ANALYSIS OF SORGHUM PRODUCTION AND ITS EFFECT ON FOOD SECURITY STATUS OF SMALLHOLDER FARMERS IN KANO STATE, NIGERIA

BY

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

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DECLARATION

I hereby declare that the work in this dissertation entitled **"Analysis of Sorghum Production and its Effect on Food Security Status of Smallholder Farmers in Kano State, Nigeria"** was written by me and is a record of my research work. No part of this dissertation has been presented in any previous application for another degree or diploma in this or any other institution. All consulted sources of information had been duly acknowledged in the text and a list of references provided.

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CERTIFICATION

This dissertation entitled: **"Analysis of Sorghum Production and its Effect on Food Security Status of Smallholder Farmers in Kano State, Nigeria"** by **Dorcas Oluwatoyin OGUNDEJI** meets the regulations governing the award of the degree of Master of Science in Agricultural Economics of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation work is dedicated to my husband and the entire members of the family.

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ACRONYMNS

ATA	Agricultural Transformation Agenda
ASFG	African Smallholder Farmers Group
COC	Cost of Calories
DFRRI	Directorate of Foods, Roads and Rural Infrastructure
FAD	Food Availability Decline
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
FEWSNET	Farming Early Warning Systems Network
FMARD	Federal Ministry of Agriculture and Rural Development
FSI	Food Security Index
GDP	Gross Domestic Product
GI	Gross Income
GM	Gross Margin
GR	Gross Ratio
KNARDA	Kano state Agricultural Development Authority
KSASC	Kano State Agricultural Sector Committee
KSG	Kano State Government
MDER	Minimum Dietary Energy Requirement
NAERLS	National Agricultural Extension and Research Liaison Services
NALDA	National Agricultural and Land Development Authority
NBS	National Bureau of Statistics
NFI	Net Farm Income
NPC	National Population Commission
OR	Operating Ratio
ROI	Return On Investment
SGDs	Sustainable Development Goals
TFC	Total Fixed Cost
TFE	Total Farm Expenses
TOC	Total Operating Cost
TVC	Total Variable Cost
UN	United Nations
USDA	United State Department of Agriculture

ABSTRACT

The study analyzed the effect of sorghum production on household food security status of smallholder farmers in Kano State, Nigeria. Primary data were obtained from 2019 cropping season with the aid of structured questionnaire. Random sampling was used to select 361 sorghum farmers. The result revealed that the mean age of the farmers was 46 years, about 95 percent were married and 85 percent of the farmers were literate. The mean farming experience in the study area was 21 years. The technical efficiency of sorghum production variables that were positively signed and significant were farm size (0.688), seed (0.204), labour and fertilizer (0.311) at 1 percent level of probability. For the technical inefficiency variables of sorghum production, membership of cooperative (-0.205) was negatively signed and significant at 10 percent level of probability. The allocative efficiency of sorghum production variables was positively signed and significant at 1 percent level of probability except cost of agrochemical which was not significant. For the allocative inefficiency variables that were positive and significant for sorghum production were membership of cooperative (0.005) and extension contact (0.017) at 10 percent and 5 percent level of probability respectively, education and farming experience were negatively signed and significant at 1 percent level of probability. Sorghum production is profitable with a return of 85 kobo for every one Naira invested in the production. The result revealed that about 69 percent of the farmers were food secured while 31 percent were food insecure. The food security indices for the food secured and insecure households were found to be 2.32 and 0.62. The results of the Logistic regression model revealed that sorghum production, adjusted household size, farming experience, membership of cooperative, extension contact and farm size influences an household to be food secured. The result indicated that the most widely used strategies by the farming households were eating less

preferred meals, skipping of meals, borrow food/money from friends/relatives, work for money/food, consumption of seed stock for next year and migration to cities. Major constraints ranked by sorghum farmers from the most important were inadequate fertilizer, inadequate fund, and lack of access to improved seeds among others. It was concluded that sorghum production contributes to households being food secured despite the constraints faced. The study, therefore, recommended that farmers should buy fertilizers in group to reduce transport and other costs and they should develop saving schemes among themselves so as to have enough capital for farming activities.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Agriculture in Nigeria provides employment for about 34.66 percent of the population as of 2020 (World Bank Data, 2020). It remains the foundation of the Nigerian economy despite the presence of oil in the country (Food and Agriculture Organization, FAO, 2018). The largest driver of the sector remains crop production as it accounts for 91.6 percent of the sector in the third quarter of 2019 with a quarterly growth which stood at 44.12 percent. Agriculture contributed 29.25 percent to the overall real GDP during the third quarter of 2019 (National Bureau of Statistics, NBS, 2019).

Sorghum (*Sorghum bicolor L*) is one of the major crops produced in Nigeria together with cassava, yams, rice, maize, millet, vegetables, groundnuts, cocoyam, sesame seed and melon seed (FAO, 2018). Food crops such as sorghum, contribute to food security to meet the consumption needs of the household, and as a source for livestock feeds. Their production is therefore important in meeting the food need of the rural households in Nigeria (Ibrahim, Adeola and Ibrahim, 2016; Sani and Oladimeji, 2017).

Sorghum is the fifth most important cereal globally and the dietary staple of around 500 million people (Food and Agriculture Organization Corporate Statistical Database FAOSTAT, 2018). In Nigeria, 50 percent of the total area devoted to cereal crops is occupied by sorghum with

estimated area of 6.86 million hectares extended North-wards from Latitude 8^0 N to 14^0N and the most common land races of sorghum are Kura, Fara-fara and Guinea (Maikasuwa and Ala, 2013). Sorghum is viciously tolerant to striga (a parasitic weed) in all the savanna zones (Sani, Haruna and Sirajo, 2013).

Nigeria is the largest producer of sorghum in Africa and globally ranks second in production (6.9 million metric tons), third in area harvested (4.8 million metric ha) but 64^{th} in yield at 1.1923 metric ton/ha (FAOSTAT, 2018). Yet, virtually the entire production is carried out on a subsistence basis. It is an important food crop in many parts of northern and southern Nigeria. It is tolerant, relative to other major cereal crops, to adverse growing conditions. Some early-maturing sorghum cultivars require less than two months of rainfall to produce grain, and the species is genetically very diverse with preferred cultivars for different uses (Elferik and Schierhorn, 2016).

Furthermore, it is one of the important cereals in drought prone areas which serve as food security crop because it is a resilient crop requiring less than 600mm annual rainfall (Bill and Melinda 2014). This two-meter tall plant from the grass family is often grown in regions that have high temperatures and lower rainfall. In wetter regions, its production is lower than that of more lucrative crops such as rice and maize. Sorghum is mainly consumed as a grain; it is also prepared into a wide variety of other food products such as porridges, breads, lactic and alcoholic beverages, and weaning meals (Odozi, 2015).

1.2 Statement of the Problem

Statistics have shown that the population of Nigeria is growing at the rate of 2.83 percent yet agricultural growth is fluctuating at 2 percent (NBS, 2016). It has also been shown that while Nigeria's overall food demand has been growing at a rate of 3.5 percent per annum, food production has been growing at a rate of 2.5 percent per annum, thus creating a food demand gap (FAOSTAT, 2018). However, it is obvious that Nigeria is endowed with both physical and human resources, and fertile land to produce enough food for the entire population and even marketable surplus for exports, but nevertheless, food has been imported to support the insufficient domestic production.

Sorghum is fast becoming a very important commodity in the food and beverage industries with the industrial demand in Nigeria estimated to be about 200,000 metric tons while the supply is 11,923 metric tons in 2017 (FAOSTAT, 2018). This implies that there is a huge gap in industrial demand.

Since the late 1970s to 2016, Nigeria has implemented several macro-economic policies, sectorial and institutional reforms aimed at ensuring high and sustainable economic growth and food security. Though, Nigeria have recorded some level of growth in the agricultural sector (NBS, 2017), however, the sector's growth remained insufficient to adequately address food security. Given the crucial role of sorghum in the food security of urban and rural households, development of sorghum production is one of the crop priorities of the Nigerian government. Agricultural Transformation Agenda (ATA) was inaugurated in 2012 and Sorghum

Transformation Plan was visible in the action plan of ATA (Federal Ministry of Agriculture and Rural Development, FMARD, 2013). However, the huge potentials of sorghum as household food, income generation and raw materials for livestock feed and industries have been constrained by continuous reduction in its annual production in Nigeria due to climate change, production, socio-economic factors and insecurity (Oyediran, Omoare and Osinowo, 2017).

In Kano State where environmental and macroeconomic conditions are unfavorable, rural farming households have been facing significant food deficits and limited livelihood options (Irohibe and Agwu, 2014). Employment opportunities such as construction work and transportation have been adversely affected by water shortages, fuel scarcity, and high prices, and as a result, poor households are now limited to casual agricultural labor and reliance on remittances. This results in their inability to meet basic food needs. In addition, while the cash income of poor households is deteriorating, their expenditures are increasing due to high food prices and seasonal farming expenses. Thus, Kano State is facing worsening food insecurity, and this has led to a high incidence of malnutrition related diseases, which not only undermine health, but hinders agricultural production in the region traditionally considered the bread basket of Nigeria (Adegboye, 2018).

Small scale farmers play a vital role in food production but in spite of these, their households are major casualties of food insecurity (Icheria, 2012). These scenarios have made it expedient to examine the effect of sorghum production on household food security status of smallholder farmers in Kano State. In an attempt to do this; the study seeks to provide answers to the following research questions:

i. What are the socio-economic characteristics of smallholder sorghum farmers in the study area?

ii. How efficient are smallholder farmers in sorghum production?

iii. Is sorghum production profitable?

iv. What is the contribution of sorghum production to household food security status of smallholder sorghum farmers?

v. What are the coping strategies employed by food insecure smallholder sorghum farmers?

vi. What are the constraints to sorghum production?

1.3 Objectives of the Study

The broad objective of the study is to analyse the effect of sorghum production on household food security status of smallholder farmers in Kano State. The specific objectives were to:

i. describe the socio-economic characteristics of smallholder sorghum farmers;

ii. estimate the production efficiency of smallholder sorghum farmers;

iii. determine the profitability of sorghum production;

iv. estimate the contribution of sorghum production to household food security status of smallholder farmers;

v. identify the coping strategies employed by food insecure smallholder sorghum farmers;

vi. describe the constraints to sorghum production.

1.4 Justification of the Study

Food security is a global concern, and any household head that is unable to feed his household is not deemed responsible (Ojeleye, Adebisi and Fadiyi, 2015). By extension, any nation unable to feed its populace cannot be said to be a responsible one. Beside, recent estimates has put the number of hungry people in Nigeria as over five million (United Nations, UN 2018) and these populace are majorly the farming households.

Sorghum has greater untapped potentials than some other crops. It is even postulated that if the twentieth century was the century of wheat, rice and maize, the twenty-first century could become the century of sorghum (Sani, Sanni, Damisa and Oladimeji, 2017). The potential for sorghum to be the driver of economic development in Africa especially in Nigeria cannot be over emphasized. Therefore, this work is focused on unleashing sorghum's capacity to be the cornerstone of food security. Increasing productivity would definitely have substantial effect on income of the smallholder farmers and food security status, and it would as well go a long way in helping the country to sustain the leading position as largest sorghum producer in Africa.

This would also provide valuable benchmark information to the partially existing knowledge about the food security of rural farm households in the study area. The outcome of this research work would be of tremendous benefit to the policy makers and help future researchers in the field since the study would make contributions on the subject matter upon which further research work can be done in the future. It would also be a base for statistical inference to other studies on analysis of food security in Kano State in particular and Nigeria in general.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 Sorghum Production in Nigeria

Sorghum is a cereal grain crop mostly cultivated in Sub-Saharan African (SSA) countries and other parts of the world to enhance food security provide employment and generate income for rural farming households. It is the world's fifth largest grain crop and it is second most important crop in terms of tonnage in Africa (Thabit, 2015). However, Africa production accounts only for a quarter of world's sorghum produced. Nigeria is the largest producer in Africa, its production represents 71 percent of the total sorghum output in the region; (Zalkuwi, 2013) and ranked second as the largest world producer of sorghum after the United States (FAOSTAT, 2018).

However, 90 percent of sorghum produced by United States is destined for animal feed, making Nigeria the world leading country for food grain sorghum production. It has about 30 species of which *Sorghum bicolor* is the most widely grown because of its intrinsic properties (FAO, 2004). *Sorghum bicolor* is an important food crop in Africa, Central America, and South Asia and is the fifth most important cereal crop grown in the world as well as the most important cereal food in the Northern states of Nigeria that covers the guinea savannah ecological zone (Mohammed, 2011).

Table 1 shows the area harvested, production and yield of sorghum in Nigeria from 2000 to 2017. There was a decrease in the area planted from 2000 to 2002, but this increased in 2009 and

2010 and later declined. Also, production increased from 2000 to 2008, but declined occurred from 2009 to 2013 which afterwards there was an increase in the tons produced. 2017 till date, the production has been the same.

Table 2.1: Area, Production and Productivity of Sorghum in Nigeria (2000-2017)

Year	Area harvested (ha)	Yield (MT /ha)	Production (tones)
2000	6885000	1.1200	7711000
2001	6437000	1.1000	7081000
2002	6489000	1.1000	7534000
2003	6935000	1.1559	8016000
2004	7031000	1.2200	8578000
2005	7284000	1.2600	9178000
2006	7308000	1.3500	9866000
2007	7812000	1.1595	9058000
2008	7617000	1.2233	9318000
2009	4736830	1.1145	5279170
2010	4960130	1.4397	7140970
2011	4661867	1.2206	5690145
2012	5099975	1.1445	5837106
2013	5449200	0.9727	5300270
2014	5702160	1.2071	6883294
2015	5899134	1.1875	7005025
2016	6651076	1.1361	755 6076
2017	5820000	1.1923	6939000

FAOSTAT 2019

2.1.1.1 Importance of Sorghum

Sorghum is grown on about 5.6 million ha in Nigeria and the current annual production is estimated to be only about 2.8 million tons (FAOSTAT, 2018). It has multifarious usages which spans across the production of malt, beer, beer powder, sorghum meal, sorghum rice, and livestock feed among others. The whole grain may be ground into flour which is then used in various traditional foods (Mohammed-Lawal, Salau and Olawusi, 2015).

The grain is one of the staple foods for poor and rural people because of its drought-and-heat-tolerant nature. It is nutritional as it contains a range of rich mineral nutrients such as iron, magnesium, thiamin, phosphorus, potassium, copper, niacin, riboflavin as well as calcium. It has a lot of health benefits which includes:

- Aids in the control of diabetes due to its help in the regulation of the body's insulin and glucose level.
- Due to its richness in calcium as well as magnesium, it can help to improve and develop the bone, and also prevents certain bone condition like arthritis.
- It helps to boost the energy levels because of the presence of Niacin
- It helps improve digestion and related issues like constipation and bloating
- It's quite rich in antioxidants

A geographical analysis of Nigeria's sorghum production and utilization gives us a general overview of the opportunities inherent in its value chain. It is observed that the major producers are in the Northern region leaving a major deficit in the Southern regions.

An assessment into the production, import and export of sorghum in Nigeria revealed in 2010, 13,000 tons of the grain was imported into the country with only 45 tons being exported. This clearly identifies a massive opportunity for investment. The yield has also been projected to increase exponentially with the use of adequate technology combined with improved and hybrid varieties (Muhammed *et al.*, 2015).

2.1.1.2 Cultivation

Sorghum requires a well tilled and prepared seed bed with a planting population of 3.0 kg to 7.0 kg seed per hectare. Planting time usually varies from September to January, depending on the

prevailing ecological conditions. NPK fertilizer are normally applied and provisions are made for irrigation and weeding (FAO, 2012).

2.1.2 Food security

Household food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food for meeting the dietary needs of all members of the household. Households are food secured when they have year round access to the amount and variety of safe foods their members needs to lead active and healthy lives (Baliwati, Brianwan and Melani, 2015). Food security exists when "all people at all times have access to safe nutritious food to maintain a healthy and active life" (FAO, 1996). Food security entails ensuring sustainable access, availability and affordability of adequate quantity and quality food to all citizens to meet up with their physiological requirements (Okuneye, 2014).This definition covers many of the dimensions and components of food security, including temporality and shocks; physical that is availability, social, and economic access to food; sufficient quantity and quality of food to meet nutritional requirements; the safety of food; and the ability of individuals to make choices and consume culturally acceptable and preferred foods; as well as linking the definition of food security to key health and productivity outcomes (Leroy, Ruel, Frongillo, Harris and Ballard, 2015).

The general economic situation in Nigeria has subjected majority of the households into problem of food crisis (food insecurity) and this condition further aggravated the poor nutrition and health status of the citizenry. Food insecurity is defined as a condition in which people lack basic food intake necessary to provide them with energy and nutrient required for full productive life (Yenesew, 2015). Food insecurity is therefore the absence of food security and it applies to a

wide range of phenomena from famine to periodic hunger due to uncertain food supply (Ayoade and Adetunbi, 2013).

Food insecurity can either be temporary (transitory food insecurity) or continuous that is chronic food insecurity (FAO, 2010). Undernourishment exists when calorie intake is below the Minimum Dietary Energy Requirement (MDER). The MDER is the amount of energy needed for light activity and to maintain a minimum acceptable weight for attained height. It varies by country and from year to year depending on the gender and age structure of the population (World Food Programme, 2010). Food Availability Decline (FAD) approached explains that famine or food shortage occurs when there is an aggregate decline in food supply. According to this approach people starve because of a local, national or regional decline in food availability to a level below the minimum requirement for survival. However, FAD has been criticized for its only dealing with supply side which disregards the demands side; it said nothing about people's income and purchasing power. Furthermore, it failed to address the vulnerability differences and access to food from outside the affected area (Ejiga, 2006).

2.1.2.1 Pillars of Food Security

The World Bank (2001) identified three pillars underpinning food security; these are food availability, food accessibility, and food utilization. This infers from the concept that food security is not just a production issue. Food availability for the farm household means ensuring sufficient food is available for them through its own production. However, due to lack of adequate storage facilities, they mostly end up selling produce during the harvesting period, and sometime rely on market purchases during the off/hungry season. Food access means reducing poverty. Simply making food available is not enough; one must also be able to purchase it,

especially the low-income households. Food access have three components: (1) Physical access to food; (2) Economic access to food; and (3) Sustainable access to food. Physical access implies food availability or food supply to the household, as there might be food availability at the national level which, however, may not trickle down to the household level (Oluwatayo, Sekumade and Adesoji, 2008). One of the major problems confronting mankind in recent times is food crisis. The sustainable production of food especially arable crops and poultry is the pillar of food security for both the family and the nation. Every household is supposed to be food secured. That is a condition in which all its members have access to adequate and sufficient food (FAO, 1996).

The level of food security is, therefore, one of the indicators of the level of development. Thus, it is imperative to group the level of world economic development into high, medium, and low-income food-deficit countries (Gregory, Ingram and Brklacich, 2005). More than two-thirds of Nigerian people are poor, despite living in a country with vast potential wealth. Apart from food production, which a large proportion of the Nigerian populace is involved in, accessibility does not therefore guarantee that all people, especially the poor, will have access to the minimum nutrition requirement because of existing regional, economic and social inequalities (FAO, 2004). Food insecurity disproportionately affects rural people particularly rural women, minorities and children (Ayantoye *et al.,* 2011). Rural people face a high risk of food insecurity due to poverty, income inadequacies, limited access to resources, underemployment, and unemployment, and many barriers to self-sufficiency, which create family frailty and crisis. In 2009, the World Summit on Food Security stated that the "four pillars of food security are availability, access, utilization, and stability" (Gregory *et al.*, 2005).

Availability

Food availability relates to the supply of food through production, distribution, and exchange (Gregory *et al.*, 2005). Food production is determined by a variety of factors including land ownership and use; soil management; crop selection, breeding, and management; livestock breeding and management; and harvesting (FAO, 2013). Crop production can be affected by changes in rainfall and temperatures. The use of land, water, and energy to grow food often competes with other uses, which can affect food production (Godfray *et al.*, 2010). Land used for agriculture can be used for urbanization or lost to desertification, salinization, and soil erosion due to unsustainable agricultural practices. Crop production is not required for a country to achieve food security. Nations don't have to have the natural resources required to produce crops in order to achieve food security, as seen in the examples of Japan (Lama, 2017). Because food consumers outnumber producers in every country, food must be distributed to different regions or nations (Tweeten, 1999; Parvathamma, 2015).

Food distribution involves the storage, processing, transport, packaging, and marketing of food. Food-chain infrastructure and storage technologies on farms can also affect the amount of food wasted in the distribution process (Jones *et al.*, 2013). Poor transport infrastructure can increase the price of supplying water and fertilizer as well as the price of moving food to national and global markets. Around the world, few individuals or households are continuously self-reliant for food. This creates the need for a bartering, exchange, or cash economy to acquire food (Gregory *et al.*, 2005). The exchange of food requires efficient trading systems and market institutions, which can affect food security Ecker and Breisinger (2012). Per capita world food supplies are more than adequate to provide food security to all, and thus food accessibility is a greater barrier to achieving food security (Parvathamma, 2015).

Access

Food access refers to the affordability and allocation of food, as well as the preferences of individuals and households (Gregory *et al.*, 2005; Parvathamma, 2015). The UN Committee on Economic, Social, and Cultural Rights noted that the causes of hunger and malnutrition are often not a scarcity of food but an inability to access available food, usually due to poverty (United Nations, 1999). Poverty can limit access to food, and can also increase how vulnerable an individual or household is to food price spikes (Ecker and Breisinger, 2012) Access depends on whether the household has enough income to purchase food at prevailing prices or has sufficient land and other resources to grow its own food. Households with enough resources can overcome unstable harvests and local food shortages and maintain their access to food (Garett and Ruel, 1999; Keku, 2017).

There are two distinct types of access to food: direct access, in which a household produces food using human and material resources and economic access, and that which a household purchases food produced elsewhere. Location can affect access to food and which type of access a family will rely on. The assets of a household, including income, land, products of labour, inheritances and gifts can determine a household's access to food. However, the ability to access sufficient food may not lead to the purchase of food over other materials and services (Ecker and Breisinger, 2012).

Demographics and education levels of members of the household as well as the gender of the household head determine the preferences of the household, which influences the type of food

that are purchased. A household's access to enough and nutritious food may not assure adequate food intake of all household members, as intra-household food allocation may not sufficiently meet the requirements of each member of the household. The United States Department of Agriculture (USDA) adds that access to food must be available in socially acceptable ways, without, for example, resorting to emergency food supplies, scavenging, stealing, or other coping strategies (Ojeleye, 2015).

Utilization

The next pillar of food security is food utilization, which refers to the metabolism of food by individuals. Once food is obtained by a household, a variety of factors impact the quantity and quality of food that reaches members of the household. In order to achieve food security, the food ingested must be safe and must be enough to meet the physiological requirements of each individual (Ecker and Breisinger, 2012*)*. Food safety impacts food utilization and can be impacted by the preparation, processing and cooking of food in the community and household. Nutritional values of the household determine food choice. Access to healthcare is another determinant of food utilization, since the health of individuals controls how the food is metabolized. For example, intestinal parasites can take nutrients from the body and decrease food utilization. Sanitation can also decrease the occurrence and spread of diseases that can affect food utilization *(Petrikova and Hudson, 2017)*. Education about nutrition and food preparation can impact food utilization and improve this pillar of food security. Utilization refers to the ability of individuals to absorb and effectively use the nutrients ingested for normal body functions.

Stability

Food stability refers to the ability to obtain food over time. Stability is a cross-cutting dimension that refers to food being available and accessible and utilization being adequate at all times, so that people do not have to worry about the risk of being food insecure during certain seasons or due to external events (Leroy *et al.,* 2015). Food security can be transitory, seasonal, or chronic. In transitory food insecurity, food may be unavailable during certain periods of time. At the food production level, natural disasters and drought result in crop failure and decreased food availability. Civil conflicts can also decrease access to food (Ecker and Breisinger, 2012). Instability in markets resulting in food-price spikes can cause transitory food insecurity. Other factors that can temporarily cause food insecurity are loss of employment or productivity, which can be caused by illness. Seasonal food insecurity can result from the regular pattern of growing seasons in food production (Parvathamma, 2015). Chronic (or permanent) food insecurity is defined as a long-term, persistent lack of adequate food. In this case, households are constantly at risk of being unable to acquire food to meet the needs of all members (Holben, 2017).

2.1.2.2 Causes of food insecurity

Food insecurity is defined as a condition in which people lack the basic food intake necessary to provide them with the energy and nutrient required for full productive life (Yenesew, 2015). Food insecurity is therefore the absence of food security and it applies to a wide range of phenomena from famine to periodic hunger due to uncertain food supply (Ayoade and Adetunbi, 2013).

Food insecurity is a multifaceted problem. It is quite an uphill task discussing the driving factors for food insecurity in Nigeria. Nigerians lack enthusiasm for local products and often consider

them inferior to imported food products. The emergence of oil sector marked the imminent end of the agriculture sector as the huge revenue generated from the petroleum products shifted attention from agriculture. The government embarked on importation food and local production shrinked away, especially as wealth from oil has changed the status and tastes of many Nigeria in favor of foreign goods (Otaha, 2013). This couple with socio-political instability which precluded the economic downturn, civil war, dwindling human resource base, gender inequality, education decadence, poor health facilities and the general loss of good governance have coexisted to further degenerate food accessibility. The following among others have however, been identified as the prime agents of food insecurity in Nigeria.

2.1.2.2.1 Insufficient production

While Nigeria only has a fixed area of arable land, its growing population will soon stretch land availability to it limits that it will not be able to sustain the population. Also, with increase in number of middle income earners in developing countries, more people can increase their meat consumption. This will increase the competition for land space putting further pressure on grain and soybean prices, supplies and reserve, since production of meats will require far more land space (Behnassi, Draggan and Yaya, 2011)

The major problem here is that the agricultural sector has remained under developed and depended too much on subsistence agriculture system with degraded low fertile soils, less external farm inputs utilization and significant loss of food crops both before and after harvest, and lack of facilities for storage and preservation of food all of which have cumulatively contributed to price fluctuation of agricultural products (Ilaboya, Atipo, Omofuma, Asekhame and Umukoro, 2012). Furthermore, agriculture is mostly practiced by the farmers who cannot

access facilities required for optimum food production. According to the World Bank's statistics, 90 percent of agricultural production in Nigeria is the output of inefficient small scale farmers. As a result, such farmers only manage to produce sufficient food to sustain their immediate families (Adeagbo, 2012).

2.1.2.2.2 Gender inequality

Gender inequality causes and is also a result of food insecurity. It is estimated that 60 percent of global chronically hungry people are women and girls, while 98 percent of them are from the south countries (Otaha, 2013). Women face lots of discrimination both in seeking education and job and face similar fate even at home within the household, yet women are mostly responsible for preparing meals and taking care of the children. They in fact, mostly spend all or a good fraction of their income on feeding and their children's needs (World Food Program, WFP, 2010).

Gender inequality is one of the primary driving forces of food insecurity because this is the most important concern of people who are denied access or unable to engage in labor (Otaha, 2013). The vulnerability of women is most pronounced when assessing the effect of food crisis. They constitute the larger ratio of the poverty ridden population especially in Africa. In many parts of the world, when a woman heads a household, they are often more vulnerable to poverty and hunger than a household headed by a man. Where there is no male income earner, negative consequences on overall income are often suffered by the household since women often times lack the ability to command labor within and outside the household. Families headed by widow- are particularly at disadvantaged position (Asian Development Bank, ADB, 2013).

The role of women in ensuring adequate land use, as well as food production, processing, distribution and marketing cannot be over emphasized. Idachaba (2006) stated that women are often deprived of access to agricultural assets, inputs and service when compared to men. Analysts, according to Otaha (2013), have suggested that if women where to have the similar access as men to productive resources, yield would increase by 20– 30 percent thereby boosting the total agricultural output by 2.5 to 4 percent in developing countries. This gain in production could have lessened the food insecurity status of most developing nations. If gender inequality is minimized and women are given better access to agricultural facilities, achieving food security will be much easier. It has been established over time by raising women's status, poverty will decline and nutrition will be enhanced.

2.1.2.2.3 Inefficient Policies and Corruption

Food insecurity has persisted in Nigeria and many developing countries because of inefficient policies especially with respect to agriculture, trade, economics and other adjourning sectors. If governments fail with these policies, hunger will naturally persist or even worsen. Indeed, many countries have failed in their efforts to develop due to failure to properly administer policies and initiatives which has connection to food (Behnassi *et al.*, 2011). This problem arises sometimes when the focus on policies objectives, structures and institutions were designed without adequate consideration of public interest. When policies designs which are not inclusive in structure, tend to disenfranchise the exempted populace (Ilaboya *et al.*, 2012).

Some of the government regulatory/policy problems affecting food security in Nigeria as identified by Okuneye (2014) include:

a. A number of national policies were not helpful in the government effort to transform the agricultural sector e.g. Land Use Act, Importation tariff and other unproductive policies.

b. Habitual alteration/termination of other non-agricultural policies but which may have bearing on agriculture due to changing government regime

c. Inadequate financing of agricultural research and industry as well as farmers' capacity building.

d. Unsustainable extension service system

e. Poor planning model and structural framework

f. Unconducive business environment that makes investment in agriculture unattractive to foreign investors.

2.1.2.2.4 Conflicts and Civil Insecurity

The spread of civil war and conflict interrupted production of food and displaced people leaving fertile land uncultivated (Adeagbo, 2012). Also, there are occasional ethno- religious crisis that has had devastating effects on the Nigerian economic development especially in the area of food production. Other conflicts may take the form of physical fighting, structural violence without declaring war which may result from premeditated pervasion of poverty, rich oppression of the poor, police brutality, intimidation of the common citizens by politicians, women and children oppression and monopolization of resources and power (Otaha, 2013).

Civil insecurity born out of the Boko Haram conflict has persisted in the extreme northeast, particularly in Borno, Yobe and Kano states, causing population displacement and limiting crop production below average, restricting market and trade activities and causing higher food prices compared to other areas of the country. Borno and Yobe states have been the focal point of the

Boko Haram crisis where farmlands have been converted to battle field and farmers are now banished to camps where they have to depend on aids for survival (Farming Early Warning Systems Network, FEWSNET, 2012).

2.1.2.2.5 Climate Change and Natural Disasters

Global changing climate is another important driver of food insecurity that cannot be underestimated. Amongst other impacts, climate change is responsible for biodiversity loss in the ecosystem as well as other physical access (Adeagbo, 2012). Climate change has become one of the key divisors that is redefining the global food equation and thus having so much impact on the food security of particularly developing nations. Behnassi, Draggan and Yaya (2011) described this climate change phenomenon as a time bomb that is already ticking and waiting to explode. Already we have begun to see the effect on global temperatures, unpredictable weather patterns and physio-biological systems (Behnassi *et al.*, 2011).

Although developed nations are largely responsible for emission of greenhouse gas, the impact of the resultant climate change is more severe in developing countries. Climate change impacts on output of agriculture, distribution of agricultural produce accessibility of foods, particularly in the developing parts of the world. People from poor and rural areas are especially vulnerable not just because of their locations but also because of their low adaptive capacity. While advancement in technology has resulted in increases in supply of food in developed countries, the production food crops still rely heavily on climate and weather conditions (Benhassi *et al.*, 2011).

Natural disasters and climate variability constitute other key factors making people from less developed nations vulnerable to food insecurity. The impact of such phenomenon as drought, flood and land slide is more pronounced in regions where agriculture highly depends of rainfall (Ilaboya *et al.*, 2011). While drought and land slide constitute a major threat for the food availability, excessive rain or flood has had a significant impact on the current hike in food prices. For example, According to Gombe State Emergency Management Agency (GSEMA) statistics, almost 1000 farms within Gombe were destroyed by flood in 2007 alone resulting in loss of tons of important local food crops as cassava, yams, maize, sugarcane and vegetable (Ojo and Adebayo, 2012) These events can in fact sometimes cause massive infrastructure destruction loss of stored food leading to inflation of food prices.

Nigeria Food Security Outlook of Famine Early Warning Systems Network (2013) reported that Nigeria witnessed an unprecedented flooding case between July and October, 2012 as a result of persistent heavy rainfall couple with the release of water from several dams. This incidence causes the displacement of about 2.8 million people were displaced several months following, the affected households could still not fully recover their livelihoods. High level of food insecurity soon ensued in the regions due to low food stocks and high food prices.

However, most households have started returning to their homes to rebuild their livelihoods (FEWS NET, 2013).

2.1.3 Smallholder farmers

Smallholder farmers are the drivers of many economies in Africa even though their potential is often not brought forward. Smallholder farmers are defined in various ways depending on the

context, country and even ecological zone. Often the term "smallholder" is interchangeably used with "small-scale", "resource poor" and sometimes "peasant farmer". In general terms, smallholder only refers to their limited resource endowment relative to other farmers in the sector. They are also defined as those farmers owning small-based plots of land (2 hectares or less) on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour (African Smallholder Farmers Group ASFG, 2013). The differences in smallholder farms between counties can be significant, and often reflect differences in the stages of development across countries. This is because the evolution of the small farm is intrinsically related to the process of economic development (FAO, 2015).

One of the main characteristics of production systems of smallholder farmers are of simple, outdated technologies, low returns, high seasonal labour fluctuations and women playing a vital role in production. Smallholder farmers differ in individual characteristics, farm size, resource distribution between food and cash crops, livestock and off-farm activities, their use of external inputs and hired labour, the proportion of food crops sold and household expenditure pattern. Smallholder farmers can play an important role in livelihoods creation amongst the rural poor (Allen and Qaim, 2012). Even though smallholder production is important for household food security, the productivity of this sub-sector is quite low. Poor yields may be one of the reasons why urban and rural households either abandon or are uninterested in agricultural production. There is therefore a need to significantly increase the productivity of smallholder farmers to ensure long term food security. This can be achieved by among others encouraging smallholder farmers to pursue sustainable intensification of production through improved inputs.

Food crop production in Nigeria is dominated by small-scale farmers who cultivate between 0.1-5.99 hectares and produce about 85-90 percent of the total foods consumed in the country (Maurice, Onu, Adebayo and Garba, 2013). These farmers are constrained by inadequate finance to expand production, hence rely on personal savings for their agricultural operations. They are also influenced by farm-specific factors, which delineate their production frontiers resulting in low outputs. Studies have shown that socio-economic characteristics affect farmers' efficiency in production as it influences production decisions, availability and level of use of modern inputs and technology.

2.1.4 Production efficiency

Production efficiency is widely used in agricultural economics to assess the performance of farmers. Efficiency can be divided into two concepts, the technical efficiency (also called output oriented efficiency), and allocative efficiency (also referred to as the input-oriented efficiency). Allocative efficiency can be viewed as the ability of a farm to use the inputs in optimal proportions given their respective prices and technology (i.e. obtaining optimal output or profits with the least cost of production). Technical efficiency, on the other hand, is the ability of a farming unit to produce a maximum level of output given the level of inputs (Farrell, 1957). In measuring output-oriented technical efficiency, the inputs are exogenously given and the objective is to maximize output as the only choice variable.

Farm production efficiency refers to the ability of a farm to produce a given set of output with the lowest amount of resources (Rahman, 2013). The efficient method of producing a product is the one which uses the least amount of resources to get a given amount of output. Efficient farms make better use of existing resources to produce maximum output or incur the lowest cost. A

farm is said to be efficient when there is maximum output, minimum risk, least cost, zero waste, maximum profit and best quality produce. There are three main types of production efficiency namely technical, allocative and economy efficiencies.

2.1.4.1 Technical efficiency (TE)

Technical efficiency is used to measure the ability of a farm to achieve maximum output from a given set of inputs under a given technology. Thus, it is the attainment of production goals without wastage (Taphe, 2015). Technical efficiency is defined as the measure of a farm's success in producing maximum output from a given set of inputs (Taru, Lawal and Tizhe, 2011). A technically efficient farm operates on the production frontier while a technically inefficient farm operates below the frontier and could be made efficient by increasing its output with the same input level or using fewer inputs to produce the same level of output. As such, the closer a firm gets to the frontier, the more technically efficient it becomes (Ogunyinka and Ajibefun, 2003).

2.1.4.2 Allocative efficiency (AE)

Allocative efficiency refers to the ability of a farm to use inputs in optimal proportions given their respective prices and the production technology (Rahman, 2013). Allocative efficiency has to do with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor cost (MVP = MFC) (Ebiowei, Chukwuemeka and Jackson, 2013). Under competitive conditions, a farm is said to be allocatively efficient if it equates the marginal returns of factor input to be the market price output (Sibiko, Ingasia, Gido and Mwangi, 2013).

2.1.4.3 Economy efficiency (EE)

Economy efficiency is derived from the product of the technical and allocative efficiencies. It occurs when a firm chooses resources and enterprises in such a way as to attain economic optimum (Kareem *et al.*, 2008). It is concerned with the realization of maximum output in monetary terms with the minimum available resources (Rahman, 2013).

2.2 Theoretical Framework

2.2.1 Theory of production

In traditional production theory, the raw materials used for the production of a commodity are referred to as factors of production. These factors are also known as inputs which involve the use of the services of land, labour, capital and organization in the process of production. The commodity produced by these inputs is referred to an output. The inputs, known as productive resources are what the firm buys while outputs are what it sells. Hence, theory of production tries to explain how the combination of numerous inputs, given the state of the existing technology leads to production of a certain output (Jhingan and Stephen, 2009).

2.2.1.1 Production

According to Jhingan and Stephen (2009), production in economic term is generally understood as the transformation of inputs into output. More explicitly, production is a sequence of technical processes requiring either directly or indirectly the mental and physical skills of craftsman and consists of changing the shape, size and properties of materials and ultimately converting them into more useful articles. Ekanem and Iyoha (1999), viewed production as not simply the process of fabricating commodities, but also covers any activity concerned with the packaging, storage,

transportation or marketing of these products as well as rendering of personal and commercial services of all kinds. In short, any activity which creates economic value represents production.

2.2.1.2 Production function

Production function has been used as an important tool of economic analysis in the neoclassical tradition. Algebraically, Philip (1894), was believed to be the pioneer economist who formulates a functional relationship that exhists between output and inputs, even though some argued that Johann von Thünen was the first to do that in the 1840's (Mishra, 2007). Production function expresses a functional relationship between quantities of inputs and output. It shows how and to what extent output changes with variations in inputs during a specified period of time (Jhingan and Stephen, 2009). Koutsoyiannis (2003) defines production function as a pure technical relation which connects factor inputs and output. It describes the transformation of factor inputs into output at any particular time period.

In the words of Ekanem and Iyoha (1999), production function is a mathematical statement of the physical relationship, given by technology, between a firms input of productive resources and its output of goods and services per unit of time. A firm's production function establishes the relationship between the rate of flow of output and the rate of flow of corresponding inputs needed to produce it, given existing technology. Hence, production function can be expressed mathematically as:

$$Q = f(X_1, X_1, X_3, \dots, X_n) \quad \text{.....(1)}$$

Where:

Q = Output

X_1, X_1, X_3... X_n = Quantity of various inputs

f = Functional relationship

Inputs

An input refers to any good or service that can be used in the production of other goods or services. In production analysis it is convenient to subdivide inputs into two categories, namely fixed inputs and variable inputs.

Fixed inputs

A fixed input is one whose quantity cannot be immediately altered in response to a desire to change the rate of output to meet prevailing market conditions.

Variable inputs

A variable input is one whose usage rate may be immediately altered in response to a desired variation in the rate of output.

It should be noted that, this distinction between fixed and variable inputs is only tenable in the short-run. In the long-run, all inputs are variable.

Short-run

It is a production time period where at least one input is fixed and thus all changes in the output is achieved by changing the usage of variable inputs.

Long-run

It is a production time period where all inputs are variables, as such changes in output can be effected by varying the usage of any input whatever way the firm deems most appropriate.

This distinction between fixed and variable inputs, shot-run and long-run helps in one's better understanding on how a firm's production environment should be. A firm's plant size or scale of production is determined by the size of its fixed input. In the short-run, the maximum output a firm can produce per unit of time is determined by its plant size while in the long-run this limit can be altered based on varying the character of the production function and the utilization of any factor input (Ekanem and Iyoha, 1999).

Therefore, production function depends on the following factors:

i) The quantity of inputs to be used;

ii) The state of technological knowledge;

iii) The possible processes of production;

iv) The size of the farm, and

v) The prices of inputs.

Given the following production function:

$$Q = f(X_1 \mid X_2, X_3, X_4, \ldots, X_n) \quad \ldots\ldots(2)$$

The vertical bar (|) demarcates between fixed and variable inputs. Inputs to the left side of the bar represent fixed inputs while those to the right are the variable inputs.

2.2.2 The law of variable proportions

In the 1840's, variable proportions production function was developed by Johann von Thunen which allows the capital-to-labour ratio to change. Von Thunen stressed that if one input (fixed) is held constant while the other (variable input) increases, then the resultant effect would be an

increase in output but at a decreasing rate. In other words, the law of diminishing returns to scale is applicable. Some economic scholars argued that he was the first to discover the modern marginal productivity theory (David and Richard, 2011).

Jhingan (2014) stressed that the law of variable proportions exists when one or more inputs are variable while the rest are fixed. The law concerns only on the rate of changes in output level as a result of increase or decrease in units of variable factor(s). For instance, when a firm increases its number of labourers in order to produce larger output, the proportion between fixed and variable inputs changes and the law of variable proportions sets in. The law in other words states that, when units of the variable inputs are increased, while holding that of fixed factors constant, a point is reached beyond which the marginal product, the average and finally the total product start declining. The law of variable proportions is also known as the law of diminishing returns.

2.2.2.1 Assumptions of the law of variable proportions

The law of variable proportions has the following assumptions:

i) Only one factor is variable while the rest are fixed.

ii) Homogeneity of all units of variable factor.

iii) Change of technology does not exist.

iv) It assumes a short-run situation only.

v) The output is measured in physical units, such as kilograms, tonnes, quintals, etc.

2.2.3 Stages of production

Following Jhingan (2014) and Ekanem and Iyoha (1999), the law of variable proportions is illustrated with the help of Figure 1. The variable input and the total physical product (TPP)

reveal the production function. The average physical product (APP) and the marginal physical product (MPP) are derived from TPP. The values of APP are obtained through dividing TPP by the corresponding units in variable inputs of labour. MPP is the additional quantity of physical product as a result of employing an extra labourer.

Stage I

In this stage, the production is characterized by: (i) Increasing returns to variable input. Thus, TPP is increasing at increasing rate; (ii) At inflection point *f*, the MPP reaches its maximum and diminishing marginal return to variable input sets in; (iii) Both MPP and APP are increasing; (iv) MPP is greater than APP; (v) The elasticity of production (E_P = MPP/APP) is greater than unity (i.e. $E_P > 1$), and (vi) Both the fixed and variable inputs are not efficiently utilized, and (vii) It is irrational stage of production, because resources are not optimized.

Stage II

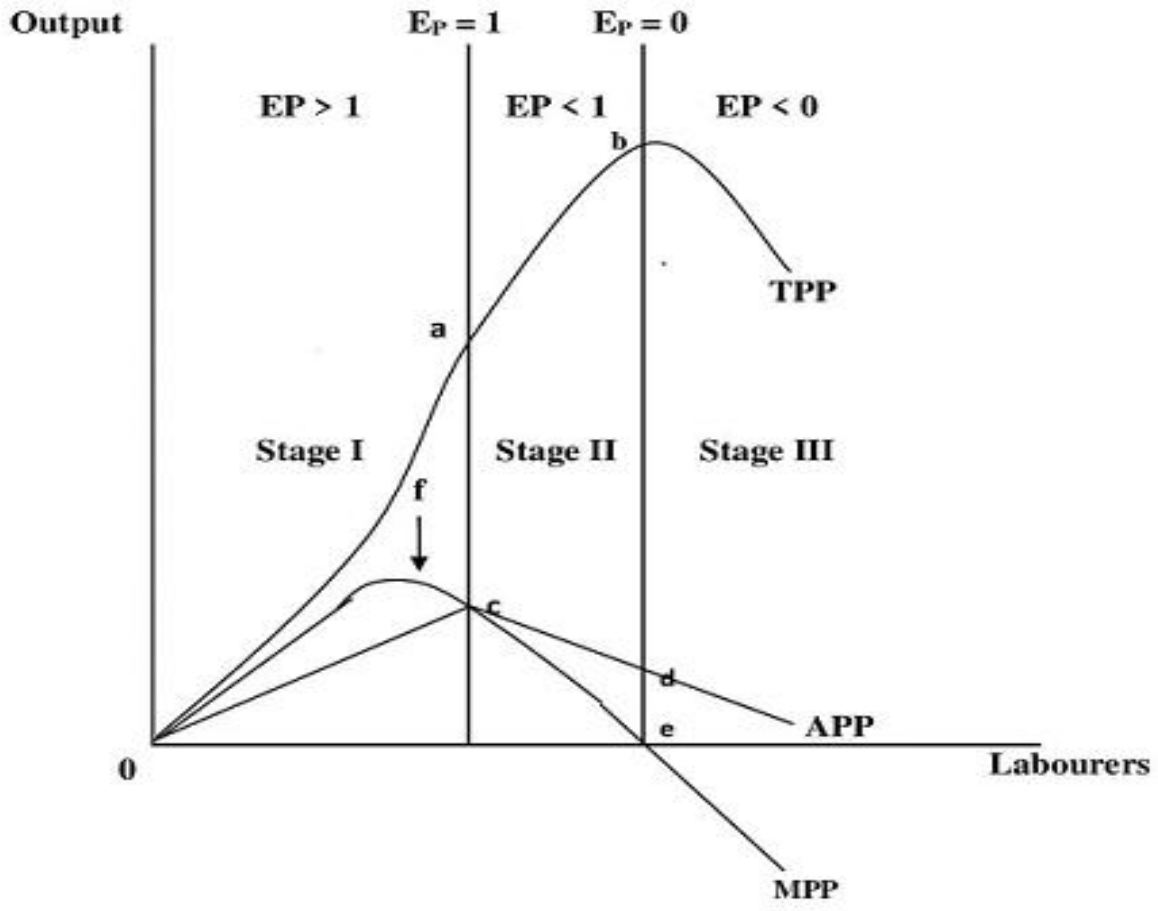
Throughout this stage: (i) TPP is increasing but at decreasing rate; (ii) Both MPP and APP are decreasing; (iii) APP is greater than MPP; (iv) The elasticity of production (E_P = MPP/APP) is less than unity (i.e. $E_P < 1$); (v) Both the fixed and variable inputs are intensively and efficiently utilized, and (vi) It is the ONLY rational stage of production where profit is optimized.

Stage III

This stage is characterized by: (i) Declining of the TPP; (ii) MPP value is negative; (iii) The elasticity of production (E_P = MPP/APP) is negative (i.e. $E_P < 0$); (iv) The fixed input(s) is over

utilized, and (v) It is irrational and economically irrelevant stage of production, because loss will only be incurred.

Figure 1: Relationship between TPP, APP, MPP and stages of production



2.2.4 The laws of returns to scale

In the long-run all factor inputs are variable and as such there is no fixed factor of production. Hence, the scale of production can be changed by varying all factor inputs. Koutsoyiannis (2003) defined returns to scale as the changes in output as all factors change by the same proportion. According to Jhingan (2014), the laws of returns to scale refer to the effects of a change in the scale of inputs upon output and in the long-run when all factors of production are variables and

also changed in equal proportions. The laws are three, namely constant, increasing and decreasing returns to scale.

2.2.4.1 Constant returns to scale

Constant returns to scale occur when factor inputs are increased in the same proportion and that leads to exactly the same proportional increase in output.

2.2.4.2 Increasing returns to scale

Increasing returns to scale occur when the producer requires lesser proportionate increases in capital and labour inputs in order to realise and maintain equal increases in output.

2.2.4.3 Decreasing returns to scale

Decreasing returns to scale occur when the producer requires larger proportionate increases in capital and labour inputs in order to realise and maintain equal increases in output.

2.3 Analytical Framework

2.3.1 Measurement of profitability

Costs and returns analysis is the basis for the measurement of profitability of farm enterprises. The procedure involves itemizing the various costs of inputs and returns from the production. More often, the values obtained are further tested statistically to verify differences between the values. Furthermore, monetary units should be used as the basis for measuring all inputs and outputs in cost and returns analysis for cropping systems (Olukosi and Erhabor, 2008).

2.3.1.1 Gross Margin Analysis

Gross margin analysis forms the basis for farm profitability analysis. It involves accurate collection of costs of variable inputs and the gross income obtained from a particular enterprise (Bernard, 2003). Essentially, gross margin is a budgeting tool used to estimate total variable costs of production and total revenue. Gross margin is the difference between gross income and total variable cost. It is a very useful planning tool in situations where fixed capital is a negligible portion of the farming enterprise as is the case in subsistence agriculture (Olukosi and Erhabor, 2008). Variable costs vary according to output and are incurred on variable inputs which can be attributed to specific enterprises. Costs incurred on variable inputs vary in proportion to the level of output, for example, cost of hired labour, maintenance costs, crop expenses and utilities. The variable cost is a major component in the derivation of gross margin. The gross farm income, also called total value of production, is the total physical product multiplied by the unit price of the product. The formula is:

Gross Margin (GM) = GI – TVC ……... [3]

Where:

GI = Gross Income (₦ /hectare)

TVC= Total Variable Cost (₦ /hectare)

2.3.1.2 Net Farm Income

The Net Farm Income (NFI) is determined by subtracting the total fixed cost (TFC) from the total gross margin (TGM) of the whole farm or all the enterprises (Olukosi and Erhabor, 2008). The total cost (TC) of production comprises two component parts, fixed costs (FC) and variable costs (VC), that is, TC = FC +VC. Fixed costs are those costs incurred on fixed inputs which

cannot be used up during one production process such as depreciation on machinery and buildings, wages of permanent staff, interest on debt and property tax Fixed cost is used to calculate the net farm income from the gross margin (Olukosi and Erhabor, 2008).

That is,

NFI = TGM – FC……..….. ……... .[4]

Where:

NFI = Net Farm Income (Naira /hectare)

TGM = Total Gross Margin (Naira/hectare)

FC = Fixed Cost (Naira /hectare)

GM = Gross Margin (Naira/hectare)

Gross ratio: This is a profitability ratio that measures the overall success of the farm.

The lower the ratio, the higher the return per naira.

GR= TFE /GI……..... …… [5]

Where:

GR = Gross Ratio,

TFE = Total Farm Expenses and

GI = Gross Income.

Operating Ratio: The operating ratio is directly related to the farm variable input usage. The lower the ratio, the higher the profitability of the farm business.

OR = TOC/GI ……..…… [6]

Where:

OR = Operating Ratio,

TOC = Total Operating Cost and

GI = Gross Income.

Return on Capital Invested: This is defined as gross margin divided by total variable cost.

RI = GM/ TVC …… [7]

Where:

ROI = Return on Capital Invested,

GM = Gross Margin and

TVC = Total Variable Cost

2.3.2 Measurement of Food Security

Household food security is a dynamic rather than a static phenomenon (Jeronim, 2010). Household food insecurity has been classified into chronic and transitory. The chronic food insecurity signifies a persistent food crises caused by the continual inability of the household to acquire needed food either through market purchase or own production (Khatri-Chatri and Maharjan, 2006). The transitory food insecurity on the other hand represents a situation whereby there is a temporary decline in the household food access to the needed food due to instability in food prices, production or income. It signifies a short time inadequacy in household food access, which obligates the vulnerable to cope in order to bridge their food consumption gap. According to FAO (2014), 25% of the people who are chronically hungry are in Sub-Saharan Africa making the food security situation of the region to be worrisome. According to Edeh and Gyimah-Brempong (2005), there is a dynamics of food security situation between post-planting and post-harvesting periods.

The measurement of food security, an important dimension of wellbeing has been approached by diverse methodologies by different researchers. As a matter of fact, no single method has been agreed on by researchers. However, they all seem to have similar objectives. According to Hoddinott and Yohannes (2002), the various methods of food security measures seek to address one or all of the following: identify the food insecure; characterize the nature of their insecurity; monitor changes in their circumstances and assess the impact of interventions. In this section, different methods of measuring food security have been reviewed with their strength and weaknesses.

2.3.2.1 Dietary diversity

This method of food security measure uses the number of different food or food groups consumed over a given reference period as an indicator of security under a variety of circumstances, including poor and middle-income countries, rural and urban areas and across seasons (Hoddinott and Yohannes, 2002). It is a qualitative measure of food consumption that reflects household access to variety of foods and is also a proxy for nutrient adequacy of the diets of individuals (Kennedy *et al*., 2010).

Dietary diversity measure of food security reflects nutrients adequacy and the economic ability of a household to access a variety of food in fact, it has been reported that there is a direct relationship between dietary diversity score and nutrient adequacy (Kennedy *et al*., 2010). According to Hoddinott and Yohannes (2002) increases in Dietary Diversity is associated with socio-economic status and household food security. However, if the data thus collected is to be

used to create an alternative measure, it is necessary to show a strong correlation with more traditional measures of food security.

Despite this weakness, Swindale and Bilinsky (2006) have referred to Household Diversity as being adjudged an attractive proxy indicator of food security based on the following reasons:

- A more diversified diet is an important outcome in itself,
- A more diversified diet is highly correlated with such factors as caloric and protein adequacy, percentage of protein from animals (high quality protein) sources and household income,
- Questions on dietary diversity can be asked at the household or individual level, making it possible to examine food security at the household and intra-household levels.

Rashid, Smith and Rahman (2006) added that the Dietary quality measure can be carried out using the daily household protein availability per adult equivalent (in which an adult is defined as a male between 30 and 60 years of the reference category). In constructing this measure, the cleared metric quantities of foods acquired by households were multiplied by the food‘s protein value, which was then multiplied by the food‘s edible proportion, which is finally divided by the number of days in the reference period and the number of adult equivalents.

2.3.2.2 Cost of calories (COC)

In this method of food security measure, the cost of buying the minimum calorie intake is used to establish a food security line which is used to classify respondents as food secure or food insecure (Amaza, Tahirou, Patrick and Amare, 2006). According to Ojogho (2010), it satisfies

the monotonicity axiom, focus axiom, symmetry axiom, transitivity axiom and decomposability by population sub group.

2.3.2.3 Caloric intake estimation

In this method, according to Orewa and Iyanbe (2010), questions on food consumed the previous day and the day after on information such as the types of food and the quantity consumed per meal per day are asked. The data gathered from such information are then used. The calorific content in each food item consumed are then used in estimating the proportion in the total food intake. The complexity of this method of measure makes it a little difficult to use.

2.3.2.4 Food Security Index (FSI)

This way of measuring food security involves the construction of a food security index. In studies like Omotesho, Adewumi, Muhammed and Ayinde (2006), the construction of the index involves two steps. The first one is identification which is the process of defining the minimum level of nutrition necessary to maintain healthy living. This is the food security line. The second step is aggregation which derives food security statistics for the household. Using the method of Food security Index also incorporates the use of daily calorie consumption. The following equation is used in estimating the food security index.

$$\text{Food Security Index} = \frac{\text{Household per capita calorie availability}}{\text{Household's daily per capita calorie requirement}} \quad \ldots\ldots\ldots\ldots \quad (8)$$

2.3.2.5 Other methods

There are other methods that have been used to measure food security. Nanama and Souli (2007) did comparism between the Months of Adequate Household Food Provisioning (MAHFP) and FANTA/Cornell methods a joint design of the Food and Nutrition Technical Assistance (FANTA) and the Cornell University Division of Nutritional Sciences. The MAHFP was

developed in the late 90‘s as a tool for identifying vulnerable groups and measuring the impacts of a project on increasing or decreasing the number of people classified in the most vulnerable groups. FANTA/Cornell, a questionnaire based method was also used for the same project. Nanama and Souli (2007) observed that even though the FANTA/Cornell method provides a more structured systematic mechanism for learning about the quantitative and qualitative aspects of food security, it has a setback in that it is biased as it elicits information from the household heads (most times males) which often are not fully aware of the survival strategies adopted.

One advantage of the FANTA/Cornell method again is that it has the capacity to highlight the special needs and concerns of the most severely food insecure group. The major weakness of the MAHFP is that it requires women to estimate the quantity of food intake but there is no uniformity in the units of measurements, which brought a major bias. Head Count Method is another method of food security measures that have been used. It measures the percentage of the households that are food insecure. When calculated, it provides an index called the food insecurity index that is obtained by estimating the percentage of the food insecure households under study (Idrisa, Gwary and Shehu, 2008). When used along with the food insecurity gap (FIG), the depth of food insecurity could be measured.

The FAO method for measuring food depravation and is based on a comparison of energy requirement norms with usual food consumption and is expressed in terms of dietary energy. One of the ways it is measured is the use of the Body Mass Index (BMI) which is used to determine the height to weight relationship. It is assumed that the underweighted individuals are food insecure. The BMI is the ratio of weight (Kg) to Height (square meters) those with BMI> 18.5 are considered to have adequate energy reserves.

2.3.3 Logit Regression Model Applications in Food Security

The logistic function was used in this research work because it represents a close approximation to the cumulative normal distribution and is simpler to work with. Meseret (2012) pointed out that a logit distribution (logit) model has gotten an advantage over the others in the analysis of dichotomous outcome variable in that, it is extremely flexible and easily used function (model) from the mathematical point of view and lends itself to a meaningful interpretation and relatively inexpensive to estimate.

Several studies on food security have employed the logit model (Robert, James and Thomas 2013), Olorunsanya, Sule, Babatunde and Awe (2012) and Omotesho *et al.* (2006). Following Meseret (2012), the logistic distribution function for food security can be specified as follows:

$$P_i = F(Zi) = F(\alpha + \sum B1X1 = \left[\frac{1}{1 + e^{\alpha + \epsilon(\beta 1 X 1)}}\right] \quad \text{..... [9]}$$

Where:

e represents the base of natural logarithm

Xi represents the ith explanatory variable

Pi is the probability that a household is being food secure, and

Bi: regression parameters to be estimated.

Interpretation of the coefficients would be understandable if the logit model can be written in terms of the odds and log of odds (Meseret 2012). The odds ratio is the probability that a household would be food secured (P*i*) to the probability that it would be food insecure (1-P*i*).

$$(1\text{-}P) = \frac{1}{1+e^{zi}} \quad \text{..... ..... [10]}$$

And putting natural logarithm

$$Zi = Ln\left[\frac{Pt}{1-Pt}\right] = \alpha + \beta 1X1 + \beta 2X2 + \cdots + \beta nXn \quad \text{[11]}$$

Where:

Zi is a function of explanatory variables

Xi is the intercept

β's are the slope parameters in the model.

2.4 Empirical Review

Review of empirical studies on food security status

Oyediran (2017) studied contributive roles of sorghum production to food security and economic of rural farming households in Katsina state, Nigeria. A simple sampling procedure was used to select the sample respondents for study. The sample size was 215 farmers. The study was conducted using key informant interviews, field observation and semi-structured interview. The study revealed that majority of respondents consumed sorghum *dawa* as breakfast (89.3 percent), sorghum *tuwo* for lunch (82.3 percent) and *fura* for refreshment (79.5 percent). Sorghum straw is however used as blood tonic herb in babies' food (64.2 percent). These findings are in tandem with the report of FAOSTAT (2012) that sorghum consumption accounts for 30 percent of the total cereal consumption in Nigeria and that it is highly consumed in the northern part of the country than any other parts.

Abdullahi *et al.* (2017) in their study examined the socio-economic characteristics of Samsorg 17 adopters and non-adopters in Kaduna and Kano States. The result revealed that most of the respondents are relatively middle aged. The results also revealed that 98 percent of the adopters were married and 97 percent of the non-adopters were married; 3.3 percent of the non-adopters

were single, while 1.7 percent of the adopters were single, majority of the respondents in the study area had Quranic education. On access to credit, the study found that 95 percent of the adopters had no access to credit, while only 15 percent of the same category of farmers had access to credit. 78 percent of the non-adopters had no access to credit, while 22 percent they had access to credit. The findings of the study indicated that high cost of fertilizer with 63 percent was the ranked first among the constraints, followed by inadequate access to good road network with 27 percent. The study recommends that farmers should buy inputs such as fertilizer in groups whereby this could reduce the cost of the input; it was also recommended that farmers should develop the habit of savings (contribution) which could assist them to finance their farming activities.

Sani, Sanni, Damisa and Oladimeji (2017) in their study on assessment of household food security among sorghum farmers under agricultural transformation agenda in Gombe State, Nigeria. Primary data were used to collect data from 172 sorghum farmers using structured questionnaire. Cost of calorie method and Logit regression models were used to analyse the data. The result of food security status of sorghum farmers indicates that majority (81.4 percent) of farming households were food secured while 18.6 percent were not food secured. However, this is in contrary view with Fakayode, Rahji, Oni and Adeyemi (2015) who posited that only 12.2 percent of the farm households were food secure, 43.6 percent were food insecure without hunger, 35.9 percent were food insecure with hunger (moderate) and 8.3 percent were food insecure with hunger (severe). They stressed further that the constraints faced by farm households in the production of major staple crops were mainly those of high cost of transportation, poor receipts from farm output sales, inadequate storage and processing facilities.

They therefore recommended among other things that credit and or subsidy should be made available to farmers.

Irohibe and Agwu (2014) assess the food security status among farming households in rural areas of Kano state, Nigeria. The results of the logistic regression revealed that educational level ($p \leq 0.05$; $z = 1.95$), sex ($p \leq 0.05$; $z = 1.99$), household size ($p \leq 0.05$; -4.29) and access to credit (≤ 0.05; $z = 2.4$) were significant determinants of food security. Also, the major effect of food insecurity on the households include reduction in household income/ savings due to increased expenditure on food (M= 3.58), among others. The perceived coping strategies in cushioning the effects of food insecurity include engaging in off-farm and non-farm jobs to increase household income, (M= 2.77), among others. The study therefore recommends the fast tracking of already established policy measures aimed at reducing food insecurity in the country. Also, efforts aimed at reducing food insecurity among rural farming households should focus on increasing household income and food supply.

Sani *et al.* (2013) in their study on economics of sorghum production in Bauchi Local Government Area of Bauchi State, Nigeria in which sixty farmers were randomly chosen and data were collected using a well prepared questionnaire supplemented with oral interview between April and May, 2012. The data were analysed using simple descriptive statistics, farm budgeting model and Cobb Douglas production model. The result showed that majority (51 percent) of the farmers fell between the ranges of 40-49 years, 53 percent had one form of education or another and 98 percent of them were married. The result also revealed that farmers in the study areas obtained a net farm income of N 14, 400 per hectare and N 1.79 as return per

Naira invested with an operating ratio, gross ratio and fixed ration of 0.47, 0.55 and 0.08 respectively. However, the major constraints identified in sorghum production were high cost of inputs, low prices of produce, inadequate provision of credit and inadequate storage facilities amongst others. Therefore, intervention such as provision of inputs, soft loans, and good storage facilities will go a long way to increase production and profitability.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

The study was conducted in Kano State, Nigeria. The area is located in north-west between latitudes 9° 30' and 10° 33' North of the equator and longitudes 7° 34' and 9° 25' East of the Greenwich Meridian (Kano State Government KNSG, 2013). The state borders Katsina State to the north-west, Jigawa State to the north-east, and Bauchi and Kaduna States to the south. It has forty four (44) Local Government Areas (LGAs) and three (3) agricultural zones. The zones include Dambatta, Gaya and Rano. The State occupies an area of about of 20,670 square kilometers of which 18,684km^2 is cultivable. Using 3.2 percent annual growth rate, the population is projected to 15,093,997 people in 2021 (National Population Commission, NPC, 2006).

A tropical wet and dry climate prevails over the state and it has two distinct seasons, the wet and dry seasons. The wet season lasts between May and early October while the dry season lasts between November and April. Annual rainfall varies from 600 mm to 1200 mm in the Guinea savannah to 300 mm to 600 mm in the Sudan savannah. The mean annual temperature is about 26^0 C in the coolest months (December/January) and 31^0 C in the hottest months (April/May). The average annual relative humidity is 31.1 percent and average monthly relative humidity ranges from 11 percent in March to 68 percent in August (Irhobie and Agwu, 2014).

Agriculture is one of the most important pillars of the State‘s economy with about 75 percent of the populace engaged directly or indirectly in this economic activity (Nigeria Galleria, 2015). Subsistence and commercial agriculture is mostly practiced in the outlying districts of the state. Some of the food crops cultivated are sorghum, millet, cowpeas, maize and rice for local consumption while groundnuts and cotton are produced for export and industrial purposes (Zoml, 2013).

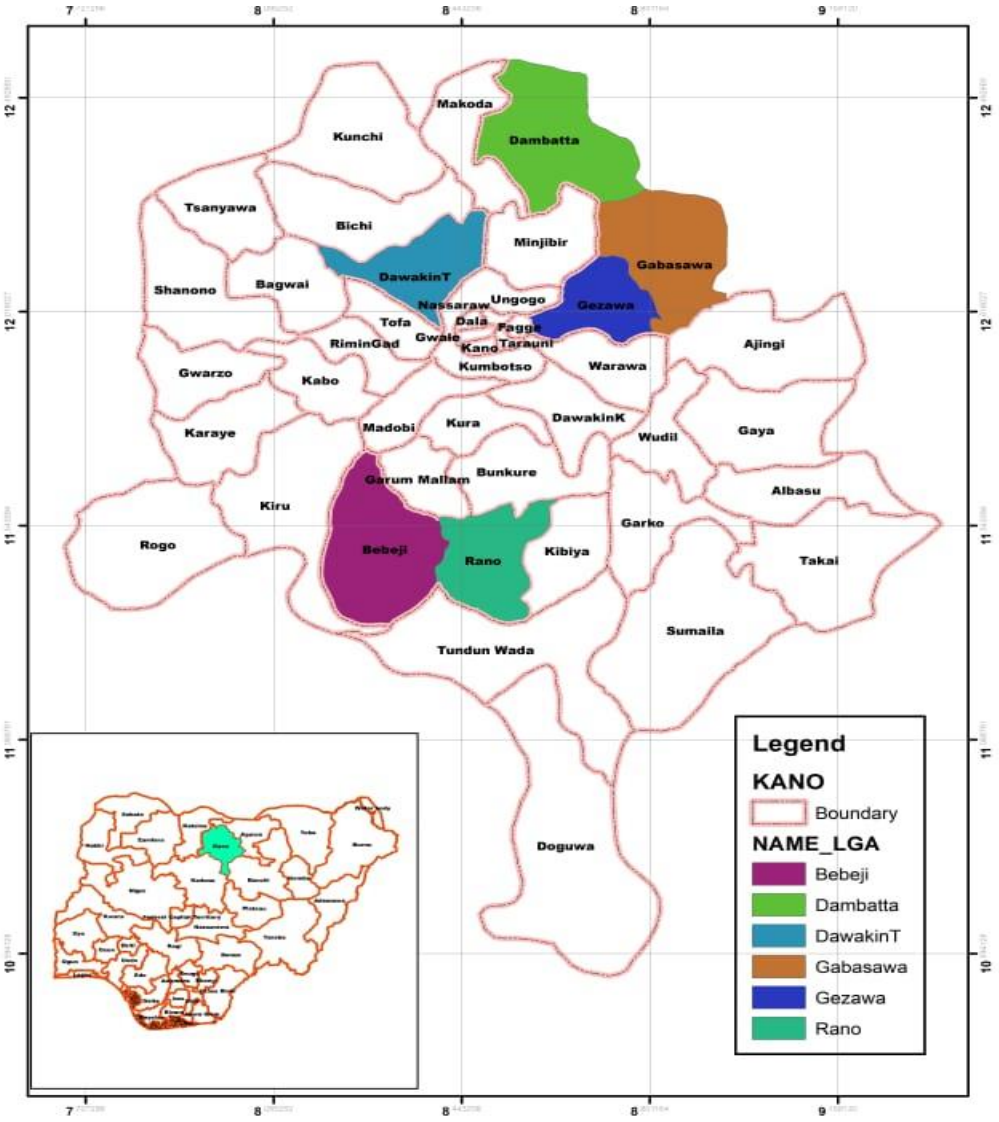


Figure 3.1: Map of Kano State showing the study area

3.2 Sampling Procedure and Sample Size

A multistage sampling procedure was used to generate data for this study. Kano state is divided into three (3) agricultural zones which are: Danbatta, Gaya and Rano. The first stage involved the selection of the three (3) agricultural zones in the state. The second stage involved the purposive selection of two (2) LGAs in each of the three agricultural zones based on high predominance of sorghum production and this gives a total of six (6) LGAs. The third stage

involved random selection using simple ballot system of two (2) villages from each of the selected LGAs to make a total of 12 villages. The last stage involved using a Slovin's formula adopted by Abdulrahman, Mani, Oladimeji, Abdulazeez and Ibrahim (2017) for calculating sample size based on the assumption of 5 percent expected margin of error, 95 percent confidence interval and applying the finite population correction factor. Expressed as:

$$Sz = \frac{N}{1+N(e)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where:

N= sample frame

e = level of significance desired

1= constant

Sz = sample size

For this study, a reconnaissance survey was first conducted with the assistance of a staff from Kano State Agricultural Development Authority (KNARDA) to identify farmers who grow sole sorghum on their farm. The list of the farmers obtained served as the sample frame.

A simple random sampling by balloting was employed in selecting sorghum farmers from each of the villages. Twelve percent (12 percent) of the sample frame (2982) was used as the sample size. In all, 358 smallholder farmers was randomly selected using balloting method.

$$\text{Sz} = \frac{2991}{1+2991(0.05^2)}$$

$$\text{Sz} = \frac{2991}{8.48}$$

$$\text{Sz} = 353$$

$$\text{Sz} = \frac{353}{2991} \times 100 = 11.8\% \text{ approximately } 12\%$$

Table 3.1: Population and sample size of sorghum farmers in the study area

Zones	LGA	No. of Villages	Name of Villages	Sample Frame	Sample Size (12Percent)
Danbatta	Danbatta	32	Ajumawa	315	38
			Gwarabjawa	245	29
	DawakinTofa	26	Danguguwa	180	22
			Bagari	202	24
Gaya	Gezawa	40	Gezawa	262	31
			Tsalle	200	24
	Gabasawa	47	Garundanga	230	28
			Mekiya	247	30
Rano	Bebeji	21	Gwarmai	305	37
			Tiga	256	31
	Rano	31	Ruwankanya	285	35
			Rurum	264	32
Total		**217**	**12**	**2991**	**361**

Source: Kano State Agricultural and Rural Development Authority (KNARDA), 2019

3.3 Data Collection

Primary data was used for this study. The data was obtained through the use of structured questionnaire with the help of trained enumerators under the supervision of the researcher which was administered to the selected smallholder sorghum farmers in the study area. Information collected include socio-economic and demographic characteristics of households such as age, marital status, household size, level of education, farm size, amount of credit received, farming experience, number of extension contact, years spent in cooperative; amount of seeds, fertilizer and agrochemical used.

3.4 Analytical Techniques

Some analytical tools were employed to analyse the data in order to achieve the objectives of the study. They include:

Descriptive statistics was used to achieve objectives (i) which is socio-economic characteristics of sorghum farmers, (v) which is coping strategies employed by food insecure smallholder sorghum farmers and (vi) which is constraints faced in sorghum production.

Stochastic frontier production model was used to achieve objective (ii) of the study which is production efficiency of the smallholder sorghum farmers.

Gross margin was used to achieve objective (iii) that is the profitability of sorghum farmers.

Food security index was used to achieve objective (iv) that is the food security status of the smallholder farmers.

Logistics regression model was used to achieve part of objective (iv) which is to find out the contribution of sorghum production to food security status of the farmers.

3.4.1 Descriptive statistics

Descriptive statistics such as frequency count, mean, standard deviation, skewness, kurtosis and coefficient of variation was used to achieve objectives (i), (v) and (vi)

3.4.2 Stochastic frontier production analysis

The stochastic frontier production function was used to achieve objective (ii). It was used to determine the production efficiency of sorghum production in the study area. It is specified implicitly as:

$$Y_i = f(X_i, \beta) \exp(V_i - U_i) \quad \text{---------- (13)}$$

Where:

Y_i = quantity of sorghum output (kg) of the ith farm

X_i = vector of input by the ith farm

β = vector of parameters to be estimated

V_i = random error outside the farmer's control and

U_i = technical inefficiency effects

The Stochastic Frontier Production Function (SFPF) specifying the technical efficiency in sorghum production in the study area is expressed explicitly as:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (V_i - U_i) \quad \text{----------..... (14)}$$

where:

ln = natural logarithm

Y = output of sorghum (Kg)

β_0 = constant term

β_1- β_5 = regression coefficients

X_1 = farm size (hectares)

X_2 = quantity of seed used (kg)

X_3 = total labour used in production (man-days)

X_4 = quantity of agrochemicals used (litres)

X_5 = quantity of fertilizer used (kg)

X_6 = quantity of organic manure used (kg)

V_i = random error term in the production that cannot be influenced by the farmer

$-U_i$ = inefficiency effect which are non-negative.

The $-U_i$ is expressed as:

$$-U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 \quad \text{---------- (15)}$$

Where:

$-U_i$ = technical inefficiency of the ith farmer

δ_0 = constant

δ_1-δ_6 = parameters to be estimated

Z_1 = level of education (non-formal = 0, Quaranic = 1, Adult education = 2, Primary = 3, Secondary = 4 and Tertiary education = 5)

Z_2 = household size (number)

Z_3= number of years in sorghum farming (years)

Z_4 = membership of cooperative (YES=1, NO=0)

Z_5 = number of extension visits per season (YES=1, NO=0)

Allocative Efficiency

Stochastic frontier cost function to be used in the study is specified as:

$C = f(p_i, y_i; \gamma) \exp e_i$ (i = 1,2,3,....., n)..... (16)

Where:

C = represents the minimum cost associated with sorghum production

P_i = vector of input prices

Y_i = sorghum output

γ = vector of parameters

e_i = composite error term

The explicit form of stochastic frontier cost function is specified as:

$\ln C = \beta_0 + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + (V_i + U_i)$..... (17)

Where;

ln = the natural logarithm

C = total cost of sorghum production (₦)

X_1 = cost of land (₦)

X_2= cost of seed (₦)

X_3 = cost of fertilizer (₦)

X_4 = cost of labour (₦)

X_5 = cost of agrochemical (₦)

X_6 = cost of organic manure (₦)

β_0 = constant term

β_1- β_4 = regression coefficients

V_i = random variability that cannot be influenced by the farmer.

U_i = deviation from minimum cost attributable to allocative inefficiency.

$U_i = \delta_0 + \delta_1 1nZ_1 + \delta_2 lnZ_2 + \delta_3 lnZ_3 + \delta_4 lnZ_4 + \delta_5 lnZ_5 + \delta_6 lnZ_6 + \delta_7 lnZ_7$..... (18)

Where;

U_i = allocative effects of individual sorghum farmer.

Z_1 = level of education (non-formal = 0, Quaranic = 1, Adult education = 2, Primary = 3, Secondary = 4 and Tertiary education = 5)

Z_2 = household size (number)

Z_3= number of years in sorghum farming (years)

Z_4 = membership of cooperative (YES=1, NO=0)

Z_5 = number of extension visits per season

δ_0 = constant

δ_1-δ_7= parameters to be estimated.

The *a priori* expectation was that the coefficients of the efficiency inputs X_1 to X_4 which are β_1, β_2, β_3 and β_4 should be positive (i.e. greater than zero) while the coefficients of the independent variables of the inefficiency inputs Z_1 to Z_7should be negative (i.e. less than zero) respectively.

Economic Efficiency

The product of technical efficiency (TE) and allocative efficiency (AE) provides the index of economic efficiency (EE).

EE = TE * AE……..... (19)

Where:

EE=Economic Efficiency,

TE=Technical Efficiency and

AE=Allocative Efficiency

3.4.3 Gross Margin

The Gross margin analysis was used to achieve objective (iii). It was used to determine the profitability of sorghum production in the study area. The formula for gross margin is stated as;

$GM = Q_y P_y - \sum X_i P_{xi}$ ..... (20)

Where:

GM = Gross Margin

Q_y = Total output of sorghum (kg)

P_y= unit price of sorghum (₦)

X_i=quantity of the input used (kg)

P_{xi} = price per unit of the input (₦)

$Q_y P_y$ = total revenue associated with the ith input (₦)

$\sum X_I P_{XI}$ = summation (overall input,i-n to give total variable cost tvc)

Thus;

GM = GFI-TVC..... (21)

Where:

GM = Gross Margin (₦/ha)

GFI = Gross Farm Income (₦/ha)

TVC = Total Variable Cost (₦/ha)

Return on naira invested was also determined by dividing Total farm income (TFI) by the Total Variable Cost (TVC).

3.4.4 Food Security Index

Food security index was used to achieve objective (iv) of this study. The approach taken in this study for the determination of food security index is to follow the identification and aggregation procedures. Identification is the process of defining a minimum level of nutrition necessary to maintain healthy living. This is referred to as the 'Food Security Line", below which people are classified as food insecure and subsisting on inadequate nutrition. The food security line was used in this study based on the daily recommended level of calories and protein, which are 2260 Kcal and 65g respectively (Olayemi, 1998). In order to generate food security indices, the nutrient content of the food items consumed were used to derive calorie availability.

$$\text{Food Security Index } Z_i = \frac{\text{Household per capita calorie availability}}{\text{Household's daily per capita calorie requirement}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

For a household to be food secured, *Zi* must be greater than or equal to 1 ($Zi \geq 1$). If *Zi* is less than 1 ($Zi < 1$), the household is food insecure. The quantity of crops produced, purchased and received as gifts were converted to kilogram and further to calorie consumed per day per household and then compared with the standard (2260kcal).

3.4.5 Logit regression

Logit regression model was used to achieve part of objective (iv). The Food Security Index was used to disaggregate the households into food secure and food insecure households. The dependent variable in this case, food security, is a binary variable which took a value of one (1) if a household is found to be food secure, and zero (0) if otherwise. A variety of models can be used to establish the relationship between the potential determinants and food security. The study employed the logit model. Following Bogale and Shimelis, (2009) and Robert *et al.* (2013), the cumulative logistic probability model can be econometrically stated as:

$$P_i = F(Z_i) = \frac{1}{1+e^{-[\alpha+\sum(BiXi)]}} \quad \text{...} \quad (23)$$

Where:

Zi = function of explanatory variables

Pi = the probability that an individual is being food secure given Xi

Xi = vector of explanatory variables

α & β = regression parameters to be estimated.

e = the base of the natural logarithm

For ease of interpretation of the coefficients, a logistic model could be written in terms of the odds and log of odd. The odds ratio is the ratio of the probability that a household would be food secure (Pi) to the probability of a household not being food secure (1-Pi). That is:

$$\frac{Pi - e^{Zi}}{1-Pi} \quad \text{..} \quad (24)$$

Taking the natural logarithm of the equation yields:

$$\text{Ln}\left[\frac{Pi}{1-Pi}\right] = Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \text{...........} + \beta_n X_n \quad \text{...........................} \quad (25)$$

If the error term, e_i is taken into consideration, the equation becomes:

$$Z_i = \alpha + \sum_{i=0}^{m} BiXi + ei \quad \text{..} \quad (26)$$

Where:

α = intercept

βs = slope parameters in the model

Z_i= function of the explanatory variable X_i

In this study the explanatory variables that were used in the model include:

X_1 = Sorghum production

X_2 =Age of household head (years)

X_3 = Education level of household head (non-formal = 0, Quaranic = 1, Adult education = 2, Primary = 3, Secondary = 4 and Tertiary education = 5)

X_4 = Access to credit/loan facilities (₦/year)

X_5 = Household size (adjusted) for male equivalent (Number)

X_6 = Marital status of household head [Married = 1, Otherwise = 0]

X_7 = Farm size (ha)

X_8= Farming experience (years)

X_9 = Extension visit (number)

The parameters of the logistic regression model were estimated using the Maximum Likelihood Approach.

3.5 Variable Definition and Measurement

In this study, the cross- sectional data needed for econometric analysis and the information that is specifically required were collected from farmers. Variables on which data were collected include socio-economic characteristics, food security and coping strategies.

i. **Age:** This is the number of years of the farmer from birth. Age of farmer was measured by the actual years the individual has lived as given by him/her. Studies have shown that young men are mostly involved in agricultural production activities and adopt new technology and innovation faster than the older age group.

ii. **Farm size:** This is the size of the farmers' farm measured in hectares. A unit increase in area of land cultivated is expected to lead to an increase in output. Also, it is expected that a household with more land will produce more crops and more marketable surplus thereby being food secure.

iii. **Household size (number per persons)**: The total number of persons living with the farmer at the time of survey. A negative relationship is expected to exist between household size and food security.

iv. **Education level:** This is the number of years a farmer has spent in formal education. By *a prior* expectation, the higher the level of education attained by a farmer, the more he will be receptive to modern technology and innovation.

v. **Farming Experience:** Farming experience is an experience gained with age while carrying out operations. As the number of years spent in sorghum production increases, their experience increase as well. It is expected to have a positive relationship with the household food security status. This was measured in years.

vi. **Amount of credit obtained**: Credit is a very strong important factor that is needed to acquire or develop enterprise. Its availability could determine adoption of recommended technologies and the extent of production capacity. It is expected to have a positive relationship with food security status and measured in Naira (₦) (Adjimoti *et al*., 2018).

vii. **Extension contact**: Agricultural extension service constitutes a driving force for any agricultural development. The relationship between agricultural extension agent and the farmer is an important determinant in improving yield of sorghum as well as in ensuring food security. The more the number of visits of an extension agent to the farmers the greater the chance for them to adopt innovation. It will be measured in terms of number visits per year made by an extension agent**.**

viii. **Co-operative membership:** This will be measured in years of participation. Co-operative groups are organized for the promotion of special interest or to meet certain needs that cannot be achieved by individual efforts. Farmers that belong to a co-operative society are likely to adopt new technologies easily than those not in any co-operative.

ix. **The Error Term**: The error term is included in the models to account for specification errors arising from incorrect inclusion of variables or inaccurate recording of observations.

x. **Quantity of seed:** This will be measured in kilograms (kg). It is included in the model to examine the actual kilograms of the sorghum seed used in a production cycle. The *a priori* expectation for quantity of seed is expected to be positive.

xi. **Quantity of labour:** Labour will be measured in man-days. This consist of both family and hired labour, it is included in the model to examine how variability in labour used will affect output. The *a priori* expectation for quantity of labour is expected to be positive; this implies that, a unit increase in quantity of labour will bring about increase in output.

xii. **Quantity of agro chemicals:** This will be measured in litres (L). It is included in the model to examine the actual amount of chemicals used in production. It is expected to have a positive effect on sorghum output; a unit increase in quantity of chemicals used will bring about increase in output.

xiii. **Quantity of fertilizer:** This will be measured in kilograms (kg). It is included in the model to examine the actual amount of fertilizer used in production. The *a priori* expectation for fertilizer is positive meaning that, a unit increase in quantity of fertilizer used will bring about increase in output.

xiv. **Output:** This will be measured in Kilograms. It is the quantity of sorghum produced.

xv. **Coping Strategies:** In order to prevent food insecurity, household made changes in the consumption pattern, diversify income generation activities, sale of assets, consumption of less preferred food, limiting the portion size of food, borrowing food or money, and begging. The coping strategies used by households in the study area for a period of 30 day were taken. The different strategies adopted were identified which tried to capture experiences of the household during the period of food insecurity.

xvi. **Food Security:** A food secure household is defined as one whose calorie supply per adult equivalent is greater than or equal to the minimum daily calorie requirement for adult of 2260 Kilocalories (Omotesho *et al.*, 2006). Households with lower calorie intakes are considered to be food insecured. Food quantities consumed at the household level in a day were converted to calories. Resulting calorie values were divided by the number of adult equivalent in the households, in order to obtain numbers that are comparable across households of different size (Maxwell *et al.,* 2008).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Sorghum Farmers

This section's focus was to describe the socio-economic characteristics of the sorghum farmers which were used in the analyses. A total of twelve variables including both discrete and continuous variables were discussed.

4.1.1 Age of sorghum farmers

Age is a socio-economic attributes upon which farmers‟ abilities and physical disposition in planning, organizing, controlling resources and accomplishing production activities and farm tasks are based (Oyewole, 2012). The role of age of farmers is very critical in agricultural production. The result presented in Table 4.1 shows that 33.24 percent of the sorghum farmers were within the age range of 50 to 59 years. A mean age of 46 years and coefficient of variation (CV) of 23.04 was observed for the farmers in the study area. This low coefficient of variation of age of the sorghum farmers implies low level of variation in age among the farmers in the study area. This average age indicates that most of the household heads are within the economically active population and therefore constitute a good labour force for sorghum farming in the study area. They are also likely to be able to make rational decisions that will affect productivity positively. However, this finding agrees with Konja, Mabe and Alhassan (2019) who reported that the average age of the farmers was found to be 46 years and they are relatively young and physically active.

Table 4.1: Distribution of sorghum farmers based on age groups

Age groups	Frequency	Percentage
20-29	18	4.99
30-39	67	18.56
40-49	114	31.58
50-59	120	33.24
60 and above	42	11.63
Total	361	100
Mean	46	
Standard dev.	10.6	
Minimum	22	
Maximum	75	
CV	23.04	

4.1.2 Level of education of sorghum farmers

The result in Table 4.2 reveals that 34.63 percent had Quaranic education; this is due to the fact that the study area is a predominantly Muslim area where Islamic education is held in high esteem. Only about 12 and 21 percent had primary and secondary education respectively while about 16 percent had tertiary education. Therefore, the farmers had one form of education or the other, thus the level of literacy is high in the area, and an educated farmer will be able to handle instruction manuals on input and machinery uses. The implication is that the prospects for the acceptance of innovations are reasonably high. This is in line with the works of Irhobie and Agwu (2014) on assessment of food security situation among farming households in rural areas of Kano State, Nigeria who posited that a greater proportion (35.8 percent) of the farming household heads had Quranic education.

Table 4.2: Distribution of sorghum farmers based on highest level of education

Highest level of education	Frequency	Percentage
Non formal	53	14.68
Quranic	125	34.63
Adult	7	1.94
Primary	44	12.19
Secondary	76	21.05
Tertiary	56	15.51
Total	361	100

4.1.3 Marital status of sorghum farmers

Result in Table 4.3 revealed that majority of the sorghum farmers were married (95.57 percent) followed by singles (4 percent) while the divorced and widower represented less that 1 percent of the sample size. This implies that marital status may influence the size of households as married farmers may have larger household sizes which may encourage them to participate in agricultural production in order to raise their income and standard of living.

This finding is in line with the work of Ogunremi and Dubugo (2016) who posited that marital status may influence the size of households as married farmers may have larger household sizes which may increase consumption expenditure thereby making them more prone to food insecurity.

Table 4.3: Distribution of sorghum farmers based on marital status

Marital status	Frequency	Percentage
Married	345	95.57
Single	14	3.88
Divorced	1	0.28
Widower	1	0.28
Total	361	100.01

4.1.4 Household size of sorghum farmers

The distribution of the sorghum farmers by household size is presented in Table 4.4. The result revealed that 48 percent had 6 to 10 members. Those with 21 and above members constituted 2.2 percent. The average household size was 9 members with estimated coefficient of variation of household size of 57.2 percent. This implies that there is a very high level of variation in the household size among the sorghum farmers in the study area. Size of the household may enhance labour availability that can be used for different activities. However, the implication of household size for food security is that small- size households are less prone to food insecurity than large-sizes households because large household sizes have low per capita (Oluwatayo, 2008). This agrees to Ojeleye (2015) who posited that 65.6 percent of the farmers had household sizes ranging between 6 -15 persons. However, the absolute number of people in a certain family cannot be used to justify the potential for productive farm work. This is because it can be affected by some important factors namely; age, sex, schooling and health status.

Table 4.4: Distribution of sorghum farmers based on household size groups

Household size groups	Frequency	Percentage
1-5	93	25.8
6-10	173	47.9
11-15	60	16.6
16-20	27	7.5
21 and above	8	2.2
Total	361	100
Mean	9	
Standard dev.	5	
Minimum	1	
Maximum	28	
CV	57.2	

4.1.5 Farming experience of sorghum farmers

The experience of the sorghum farmers showed that 27.42 percent had 11-20 years of experience. The maximum farming experience observed was 55 years while the minimum was one (1) year and average of 21 years of experience in farming. Experience is always regarded as a necessary factor to establish mastery in the effective use of resources. This clearly revealed that sorghum farmers were experienced in farming, although there was great variability in farming experience. The implication of this finding is that sorghum farmers' experience would be important in raising their production efficiency. This is in line with the findings of Oladimeji and Abdulsalam (2013) and Sani *et al.* (2017) who posited that 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.

Table 4.5: Distribution of sorghum farmers based on farming experience groups

Farming experience	Frequency	Percentage
1-10	95	26.31
11-20	99	27.42
21-30	92	25.48
31 years and above	75	20.77
Total	361	100
Mean	21.16	
Standard dev.	13.49	
Minimum	1	
Maximum	55	
CV	63.75	

4.1.6 Farm size of sorghum farmers

Land is a traditional input in farm production and one without which production is impossible. But, at the same time land must be allocated rationally for maximization of inputs. In this study,

it was found that sorghum farmers varied in terms of the number of hectare used for sorghum production. 44.0 percent of them used 2.0 - 2.6 hectares followed by those who used between 2.7-3.3 hectares (15.5 percent). On average, 2 hectares were used by the farmers for sorghum production. This imply that sorghum farmers in the study area were small scale farmers. The finding of this study is consistent with Keku (2017) in his work on Analysis of food security and coping strategies of rural farm households in Kaduna State, Nigeria who reported that most Nigerian farms are small-sized family farms in which family members contribute the required labour.

Table 4.6: Distribution of sorghum farmers based on farm size

Farm size	**Frequency**	**Percentage**
0.6-1.2	54	15.0
1.3-1.9	48	13.3
2.0-2.6	159	44.0
2.7-3.3	56	15.5
3.4-4.0	44	12.2
Total	361	100
Mean	2.18	
Standard dev.	0.94	
Minimum	0.5	
Maximum	4.0	
CV	43.1	

4.1.7 Number of contact with extension agents per season

Agricultural extension service constitutes a driving force for any agricultural development. The relationship between agricultural extension agents and the farmer is an important determinant in the adoption and sustenance of improved farm practices. The ultimate aim of extension services

is to enhance farmers' ability to efficiently utilize resources through new technology used in sorghum production instead of using traditional methods which are inefficient, resulting to low yield.

About 92 percent of the sorghum farmers were without extension services contact. The maximum and minimum extension contacts observed was 10 and 0 times in a cropping season respectively with average of 1 times per season in sorghum production. 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. The implication is that sorghum farmers were probably lacking in important information needed to increase their production and therefore relied exclusively on their experiences which may not be enough all the time. According to Jafaar (2016), extension service is very essential to the improvement of farm productivity and efficiency among farmers.

Table 4.7: Distribution of sorghum farmers based on contact with extension agents

Number of contacts with extension agents	**Frequency**	**Percentage**
Access	29	8.03
No access	332	91.97
Total	361	100
Once	5	1.38
Twice	4	1.11
Thrice	7	1.94
4 and above	13	3.60
Total	29	8.03
Mean	1	
Standard dev.	1.55	
Minimum	0	
Maximum	10	
COV	30.3	

4.2. Production Efficiency of Smallholder Sorghum Farmers

This section focused on discussing the result of production efficiency of smallholder farmers in Kano State. In particular, both production and cost functions were estimated in this regard where the relationship between inputs and output with and without price considerations was first examined and then the frequency analysis of their level of production efficiency was undertaken.

4.2.1 Technical efficiency in sorghum production

The model specified was estimated by the maximum likelihood (ML) method using frontier 4.1 software developed by Coelli (1995) adopted by Sani and Oladimeji (2017). The ML estimates and inefficiency determinants of the specified frontier are presented in Table 4.8. The result revealed that the generalized log likelihood function was -236.772. 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 88 percent and it was statistically 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 88 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 ($\boldsymbol{\sigma 2}$) was significantly different from zero at $P<0.01$ level of probability. This indicates a good fit and correctness of the specified distributional assumptions of the composite error terms while the gamma γ indicates the systematic influences that are unexplained by the production function and

the dominant sources of random error. This means that the inefficiency effects make significant contribution to the technical inefficiencies of sorghum farmers.

Table 4.8: Maximum likelihood estimates of the stochastic frontier Cobb-Douglas production function technical efficiency for sorghum production

Variable	Param.	Coef	Std Error	T-value
Production model				
Constant	β_0	7.399***	0.500	14.79
Land	β_1	0.668***	0.137	4.88
Seed	β_2	0.204***	0.060	3.42
Labour	β_3	0.024	0.074	1.35
Agrochemical	β_4	-0.018	0.041	-0.43
Fertilizer	β_5	0.311***	0.062	5.04
Organic manure	β_6	-0.094	0.071	-1.32
Inefficiency model				
Constant	δ_0	-0.504	0.525	-0.96
Education	δ_4	0.009	0.049	0.18
Household size	δ_2	-0.020	0.021	-0.97
Farming experience	δ_5	0.007	0.007	0.92
Cooperative	δ_8	-0.205*	0.108	-1.89
Extension contact	δ_7	-0.004	0.080	-0.06
Goodness of fit				
Sigma-squared	σ^2	0.749***	0.185	4.05
Gamma	γ	0.884***	0.039	22.88
Restricted log likelihood function (RLL)		-275.988		
Unrestricted log likelihood function (ULL)		-236.772		
Likelihood ratio test (LR test)		82.575***		
Mean Technical Eff		**0.67**		
Observations		361		

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

The estimated coefficients of some of the parameters of production function (land, seed and fertilizer) were positive and significant at $p<0.01$ level of probability. The average technical efficiency for the farmers was 0.67 implying that, on the average, the sorghum farmers were able to obtain 67 percent of potential output from a given mixture of production inputs. Thus, in a short run, there is minimal scope (33 percent) of increasing the efficiency.

The estimated coefficient for land 0.668 is positive and statistically significant at $p<0.01$ level. The estimated coefficient 0.668 implies that increasing land by a unit will increase sorghum output by 0.668 units all things being equal. The positive and significant effect of land on sorghum output among sorghum farmers is consistent with the *a priori* expectation. This relationship relates the extensive nature of Nigerian agriculture in general and sorghum in particular. This result is consistent with result of Taphe *et al.* (2015), in their work on resource productivity and technical efficiency of small scale groundnut farmers in Taraba state, Nigeria who posited that land was significant and positively related to output of groundnut farmers in Taraba State.

The estimated coefficient for seed 0.204 is positive and statistically significant at $p<0.01$ level of probability. The estimated coefficient 0.204 implies that increasing seed by a unit will increase sorghum output by 0.204 units all things being equal. The significance of seed quantity is however, due to the fact that seed determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance. This is in line with the findings of Zalkuwi *et al.* (2014), who observed in their work on resource productivity of maize in Numan LGA of Adamawa State, Nigeria, that the estimated coefficient of seed and labour inputs were positive as expected and significant at 1 percent level which implies that the more seed is applied and the more labour employed the better the output of maize.

The coefficient of fertilizer has a positive value (0.311) and was significant at $p<0.01$ level of probability. This implies that a unit increase in fertilizer will lead to a corresponding increase in sorghum output by 0.311 units and this is consistent with the *aprior* expectation. The significance of fertilizer may be due to the good absorption of fertilizer and the conducive environment. The result is conforming to the report of Mabe, Donkoh and Al-hassan, (2018) where fertilizer was reported to be significant at 1% level of probability.

Inefficiency model

The inefficiency model was stated as a function of 5 independent variables namely, household size, education, farming experience, extension contacts and membership of cooperative. Conversely only membership of cooperative significantly influenced technical inefficiency. The estimated result of the inefficiency model is contained in Table 4.8. Usually, a negative sign on a parameter means that the variable reduces technical inefficiency, while a positive sign increases technical inefficiency.

Membership of cooperative showed a negative relation with technical inefficiency and is significant at $p<0.10$ for sorghum farmers. The negative coefficient reveals that a high membership of cooperative results in a reduction in technical inefficiency of sorghum farmers. This is contrary to the study of Galawat and Yabe (2012), that reported cooperative membership to have positive relationship on efficiency in evaluation of technical, allocative, and economic efficiency in rice production; a case study on rice farmers in Brunei Darussalam.

Table 4.9: Frequency distribution of sorghum farmers based on level of technical efficiency

Efficiency level	Frequency	Percent
0.01-0.20	8	2.2
0.21-0.40	48	13.3
0.41-0.60	60	16.6
0.61-0.80	155	42.9
0.81-1.00	90	24.9
Total	361	100
Mean	0.67	
Standard deviation (σ^2)	0.19	
Minimum	0.12	
Maximum	0.94	

Table 4.9 presents the distribution of sorghum farmers in terms of their level of technical efficiency. The level of technical efficiency of the smallholder sorghum farmers was categorized into five groups with an average class interval of about 0.20. The lowest technical efficiency level group was comprised of farmers whose technical efficiency level ranged from 0.01-0.20 while the highest technical efficiency level group was made up of those whose technical efficiency level ranged from 0.61-0.80. The middle technical efficiency group, on the other hand were those whose level of technical efficiency ranged from 0.41-0.60.

The frequency column showed the number of sorghum farmers who have been estimated to fall in a given technical efficiency group. The percent column revealed that 2.2 percent of sorghum farmers were in the lowest technical efficiency level group, 16.6 percent in the middle technical efficiency level group, and 42.9 percent in the highest technical efficiency level group. The

implication of the finding is that the majority of sorghum farmers had a high level of technical efficiency. Averagely, a sorghum farmer was about 67 percent (μ = 0.67) technically efficient, although there was an important variability (σ^2 = 0.19) among sorghum farmers in terms of technical efficiency. The implication is that, on average, the sorghum farmers produced about 67 percent of the maximum output, or about 33 percent of the potential output was lost due to technical inefficiency. Overall, the level of technical efficiency of smallholder farmers ranged from 0.12 to 0.94, meaning that, the least technically inefficient sorghum farmer produced only 12 percent of the potential output while the most technically efficient produced up to 94 percent of the maximum output. The magnitude of the mean technical efficiency of the farmers is a reflection of the fact that most of the sampled farmers carry out sorghum production under technical conditions, involving the use of inefficient tools, local seed varieties and so on.

4.2.2 Allocative efficiency in sorghum production

The ML estimates and inefficiency determinants of the specified frontier are presented in Table 4.10. The result revealed that the generalized log likelihood function was 168.12. 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 estimated gamma parameter (γ) of 0.99 is highly significant at 1 percent level, indicating that 99 percent of the variation in the total cost of production among the sampled farmers is due to differences in their cost efficiencies. Since these factors are under the control of the farmer, reducing the influence of the effect of γ will greatly enhance the allocative efficiency of the farmers and improve their yield. The value of sigma squared ($\boldsymbol{\sigma 2}$) was significantly different from zero at 1 percent level of probability. This indicates a good fit and correctness of

the specified distributional assumptions of the composite error terms while the gamma γ indicates the systematic influences that are unexplained by the production function and the dominant sources of random error. This means that the inefficiency effects make significant contribution to the allocative inefficiencies of sorghum farmers.

The average allocative efficiency for the farmers was 0.65 implying that, on the average, sorghum farmers are able to obtain 65 percent of potential output from a given mixture of production inputs. Thus, in a short run, there is minimal scope (35 percent) of increasing the efficiency.

Table 4.10: Maximum likelihood estimates of the stochastic frontier Cobb-Douglas cost function for sorghum production

Variable	Param.	Coef	Std Error	T-value
Production model				
Constant	β_0	-0.803***	0.350	-2.29
Cost of land	β_1	0.160***	0.014	11.78
Cost of seed	β_2	0.121***	0.017	7.25
Cost of organic manure	β_3	0.101***	0.017	6.05
Cost of fertilizer	β_4	0.159***	0.016	10.00
Cost of agrochemical	β_5	-0.011	0.028	-0.38
Cost of labour	β_6	0.650***	0.022	29.88
Inefficiency model				
Constant	δ_0	0.350***	0.091	3.86
Education	δ_2	-0.020***	0.006	-3.49
Household size	δ_3	0.001	0.002	0.56
Farming Experience	δ_4	-0.004***	0.001	-3.72
Membership of cooperative	δ_5	0.005*	0.003	1.64
Extension contact	δ_7	0.017**	0.008	2.20
Goodness of fit				
Sigma-squared	σ^2	0.025***	0.002	11.13
Gamma	γ	0.988***	0.023	42.12
Restricted log likelihood function (RLL)		168.12		
Unrestricted log likelihood function (ULL)		134.91		
Likelihood Ratio test (LR test)		66.42***		
Mean AllocativeEff		**0.65**		
Observations		361		

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

The allocative efficiency coefficients for cost of farm land for sorghum farmers has a positive value (0.160) and statistically significant at $p<0.01$. This implies that a unit increase in cost of farm land will lead to a corresponding increase in cost of production by 0.160 units. The positive and significant effect of cost of farm land by sorghum farmers on cost of production is consistent with the *a priori* expectation. This is in line with the finding of Mburu, Ackello-Ogutu and

Mulwa, (2014) where they reported a positive and significance of cost of land in analysis of economic efficiency and farm size: a case study of wheat farmers in Nakuru district, Kenya.

The cost elasticity with respect to the price of seed was 0.121 which was significant at $p<0.01$. The implication is that the actual total cost of sorghum production increased by about 0.121 unit, on average, for every 1 unit increase in the price of seed used, when holding other independent variables constant. This could be resulting from high cost of improved seeds, indicating the relevance of cost of seed to sorghum production. This is obvious as seed is the variable that is transformed into output, hence output cannot be realized without seed. This is in line with the work of Taphe *et al*. (2015), who reported that cost of groundnut seed was a positive determinant in the total cost of production from their study on resource productivity and technical efficiency of small scale groundnut farmers in Taraba State.

The cost elasticity with respect to the price of fertilizer was 0.159 which was significant at $p<0.01$. The implication is that the actual total cost of sorghum production increased by about 0.159 unit, on average, for every 1 unit increase in the price of fertilizer used, when holding other independent variables constant. These findings were consistent with the a priori expectation as increase in the price of inputs would directly increase the total cost of production, all things being equal.

The cost elasticity with respect to the cost of organic manure was 0.101 which was significant at $p<0.01$. The implication is that the actual total cost of sorghum production increased by about 0.101 unit, on average, for every 1 unit increase in the price of organic manure used, when holding other independent variables constant.

The cost elasticity with respect to the cost of labour was 0.650 which is significant at $p<0.01$. The implication is that a unit increase in cost of labour will lead to a corresponding increase in cost of production by 0.650 units. The positive and significant effect of cost of labour by sorghum farmers on cost of production is in conformity with the *a priori* expectation.

Inefficiency model

The estimated coefficient of the explanatory variables in the inefficiency cost model shows that all the coefficients have the expected signs. Education, Experience, Extension contact and cooperative were found to be statistically significant.

The coefficient for educational level of sorghum farmers was negative and statistically significant at $p<0.01$. 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), on his work on profitability and production efficiency in cotton production in North-west Nigeria that education has a negative effect on allocative efficiency.

The coefficient of farming experience was negative and statistically significant at $p<0.01$. This shows that it increases allocative efficiency and reduces allocative inefficiency. This might be due to their ability to draw on past experience and apply to their present farming conditions.

The coefficient of extension contact variable is estimated to be positive and statistically significant at $p<0.05$, indicating that increased extension services to farmers tend to increase cost inefficiency in sorghum production. Advisory services of extension assist farmers in making sound production and marketing decisions which helps in enhancing cost efficiency. This is in tandem to the report of Maurice *et al.* (2015), in their report on analysis of cost efficiency in food crop production among small-scale farmers in Adamawa State, that extension contact was statistically significant and positively related to cost efficiency.

The coefficient of membership of cooperative association of sorghum farmers has a positive value (0.005) and statistically significant at $p<0.10$. This implies that holding other factors constant, a unit increase in the membership of cooperative association of sorghum farmers will increase their cost inefficiency by magnitude of 0.005 units. This is contrary with *a priori* expectation.

Table 4.11: Frequency distribution of sorghum farmers based on level of allocative efficiency

Efficiency level	Frequency	Percent
0.01-0.20	3	0.83
0.21-0.40	2	0.55
0.41-0.60	106	29.36
0.61-0.80	184	50.97
0.81-1.00	66	18.28
Total	361	100
Mean	0.65	
Standard deviation ($\sigma 2$)	0.12	
Minimum	0.19	
Maximum	0.98	

Table 4.11 presents the distribution of the sorghum farmers based on their level of allocative efficiency. Only 2 sorghum farmers (0.55 percent) were found in the lowest allocative efficiency class which ranged from 0.21 to 0.40 while a total of 184 (50.97 percent) sorghum farmers were found in their highest allocative efficiency class which ranged from 0.61 to 0.80. In the middle allocative efficiency class which ranged from 0.41 to 0.60, 106 sorghum farmers (29.36 percent) were found. On average, the estimated level of allocative efficiency was 0.65 with a standard deviation of 0.12. Several implications were drawn from these findings. Firstly, it was observed that the lowest level of allocative efficiency was 0.19 which implied that the minimum cost of sorghum production was 19 percent of the actual cost of the least allocatively efficient sorghum farmer. The most allocatively efficient farmers could still increase its minimum cost of sorghum production by 2 percent.

4.2.3 Economic efficiency in sorghum production

Table 4.12 presents the distribution of sorghum farmers based on their level of economic efficiency. The level of economic efficiency of sorghum farmers ranged from 0.08 to 0.84 with an average of 0.45. The implication is that the least economically efficient sorghum farmers could still increase his/her level of economic efficiency by 92 percent while the most economically efficient sorghum farmer could still increase his/her level of economic efficiency by 16 percent without reducing output or increasing inputs.

Table 4.12: Frequency distribution of sorghum farmers based on level of economic efficiency

Efficiency level	Frequency	Percent
0.01-0.20	23	6.37
0.21-0.40	100	27.70
0.41-0.60	196	54.29
0.61-0.80	39	10.80
0.81-1.00	3	0.83
Total	361	100
Mean	0.45	
Standard deviation ($\sigma 2$)	0.14	
Minimum	0.08	
Maximum	0.84	

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

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

4.2.4.1 Average efficiency and farming experience of sorghum farmers

The result in Table 4.13 shows that efficiency seemed to be quite stable among the experienced farmer groups, as there was relatively insignificant difference in their average efficiencies but from farming experience 21-30 years both the average technical efficiency (TE), average allocative efficiency (AE) and average economic efficiency (EE) of sorghum farmers increased slightly suggesting that they were more efficient.

Table 4.13: Average efficiency distribution and farming experience of sorghum farmers

Farming experience (years)	Average TE	Average AE	Average EE
1 – 10	0.65	0.65	0.42
11 – 20	0.66	0.69	0.45
21 – 30	0.69	0.68	0.47
31 and above	0.63	0.74	0.46

4.2.4.2 Average efficiency and education of sorghum farmers

The result in Table 4.14 shows that those with adult education had greater technical efficiency (0.75) while those with tertiary education had the greater allocative efficiency. Adult and secondary education had the same economic efficiency (0.47). This shows that education influences the efficiency of the sorghum farmers.

Table 4.14: **Average efficiency distribution and education of sorghum farmers**

Highest level of education	Average TE	Average AE	Average EE
No education	0.71	0.60	0.43
Arabic	0.66	0.69	0.45
Adult	0.75	0.64	0.47
Primary	0.63	0.71	0.45
Secondary	0.68	0.70	0.47
Tertiary	0.60	0.72	0.42

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

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

4.2.5.1 Average efficiency and farm size of sorghum farmers

Table 4.15 shows the average efficiency distribution of sorghum farmers based on farm size. From the results, farmers who had relatively large farm size between 3.4 - 4.0 hectares had greater technical efficiency (0.76) than those who had smaller farm size. The allocative and economic efficiency varied based on the farm size too. The implication of this result is that with increase in farm size, technical efficiency also increased. This finding is similar to the findings of Adzawla, Fuseini and Donkoh (2013), which found out those farmers who had farm size (2 acres), had greater

efficiency (0.93) than those who had smaller farms.

Table 4.15: Average efficiency distribution and farm size of sorghum farmers

Farm size (ha)	Average TE	Average AE	Average EE
0.5-1.2	0.45	0.73	0.33
1.3-1.9	0.64	0.69	0.45
2.0-2.6	0.69	0.70	0.48
2.7-3.3	0.70	0.62	0.43
3.4-4.0	0.76	0.65	0.49

4.2.5.2 Average efficiency and seed of sorghum farmers

Table 4.16 shows the average efficiency distribution of sorghum farmers based on seed usage. From the results, farmers who used relatively seed rate between 11.9–14.6 kg had greater technical efficiency (0.69). Farmers who used 14.7-16 kg of seeds had greater allocative and economic efficiency.

Table 4.16: Average efficiency distribution and seed usage of sorghum farmers

Seed usage (kg)	Average TE	Average AE	Average EE
9-10.4	0.62	0.67	0.45
10.5-11.8	0.65	0.70	0.44
11.9-13.2	0.69	0.68	0.44
13.3-14.6	0.69	0.70	0.45
14.7-16	0.66	0.73	0.53

4.2.5.3 Average efficiency and labour of sorghum farmers

Table 4.17 shows the average efficiency distribution of sorghum farmers based on labour usage. From the results, farmers who used labour relatively between 150 and above man-days had greater technical efficiency than those who used lesser labourer. The implication is that the more

labourers used, the greater the technical efficiency. The least allocative efficient labour man-days fall in the range of 200-249 man-days.

Table 4.17: Average efficiency distribution and labour usage of sorghum farmers

Labour (mandays)	Average TE	Average AE	Average EE
34-99	0.62	0.68	0.42
100-149	0.65	0.71	0.46
150-199	0.69	0.71	0.49
200-249	0.69	0.65	0.44
250-300	0.66	0.69	0.44

4.3 Profitability of Sorghum Production

4.3.1 Gross margin

Gross margin analysis was used to determine the profitability of sorghum production in the study area. The details of profitability of sorghum production are presented in Table 4.18. The result revealed that the total variable cost was ₦92, 766.2 per hectare and the total revenue to be ₦172, 200 per hectare with a gross margin of ₦ 79, 433.8

Labour constitutes the highest variable cost for sorghum production in the study area representing 62.74 percent (₦58, 200) of the total cost of production in which first weeding/thining accounted the most. This result is expected as labour constitutes a high proportion of cost among small-scale farmers involved in Agriculture due to the use of family

labour as a support in developing countries, Nigeria inclusive (Girei, Saingbe, Ohen and Umar 2018).

Table 4.18: Average costs and returns estimates of sorghum production per hectare basis

Variable	Quantity	Unit Price	Value(₦/ha)	% of TVC
Total Revenue (TR)	**1435**	**120**	**172, 200**	
Seed (kg)	17	145	2, 465	2.65
Agrochemicals (Litre)	0.8	1671	1, 336.8	1.44
Labour (Man-day)				62.74
Planting	6	700	4200	4.53
Weeding/thinning	20	1000	20000	21.56
Fertilizer application	10	800	8000	8.62
Harvesting	10	1000	10000	10.78
Threshing	20	800	16000	17.25
Fertilizer (kg)	200	85.35	17,070	18.40
Organic manure (mangala)	10.8	1268	13, 694.4	14.76
Total Variable Cost			**92, 766.2**	100
Gross Margin (GR-TVC)			**79, 433.8**	
RNI (TR/TVC)			**1.85**	

Fertilizer is the second most costly input in sorghum production having cost of ₦17, 070 per hectare which is 18.40 percent of the total variable cost. The money spent on fertilizer is not much as expected; this is since sorghum does not really need much fertilizer.

Organic manure constitutes about 14.76 percent of the total variable cost of sorghum production having a cost of ₦13, 694.4. Organic manure was used to augment fertilizer usage in the study area.

Seed contributes 2.65 percent to the total variable cost in sorghum production enterprise with ₦2, 465 per hectare. This may be due to the availability of quality seeds and a uniformity or regulated market price.

Agrochemicals have the lowest cost in sorghum production enterprise with ₦1, 336.8 per hectare which is 1.44 percent of the total variable cost. This may be due to the climatic conditions of the period and the effects of pest and diseases attack during the season of production.

4.3.2 Return to investment in sorghum production (RNI)

Table 4.18 further shows the average rate of return on investment per hectare (return per naira invested per hectare) was ₦ 1.85, indicating that for every ₦ 1 invested in sorghum production, a profit of 85 kobo was made. This implies that sorghum production was profitable in the study area. This is in line with the findings of Mohammed *et al.* (2015) in their work on Economics of On-Farm Sorghum-Legume Strip Cropping System in Kano State, Nigeria that sorghum production is profitable.

4.4 Food Security Status of smallholder sorghum farmers

Food security status of sorghum farming households in the study area is presented in Table 4.19. The average daily calorie consumption for food secure households is given as 5243.72 kcal. That of the insecure households was 1406.12 kcal. It is to be noted that based on the recommended daily calorie intake of 2260 kcal, the food secured household had 2983.72 kcal in excess of the recommended intake while for the insecure household, their average daily household per capita calorie consumption was 853.88 kcal short of the recommended value. The result showed that

68.98 percent of the sorghum farming households was food secure while 31.02 percent were food insecure.

The mean food security index of food secured and food insecure households were 2.32 and 0.62 respectively. The food insecurity gap of 1.32 and 0.38 implies that on average, the food insecure households consumed 38 percent less than their daily calorie requirements while food secured households consumed 32 percent in excess of their daily calorie requirements. Per capita daily calorie requirement was estimated to be 2,260 kcal which is lower than the national weighted average of 2,849 kcal (World Food Program, 2010). However, households suffering from food insecurity were more likely to have adults who have lower nutrient intakes than their food secured counterparts.

Table 4.19: Summary of Households Food Security Analysis

Variable in average	Value
Food secured households (No)	249
Food security Index	2.32
Food security gap	1.32
Average household daily calorie consumption (kcal)	5243.72
Average calorie consumption excess of recommended (2260kcal)	1406.12
Average total sorghum output	2897.17
Average adjusted household size	4.32
Percentage of food secured households	69
Food insecure households (No)	112
Food insecurity Index	0.62
Food insecurity gap	0.38
Average household daily calorie consumption (kcal)	1406.12
Average calorie consumption shortage of recommended (2260kcal)	853.88
Average total sorghum output	1749.33
Average adjusted household size	9.60
Percentage of food insecure households	31

In a study of food security measurement and income diversification strategies carried in Oyo state by Oyewole (2012), he found that the average per capita calorie consumption was 1547.66 kcal for the insecure farm households, and for the food secure households, the average daily per calorie intake was found to be 4816.69 kcal. He also reported 31.5 percent and 66.4 percent food insecure and secure households respectively.

4.5. Contribution of Sorghum production to food security status

Table 4.20 revealed the contribution of sorghum production to household food security status. Based on the contribution of sorghum production on household food security, the study revealed information concerning the influence of the sorghum crop and other associated factors to household food security using Binary Logistic Regression Analysis. The likelihood ratio test was -141.555 significant at $p<0.000$. This indicates that all the variables included in the model are jointly significant in predicting the households' food security. The result showed that sorghum production, adjusted household size, farming experience, membership of cooperative, extension contact and farm size were statistically significant and contributes to households being food secured in the study area. The odds-ratio of these significant variables provides the marginal effect of the independent variables on the dependent variable. The marginal effects give the expected change in probability of a particular contribution to food security with respect to a unit change in an independent variable.

The estimated odds ratio for sorghum production was observed to be positive and significant at $p<0.01$ which influences the households being food secured. This could be that the profit realized from sorghum production can be used to stock up grains thereby increasing the chance for the household to be food secured.

Table 4.20: Binary logistic regression analysis of the contribution of sorghum production and other selected factors on food security

Variable	**Odds Ratio**	**Std. Error**	**Z**	**P>|Z|**
Sorghum production	1.000 ***	1.24e-06	3.45	0.001
Age	1.022	0.021	1.05	0.294
Marital status	0.637	0.324	-0.89	0.376
Education	0.967	0.088	-0.37	0.710
Household size	0.668***	0.034	-7.82	0.000
Farming experience	0.963***	0.013	-2.69	0.007
Membership of cooperative	1.118**	0.051	2.45	0.014
Credit	1.000	0.000	1.19	0.234
Extension contact	1.367**	0.183	2.33	0.020
Farm size	1.745***	0.329	2.96	0.003
Constant	85.437**	183.945	2.07	0.039
Diagnostic statistics				
Pseudo R^2	0.367			
Prob> chi^2	0.000			
LR $chi^2(10)$	164.03			
Log likelihood	-141.555			

*****p<0.01, **p<0.05 and *p<0.10**

The estimated odds ratio for extension contact was found to be positive and statistically significant at $p<0.05$ influence to the household on becoming food secure. This implies that

improving extension service would have influence in helping the farmer know the right decisions to take in sorghum production which in turn will help in reducing household food insecurity.

The odds ratio for adjusted household size was found to be negative and significant at $p<0.01$. This implies that the lesser the household size, the greater the probability of being food secured. Although small households have reduced consumption expenditure compared to large households, they have limited labour which will increase their production expenditure if they are to cultivate more lands. This finding is in contrast with the work of Oyewole (2012) who observed household size to be positively related to probability of being food secured.

Total farm size was found to be positive and statistically significant at $p<0.01$. This implies that increasing farm size would have influence in sorghum production which in turn will help in reducing household food insecurity. This finding is in contrast with the work of Bala (2016) who found out that farm size had a negative relationship with the food security of women ginger producers in Kaduna state.

The odds ratio for membership of cooperative was positive and statistically significant at $p<0.05$. This implies that encouraging farmers to join cooperatives would have influence in sorghum production and give better insights on how to go about securing inputs for their farms at subsidized rates for increased sorghum output.

The odds ratio obtained for years of farming experience was negative and statistically significant at $p<0.01$. This implied that for every additional year in farming experience, the odds ratio of the households being food secured decreased by 0.963.

Other factors influencing food security although not significantly were age, marital status, education and credit.

4.6 Coping strategies of sorghum farmers

When faced with food challenges, people have often devised strategies to cope with the situations at least in the short term before finding adaptive measures for the long term. This is not different for sorghum farmers in the study area. The coping strategies adopted by farming households in the study area to mitigate effects of food insecurity is presented in Table 4.21. The result from the analysis revealed that the most widely used strategies by the farming households in the study area in order of importance are eating less preferred meals, skipping of meals, borrow food/money from friends/relatives, work for money/food, consumption of seed stock for next year, and migration to cities.

Table 4.21: Distribution of sorghum farmers based on coping strategies

Coping strategies	Frequency*	Percent	Rank
Eating less preferred food	189	46.67	1st
Skipping of meals	90	22.22	2nd
Borrow food/money from friends/relatives	61	15.06	3rd
Work for money/food	32	7.90	4th
Consumption of seed stock for next year	29	7.16	5th
Migration to cities	4	0.98	6th

*Multiple response

About 46.67 percent of the sorghum households employed eating less preferred food as a strategy to mitigate effects of food insecurity. This implies that when households are faced with food shortage, the immediate strategy they adopt is to eat less preferred and less expensive food. It might be argued that food intake and expenditures cannot be reduced, because households are already at subsistence level, and further reductions in consumption will present potentially severe consequences for lives. This has significant consequences in the health and virility of the farm family as is predisposes the family members to nutritional deficiencies and the attendant health risks. The result of the study is consistent with the findings of Demi and Kuwormu (2013) who revealed that eating less preferred food, limiting size of food consumed (rationing) and skipping meal within a day were preferred strategies households adopted to minimize the impact of food insecurity. The finding of this study is not consistent with the finding of Awotide *et al.* (2011) who found that cutting down of expenditure on non – food items and withdrawal from personal saving were preferred strategies among farming households in Osun State.

The result shows that 15.06 percent of the sorghum farming households employed the use of borrowing of money from relatives and friends to cushion the effect of food insecurity. This strategy was seen by households as loss of pride and those who practiced this strategy borrowed money mostly from relatives and friends and not from a neighbor for fear of being insulted when misunderstanding break up. This is in line with the work of Ojeleye (2015) who found that borrowing money from friends or relatives was one of the major coping strategy employed by the respondents in Kaduna state.

About 19.19 percent of the sorghum farm households employed reducing food consumption/skipping meals as a strategy to mitigate effects of food insecurity. This implies that when households are faced with food shortage, the immediate strategy they adopt is to eat less preferred and less expensive food. It might be argued that food intake and expenditures cannot be reduced, because households are already at subsistence level, and further reductions in consumption will present potentially severe consequences for lives. The result of the study is consistent with the findings of Orewa and Iyangbe (2010) and Demi and Kuwormu (2013) who revealed that limiting size of food consumed (rationing) and skipping meal within a day were preferred strategies households adopted to minimize the impact of food insecurity.

The result however further presents that just about 13 percent of the respondents were involved in the consumption of seed stock for the following year. This means that these farm families will literally have no seed to plant for the coming year except to probably borrow seeds or money to purchase seed for next production. A vicious cycle of poverty may ensure if no intervention come to the aid of these farm families as this is indicative of high degree of food insecurity.

The result also revealed that some (7.90 percent) of the sampled household heads employed coping strategy of working and sending out children to work in both farming and non-farming ventures to raise money in order to mitigate food insecurity and hunger. This is because it enables households to modernize their production by giving them the opportunity to apply the necessary input, and reduce the risk of food shortage during periods of unexpected crop failures through food purchase. Diversification of sources of income is a strategy, which allows household heads to reduce the risk of starvation for themselves and their families during periods

of chronic or transitory food insecurity. In the study area, households diversify their income by engaging in trading, driving, capentery, brick making, car painting and other income generating activities and this is in agreement with Irhobie and Agwu (2014).

4.7 Constraints in sorghum production

The problems faced by sorghum farmers in the study area were ranked according to their severity as stated by the farmers (Table 4.22). Inadequate fertilizer was reported by about 38.76 percent (169 farmers); thereby suggesting that it was the most serious constraint to sorghum production. This has limited their production capacity. According to the respondents, fertilizer is made available when farmers are far into the production period, sometimes at the middle of the raining season at exorbitant price.

Insufficient fund was also cited as very severe constraints to sorghum production (27.98 percent) in the study area. This may account for the reason most respondents are small- scale farmers. Also, the stringent conditions and bureaucratic bottleneck of credit institutions shy farmers away from obtaining loans to finance their farm operations. Credit is a very strong factor that is needed to acquire or develop any enterprise; its availability could determine the extent of production capacity. It agrees with findings of Nasiru, (2010) who noted that access to micro-credit could have prospect in improving the productivity of farmers and contributing to uplifting the livelihoods of disadvantaged rural farming communities.

Table 4.22: Distribution of sorghum farmers based on constraints faced in sorghum production

Constraints	Frequency*	Percent	Rank
Inadequate fertilizer	169	38.76	1st
Insufficient fund	122	27.98	2nd
Lack of access to improved seeds	78	17.89	3rd
Inadequate storage facilities	55	12.55	4th
Pest infestation	7	1.60	5th
Shortage of rainfall	5	1.15	6th
Total	**436**	**100**	

***multiple responses**

Another problem considered as being very severe by the sorghum farmers is lack of access to improved sorghum seed. This is perceived by about 18 percent of the farmers. This may be due to non-awareness, poor education and poor access to extension service. The result of the study supported the finding of Muhammed *et al.* (2011) whose report found out that one of the major constraints to sorghum production include inadequate access to improved seed in Nigeria.

Inadequate storage and processing facilities was ranked fourth. Post-harvest losses account for about 15-50 percent of food shortage in Nigeria depending on food type (Edache, 2002; Maina, 2010). The provision of storage and processing facilities is very essential for sustainable food crops production in the study area. It was observed in the course of this research work that the method of storage was traditional in nature.

Problem of pests and disease attack was reported by 1.60 percent of sorghum farmers. This may be due to non-usage of quality or appropriate usage of agrochemicals or availability of fund to purchase agrochemicals to control the pests and diseases. Pests and diseases reduce the quantity

and quality of sorghum output. Nwike and Ugwumba (2015) that report pests and diseases attack as a major constraint in their report on profitability of rice production in Aguata agricultural zone of Anambra State.

About 1.15 percent of the farmers reported on the issue of shortage of rain. This finding once again is consistent with the fact that the deviation from the expected sorghum output was not just the result of mismanagement of resources but also the result of random shocks such as climate change.

The findings of this study agree with Keku (2017) who reported that poor accessibility to credit facilities, high cost of fertilizer, storage and marketing facilities and production inputs are important factors causing food insecurity in Nigeria, The implication of this finding is that if farmers can have access to all these inputs listed above, it can go a long way in improving food security in the area as this can help farmers to achieve high crop yield, ability to process and store their farm products.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The broad objective of the study was to analyse the effect of sorghum production on food security status of smallholder farmers in Kano State. Six objectives were derived to that effect: to describe the socio-economic characteristics of smallholder sorghum farmers, estimate the production efficiency of smallholder sorghum farmers, determine the profitability of sorghum production, estimate the contribution of sorghum production to food security status, identify the coping strategies employed by food insecure smallholder sorghum farmers and to describe the constraints to sorghum production in the study area. A sample size of 361 sorghum farmers was interviewed.

Data used in the analyses were collected using well-structured questionnaires by trained enumerators on socio-economic and demographic characteristics of households such as age, marital status, household size, level of education, farm size, farming experience, number of extension contact, years spent in cooperative, amount of seeds, fertilizer, labour, agrochemicals, sorghum output and utilization. Various tools of analyses were employed to achieve the objectives of the study such as descriptive statistics, stochastic frontier production and cost functions, gross margin, food security index and logistic regression model.

On average, a sorghum farmer was 46 years old, belonged to a household of size 9, had 21 years of farming experience, and had 2 hectares of sorghum, with Arabic education (34.63 percent) as the major form of education, majority were married (95.57 percent), had farming as their main occupation (81.44 percent) and had no contact with extension agents (92 percent).

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 361 sampled farmers in the study area was 0.67 implying that on the average, output decreased by 33 percent from the maximum possible level due to inefficiency. The estimated coefficients of all the parameters of production function (land, seed, and fertilizer) were positive and significant at $p<0.01$ level of probability and hence play a major role in sorghum production in the study area. Membership of cooperative was statistically significant at $p<0.10$ levels which was found to be factor influencing the technical inefficiency of sorghum farmers. 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. The estimated coefficients of cost of land, cost of seed, cost of organic manure, cost of fertilizer and cost of labour were all positive and significant at $p<0.01$ level of probability. Education, farming experience, membership of cooperative and extension contact were statistically significant and found as factors influencing allocative efficiency.

The TVC incurred and revenue obtained per hectare on average for sorghum was estimated to determine the profitability of sorghum production in the study area. The total revenue was ₦172, 200 while the total variable cost was ₦92, 766.2. The gross margin was therefore ₦79, 433.8.

The rate of return on investment (return per naira invested) was ₦1.85 indicating for every ₦1 invested in sorghum production in the study area, a profit of 85 kobo was made. Thus, it could be concluded that sorghum production in the study area is profitable.

The result of food security status of sorghum farmers indicates majority (68.98 percent) of farming households were food secure while 31.02 percent were not food secured. The food security index was found to be 2.32 while the food insecurity index 0.62. The food insecurity gap/surplus gap index was found to be 1.32 for food secure while 0.38 to be food insure. The available household daily calorie consumption (kcal) for both food secured and food insecure were 5243.72 and 1406.12 respectively.

Variable identified to have influence on household food security status are household size ($p<0.01$), farming experience ($p<0.01$), membership of cooperative ($p<0.05$), extension contact ($p<0.05$) and farm size ($p<0.01$) which influence significantly. In addition, production of sorghum ($p<0.01$) in households increase the chance of household to become food secured. Other factors which influence food security include; education, age, credit and marital status but they were not statistically significant.

The coping strategies adopted by sorghum farmers when faced with food challenges to mitigate the effects of food insecurity in order of importance are eating less preferred meals, borrow money/food from friends and relatives, skipping of meals, consumption of seed stock for next

year, work for money/food and migration to cities. The constraints faced by sorghum farmers in the study area according to their severity was inadequate fertilizer, insufficient fund, lack of improved seeds, storage facilities, shortage of rainfall and pest infestation.

5.2 Conclusion

Based on the findings of this study, it is therefore concluded that sorghum production is a profitable venture considering the rate of return on investment (return per naira invested). However, in spite of the profitability of sorghum production, the farmers were yet to operate on their production frontiers. The inability of the farmers to achieve their best in the efficiency of production was due to the presence of technical, allocative and economic inefficiency effects. Results revealed that increase in farm size, extension contact and membership of cooperative as well as increase in the quantity of sorghum output contributes to the household food security status of sorghum farmers in Kano state. Given that sorghum is an important staple food in Nigeria, any attempt to increase its production would be a right step towards the resolution of food insecurity.

5.3 Recommendations

In light of the findings of this study, the following recommendations are proposed:

1. Government and farmer groups should provide inputs to farming households during farming seasons at affordable prices in order to increase their farm size and food production capacity since farm size was one of the factors that influenced household food security status.

2. Due to the problems faced in the study area, farmers are encouraged to buy fertilizers in groups to reduce transport and other costs and they should develop saving schemes among themselves so as to have enough capital for farming activities.

3. Since sorghum production is a profitable venture, the farmers should be sensitized by cooperative groups on the need to go into the production to boost their income which will in turn make them less prone to insecurity.

5.4 Contributions to Knowledge

Some of the important contributions of this study to the body of the literature are:

1. Sorghum farmers in the study area achieved a mean technical efficiency of 67 percent and allocative efficiency of 65 percent.
2. The study revealed that sorghum farmers with larger farm size between 3.4 – 4.0 hectares had greater technical efficiency than those who had smaller farm size.
3. An average of 85 Kobo/hectare is realized for every naira invested in sorghum production.
4. Sorghum production has a significant contribution to household food security status.

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APPENDIX 1

DEPARTMENT OF AGRICULTURAL ECONOMICS, FACULTY OF AGRICULTURE,

AHMADU BELLO UNIVERSITY, ZARIA.

SURVEY QUESTIONNAIRE FOR SMALLHOLDER SORGHUM FARMERS.

Dear Respondent,

I am a post graduate student (M.sc) of the aforementioned department carrying out a research on the topic**: ANALYSIS OF SORGHUM PRODUCTION AND ITS EFFECT ON HOUSEHOLD FOOD SECURITY STATUS OF SMALLHOLDER FARMERS IN KANO STATE, NIGERIA.** Please kindly answer the following questions to the best of your knowledge. Information provided will be treated confidentially.

Thank you.

Instruction: Kindly tick (√) or fill in the blank spaces as appropriate.

Village/Community……..…… L.G.A……

SECTION A: SOCIOECONOMIC CHARACTERISTICS

1. Name of Farmer ……

2. Gender: Male ( ) Female ( )

3. Age (Years) ……..……...

4. Marital Status: Married ( ) Single ( )

5. Level of Education: a. No Formal Education ( ) b. Arabic Education ( ) c. Adult Education ( ) d. Primary Education ( ) e. Secondary Education ( ) f. Post-Secondary Education ( )

6. Household Size

Categories	**Males (No)**	**Females (No)**
Children (Not capable of farm work, 1-15 yrs)		
Children (Capable of Farm work, 16-30)		
Dependents (Not capable of Farm work, > 60yrs		
Dependents (Capable of farm work, 15-49 yrs		

7. How long have you been in farming? (Years of experience) ……

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

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

10. What benefit did you derive as a member? .....

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

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

Source of Loan	Amount	Interest Rate
Commercial Bank		
Bank of Agriculture		
Cooperative societies		
Money lenders		
Family and friends		
Others (specify)		

13. Have you been visited by an extension agent in the last one year? Yes ( ) No ( )

14. If yes, how many times in the last one year? ……

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

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

17. Have you been trained on any aspect of farming? Yes ( ) No ( )

18. If yes, what activities, which organization conducted the training and what benefit did you derive from the training? .....

Activities/Technology	Organization	Benefit
Fertilizer application		(a)Not beneficial( ) (b) Somehow beneficial ( ) (c) Beneficial ( ) (d) Very beneficial ( )
Intercropping		(a)Not beneficial( ) (b) Somehow beneficial ( ) (c)

		Beneficial ( ) (d) Very beneficial ( )
Plant Spacing		(a)Not beneficial( ) (b) Somehow beneficial ( ) (c) Beneficial ( ) (d) Very beneficial ( )
Pest control		(a)Not beneficial( ) (b) Somehow beneficial ( ) (c) Beneficial ( ) (d) Very beneficial ( )

SECTION B: INFORMATION ON INPUTS USED IN PRODUCTION

a. Farm size (Ha)

19. What is the total farm size you have? .....

20. How many plot of land is allocated to sole sorghum production? ……..

21. How did you acquire your land? a. inheritance ( ) b. .Borrowed ( ) c. Leased ( ) d. Purchased ( ) e. Gift ( )

22. What does it cost to rent one Hectare of land per season in your village? ....…….....

Variable inputs (Last production Cycle)

b. **Seed (Kg)**

23. How many quantity (kg) of seed do you use in sorghum production? ……

24. Variety of sorghum used Hybrid ( ) Local ( )

25. How much does it cost? ……..

c. **Fertilizer (kg)**

26. How much quantity (kg) of fertilizer do you use in sorghum production? ……

27. Fertilizer type used Organic ( ) Inorganic ( )

28. How much does it cost? …….

d. **Agrochemical**.

29. How much quantity (litres) of agrochemical do you use in sorghum production? ……

30. How much does it cost? ……

31. Labour input

Operation	**Hired Labour**			**Family Labour**		
	No of people	**No of Hours**	**Cost (₦)**	**No of people**	**No of Hours**	**Cost (₦)**
Land preparation						
Planting						
Fertilizer application						
1st weeding						
2nd Weeding						

Harvesting						
Processing						
Transportation						

SECTION C: INFORMATION ON OUTPUT

32. Output of sorghum (kg)

Plot Number	**Output (kg/bags)**	**Quantity sold (kg)**	**Price/Unit**	**Qty reserved for planting (kg/mudus)**	**Qty consumed (kg/bags)**
1					
2					
3					

33. Where do you sell your produce? a. Farm gate ( ) b. Rural market ( ) c. Urban market ( )

34. To whom did you sell your produce? a. Assemblers ( ) b. Wholesalers ( ) c. Retailers ( ) d. Consumers ( )

35. When do you sell your produce? a. Immediately after harvesting ( ) b. Few months after harvest ( ) c. off season ( )

SECTION D: FOOD SECURITY STATUS

36. Have you ever experienced food shortages/less to eat in the last 5 years?

Yes ( ) No ( )

37. If yes, usually in which months of the year?

Seasons	**Duration**	**Response (tick)**
A. January-March		
B. April-June		
C. July-September		
D. October-December		

38. Do you think that your household is currently food secure? Yes ( ) No ( ).

39. Please complete the table below with respect to your food consumption during these seasons.

Food items	**Quantity of food consumed during each season**			
	Jan-March	**April-June**	**July-Sept.**	**Oct- Dec.**
Rice				
Maize				
Millet				
Yam				
Cowpea				
Acha				
Garri				
Bread				
Egg				
Fish/meat/chicken				
Fruits				

Vegetable				
Cooking oil				
Maggi				
Sugar				
Milk				
Others (specify)				

40. What do you think is the cause of the food shortage?

a. Inadequate food storage facilities ( )

b. Inadequate money to buy during those periods ( )

c. Inadequate farm inputs such as fertilizer, pesticides, improved seeds etc ( )

d. Lack of knowledge of innovations such as improved technology ( )

e. Others (specify) …….

SECTION E: COPING STRATEGIES

41. How did you fend for the household during the period(s) of food shortages?

	Coping Strategy	**Daily**	**Very often**	**Very rarely**	**Never**
a	Buying from market				
b	Eating less preferred food (e.g. fish for meat)				
c	Borrow money or food from friends/relatives				
d	Consumption of seed stock for next year				

e	Reduced number of meals for adults				
f	Work for food or money				
g	Send out children for paid jobs				
h	Gather wild food like hunting/scavenging				
i	Sale of assets like land				
j	Stealing				
k	Migrate to cities				
l	Others (specify)				

*****Note that you can mark more than one strategy used.**

42. What do you think can be done to avoid food shortages?

a. Increase loans to farmers ( ) b. Government should intervene in food production ( )

c. Provision of improved technology at affordable prices ( )

d. Provision of more storage facilities ( ) e. Better healthcare facilities ( )

f. Improvement in extension services ( ) g. Others (specify) ……..

SECTION F: CONSTRAINTS TO SORGHUM PRODUCTION

43. State the constraint(s) affecting your production

i ……

ii. ……

iii. ……

iv. ……

v. ……

44. What suggestion(s) will you give to help in solving the above constraints?

i ……

ii. ……

iii. ……

iv. ……

v. ……

Thanks for your Attention.

APPENDIX 2

Equivalent male adult scale weights to determine adjusted household size.

Age category	Male	Female
Under 1yr	0.00	0.00
1 - 4.99yrs	0.25	0.20
5 – 9.9yrs	0.60	0.50
10 – 14.9yrs	0.75	0.75
15 – 59.9yrs	1.00	0.90
60yrs and above	0.80	0.65

Source: Omotesho *et al*., 2006; Keku, 2017

APPENDIX 3

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Nutrient Composition of Commonly Eaten Foods in Nigerian—Raw, Processed and Prepared.

Food items	Kcal/Kg	Food items	Kcal/Kg
Staple Foods		Mango	590
Cassava Tuber	1500	Pawpaw	300
Cassava Flour	3870	Pineapple	320
Cassava Chips	3000	Apple	570
Garri	3840	Coconut	580
Yam Tuber	1100	Guava	730
Yam Flour	3810	Sugarcane	360
Yam Ships	3000	**Meat and Animal products**	
Sweet Potato Tuber	1100	Cow meat	2370
Sweet Potato Chips	900	Goat meat	2370
Irish Potato	1200	Sheep Meat	2370
Cocoyam Tuber	3830	Pork	2370
Maize Green	3100	Bush meat	2370
Maize Grain	4120	Chicken	2380
Maize Flour	4120	Turkey	2380
Sorghum Grain	3500	Fish	2230
Sorghum Flour	3500	Snail	2245
Millet Grain	3500	Shrimps	2230
Millet Flour	3500	Crayfish	2200
Rice	1230	Crabs	2200
Wheat Grain	3400	Eggs (pieces)	1400
Wheat Flour	3300	**Dairy Products**	
Cowpea (Beans)	5920	Milk	4900
Ground Nut	5950	Cheese	4000

Soybeans	4050	Yoghurt	4100
Soybean Flour	2600	Ice cream	4100
Melon (Shelled)	5670	Beverages	
Plantain	770	Cocoa	1200
Banana	960	Tea (Leaves)	1200
Vegetables		Tea (liquid)	1200
Okra	4550	Coffee (Powder)	1340
Tomato	880	Coffee (Liquid)	1340
Pepper	3930	**Drinks**	
Onion	440	Soft drinks	620
Carrot	400	Orange juice	400
Egg Plant	440	Apple Juice	550
Cucumber	270	Pineapple Juice	560
Cochorus/Ewedu	500	Local Beer	740
Spinach	220	Bottled Beer	460
Bitter Leaf	220	Wine	330
Water Leaf	180	**Condiments and Spices**	
Cabbage	230	Maggi	220
Pumpkin	440	Salt	180

Source: Babatude *et al*., (2007)