints to sorghum production which is ranked fourth. Most of the farmers used seeds gotten from previous harvest instead of using improved seed.Seed is the single most important input in crop production. It carries the genetic potential of the variety and determines the ultimate productivity of other inputs. Pest and disease ranked fifth which are responsible for pre-harvest and post-harvest losses by sorghum producers. This affects sorghum production in the study area as it causes low productivity of the farmers. Babangida (2016), noted that pest and disease infestation constituted 69percent of yield reduction.

Weed Infestation rankssixth as attested to by the farmers as affecting sorghum production in the study area. Directly or indirectly, weeds reduce sorghum productivity

Inadequate extension worker to disseminate new ideas and innovation to sorghum farmers is ranked seventh as one of the problems affecting sorghum production. Inadequate extension services limit awareness of the availability of improved sorghum varieties and improved production technology currently available at the research stations.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study looked at profitability and efficiency of sorghum production in Funakaye, Balanga and YamaltuDeba Local Government Areas of Gombe State, Nigeria. Two villages each were randomly selected from the three Local Government Areas giving a total of six villages and 234 sorghum farmers were sampled. Primary data were collected from 234 respondents using structured questionnaire. The statistical tools used to analyze the data were descriptive statistics, stochastic frontier version 4.1 and gross margin.

The result of the analysis shows 34 percent of the sorghum farmers were within the age range of 40-49 years. Majority of the sorghum farmers had one form of formal education or the other while 46 percent had no formal education. 35 percent had household sizes ranging from 6-10 persons and 24 percent had household sizes ranging from 11-15 persons with average of 12 persons.Some 38 percent of the sorghum farmers had farming experience range from 1-10 years. 91 percent of the sorghum farmers are males. However, majority of the sorghum farmers do not belong to cooperative association.Majority of the farmers (74 percent) had farm size ranging from 1-5 hectares. Also, themajority (87 percent) of the sorghum farmers do not have contact with extension agent. About 80 percent of the farmers finance their production through personal savings, while majority of the sorghum farmers acquired their land through inheritance.

The stochastic frontier production function was estimated for technical, allocative and economic efficiency. It was observed from the study that the mean technical efficiency for the 234 sampled farmers in the study area was 0.63implying that on the average, output fall by 37

percent from the maximum possible level due to inefficiency compared to the most efficient farmer. The estimated coefficients of all the parameters of production function (land, seed, fertilizer, manure and herbicides) were positive while (pesticides and labour) were negative. Fertilizer, manure, herbicides and labour were significant at 1 percent level while land was significant at 10 percent level of probability and hence play major roles in sorghum production in the study area except seed which is positive and statistically not significant. The mean allocative efficiency was 0.65.The result indicates that average sorghum farmer in the study area could enjoy cost saving of about 35 percent. Age, household size, years of cooperative membership and access to credit was statistically significant at 5 percent to 10 percent levels which are found to be the factors influencing the technical efficiency of sorghum farmers. Age, educational level, household size, and access to credit were statistically significant and were found as factors influencing allocative efficiency.

The total variable cost (TVC) incurred and revenue obtained per hectare for sorghum were estimated to determine the profitability of sorghum production in the study area. The total revenue (TR) was ₦354,946.6 while the total variable cost (TVC) was ₦167,188.6. The gross margin was therefore ₦187,758. The rate of return on investment (return per naira invested) was ₦2.12 indicating that for every ₦1 invested in sorghum production in study area; a profit of 1.12 kobo was made. Thus, it could be concluded that sorghum production in the study area is profitable.

The eight major constraints associated with sorghum production ranked in order of importance were cost of fertilizer, inadequate capital, cost of labour, inadequate improved seed, pestand diseases, weed infestation, inadequate extension workers and inadequate storage facilities. The constraints were reported by 80 percent, 76 percent, 51 percent, 46 percent, 36 percent, 35 percent, 30 percent and 13 percent of the sorghum farmers respectively

5.2 Conclusion

Based on the findings of this study, it can be concluded that sorghum production is profitable in the study area with gross margin of ₦187, 758 and with ₦2.12 return per naira invested. The results revealed that 92 percent of random variation in the yield of sorghum farmers was due to the farmers' inefficiency in their respective sites. And 11.64 percent of the variability in the output of sorghum farmers that are unexplained is due to allocative inefficiency of the sorghum farmers.Given that sorghum is an important staple food in Nigeria, any attempt to increase its productivity would be a right step towards combating food crises.

Also based on the findings, it can be concluded that the major input variables influencing sorghum output were Farm size, fertilizer, manure, agro chemicals and labour.These results imply that in order to improve output level in sorghum production, there is need to improve on the major variable inputs.Furthermore, the estimated mean values for technical, allocative and economic inefficiencies in sorghum production suggests that some gap exist for farmers to increase their levels of technical, allocative and economic efficiencies by allocating the existing resources more optimally. These results suggest that substantial gains in output and decrease in cost can be attained given existing technology.

Results of the factors influencing technical, allocative and economic efficiency indicates that farmers' socio-economic variables are among the factors influencing efficiency in sorghum production. Conclusions from these findings are that there is ample opportunity to increase the present level of efficiency of sorghum production in the study area. This can be achieved through improvement of specific factor which include educational level of farmers, household size, access to credit, extension contact, and membership of cooperatives.

5.3 Contribution of the Study to Knowledge

i. The study revealed that the more the quantity of fertilizer applied the lesser the technical efficiency. Farmers that applied 25-50kg had average technical efficiency of 0.65 but farmers that applied 100-125 had average technical efficiency of 0.60.

ii. The study revealed that sorghum farmers with larger farm sizeswere more efficient with average technical efficiency of 0.72, average allocative efficiency of 0.63 and economic efficiency of 0.46.

iii. The study revealed that despite constraints faced by sorghum farmers, sorghum production is profitable with gross margin of ₦187,758. The rate of return on investment (return per naira invested) is ₦2.12, indicating that for every ₦1 invested in sorghum production in study area; a profit of 1.12 kobo will be made.

iv. The study revealed that sorghum farmers in the study area achieved a mean technical efficiency of sixty three (63) percent and allocative efficiency of sixty five (65) percent.

5.4 Recommendations

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

i. Cooperative membership is negative and statistically significant. Hence farmers should be encouraged to join cooperative societies in other to enhance their farming skills.

ii. Fertilizer is one of the inputs that positively and significantly affect sorghum,and cost of fertilizer is the most severe problem faced by sorghum farmers;therefore, it is recommended that adequate supply of fertilizer should be made available to farmers at affordable price in order to enhance sorghum production. Also since with increase in quantity of fertilizer application, the average technical efficiency of farmers decreases, it is also recommended that farmers should adopt the recommended rate of fertilizer application so as to be more efficient.

iii. The problem of inadequate capital was one of the most important constraints to sorghum production. Thus, credit should be made more accessible to sorghum farmers through reduction of interest rate and farmers should equally be educated in the use of such credit for more and significant impact.

iv. Extension contact is one of the constraints of sorghum farmers. It is generally known that investment in extensions service is critical to reducing the level of inefficiency. There should be improved extension linkages to sensitize sorghum farmers on the need to adopt the recommended practices for sorghum production

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Appendix 1

Research Questionnaire

Profitability and Efficiency of Sorghum Production in Funakaye, Balanga and YamaltuDeba Local Government Areas of Gombe State, Nigeria

Dear Respondent,

This questionnaire will be used by a student of the Department of Agricultural Economics, Ahmadu Bello University, Zaria. Please, fill as appropriate. All information will be treated with confidentiality and strictly for the purpose of research. Thanks for your co-operation.

Village …… L.G.A……

SECTION A: SOCIO-ECONOMIC CHARACTERISTICS

1. Name of farmer……
2. Sex: Male ( ) Female ( )
3. Age (years)……
4. Marital status: Married ( ) Single ( ) Divorced( ) Widowed( )
5. Highest level of Education:

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

6. Education ( ) (d) Tertiary Education ( ) (e)Arabic ( ) (f) Adult( )
7. Household Size (All the number of the people depending on you for living)…….
8. How long have you been in sorghum farming? (Years of experience)……
9. Do you belong to any co-operative/Association? Yes ( ) No ( )
10. If yes, (Years of participation) ----------
11. What is your major source of capital for sorghum farming?

(a)Personal savings ( ) (b) credit ( ) (c) Friends and family ( ) d. Money Lenders ( )

12. Have you ever been visited by an extension agent? (a) Yes ( ) (b) No ( )
13. If yes, how many times …….
14. What activities did the agent teach you? .....
15. Of what benefit were the techniques learnt to you to the success of your farm? ....
16. Have you been trained on sorghum farming? Yes ( ) No ( )
17. If yes, which organization conducted the training? …….
18. Was the training beneficial to you?

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

SECTION B: INFORMATION ON INPUTS (LAST PRODUCTION CYCLE)
Farm size (Ha)

i. How many sorghum farm plots do you have? .....
ii. How did you acquire your land (tick in the table below)

Plot size (ha)	Mode of acquisition				
	(a) Inheritance	(b) lease	(C) borrowed	(d) Gift	(e) purchased
Size(ha)					

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

1. Seed (Kg)

Type of Seed	Quantity of Seed (Kg) for sorghum	Value for the quantity of seed (₦)
Local name……		
Improved name……..		

2. Fertilizer Acquisition

Fertilizer type	Quantity for sorghum (Kg)	Value for the quantity (₦)
NPK		
UREA		
SSP		

3. Manure Acquisition

Manure type	Quantity for Sorghum (Kg)	Value for the quantity (₦)
Poultry droppings		
Cow dung		

4. Herbicide Acquisition

Type of Herbicide	Quantity of Herbicide (Litre)	Value for the Herbicide (₦)

5. Pesticides Acquisition

Type of Insecticide	Quantity of Insecticide (Litre)	Value for the insecticide (₦)

6. Labour input

Land preparation

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day/hour	Cost(₦)

Planting

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day	Cost(₦)

Fertilizer Application

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day/hour	Cost(₦)
1st Application					
2nd Application					

First Weeding

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day/hour	Cost(₦)

Second Weeding

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day/hour	Cost(₦)

Reconstruction of Ridges (Bankasa)

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day/hour	Cost(₦)

Harvesting

Hired Labour			Family Labour		
No of people	Man-day/hour	Cost (₦)	No of people	Man-day/hour	Cost(₦)

Information on sorghum output

Plot No	Quantity of sorghum Harvested in (Kg)	Total quantity sold	Price/Unit(₦)
1			
2			
3			

Constraints of sorghum production

S/n	Constraints
1	
2	
3	
4	
5	

Suggest possible solutions

1) ……
2) ……
3) ……
4) ……
5) ……
6) ……

Appendix 2

Result of Analysis

Output from the program FRONTIER (Version 4.1c)
Instruction file = terminal
Data file = i.txt
Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged
Technical efficiency estimates:

Sigma-squared 0.51623704E+05

Log likelihood function = -0.16845827E+04

firm	year	eff.-est.
1	1	0.31869808E+00
2	1	0.56870242E-01
3	1	0.11381357E+00
4	1	0.17980921E+00
5	1	0.31813968E-01
6	1	0.93329819E-01
7	1	0.21215636E+00
8	1	0.35352545E-01
9	1	0.45008948E-01
10	1	0.38690521E-01
11	1	0.24611761E-01
12	1	0.59514519-254
13	1	0.10605270E+00
14	1	0.10635378E+00
15	1	0.41779199E-01
16	1	0.12256494E+00
17	1	0.24633139E-01
18	1	0.12208808E+00
19	1	0.81260746-254

20	1	0.13528279E-01
21	1	0.16947628E-01
22	1	0.31342334E-01
23	1	0.85159211E-01
24	1	0.45729468E-01
25	1	0.81838415E-01
26	1	0.80521620E-01
27	1	0.81858328E-01
28	1	0.42189616E-01
29	1	0.10611751-253
30	1	0.10633752-253
31	1	0.87803298E-02
32	1	0.19796535E-01
33	1	0.10633912E+00
34	1	0.18812350E-01
35	1	0.10630016E+00
36	1	0.67544211E-01
37	1	0.21054119E-01
38	1	0.38658425E-01
39	1	0.56495884-254
40	1	0.56456936-254
41	1	0.73983671E-01
42	1	0.84721104E-01
43	1	0.12544712E+00
44	1	0.85590506E-01
45	1	0.50148874-255
46	1	0.35140111E-01
47	1	0.34166001E-01
48	1	0.22745003E-01

49	1	0.15904930E+00
50	1	0.13137921E-01
51	1	0.23918266E+00
52	1	0.28491633E+00
53	1	0.45652782E+00
54	1	0.24445377E-01
55	1	0.11107619E+00
56	1	0.32762180E+00
57	1	0.22767799E+00
58	1	0.70192478E-01
59	1	0.94359614-254
60	1	0.56963663E+00
61	1	0.22806625E+00
62	1	0.17569907E-01
63	1	0.85308879E-01
64	1	0.17109992E+00
65	1	0.28503657E+00
66	1	0.51249148E+00
67	1	0.22820659E+00
68	1	0.79350571E-01
69	1	0.19625310E+00
70	1	0.13483427E-01
71	1	0.21668467E+00
72	1	0.24391264E-01
73	1	0.10532380-253
74	1	0.12192490E+00
75	1	0.56632865E-01
76	1	0.22862138E-01
77	1	0.81054200-255

78	1	0.25346701E+00
79	1	0.45450984E+00
80	1	0.22821157E+00
81	1	0.89918170E-01
82	1	0.10393211E-01
83	1	0.22822900E+00
84	1	0.15243008-253
85	1	0.81933353E-01
86	1	0.28276853E+00
87	1	0.14685494E+00
88	1	0.11421910E+00
89	1	0.17577622E-02
90	1	0.24480536E+00
91	1	0.17072459E+00
92	1	0.15162627-253
93	1	0.25331494E+00
94	1	0.57412685E-01
95	1	0.85663841E-01
96	1	0.12217134E+00
97	1	0.82464703E-01
98	1	0.33110609E+00
99	1	0.15661886E+00
100	1	0.40003626E-01
101	1	0.81753501E-01
102	1	0.30446494E+00
103	1	0.85827353E-01
104	1	0.81362630-255
105	1	0.92793364E+00
106	1	0.85520428E-01

107	1	0.21308923E+00
108	1	0.28505588E-01
109	1	0.86464929E-01
110	1	0.57069648-254
111	1	0.73546766E+00
112	1	0.85673450E+00
113	1	0.63882531E-01
114	1	0.57267646E-01
115	1	0.45725096E-01
116	1	0.49335926E-01
117	1	0.10863522E+00
118	1	0.12290617E+00
119	1	0.16433721E-01
120	1	0.32535423E-01
121	1	0.63448558E-01
122	1	0.40662561E-01
123	1	0.50426576-254
124	1	0.36376934E-01
125	1	0.15405207E+00
126	1	0.20989438E-01
127	1	0.33340325E+00
128	1	0.59739054E-01
129	1	0.32939603E-02
130	1	0.36601438E-01
131	1	0.45777661E+00
132	1	0.49117278E-01
133	1	0.12273078E+00
134	1	0.32833378E-01
135	1	0.32827655E-01

136	1	0.12732152E+00
137	1	0.55501677E-01
138	1	0.28530122E-01
139	1	0.28531354E-01
140	1	0.61465900E+00
141	1	0.18816388E+00
142	1	0.18317681E+00
143	1	0.56624664E-01
144	1	0.63724974E-01
145	1	0.30634986E+00
146	1	0.28601492E-01
147	1	0.63821079E-01
148	1	0.38139207E+00
149	1	0.12260625E+00
150	1	0.81447533-254
151	1	0.24461945E-01
152	1	0.42956760E+00
153	1	0.12662756E+00
154	1	0.53064596E-01
155	1	0.11382498E+00
156	1	0.76092011E-01
157	1	0.62881349E-01
158	1	0.43765285E-01
159	1	0.91622821E-02
160	1	0.38222496E-01
161	1	0.12330712E+00
162	1	0.11449528E+00
163	1	0.17102104E+00
164	1	0.12217779E+00

165	1	0.13293896E+00
166	1	0.49013736E-01
167	1	0.21924477E-01
168	1	0.13094532E+00
169	1	0.81891946E-02
170	1	0.14844314E+00
171	1	0.11404330E+00
172	1	0.10600909E+00
173	1	0.17765449E+00
174	1	0.24573480E-01
175	1	0.94217918E-02
176	1	0.73276056E-01
177	1	0.15922068E+00
178	1	0.18294998E+00
179	1	0.40925126E-01
180	1	0.11440291E+00
181	1	0.10945474E-01
182	1	0.85730311E-01
183	1	0.12285742E+00
184	1	0.74003562E-01
185	1	0.28066011E-01
186	1	0.10609423E+00
187	1	0.12250113E+00
188	1	0.90111278E-01
189	1	0.12238227E+00
190	1	0.14160411E+00
191	1	0.12282355E+00
192	1	0.24518437E+00
193	1	0.13917595E+00

194	1	0.82267689E-01
195	1	0.75911493E-01
196	1	0.42462513E+00
197	1	0.11281889E-01
198	1	0.10121155E+00
199	1	0.76104945E-01
200	1	0.12173443E-01
201	1	0.12689323E+00
202	1	0.12659334E+00
203	1	0.48980865E-01
204	1	0.81846634E-01
205	1	0.52800252E-01
206	1	0.22746120E+00
207	1	0.94079517E-01
208	1	0.10587194E+00
209	1	0.39776207E+00
210	1	0.10583867E+00
211	1	0.38101777E+00
212	1	0.30192420E+00
213	1	0.15227580E+00
214	1	0.48521543E-01
215	1	0.38132639E+00
216	1	0.38106558E+00
217	1	0.44325749E+00
218	1	0.81391194E-01
219	1	0.65152922E-01
220	1	0.22747178E+00
221	1	0.73751049E-01
222	1	0.14228144E+00

223	1	0.11116918E+00
224	1	0.13754832E+00
225	1	0.10257145E+00
226	1	0.14219493E+00
227	1	0.81596654E-01
228	1	0.31728456E+00
229	1	0.95527560E-01
230	1	0.24556674E+00
231	1	0.65886599E+00
232	1	0.28548818E+00
233	1	0.28546716E+00
234	1	0.53061943E+00

Mean efficiency = 0.63254556E+00