PRODUCTIVITY OF HUNGRY RICE (*Digitaria exilis*) IN SELECTED LOCAL GOVERNMENT AREAS OF KADUNA STATE, NIGERIA.

BY

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DECLARATION

I hereby declare that this Thesis entitled "**Productivity of Hungry Rice (*Digitaria exilis*) in Selected Local Government Areas of Kaduna State, Nigeria**" has been written by me and it is a record of my research work. It has not been presented in any previous application for another degree or diploma at any institution. All borrowed ideas have been duly acknowledged in the text and a list of references provided.

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CERTIFICATION

This Thesis, entitled "**Analysis of the Productivity of Hungry Rice (*Digitaria exilis*) in Selected Local Government Areas of Kaduna State, Nigeria**" by Kalat Patience **Duniya** meets the regulations governing the award of the Degree of Master of Science (M.Sc.) in Agricultural Economics of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the Almighty God, to my parents: Elisha and Rifkatu Duniya and to my siblings: Elizabeth, Lydia, Samuel, Buli and Kuzangka for their affection, love and dedicated partnership in the success of my life.

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ABSTRACT

The study analyzed the productivity of hungry rice (acha) using data collected through structured questionnaire administered to 194 randomly selected acha farmers in Kaduna State. Data were analysed using the stochastic frontier production function, gross margin analysis and the t-test of significance. The maximum likelihood error estimates revealed a positive relationship between output and all inputs, statistically significant (P < 0.01). The magnitudes of the coefficients of the inputs showed that output was inelastic to farm size, labour, seed rate, fertilizer and agrochemicals. The return to scale coefficient (1.42) obtained indicate that the farmers were operating at increasing returns to scale, that is, stage one of the production. The technical efficiency of farmers revealed that farmers were fairly technically efficient (81%). 98% of the inefficiency was as a result of the selected variables (contact with extension agent, household size, level of education, off farm income, processing cost, harvesting cost, transportation cost and farm distance) which were significant at different levels (P<0.01, P<0.05 and P<0.10). Gross margin of ₦27, 920.59, Gross ratio of 55%, profit margin of 45% and a return on investment of 1.81 were obtained as profitability measures, implying that for every ₦1 invested in acha production, a profit of 81 kobo was made. Most important constraints faced by farmers include high cost of labour, inadequate capital and high cost of inputs. The study recommends increase in the provision of extension services and training on correct input application and improved farming technologies to increase acha productivity; continuous increase in the use of the production inputs; and also suggests the need to develop good roads so as to reduce transportation costs, provide good social amenities and market infrastructure to reduce urban drift of youths who are the major source of labour in the study area.

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CHAPTER 1

INTRODUCTION

1.1 Background to the Study

Increase in agricultural productivity and changes in food prices are critical drivers of development, food security and poverty reduction which are challenged by growing threats facing global and local agricultural food systems. The agricultural sector provides livelihood directly and indirectly to a significant portion of the population of all developing countries, especially in rural areas, where poverty is more pronounced (Food and Agricultural Organisation, 2001). Thus, a growing agricultural sector contributes to both overall growth and poverty alleviation.

Within the context of growth in food and agriculture, emphasis is placed on productivity because expansion of arable land is very limited in most countries due to physical lack of suitable land and/or because of environmental priorities. As observed by Pardey *et al.* (2012), the long-term issues related to agricultural productivity, food prices, food security, poverty and hunger turn mainly on the future path of agricultural supply; in particular, the growth of agricultural productivity given increasing constraints on the natural resource base available for food production. In addition, the difference between actual and technically feasible yields for most crops implies great potential for increasing food and agriculture production through improvements in productivity, even without further advances in technology. Hence, efficient adjustment procedures and economically efficient utilization of productive resources are twin forces that a society has to contend with, be it developed or developing countries.

Nigeria, like in most developing countries is characterized by low crop productivity per hectare, small land holdings: thus, small scale farming and rudimentary farming systems which can be attributed to poor and inefficient use of resources (Fasasi, 2006). The productivity of a production unit can be measured by the ratio of its output to its input. However, productivity varies according to differences in production technology, production process and differences in the environment in which production occurs. Lovell (1993) emphasized that price is the most important determinant of profit or loss in the farm enterprise which is an indicator of productivity, as it provides incentive for producers to grow more.

The increasing problem of food insecurity in Nigeria and the recognition of orphan crops like hungry rice, as a potential buffer against famine are expected to stimulate the expansion of land area devoted to its cultivation in the country. However, available statistics demonstrates the reduction of hungry rice harvested area in several countries, except in Nigeria, Cote D'Ivoire, and Guinea, implying the significance of the crop in the country. In year 2002, a total area of 347,380 hectares was devoted to hungry rice production in Africa (Cruz, 2004), with Nigeria alone providing almost half of that area (150,000 ha).

Hungry rice *(Digitaria exilis),* is commonly known as 'acha' in Nigeria; 'fonio', 'pom', 'fundi' and 'kabug' in other West African countries. The plant originated in West Africa and it thrives well in the sandy, rocky soils of the Sahel both in drought and flood, and grows so fast that two or three crops can be harvested each year (Morales, 2003; Abdullahi and Luka, 2003). It grows well in Nigeria, mostly cultivated around Plateau, Bauchi, Kaduna and Niger states, and is a staple food in these parts of Nigeria and across fifteen North West African countries (Jideani, 1999).

Hungry rice (acha), is a crop that fits well into the low-input farming systems of the resource-poor farmers as it has a unique ability to tolerate poor and marginal soils and can withstand drought (Vietmeyer *et al.*, 1996; Aslafy, 2003). It is one of the crops in the West African sub region neglected by research and thus described as one of the orphan crops. It remains an important crop for West African farmers although its production is inhibited by several factors, among which are poor agronomic performances because of unimproved seeds and husbandry practices as well as difficulties in distinguishing between the different species belonging to the genus *Digitaria* (Abdullahi and Luka, 2003). Though the crop has been completely neglected in the past (Kwon-Ndung and Misari, 1999), it is now considered as an important crop for improvement as a cultivated species (Ibrahim, 2001; Morales-Payan *et al*., 2002) and also a recommended diet for diabetic patients due to its low sugar level.

1.2 Statement of the Problem

Agriculture is a key pillar in economic development in developing countries. The adoption of new technologies designed to enhance productivity and income has received particular attention as a means of accelerating economic development. However, productivity growth is not only achieved through technological innovation but also through the efficiency with which the resources are used under the technology. The potential importance of efficiency as a means of fostering agricultural productivity has been recognized by many researchers; hence, efficiency can be seen as an indicator of productivity.

One critique of literature on acha productivity (Cruz, 2004; CIRAD, 2011) is that the measure used, land productivity, is inappropriate because it only compares total output to the size of the farm, ignoring other factors of production and inputs. Land productivity is known to be an incomplete measure of economic efficiency since physical productivity is said to be a measure of technical efficiency. Certainly, by raising agricultural productivity, (that is, increase yield per hectare, as well as considering other production inputs), food availability could be increased; hence increased food security.

The focus on acha is derived from the fact that acha consumption is on the increase due to the increasing awareness of its nutritional value (Jideani and Jideani, 2011). Its production has been described to be low ranging from 600-700kg/ha (Cruz, 2004; CIRAD, 2011) in West Africa and even lower (400-500kg/ha) in Nigeria (Kwong-Ndung *et al.*, 2001). Despite its ancient heritage and widespread importance, knowledge about its production remains very scanty even within West Africa itself. The crop has received but a fraction of the attention accorded to maize, sorghum and pearl millet, and a mere trifle considering its importance in the economy and its potential for increasing the food supply.

However, few studies on acha production have shown an increasing importance of the crop amidst growing utilization as food. A review by Jideani (2012) shows the need for more scientific investigation on acha, iburu and tamba cereal grains. Although, a significant part of literature has focused on land productivity, production forecast, adaptability, evaluation and chemical composition, medicinal and nutritional effects, the area of measuring technical efficiency which is an indicator of productivity and other factors affecting acha production were not considered.

One way of reducing the cost of production is to increase farm output by increasing technical efficiency. In this regard, it is necessary to quantify current levels of technical efficiency so as to estimate losses in acha production that could be attributed to inefficiencies due to differences in socio-economic and transaction cost variables. It is therefore, with the hope of detecting these in an effort to increase domestic production and supply that the research will be conducted. Based on the foregoing, this study provided answers to the following research questions:

i) What is the relationship between inputs and output in acha production in the study area?

ii) Are farmers technically efficient in acha production?

iii) What socio-economic and transaction cost factors affect technical efficiency of acha farmers?

iv) How profitable is acha production?

v) What are the constraints to acha production in the study area?

1.3 Objectives of the study

The broad objective of the study is to evaluate the productivity of acha in selected areas of Kaduna State. The specific objectives are to:

i) examine the relationship between inputs and output in acha production,

ii) determine the technical efficiency of acha farmers,

iii) determine the influence of socio-economic and transaction cost factors on the technical efficiency of acha farmers,

iv) determine the profitability of acha production and

v) identify and describe the constraints faced by acha farmers in the study area.

1.4 Hypotheses

The hypotheses tested in this study include:

i) Socio-economic characteristics and transaction costs of farmers have no significant influence on their technical efficiency.

ii) There is no significant difference between costs and returns of acha farmers in the study area.

1.5 Justification of the study

The research seeks to evaluate the productivity of acha with a view to bringing into limelight the benefits derived from the production of acha so as to motivate the general populace on how to engage in and boost productivity. It will also help to determine the productivity of resource use, their efficiencies and profitability of acha production. This would provide empirical evidence of the gaps that exist in the farmers' current level of productivity. Identifying areas of inefficiency will identify the gap between the actual and potential yields of hungry rice, as these gaps would serve as intervention points that would assist in enhancing the productivity and profitability of the farmers, as well as encouraging them to beef up their current level of output so as to bridge the current shortfalls in local supplies.

The study will also serve as a base for further research as information was generated on the productivity of acha. It will therefore, benefit the farmers, students and potential investors. Aside, analysts, researchers and extension workers need a more basic knowledge that relates product output to factor inputs. This knowledge will enable them to meaningfully derive a workable framework for the adjustment of production and employment of resources to economic growth or trends. The result could help policy makers take more informed decisions that could help reshape production of orphan crops in the country so as to enhance food security.

CHAPTER 2

LITERATURE REVIEW

2.1 Origin and Distribution of Hungry Rice (Acha)

Acha *(Digitaria exilis)*, which is also known with other names such as fonio, iburu, findi, fundi, pom and kabug in different West African countries has been reported to be the oldest West African cereal, since its cultivation is thought to date back to 5000 BC (National Research Council, 1996), or 7000 years ago (Cruz, 2004). The Europeans coined the English name "Hungry rice" which is considered misleading by some authors: Kwon-Ndung and Misari (1999), Ibrahim (2001) and Anonymous (2003).

Acha is a cereal which grows well in Nigeria and is a staple food in some parts of Nigeria and across fifteen North West African countries (Jideani, 1999). It is indigenous to the savannah regions of West Africa (Purseglove, 1988). It belongs to the family *Graminae*, tribe *Poaceae*, sub-tribe *Digitariinae* and genus *Digitaria*. Of this genus, there are about 300 annual and perennial species, most of which are important pasture grasses, as such, this crop can as well be easily mistaken for pasture grass. It closely resembles the wild *Digitaria longiflora* (Retz) (Purseglove, 1988) and grows under varying conditions from poor dry upland soils to hydromorphic valleys suitable for rice production (National Research Council 1996). The plant originated in West Africa and it thrives well in the sandy, rocky soils of the Sahel both in drought and flood, and grows so fast that two or three crops can be harvested each year (Morales-Payan *et al.*, 2003; Abdullahi and Luka, 2003). It grows well in Nigeria, mostly cultivated around Plateau, Bauchi, Kaduna and Niger States, and is a staple food in these parts of Nigeria and across fifteen North West African countries (Jideani, 1999).

Hungry rice consists of two major types or species: *Digitaria exilis* (acha) and *Digitaria iburua* (iburu),which are the white and black varieties respectively. Of the two species, white fonio (acha) is the most widely used, especially on the upland plateau of central Nigeria, while the black fonio (iburu) is restricted to the Jos-Bauchi Plateau of Nigeria as well as to northern regions of Togo and Benin (National Research Council, 1996), although its restricted distribution should not be taken as a measure of relative inferiority.

2.2 Hungry Rice (Acha) Production in Nigeria

In an earlier study, Dachi and Omueti (2000) reported that acha responds positively to fertilizer application. Dachi and Gana (2008) also reported that acha can be cultivated two to three times a year since it matures within an average of 120 days. Among the West African countries, the most leading producing countries of acha are Nigeria, Guinea, Burkina Faso and Mali. Annual production in West Africa is estimated at about 250,000tonnes (Cruz, 2004). The global land area being put to its production is estimated to be 380,000 ha with an annual production of 250,000 tones (Cruz, 2004). The average production of acha per hectare has remained low ranging from 600-700kg/ha (Cruz, 2004; Kwon-Ndung and Misari, 1999). In Nigeria, annual output of 103,098 metric tonnes, 112,000 metric tonnes and 126,000 metric tonnes of acha have been reported (Abdullahi and Luka, 2003) over a land area of about 150,000 hectares.

In Kaduna State, the crop is grown in Jaba, Lere, Jema'a, Kachia, Sanga, Saminaka and Kagarko Local Government Areas (LGAs) with Jaba, Kachia and Kagarko as the leading producing local government areas of the State. Specific areas of production in the state include Duya, Chori, Sambang, Gure, Kaninkon, Kufai, Gwantu, Sanga, Jere, Nok, Fadan Kagoma, Issah, Gujeni, Kubacha, Sabon Sarki, Kurmin Musa, Kasabere, Katugal and Kwasere among others. The area cropped to acha in 2001 was 17, 624.25ha and 19, 783.44 ha in 2002, corresponding to yields of 21 862.65 and 21 899 tonnes (Kaduna State Agricultural Development Programme, 2003). The production potential for the state is about 2.5 million ha.

Niger State has a sparse acha production distribution. The crop is grown mainly in Paiko, Suleja, Kontagora, Gurara and Munya Local Government Areas (LGAs). The areas of production are specifically in Chimbi, Kafin Koro, Kwakuti, Suleja, Dikko, New Wuse, Boi, Daku, Nanati, Nirungu, Gurara and Shako. The land area cropped to acha has not been documented although there is great production potential in about 15 LGAs covering over 1.8 million ha (Niger State Agricultural Development Programme, 2003).

In Kebbi State, acha is grown in Danko-Wasagu, Zuru and Sakaba Local Government Areas (LGAs). The specific production areas are Danko, Rade, Ribah, Zuhu, Mukuku, Dabai, Filin Jirgi, Kobo and Tadurga. Although there is no documentation of land area cropped to acha in this state, there is potential for growing the crop in six LGAs of the state in an area of 1.1 million hectares (Kebbi State Agricultural Development Project, 2003).

In Plateau State, acha is grown in 12 out of the 17 Local Government Areas (LGAs), mainly in the mid to high altitude areas of the State. The State accounts for about 80% of acha produced in Nigeria. The areas of high density production in the state that hosts the widest diversity of this crop in Nigeria include Ganawuri Chiefdom in Riyom LGA, Richa, Mbar, Mushere and Daffo in Bokkos LGA, Vwang and Gyel in Jos South LGA, Bachit in Riyom LGA, Fan, Heipang and Gashish in Barkin Ladi LGA, Miango and Rukuba in Bassa LGA, Mangu and Jipal in Mangu LGA, Kagu in Pankshin LGA and Garam, Langshi and Tabulung in Kanke LGA. The area where acha is grown in Plateau State is not properly documented, although the Plateau State Agricultural Development Project (PADP) crop area yield survey report of 1999 indicated that 28, 260.2 hectares of acha field yielded about 26, 000 million tonnes (PADP, 1999). This figure may have increased significantly due to the high price premium placed on acha in recent times and the high cost of fertilizers that has forced farmers to abandon the production of other cash crops, such as potato that competes in land area with acha. There is great production potential in this State because of the traditional attachment to the crops. Hardly any farming family in this location will not plant acha in a season, no matter how small the area.

In Nasarawa State, acha is mainly grown in Wamba, Akwanga, Nasarawa Eggon, Kokona, Keffi, Karu and Toto Local Government Areas (LGAs). The production area has increased from 7000 hectares in 1999 to 9,200 hectares in 2001 (Nasarawa State Agricultural Development Project, 2003).This is an indication that the prospects for further expansion exist.

At the Federal Capital Territory (FCT), Abuja, the Niger State Agricultural Development Project (2002) reported that the crop is sparsely grown among farmers. In the eastern part of the territory, the crop has been identified with farmers in Bwari town and neighbouring villages. Farmers from the western parts of Rubochi and surrounding villages, and parts of Abaji cultivate acha. Although there is no information on the production area, there is great potential for acha production in the FCT.

2.3 Economic Importance of Hungry Rice (Acha)

2.3.1 Utilisation as food for man

Acha has promising unique nutritional qualities. Nutrition experts have acknowledged it as exceptional. It has relatively low free sugar and low glycemic content and this makes it adequate as a suggested diet of diabetic patients (Cruz, 2004; Balde *et al.*, 2008). *In-vitro* starch digestibility and glycemic property of acha, iburu and maize porridge has been reported (Jideani and Podgorski, 2009). It contains about 91% of carbohydrate. It has a high crude protein content of about 8.7% and in some black acha samples, may be up to 11.8%, which is high in leucine (19.8%), methionine and cystine (of about 7%) and valine (5.8%) of the essential amino acids (Carbiener *et al.*, 1960; Temple and Bassa, 1991). Sometimes considered as “a small seed with a big promise”, acha provides food early in the season when other crops are yet to mature for harvest, hence the name hungry rice (Ibrahim, 2001). It has the potentials for reducing human misery during hungry times, among the over 2000 crops that are native to Africa, which could be effective tools as well in fighting hunger in the continent (Vietmeyer *et al.*, 1996).

According to Jideani (1999), the major classes of traditional foods from acha grains are thick and thin porridges; steam cooked products, e.g. couscous; and nonalcoholic and alcoholic beverages. Fonio (acha and iburu), is included in a list of grains considered as whole grains when consumed in whole form (Jones, 2009; Jideani and Jideani, 2011). The proteins in these grains are not easily extractable; however, the digestibilities of the proteins are better than those of sorghum and millet. The high levels of residue protein in them may have important functional properties, as such, diets from acha are consequently tolerated by diabetic patients due to the low carbohydrate contents (Temple and Bassa, 1991). Technologically, acha can be utilized in ways similar to rice. The two grains (acha and iburu) require minimal processing due to grain size and location of constituents. McWatters (2000) also described how food products from acha are preferred to those from other cereals. Whole acha grains are now used for quick cooking, non-conventional food products including weaning foods of low bulk density and breakfast cereal with good fiber content. The grains could be used in a wide variety of other products. Cookies, crackers, and popcorn, made in an almost endless array of forms are examples. The breeding of acha cultivars with good kernel properties is critically important to their utilization potential. Coda *et al.* (2010) reported that acha and iburu flours have potential for sourdough fermentation and that sourdoughs from fonio flour were clearly differentiated.

2.3.2 Utilisation as feed for animals

As stated by Clottey *et al.* (2002), acha grain with its rich amounts of amino acids present in the high protein component for a cereal can be a very good feed source for poultry and pigs. The macro elements, phosphorous and potassium levels, in acha grains can be relied upon to meet the specifications for the formulation of animal diets. Acha grains can provide adequately the trace elemental (Zn, Cu, Mn and Fe) needs of monogastrics. The straw from the crop is used for stuffing mattresses or as beddings for livestock, hay making, silage, and also serve as good fodder for livestock. Recent discoveries revealed that acha is cultivated and used as forage in the Dominican Republic Island of South America (Pablo *et al.*, 2003). Animal study also showed that rats fed with acha-soybean and acha-biscuits had feed efficiency ratios of 0.154 and 0.151; and protein efficiency ratios of 0.996 and 0.985, respectively (Ayo *et al*., 2010).

Amidst the crop's growing utilization as food, it serves as raw material for drug/pharmaceutical industries. Acha (*Digitaria exilis)* starch has been compared with maize starch as a binder at various concentrations and was found to be as good as maize starch in the formulation of paracetamol tablets (Musa *et al., 2008 and* Iwuagwu *et al*., 2001).

2.4 Constraints to Effective Production of Hungry Rice (Acha) in Africa.

The increasing problem of food insecurity in Africa and the recognition of Acha as a potential buffer against famine are expected to stimulate the expansion of land area devoted to acha cultivation in the continent. However, available statistics demonstrates the reduction of acha harvest area in several countries, except in Nigeria, Cote D'Ivoire, and Guinea. In year 2002, a total area of 347,380 hectares was devoted to acha production in Africa (Cruz, 2004), with Nigeria alone providing almost half of that area (150,000 ha). Several factors are responsible for the general decline in acha production, some of which include lodging, small grain size, lower yields than other cereals, shattering and drudgery in post-harvest handling especially polishing of the small grains (Vietnameyer *et al*., 1996; Kwon-Ndung and Misari, 1999; Anonymous, 2003).

A survey of farmers' acha husbandry activities in Nigeria (Kwon-Ndung and Misari, 1999) demonstrates the lack of improved agronomic practices in acha production, especially in the area of weed control. Apart from the general poor husbandry, the husking process of acha grains is very tedious and time-consuming (Vietameyer *et al*., 1996; Kwon-Ndung and Misari, 1999), constituting a major bottleneck in its processing and utilization. Years of research by Non Governmental Organisations and research institutions have contributed immensely in addressing the husking problem of acha. The breakthrough in acha processing may enhance acha production to meet local demands in Africa and even for export (Aslafy, 2003). This might be responsible for the increased interest in acha production in Africa in recent years. The scientific challenge now is to develop new improved high-yielding and non-shattering varieties of acha with larger grain size (Vietmeyer *et al*., 1996), shorter and stronger culms (Kwon-Ndung *et al.*, 2001) and with good grain quality.

2.5 Agricultural Productivity and Efficiency.

Agricultural resource productivity according to Olayide and Heady (1982) is the index of the ratio of the value of total farm output to the values of inputs used in the production. That is, it is a measure of economic progress. It plays a role in measuring problems such as: allocation of resources, distribution of income, efficiency or productivity measurements and the relationships between stocks and flows. Thus, resource productivity can be defined in terms of individual resource inputs or in terms of their combinations. Maximum resource productivity implies obtaining the maximum from the minimum possible sets of inputs which signifies an efficient utilization of resources in the production. Cost of production is related to productivity and efficiency of production. High costs could be as a result of poor allocative efficiency or technical inefficiency. Reduction in economic inefficiency can reduce the costs of production according to the findings and conclusion of Nyoro *et al*. (2004).

The concept of efficiency is concerned with the relative performance of the process of transforming inputs to outputs. Three types of efficiency are identified in literature: technical, allocative and economic efficiency (Olayide and Heady, 1982). Technical Efficiency is the ability to produce a given level of output with a minimum quantity of inputs under certain technology. Allocative efficiency refers to the ability of choosing optimal input levels for given factor prices. Overall productive efficiency is the product of technical and allocative efficiency. Several studies have been carried out on resource use efficiency among which are Rahman *et al.* (1998), Bhasin (2002) and Umoh (2006). Technical efficiency has been viewed by these authors as the ability of the farmer to obtain maximum output from a given set of inputs under given technology. Technical efficiency focuses on the physical productivity which occurs when a larger quantity of output is consistently produced from same quantities of inputs, while allocative efficiency on the other hand is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of inputs. According to Olayide and Heady (1982), efficiency measure as the average productivity of say labour, capital, land, water, etc. can only be a meaningful index of technical efficiency if any of the resources is limiting in the production process. The degree to which technical and allocative efficiencies are achieved is commonly referred to as production efficiency (Omolola, 1991; Bravo-Ureter and Pinheiro, 1997).Thus, if a farmer has achieved both technically and allocatively efficient levels of production, then the farmer is economically efficient. In this case, new investment streams may be critical for any new development.

Following Lovell (1993), the productivity of a production unit can be measured by the ratio of its output to its input. However productivity varies according to differences in production technology, production process and differences in the environment in which production occurs. The main interest here is in isolating the efficiency component in order to measure its contribution to productivity. Producers are efficient if they have produced as much as possible with the inputs they have actually employed and if they have produced that output at minimum cost (Greene, 1997). It is important, however, to be aware that efficiency is only one part of the overall performance. A complete analysis also involves the measurement of effectiveness, and the degree to which a system achieves programmes and policy objectives in terms of outcomes, accessibility, quality and appropriateness (Worthington and Dollery, 2000). This notion of efficiency refers to the neoclassical efficient allocation of resources and the Pareto optimality criterion (Latruffe, 2010).

There has been a growing interest in methodologies and their applications to efficiency measurement. While early methodologies were based on deterministic models that attribute all deviations from maximum production to inefficiency, recent advances have made it possible to separately account for factors beyond and within the control of firms such that only the latter will cause inefficiency. Efficiency measurement tools include linear programming of the data envelopment analysis (DEA), limdep and the stochastic frontier production function (SFPF). Identification of factors influencing efficiency has also been an important exercise but debate as to whether the single or two-stage method is appropriate is not settled.

Battese and Coelli (1995) and Kumbhakar (1994) challenged the two stage approach by arguing that the farm specific factors should instead be incorporated directly in the first stage estimation of the stochastic frontier because such factors can have a direct impact on efficiency and they proposed a model incorporating these variables. Nevertheless, the two-stage method is mostly preferred due to a roundabout effect of variables on efficiency (Bravo-Ureta and Evenson, 1994). The stochastic frontier production function accounts for the presence of measurement errors and other noise in the data, which are beyond the control of firms. Stochastic frontiers have two error terms. The first accounts for the presence of technical inefficiencies in production and the second accounts for measurement errors in output, weather, etc and the combined effects of unobserved inputs in production.

The frontier functional approach is capable of estimating inefficiency level of each producer. In contrast, the conventional estimation approach assumes all producers act efficiently, implying that there exists no inefficiency in production. Furthermore, the frontier functional approach enables separation of the efficiency component of productivity from the technological component (Ueda, 2002). Despite its well-known limitations, a Cobb-Douglas functional form for the stochastic frontier production function (SFPF) is mostly used where the methodology employed in the study requires that the production function be self-dual. It has been widely used in farm efficiency analyses both for developing and developed countries.

Stochastic frontier approach has found wide acceptance within the agricultural economics literature because of its consistency with theory, versatility and relative ease of estimation. The measurement of efficiency (technical, allocative and economic) has remained an area of important research both in the developing and developed countries. This is especially important in developing countries, where resources are meager and opportunities for developing and adopting better technologies are dwindling. Efficiency measures are important because it is a factor for productivity growth. Such studies benefit these economies by determining the extent to which it is possible to raise productivity by improving the neglected source of growth, that is, efficiency, with the existing resource base and available technology.

2.6 Previous Studies on Efficiency Using the Stochastic Frontier Production Function (SFPF)

A study by Battese and Coelli (1995) on paddy rice farms in Aurepalle India used panel data for 10 years and concluded that older farmers were less efficient than the younger ones. Farmers with more years of schooling were also found to be more efficient but declined over the time period.

Battese *et al*. (1996) used a single stage stochastic frontier model to estimate technical efficiencies in the production of wheat farmers in four districts of Pakistan ranging between 57 and 79 percent. The older farmers had higher technical efficiencies.

Bedassa and Krishnamoorthy (1997) used a two-step approach to estimate technical efficiency in paddy farms of Tamil Nadu in India. They concluded that the mean technical efficiency was 83.3 percent, showing potential for increasing paddy production by 17 percent using present technology. Small and medium-scale-farmers were more efficient than the large-scale farms. In addition, the study concluded that animal power was over utilized and therefore suggested reduction. However, the paddy rice farmers could still benefit by increasing the fertilizer use and expansion of land.

Seyoum *et al*. (1998) used a translog stochastic production frontier and a Cobb-Douglas production function. Some of the key conclusions from this study were that younger farmers were more technically efficient than the older farmers. In addition, farmers with more years of school tended to be more technically efficient. On the other hand, those that obtained information from extension advisers tended to have higher technical efficiency. They obtained a mean technical efficiency of farmers within the SG 2000 project to be 0.937, while the estimate of the farmers outside the project was 0.794. However, the study should have squared the age to address the linear relationship of the age variable.

A study by Wilson *et al*. (1998) on technical efficiency in UK potato production used a stochastic frontier production function to explain technical efficiency through managerial and farm characteristics. Mean technical efficiency across regions ranged from 33 to 97 percent. There was high correlation between irrigation of the potato crop and technical efficiency. The number of years of experience in potato production and small-scale farming were negatively correlated with technical efficiency.

A study by Liu and Jizhong (2000) on technical efficiency in post-collective Chinese Agriculture concluded that 76 and 48 percent of technical inefficiency in Sichuan and Jiangsu, respectively, could be explained by inefficiency variables. They used a joint estimation of the stochastic frontier model.

Awudu and Huffman (2000) studied economic efficiency of rice farmers in Northern Ghana. Using a normalized stochastic profit function frontier, they concluded that the average measure of inefficiency was 27 percent, which suggested that about 27 percent of potential maximum profits were lost due to inefficiency. This corresponds to a mean loss of 38,555 cedis per hectare. The discrepancy between observed profit and frontier profit was due to both technical and allocative efficiency. Higher levels of education reduced profit inefficiency while engagement in off-farm income earning activities and lack of access to credit increased profit inefficiency. The study also found significant differences in inefficiencies across regions.

Awudu and Erberlin (2001) used a translog stochastic frontier model to examine technical efficiency in maize and beans in Nicaragua. The average efficiency levels were 69.8 and 74.2 percent for maize and beans, respectively. In addition, the level of schooling representing human capital, access to formal credit and farming experience (represented by age) contributed positively to production efficiency, while farmers' participation in off-farm employment tended to reduce production efficiency. Large families appeared to be more efficient than small families. Although a larger family size puts extra pressure on farm income for food and clothing, it does ensure availability of enough family labor for farming operations to be performed on time.

Positive correlation between inefficiency and participation in non-farm employment suggests that farmers re-allocate time away from farm-related activities, such as adoption of new technologies and gathering of technical information that is essential for enhancing production efficiency. The result indicated that efficiency increased with age until a maximum efficiency was reached when the household head was 38 years old. The age variable probably picks up the effect of physical strength as well as farming experience for the household head.

A study on gender differentials in technical efficiency among maize farmers in essien udim local government area, Nigeria by Simonyan *et al.* (2011) estimated farm level technical efficiency for male and female farmers were 93 percent and 98 percent respectively. Results further indicated that the estimated production function revealed that farm size at 1 percent and quantity of fertilizer at 1 percent significantly influenced the maize production function for male farmers while farm size at 1 percent, labour at 5 percent, maize seeds at 10 percent and quantity of fertilizer at 10 percent significantly influenced that of the female farmers.

In a study by Wilson *et al*. (2001), a translog stochastic frontier and joint estimate technical efficiency approach was used to assess efficiency. The estimated technical efficiency among wheat producers in Eastern England ranged between 62 and 98 percent and farmers who sought information, who had more years of managerial experiences and had large farms, were associated with higher levels of technical efficiency.

A study by Mochebelele and Winter-Nelson (2002) on smallholder farmers in Lesotho used a stochastic production frontier to compare technical inefficiencies of farmers who sent migrant labor to the South African mines and those who did not. They concluded that farmers who sent migrant labor to South Africa were closer to their production frontier than those who did not.

Belen *et al*. (2003) assessed technical efficiency of horticultural production in Navarra, Spain. They estimated that tomato producing farms were 80 percent efficient while those that raised asparagus were 90 percent efficient. Therefore, they concluded that there existed a potential for improving farm incomes by improving efficiency.

A meta analysis by Thiam *et al.* (2001) on 32 frontier studies using farm level data from 15 different developing countries found that cross-sectional data exhibited significantly lower technical efficiency estimates than studies that used panel data. According to Green (1993), models relying on panel data are likely to yield more accurate efficiency estimates given that there are repeated observations on each unit. However, no a priori expectations regarding the impact of data type (that is, cross-sectional versus panel) on the magnitude of efficiency scores have been developed.

Fleming and Coelli (2004) assessed the performance of a nucleus estate and smallholder scheme for oil palm production in West Sumatra, using stochastic frontier production function in measuring their technical efficiency. Their results indicated a mean technical efficiency of 66%. No clear relationship was established between technical efficiency and the use of female labour, suggesting there is no need to target extension services specifically at female labourers in the household. Education was found to have an unexpectedly negative impact on technical efficiency, indicating that farmers with primary education may be more important than those with secondary and tertiary education as targets of development schemes and extension programs entailing non-formal education.

Gautam and Jeffrey (2003) applied the stochastic cost function to measure efficiency among smallholder tobacco cultivators in Malawi. Their study revealed that larger tobacco farms were less cost inefficient. The paper uncovered evidence that access to credit retards the gain in cost efficiency from an increase in tobacco acreage: a suggestion that the method of credit disbursement was faulty.

Bravo-Ureta and Evenson (1994) concluded that Paraguan cotton had 40.1 percent average economic efficiency while cassava producers were 52.3 percent efficient. They concluded that there was room for improvement in productivity for these basic crops. However, they did not find a relationship between economic efficiency and socioeconomic characteristics. This observation was explained by the possibility of existence of a stage of development threshold below which this type of relationship is not observed.

A study on technical efficiency differentials in rice production technologies in Nigeria by Ogundele and Okoruwa (2006) showed that the use of some critical inputs such as fertilizer and herbicide by the farmers were found to be below recommended levels per hectare. Applying stochastic frontier analysis revealed that there was also significant difference in the use of such inputs as labour between the two groups of farmers. Variables tended to contribute to technical efficiency were hired labour, herbicide and seeds, while fertilizer was found not to have contributed significantly to technical efficiency. The estimated technical efficiencies for the two groups were correspondingly high (>0.90), which indicated a little opportunity for increased efficiency given the present state of technology. The test of hypothesis on the differentials in technical efficiency between the two groups of farmers showed that there was no absolute differential.

Mohammed *et al*. (2011) used the marginal value product (MVP) of the variable inputs to compute and compare input prices in order to determine the efficiency of the inputs used in sorghum farming. It was reported that seed, fertilizer and other inputs were under-utilized. Firms operating on the frontier are said to be fully efficient in their use of inputs and those operating beneath it are said to be inefficient.

Olarinde (2010) in his estimation of technical efficiencies of maize farmers in two states of Nigeria employed the translog stochastic frontier production function and indicated that the sampled farmers were not technically efficient with mean technical efficiencies of only 0.5588 and 0.5758 in Oyo and Kebbi states respectively. There were however increasing returns-to-scale in both states. The main determinants of technical efficiency were found to include extension services and farm distance in the two states, farming experience in Oyo State, credit accessibility, number of other crops grown and rainfall (precipitation) in Kebbi State.

A study carried out to investigate technical inefficiency of production among the food crop farmers of the National Directorate of Employment in Ondo State of Nigeria, by Ajibefun and Abdulkadri (1999), considers translog stochastic frontier production functions in which the technical inefficiency effects are defined by three different sub models. Given the specifications of the stochastic frontier production function, the null hypothesis, that the frontier is adequately represented by the Cobb-Douglas function, was accepted, but the null hypothesis that the farmers are fully technically efficient, which implies that inefficiency effects are absent from the model, was rejected. Further, the null hypothesis of half-normal distribution for the inefficiency effects was rejected. Predicted technical efficiencies vary widely across farms, ranging between 21.7% and 87.8% and a mean technical efficiency of 67%.

Alabi *et al*. (2010) used the stochastic production function in estimating the technical efficiency in sesame production in Nasarawa Doma Local Government Area of Nasarawa State. The model was estimated by the maximum likelihood method which shows the elasticity of production for seeds (0.51); labour (0.71); capital (0.356); farm size (0.55) had significant effect on sesame output. The inefficiency model revealed that education and access to credit were significant at 5 percent and positively affects farmer's efficiency level. Also, technical efficiency in cassava-based food crop production systems in Delta State was studied by Chukwuji (2010) using stochastic frontier function; he discovered that 71 and 67 percent of the variations in output is attributable to difference in technical inefficiencies. Mean technical efficiencies for mixed crop and mono crop farmers were 80 and 71 percent respectively. Level of formal education, contacts with extension agents, farming experience and capital to labour ratio and credit to total cost ratio had positive effect on efficiency.

In a research conducted by Ogundari *et al*. (2006) to determine economies of scale and cost efficiency in small scale maize production in Nigeria, they observed a cost efficiency score of 1.16 as the mean cost efficiency of the farms. Meaning that, an average maize farm in the sample area has costs that are about 16% above the minimum defined by the frontier. In other words, 16% of their costs are wasted relative to the best practiced farms producing the same output (maize) and facing the same technology. All parameters estimate have the expected sign with cost of labour, cost of seed, annual depreciation cost and maize output highly significant at 5% meaning that these factors were significantly different from zero and thus were important in maize production.

Nsisak-Abasi and Sunday (2013) in their study on the sources of technical efficiency among subsistence maize farmers in Uyo, Nigeria revealed a mean technical efficiency of 0.71among farmers, implying that production can still be increased by 29 percent using available technology. Their results also show that farm size, labour seeds, age, technical assistance, access to credit and market have significant impact on technical efficiency. Similarly, a study on the sources of technical efficiency among smallholder maize farmers in Osun State of Nigeria by Olatomide and Omowumi (2010) revealed an estimated return to scale of 0.97, implying that maize was produced close to constant returns to scale on the sample plots. The mean technical efficiency level among the sampled smallholder maize farmers was 46.23 with a standard deviation of 23.3% and a range from 8.12 - 93.95%.

2.7 Review of Analytical Framework

2.7.1 Stochastic frontier production function

According to Battese and Coelli (1992), the stochastic frontier production function has been a significant contribution to the econometric modeling of production and the estimation of efficiencies of firms. Stochastic frontier is an econometric analytical technique, which allows for variation in output of individual producer from the frontier of maximum achievable level to be accounted for by factors which cannot be controlled by the firm. This model involves two random components, one associated with the presence of technical inefficiency and the other being a traditional random error.

The model simultaneously estimates the individual efficiency of the respondent farmers as well as determinants of technical efficiency (Batesse and Coelli, 1995). In addition, the use of stochastic frontier production functions is versatile and easy to use following its recent integration in Limdep (Green, 2002), a one-step process as compared to the two-stage process used in previous studies. The production technology of a firm is represented by a stochastic frontier production function (SFPF) as:

$$Y = f(X;\beta) + e \text{ -- } (1)$$

Where,

Y measures the quantity of agricultural output

X is a vector of the input quantities and

β is a vector of unknown parameters.

The essential idea behind the stochastic frontier model is that ‘e’ is a composite error term which can be written as:

$$e = v - u \text{ -- } (2)$$

Where,

v = two sided ($-\propto < v < \propto$) normally distributed N (0, δ^2v) random error that captures the stochastic effects outside the farmer's control e.g. weather, natural disasters and lucks.

u = one sided ($u \geq 0$) efficiency component that captures the technical inefficiency of the farmer. It measures the shortfall in output Y from its maximum value given by the stochastic frontier:

$f(X;\beta)+v$ -- (3)

This is assumed to be independently and identically distributed as half-normal, u~ N(0,δ^2u). As v captures the stochastic effect outside the farmer's control, subtracting v from both sides of the equation (1) yield the stochastic production frontier as:

$Y^* = f(X;\beta) - u$ -- (4)

Where,

Y* is defined as the farmer's observed output adjusted for the statistical noise contained in v.

Technical efficiency of an individual firm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by that firm. Thus, technical efficiency of firm i in the context of the stochastic frontier production (1) denoted by TE is given by:

$$TE = \frac{Y(observed\ output)}{Y^*(frontier\ output)} = \frac{F(X\beta)exp^{(v-u)}}{F(X\beta)exp^{(v)}} = exp^{-u} \text{ ---------------------------- (5)}$$

The maximum likelihood estimation of equation above yields estimators for β and λ

Where,

$$\lambda = \frac{\delta u}{\delta v} \text{ ---(6)}$$

$$\delta^2 = \delta^2_u + \delta^2_v \text{ ---(7)}$$

Battese and Coelli (1995) therefore expressed stochastic production frontier implicitly as:

$$Y_{it} = X_{it}\beta + E_{it} \text{ --(8)}$$

Where:

$$E_{it} = V_{it} - U_{it} \text{ -- (9)}$$

X_{it} = exogenous variables associated in the firm production

Y_{it} = appropriate function of the production for the *i*th sample firm in the *t*th time period

β = vector of the coefficients for the associated independent variables in the production function

U_{it} = one sided component, which captures deviation from frontier as a result of inefficiency of the firm

V_{it} = effect of random shocks outside the producer's control, observation and measurement error and other stochastic (noise) error term. Thus, V_{it} allows the frontier to vary across entreprises or over time for the same entreprise and therefore the frontier is stochastic. Several studies specified a Cobb-Douglas production function to represent the frontier function. The Cobb-Douglas function however, restricts the production elasticities to be constant and the elasticities of input substitution to unity (Wilson, *et al*., 1998). Also, there are times when the marginal effect of a variable depends on another variable, hence the need to choose functional forms that include interaction terms (Gujarati, 2004; Asteriou, 2011). This study therefore employed the stochastic frontier production function using the translog functional form which is specified as:

$$\ln Y_t = \beta_0 + \sum \beta_k \ln X_{ki} + \frac{1}{2}\sum\sum \beta_{kj} \ln X_{ki} \ln X_{ji} + (v_i - \mu_i) \text{ ------------------- (10)}$$

2.7.2 Inefficiency effects

2.7.2.1 Socio-economic characteristics of farmers

Alabi *et al*. (2010) used the stochastic production function in estimating the technical efficiency in sesame production in Nasarawa Doma Local Government Area of Nasarawa State. The inefficiency model revealed that education and access to credit were significant at 5 percent and positively affected farmer's efficiency level. Also, technical efficiency in cassava-based food crop production systems in Delta State was studied by Chukwuji (2010) using stochastic frontier function; he discovered that level of formal education, contact with extension agent, farming experience, capital to labour ratio and credit to total cost ratio had positive effect on efficiency.

Fleming and Coelli (2004) assessed the performance of a nucleus estate and smallholder scheme for oil palm production in West Sumatra, using stochastic frontier production function in measuring their technical efficiency. Their results revealed that education had an unexpectedly negative impact on technical efficiency, indicating that farmers with primary education may be more important than those with secondary and tertiary education as targets of development schemes and extension programs entailing non-formal education. Also, Piesse and Thirtle (2000) fitted the translog stochastic frontiers with inefficiency effects to a panel of Hungarian firm level agricultural enterprises and light manufacturing sector during the early transition period (1985-1991). Their findings revealed that the inefficiencies were explained by over capitalization, subsidies and excessive management.

2.7.2.2 Transaction costs

Stifel and Minten (2008) present evidence that transaction costs can affect directly agricultural productivity, in their study on rice yield and input use in Madagascar. Productivity can be affected through input adoption. As the price of imported inputs rises the higher are transportation costs but also through increased price volatility or differing specialization patterns and crop mix.

According to Hockmann *et al.* (2012), external transaction costs result in allocative inefficiency and find their expression in the variation of prices among agricultural enterprises. Thus, analysing the variation of prices among farms provides information about market access and the significance of market transaction costs. Internal transaction costs determine the degree to which producers are able to exploit production possibilities. Thus, technical inefficiency can be regarded as an indicator of internal transaction costs.

Dorosh *et al*. (2010) also showed a significant effect of road infrastructure on agricultural output and input adoption using a more aggregated cross-sectional spatial approach for sub-Saharan Africa. One factor explaining the inverse relationship between productivity and transportation costs runs through the effect they have on the level of specialization and choice of the crop mix. The evidence on the link between transaction costs and specialization is mixed. Qin and Zhang (2011) directly linked the Herfindal specialization index to road access in a Chinese rural province and find a higher degree of specialization among farmers.

Stifel *et al.* (2003) found for a sample of households in Madagascar a lower level of concentration of agricultural production in more isolated areas and a shift towards staple food production at the expense of more valuable crops. On the other hand, Gibson and Rozelle (2003) found that increased isolation reduces the number of income generation activities pursued by households and thus increases specialization. Omamo (1998) uses simulation techniques to show that households facing higher transaction costs tend to alter the crop mix and increase the share of food crops at the expense of cash crops.

2.7.3 Profitability analysis in agriculture

2.7.3.1 Concepts of cost and benefit

The concept of cost and benefit embodies intuitive rationality in that any course of action is judged acceptable if it confers a net advantage, that is, if benefit outweighs cost. Cost-benefit analysis involves the identification, classification and aggregation of all cost elements that affect the feasibility and viability of a project. Two types of cost are identified (Olukosi and Ogungbile, 1989; Heady and Olayide, 1982): fixed and variable costs. Fixed costs are the costs of all those inputs such as land, machines, processing and storage facilities, buildings and breeding stock (in the case of animals) which do not change as production changes. The variable costs on the other hand are the cost of those items which relate directly to the level of production such as costs of labour, seeds, feed, fertilizer, chemicals, drugs and veterinary services. Summing up the total fixed and variable costs gives the total cost of production. Careful consideration of the fixed and variable costs will ensure minimization of the initial cost of production. The benefit elements are more difficult to quantify than the cost elements of production. Benefits are mostly quantified based on reduced cost of production. When initial cost is minimized, then benefit will be greater and as such, a good measure of profitability.

2.7.2.2 Net farm income

The net farm income is the difference between the gross income (GI) and the total cost (TC) of production (Olukosi and Erhabor, 1988). It is given by:

$$NFI = GI – TC \text{ --- } (11)$$

Where,

NFI is the net farm income

GI is the gross income and

TC is the total cost of production.

The gross income is the total return or total value product (TVP) which is the total output multiplied by the price per unit of produce, that is;

$$TVP = Q*P_y \text{ --- } (12)$$

Where Q is the quantity of output or total physical product (TPP) and P_y is the price per unit of output. The total cost (TC) of production is given by:

$$TC = TVC + TFC \text{ --- } (13)$$

Where, TVC is the total variable cost and TFC is the total fixed cost.

The total variable cost include all cost of variable inputs such as labour, fertilizer, seeds and chemicals, while the total fixed cost include depreciation of farm tools such as hoes, cutlasses, interest on capital and cost of renting land.

In the case of small scale traditional farms with negligible fixed cost, the gross margin analysis (GMA) is a good approximation of the net farm income. This implies that;

$$GM = TR – TVC \text{ --- } (14)$$

Where, TR is the total revenue or gross income, TVC is the total variable cost and GM is the gross margin.

CHAPTER 3

METHODOLOGY

3.1 Description of Study Area

The study was conducted in Kaduna State, Nigeria. The State occupies about 46,016 square kilometers which represents about 5 percent of the land area (923,768 square kilometers) of Nigeria. The State is made up of twenty three local government areas as shown on Figure 1. It had a population of 6,066,562 people in 2006 (National Population Commission, 2006). Based on this figure, the current projected population of the State at 3.2 percent national population growth rate is 7,037,153 people, comprising of 606,007 farm families (KADP, 2012). The State lies between latitude 09^0 02' and 11^0 32' North of the equator and 06^0 15'and 80^0 50' East of the prime meridian. It shares borders with Abuja in the south-east, Katsina, Kano and Zamfara in the north, Nasarawa and Plateau in the north-east, Niger in the north-west and Bauchi in the south-west of the state.

The vegetation of the State is divided into Northern Guinea Savanna in the North and Southern Guinea Savanna in the South. The soils are a mixture of fine sand and clay which have been described as sandy loam in nature. The climate varies from the northern to the southern parts of the State. The mean annual temperature varies between 24^0C and 27^0C. The wet season usually last for about six months (May-October) with great variation as one moves northwards. The rainfall is very much heavier in the southern part of the State which has an average of 1,524mm than in the extreme northern part with an average of 1,016mm.

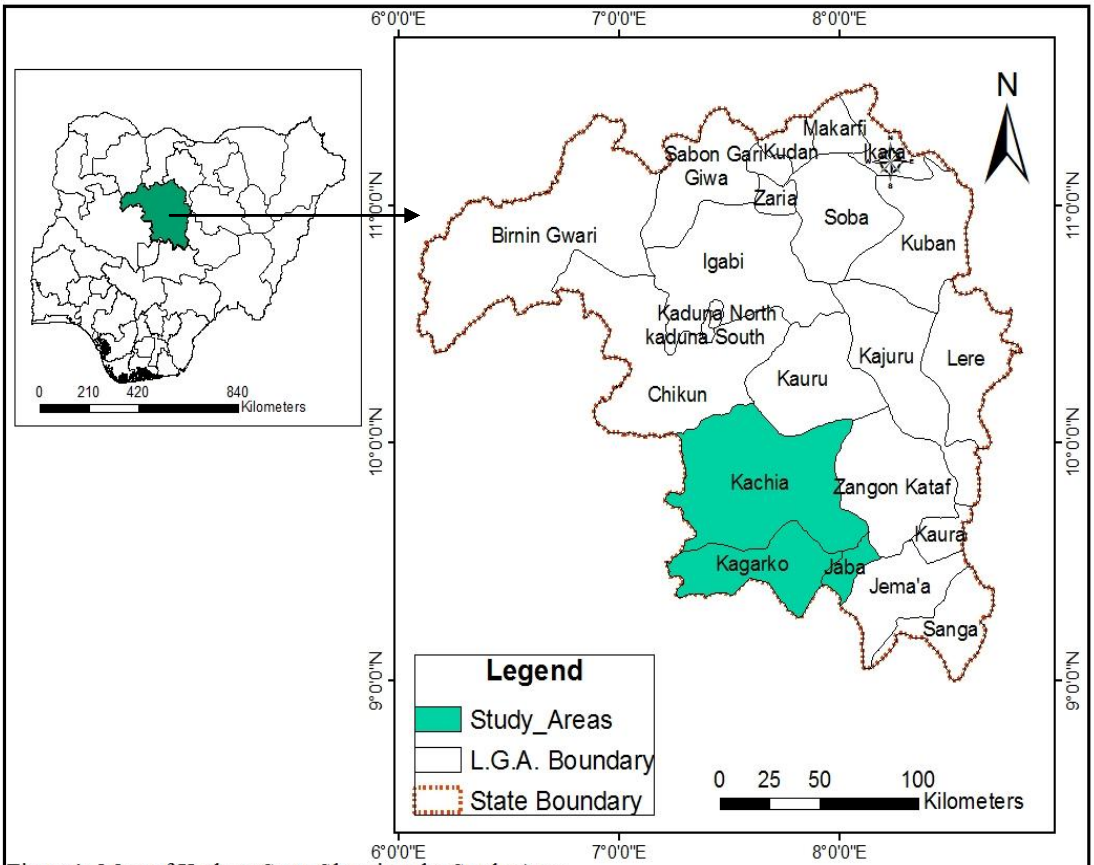

Figure1: Map of Kaduna State Showing the Study Area

Many people in the State are engaged in agricultural production activities and most of these activities are usually carried out through the use of family labour which is dependent on the household size. Crops mostly grown in the State include maize, sorghum, acha, millet, rice, groundnut, yam, cocoyam, potato, ginger and sugarcane among others. Livestock reared include cattle, sheep, goats, poultry and pigs.

3.2 Sampling Technique and Sample Size

The field survey employed the list of acha farmers from Kaduna State Agricultural Development Programme (Agricultural Production Survey of 2011). Multi-stage sampling technique was employed in selecting the farmers for this study. First, out of the 23 Local Government Areas in Kaduna State, Jaba, Kachia and Kagarko were purposively selected for this study on the basis of being the prominent acha producing

Local Government Areas in the state (KADP, 2011). Secondly, eleven villages were purposively selected (three from each of these Local Government Areas) on the basis of the popularity of acha production and accessibility of the farmers. Thirdly, simple random sampling was employed in selecting farmers from each of the villages for enumeration so as to avoid being biased. Due to the homogeneity of the target population, twenty percent of the sampling frame from each of the villages was used as the sample size. In all, a total of 194 acha farmers were enumerated. The sampling frame and size employed in this study are as shown in Table 1.

Table 1: Population and sample size of acha farmers

LGA's	**Villages**	**Sampling frame**	**Sample size (20%)**
Jaba	Sambang Gida	72	14
	Sambang Daji	120	24
	Chori	115	23
	Nok	130	26
Kachia	Gidan Tagwai	110	22
	Kurmin Musa	98	19
	Jaban Kogo	70	14
Kagarko	Idah/Issah	77	16
	Kurmin Jibrin	65	14
	Kenyi	81	16
	Kushe Makaranta	33	6
Total	11	971	194

Source: Kaduna State Agricultural Development Programme

3.3 Data Collection

Primary data were used for this study. The data were collected based on the 2011 cropping season using structured questionnaire with the aid of oral interview. Variables on which the data were collected include the following:

i) Socio-economic variables such as age, sex, marital status, educational level, household size, farming experience, farm size, main occupation, access to and amount of credit and contacts with extension workers.

ii) Production variables which include inputs such as land area in hectares devoted to acha production, labour used (man-days) in land preparation, planting, weeding, fertilizer application, harvesting and threshing, quantity of seeds (kg) used in planting, quantity of fertilizer used (kg) and quantity of agrochemicals used (litres); output in kilogramme; costs of inputs and value of output measured in naira.

iii) Marketing information: time of sales, quantity of acha sold, place of sale and prices.

iv) Challenges/problems faced by farmers in acha production in the study area.

Other information were sourced from text books, journals, proceedings, magazines, Kaduna State Agricultural Development Project, internet and other articles relevant to the study.

3.4 Analytical Techniques

The following analytical tools were used to achieve the objectives of the study:

i) Descriptive Statistics

ii) Stochastic Frontier Production Function Analysis

iii) Farm Budgeting Technique (Gross Margin Analysis)

iv) T- test of Significance

3.4.1 Descriptive Statistics

Descriptive statistics (mean, percentage and frequency distribution) were used to describe the variables included in the model and to achieve objective (v) of the study.

3.4.2 Stochastic Frontier Production Function (SFPF)

The stochastic frontier production function as used by Damisa *et al.* (2013), Olarinde (2010), Rahman and Umar (2009), Oluwatayo *et al*. (2008), Thomas (2007), Kibaara (2005) and Parikh and Shah (1995) among others, derived from the error model of Aigner *et al.* (1977) was employed to achieve objectives (i), (ii) and (iii) of the study. The stochastic production function with a multiplicative disturbance term is of the form:

$$\mathrm{Y} = f(X\beta)e^{\mu} \text{ -- (15)}$$

Where Y is the farm output in kg, X is a vector of input quantities, β is a vector of parameters and *e* is a stochastic disturbance term consisting of two independent elements U and V, given by:

$$e = v - u \text{ -- (16)}$$

The symmetric component, v, accounts for factors outside the farmers' control, such as weather and diseases, while the one side component, u, reflects the technical inefficiency relative to the stochastic frontier, f (Xβ). The distribution of 'u' is half normal. The frontier of the farm therefore is given by combining (1) and (2) as shown:

$$\mathrm{Y} = f(X\beta)e^{v-\mu} \text{ ____ (17)}$$

Thus, the empirical stochastic frontier production model that was used in this study is specified in a translog functional form as follows:

$$\ln \mathrm{Y}_t = \beta_0 + \sum \beta_k \ln \mathrm{X}_{ki} + \frac{1}{2}\sum\sum \beta_{kj} \ln \mathrm{X}_{ki} \ln \mathrm{X}_{ji} + (v_i - \mu_i) \text{ ------------------- (18)}$$

Hence, the parameters, variables and the interactions that were included in the production function model are shown below:

$$\text{In } Y = \text{In}\beta_0 + \beta_1 \text{In } X_1 + \beta_2 \text{In} X_2 + \beta_3 \text{In} X_3 + \beta_4 \text{In } X_4 + \beta_5 \text{In} X_5 + \beta_6 \text{In}(X_1)^2 + \beta_7 (X_2)^2 + \beta_8 \text{In}(X_3)^2 + \beta_9 \text{In}(X_4)^2 + \beta_{10} \text{ In}(X_5)^2 + \beta_{11} \text{In}(X_1 X_2) + \beta_{12} \text{In}(X_1 X_3) + \beta_{13} \text{ In}(X_1 X_4) + \beta_{14} \text{ In}(X_1 X_5) + \beta_{15} \text{ In}(X_2 X_3) + \beta_{16} \text{ In}(X_2 X_4) + \beta_{17} \text{ In}(X_2 X_5) + \beta_{18} \text{ In } (X_3 X_4) + \beta_{19} \text{ In } (X_3 X_5) + \beta_{20} \text{ In } (X_4 X_5) + V - U \text{-------------------------} (19)$$

Where,

In = natural logarithm to base e,

Y_i = output of acha (kilogrammes)

X_1 = farm size (hectares)

X_2 = labour used in acha production (man-days)

X_3 = quantity of seeds used (kilogrammes)

X_4 = quantity of fertilizer used (kilogrammes)

X_5 = quantity of chemicals used (litres)

V_i = assumed independently distributed random error or random shock having zero mean. It is associated with random factors such as measurement errors in production and weather which the farmer does not have control over.

U_i = one sided component, which captures deviation from frontier as a result of inefficiency of the farmer and ranges between zero and one. It is associated with farm-specific factors, which lead to the ith firm not attaining maximum efficiency.

The average level of technical efficiency measured by mode of truncated normal distribution has been assumed (Yao and Liu, 1998; Khumbhakar and Lovell, 2000) to be a function of socio economic factors. Some authors (Kibaara, 2005) included some management practices variables as were also assumed to have influence on efficiency. This study has departed from these by including some transaction cost variables which are assumed to also have influence on efficiency (Hockmann *et al.,* 2012). External transaction costs result in allocative inefficiency and their expression is in the variation of prices. Thus, analysing the variation of prices among farms provides information about market access and the significance of market transaction costs. Internal transaction costs determine the degree to which producers are able to exploit production possibilities. Thus, technical inefficiency can be regarded as a function of socio economic characteristics and internal transaction costs. It is assumed that these inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal distribution with mean U_{ij} and variance δ_u^2, where U_{ij} is the technical inefficiency and its determinants in crop production specified as;

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + W$$

-- (20)

Where:

U_i = technical inefficiency of the ith farmer

Z_1 = Household size of farmer (number of people)

Z_2 = Years of formal education of the farmer

Z_3 = Years of farming experience of the farmer in crop production

Z_4 = Contacts with extension agents during the cropping season (number of visits)

Z_5 = Annual non farm income of the farmer in naira (₦)

Z_6= Harvesting cost in naira (₦)

Z_7= Storage cost in naira (₦)

Z_8= Threshing cost in naira (₦)

Z_9= Transportation cost in naira (₦)

Z_{10}= Farm distance (km)

W = the random variable which is defined by the truncation of the normal distribution with zero mean and variance, such that the point of truncation is -$Z_{it}\delta$, that is, W ≥ $Z_{it}\delta$.

The parameters of the models were obtained by the Maximum Likelihood Estimation method using the computer programme, frontier version 4.1 (Coelli, 1994). The *a priori* expectation is that the estimated coefficients of the inefficiency function provide some explanation for the relative efficiency levels among individual farms. Since the dependent variable of the efficiency function represents the mode of the inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on inefficiency and a negative sign indicate the reverse. Also the estimated positive coefficient for inputs implies that the associated variable has positive effect on efficiency and a negative sign indicates the reverse. These assumptions are consistent with U_{it} being a non-negative truncation of the N ($z_{it}\delta$, σ) distribution (Battese and Coelli, 1995).

3.4.3 Gross Margin Analysis

The gross margin analysis and profitability ratios were employed to achieve objective (iv) of the study, that is, the profitability of acha production in the study area. The gross margin (GM) is the difference between the gross income (GI) and the total variable cost (TVC) of production (Olukosi and Erhabor, 1988). It is given by:

$$GM = GI - TVC \quad (21)$$

$$GM = \sum Q_y P_y - \sum X_i P_{xi} \quad (22)$$

Where,

GM = gross margin in naira (₦)

Q_y = Output in kilogram (kg)

P_y = Price per unit of output in naira (₦)

Q_yP_y = GI = gross income or revenue in naira (₦)

X_i = Quantity of input used in producing acha

P_{xi} = Price per unit of input in naira (₦)

$\sum$ = Summation sign

$\sum X_iP_{xi}$ = TVC = total variable cost of producing acha in naira (₦)

The gross income (GI) is the total return or total value product (the total output multiplied by the price per unit of produce). That is;

$Q*P_y$ --- (23)

Where,

Q = quantity of output and

P_y = price per unit of output in naira (₦)

The total variable costs (TVC) include all cost of variable inputs such as labour, fertilizer, seeds and chemicals.

Other profitability ratios such as the profit margin (PM), gross ratio (GR) and rate of return on investment (ROI) were also computed as:

$$PM(\%) = \frac{\text{gross margin}}{\text{gross income}} * 100 \text{-- (24)}$$

$$GR(\%) = \frac{\text{total variable cost}}{\text{gross return}} * 100 \text{--(25)}$$

$$ROI = \frac{\text{gross income}}{\text{total variable cost}} \text{---(26)}$$

3.4.4 T - test of significance

The t-test of significance was used to test hypothesis (ii), that is, whether there is significant difference between costs and returns of acha farmers in the study area. It is a useful technique for comparing mean values of two sets of numbers. The one sample t-test was used to evaluate whether the difference between the two means (cost and return) is statistically significant or not. The formula is given by:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \text{ -- (27)}$$

Where:

$\bar{X}_1$ = average return for respondents naira (₦)

$\bar{X}_2$ = average cost for respondents in naira (₦)

$\sigma_1^2 =$ variance for farmers' return

$\sigma_2^2 =$ variance for farmers' cost

n_1 = sample size of farmers' return

n_2 = sample size of farmers' cost

3.5 Description and Measurement of Variables Included in the Model

Dependent Variable

Output of acha (Y): This refers to the total quantity of acha produced in the 2011 cropping season. It was measured in kilogrammes.

Independent Variables

Farm size: This refers to the area of land devoted to acha cultivation in the 2011 cropping season. It was measured in hectares and it is expected to have a positive relationship with the dependent variable.

Labour: This includes total family and hired labour employed in acha production activities. It was measured in man days and is expected to have a positive relationship with the dependent variable.

Seeds: This refers to the quantity of seeds used in planting and was measured in kilogrammes. It is expected to have a positive relationship with the dependent variable.

Fertilizer: This refers to the quantity of inorganic fertilizer used in acha production. It was measured in kilogrammes and it is expected to have a positive relationship with the dependent variable.

Agrochemicals: This includes herbicide and pesticide used in acha production and was measured in litres. It is also expected to have a positive relationship with the dependent variable.

Household size: A farming household comprises the head of household, the spouse(s), the children, and all other relatives or individuals living and feeding from the same pot with the household head. In several instances, this is usually larger than the conventional family size, which consists of the father, the mother and the children only (the nuclear family). Thus a farming household may include members of the extended family. This was measured as number of persons in the household and it is expected to have a negative relationship with technical efficiency if the household depends more on family labour.

Production experience: This was measured as the total number of years a farmer has been farming acha. The more experienced the farmer is, the greater the likelihood that managerial ability will improve. It is therefore expected to have a negative relationship with technical efficiency.

Level of formal education: This was measured in total number of years a farmer has spent schooling. Farmers who can read and write have a greater tendency to be more efficient in terms of input use and adoption of new technologies. It is expected to have a negative relationship with technical efficiency

Contacts with extension agents: This is the number of times a farmer had acha related extension visits during the cropping season. It is expected to have a negative relationship with technical efficiency because farmers tend to adopt innovation faster with more extension visits, thereby reducing inefficiency.

Off farm income: This refers to the total amount of money earned by a farmer outside farming activities in the last twelve months of the cropping season and was measured in naira. The amount of credit received by farmers either in cash or in kind from lending agencies (banks, government, friends, money lenders and relatives) is also considered to part of off farm income. This was measured in naira and is expected to have a negative relationship with technical efficiency.

Gross margin: This is the difference between total revenue and total variable cost of production. It was measured in naira/hectare

Gross income: This is the total revenue accruable from acha production and was measured in naira/hectare.

Total variable cost: Is the cost of all variable inputs such as labour, seeds, fertilizer and chemicals used in producing acha. It was measured in naira/hectare.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Description of Variables Included in the Model

Descriptive statistics of the variables employed in the study are presented in Table 2. The levels of input usage and output were described as well. The yield averages 495 kilogrammes per hectare.

Table 2: Descriptive statistics of variables

Variables	Unit	Mean	Min	Max	SD
Yield	Kilogramme/ha	495.37	100	2800	299.46
Land	Hectare	0.95	0.30	2.50	0.42
Labour	Man days/ha	61.64	12.0	450	18.77
Seed	Kilogramme/ha	39.20	7.00	152	46.67
Fertilizer	Kilogramme/ha	60.70	0.00	400	65.39
Herbicide	Litre/ha	0.42	0.00	6.0	0.91
Household size	Number of persons	6	1	11	1.73
Formal education	Number of years	11.73	0	17	4.23
Farming experience	Number of years	24.65	3	50	9.97
Extension contacts	Number of visits	1.39	0	9	1.84
Off-farm income	Naira per annum	153917.53	0	230000	111970.59
Processing cost	Naira	6886.08	1500	20000	4227.19
Storage cost	Naira	589.43	200	1500	300.83
Transportation cost	Naira	1310.31	300	5000	1101.91
Harvesting cost	Naira	4314.95	800	9000	2265.13
Farm distance	Kilometres	0.498	0.25	1.25	0.22

SD= Standard Deviation

This average yield was obtained by using averages of 61.64 man-days/ha of labour, 39.20 kg/ha of seed, 60.70 kg/ha of fertilizer and 0.42 litre/ha of herbicide. The variability in the total yield of the farmers as indicated by the standard deviation (299.46) implies that the farmers operated at different levels of input use, which affected their output levels. The variability in land size, labour, seed, fertilizer and herbicide are revealed by the standard deviations (0.42, 18.77, 46.67, 65.39 and 0.91 respectively). This large variability recorded could be due to changes in the use of available inputs at the farmers' disposal for acha production in the production season. In addition, the household size, level of formal education, farming experience, extension contacts, off farm income, farm distance, costs of processing, storage, transportation and harvesting also showed variability in terms of their standard deviations (1.73, 4.23, 9.97, 1.84, 111,970.59, 0.22, 4227.19, 300.83, 1101.91 and 2265.13 respectively).

4.2 Technical Relationship between Inputs and Output

The maximum likelihood error (MLE) estimates of the stochastic frontier translog production function model are presented in Table 3. The variance parameters (δ^2 and γ) were 1.4792 and 0.9892, respectively. The sigma squared (δ^2) is statistically significant at 1% level indicating the goodness of fit and correctness of the distributional form assumed for the composite error term, while the gamma γ indicates the systematic influences that are un-explained by the production function and the dominant sources of random errors. The result further revealed a generalized likelihood ratio statistic of 94. The log likelihood ratio value represents the value that maximizes the joint densities in the estimated model, as such, the translog functional form is an adequate representation of the data. The technical relationship between the output of acha and the inputs are explained from the estimates of the first order terms:

Farm size (X_1)**:** The coefficient of farm size was positive (0.8475) and significant ($P<0.01$). The magnitude of the coefficient of farm size shows that output is inelastic to land or farm size. This shows that as farm size increases by a unit, output also increases by 0.6365. The result is in line with the findings from Umoh (2006) and Okike's (2000) study of farmers in the savanna zone of Nigeria that reported farm size to be significant and positive for the low-population-high-market domain. It is also similar to findings reported by Goni *et al.* (2007) and Ugwumba (2010) in Nigeria, who observed that land size influenced output positively and was underutilized mainly due to land tenure problems associated with land fragmentation. Therefore based on the results it is implied that as the sizes of land holding continue to decline, it is increasingly going to become difficult to increase productivity through expansion in plot sizes. It may be possible that competition between infrastructure development and crops for land is not yet keen enough to jeopardize the expansion of acha production. This means that there is still some scope for increasing output per plot by expanding farmland.

Labour (X_2): The coefficient of labour was significant ($P<0.05$) and had a positive sign (0.0921). This shows the importance of labour in acha farming in the study area. This finding agrees with several other studies (Okike, 2000) which have shown the importance of labour in farming, particularly in developing countries where mechanization is only common in big commercial farms. In the study area, farming is still at the subsistence level generally. This involves the use of traditional farming implements such as hoe, machete and manual, human power plays crucial role in virtually all farming activities. This situation has variously been attributed to small and scattered land holdings, poverty of the farmers and lack of affordable equipment (Umoh, 2006).

Table 3: Stochastic frontier production function estimates of acha farmers.

Variable	Parameter	Coefficient	SE	t-statistics
Production Model				
Constant	β_0	3.9836***	0.9892	4.0272
lnland (X_1)	β_1	0.8475***	0.1184	7.1526
lnlab (X_2)	β_2	0.0921**	0.0367	2.5186
lnseed (X_3)	β_3	0.3510	0.3209	1.0248
lnfert (X_4)	β_4	0.0419***	0.0061	6.8955
lnagrochem (X_5)	β_5	0.0917***	0.0342	2.9238
lnland^2 $(X_1)^2$	β_6	0.8677**	0.3923	2.0221
lnlab^2 $(X_2)^2$	β_7	0.1318**	0.0585	2.2534
lnseed^2 $(X_3)^2$	β_8	0.4010*	0.2103	1.9004
lnfert^2 $(X_4)^2$	β_9	0.0066*	0.0034	1.9442
lnagrochem^2 $(X_5)^2$	β_{10}	0.2579***	0.0570	4.5219
*lnland*Inlab (X_1X_2)*	β_{11}	1.1679	0.7429	1.5719
*lnland*Inseed (X_1X_3)*	β_{12}	0.0249	0.2356	0.1059
*lnland*Infert (X_1X_4)*	β_{13}	0.0714	0.0959	0.7445
*lnland*lnagrochem(X_1X_5)*	β_{14}	1.4862***	0.4440	3.3431
lnlab lnseed (X_2X_3)*	β_{15}	0.1120*	0.0604	1.8547
*lnlab*Infert(X_2X_4)*	β_{16}	-0.0199	0.0130	-1.5271
lnlab lnagrochem(X_2X_5)*	β_{17}	-0.1831*	0.0951	-1.9248
lnfert lnseed(X_4X_3)*	β_{18}	0.0039	0.0076	0.5145
*Inagrochem*Inseed(X_5X_3)*	β_{19}	-0.0014	0.0683	-0.0209
Variance Parameters				
Sigma Squared	δ^2	1.4792***	0.2198	6.7168
Gamma	γ	0.9892***	0.0216	44.7895
Mu	μ	0.7883		
Log Likelihood Function		-3.8421		
Likelihood ratio test		94.0080		

*SE= standard error, *** P<0.01, ** P<0.05, *P<0.1*

Seed (X_3): The coefficient of planting material (seed) was positive (0.3510) and not significantly different from zero. The positive estimate for the coefficient of seeds implies that a unit increase in quantity of seeds used for planting will lead to an increase in output by a magnitude of 18.65%. It appears that, in general, the farmers need to increase the quantity of the acha seeds presently being sown as they tend to sow lower seed rate (39.2kg/ha), which resulted in lower stand establishment of the acha plants and in turn resulted in less crop yield.

Fertilizer (X_4): The production elasticity of output with respect to quantity of fertilizer was 0.0419. This means that by increasing the quantity of fertilizer by a unit, output level will improve by 0.0419. The estimated coefficient is statistically significant (P<0.01) and the finding agrees with several studies (Goni *et al.,* 2007; Ugwumba, 2010).

Agrochemicals (Herbicide) (X_5): The use of agrochemicals has a positive impact (0.0197) on output. The coefficient is statistically significant (P<0.01), implying that for each additional increase in a unit of agrochemicals used, there is an increase in the output of acha by a magnitude of 0.0197.

Interaction Between Variables: The second order terms which show possible non-linear changes of the effects over time revealed that all the coefficients of the square term (own interactions) are statistically significant at different levels and all showed direct (positive) relationships with output. Of the cross derivatives, some (*lnland*lnlab, lnland*lnseed, lnland*lnfert, lnland*lnagrochem, lnlab*lnseed, lnfert*lnseed and lnfert*lnagrochem)* showed positive relationships with the output, while others (*lnlab*lnfert, lnlab*lnagrochem and lnagrochem*lnseed)* showed negative relationships with the output. Only three of the cross interactions maintained statistical significance: *lnland*lnagrochem, lnlab*lnseed and lnlab*lnagrochem,* at P<0.1, P<0.01 and P<0.1 respectively. It can also be noted from this result that *lnseed* in the first order is not significant, but is significant in the square term and cross interactions of the second order derivatives

4.3 Input Elasticities and Return to Scale of Acha Farmers

The elasticity values obtained from the first order maximum likelihood error (MLE) estimates as shown (Table 4) indicate the relative importance of every factor used in acha production. The result showed that output is inelastic to all inputs; that is, an increase by one percent of each input results in a less than one percent increase in output.

Table 4: Input elasticities and returns to scale of acha production inputs

Variables	**Coefficients**
Land size	0.8475
Labour	0.0921
Seeds	0.3510
Fertilizer	0.0419
Agrochemicals	0.0917
Return to scale	**1.4242**

It shows that yield has the highest responsiveness to land, followed by seed rate, labour, agrochemicals and fertilizer respectively. The return to scale has a value of 1.42. If all factors are varied by the same proportion, the return to scale coefficient (sum of all inputs' coefficients) indicates the percentage by which output will be increased. In this case, the return to scale coefficient (1.42) which is greater than one implies that the farmers are operating at increasing returns to scale, that is, stage one of the production phase. The implication of such a result is that a proportional increase of all the factors of production leads to a more than proportional increase in production. This result further means that farmers should continue to increase the use of inputs until the rational stage is reached in order to boost production. Similar results were obtained by Ajibefun *et al.* (2002) in their study in Nigeria. Therefore, an increase in all inputs by one percent increases acha yield by more than one percent.

4.4 Individual Farm Specific Technical Efficiency Scores

Along with the parameters already presented and discussed, the technical efficiency score of each respondent was also estimated and the result is presented in Table 5. Most of the respondents (about 84%) were found to be more than 70% technically efficient. Only about 16% of the respondents were found to be less than 70% efficient. The most efficient farmer operated at 96% efficiency, the least efficient farmer was found to operate at 38% efficiency level, while the mean technical efficiency was 81%.

Table 5: Farm-specific technical efficiency indices among farms

Class interval of efficiency indices	**Frequency**	**Percentage**
0.31- 0.40	3	1.55
0.41- 0.50	5	2.58
0.51- 0.60	4	2.06
0.61- 0.70	18	9.28
0.71- 0.80	34	17.53
0.81- 0.90	77	39.69
0.91-1.00	53	27.32
Total	**194**	**100.00**

Mean efficiency = 0.8,1Minimum efficiency = 0.38, Maximum efficiency = 0.96

From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency in their farming activities as about 19% efficiency gap from the optimum (100%) is yet to be attained by all farmers. The implication of the result is such that on the average, farmers were able to obtain 81% efficiency from a given combination of the production inputs. The average farmer requires 11% cost saving, that is, [(1-0.81/0.96)*100] cost saving to attain the status of the most efficient crop farmer while the least performing farmer would need 60% cost saving, that is [(1- 0.38/0.96)*100] to attain the status of the most efficient farmer.

4.5 Inefficiency Effects

The contribution of farmers' socio economic and transaction cost variables (Z_1-Z_{10}) to farm inefficiency is also presented in Table 6. The result reveals a significant value of γ to be 0.98, which means that 98 percent of the total variation in farm output is due to the inefficiency variables. Hence, the hypothesis that the inefficiency effects have no influence on technical efficiency ($\gamma = 0$) of acha farmers is rejected, meaning that the inefficiency effects contribute to the technical efficiencies of acha farmers. Some of the included variables have significant effects on the technical efficiency of the farmers while others have no significant effects. Also, the signs of the coefficients of some variables agree with the a priori expectations (negativity of coefficients), while others do not. These selected and included variables being significant or insignificant are discussed as follows:

Household size of farmers: The coefficient of household size (-0.6791) is inversely related to technical inefficiency and is statistically significant ($P<0.01$). This means that the larger the household size, the greater the technical efficiency of acha farmers. Household size plays a significant role in subsistence acha farming where the acha farmers rely on household members for the supply of about 80% of the farm labour requirement (Kwong-Ndung and Misari, 1999). This is particularly so in view of the increasing cost of hired labour and the inability of the farmers to make use of improved mechanical tools either due to high cost or relative smallness of farm sizes. This result agrees with findings by Khairo and Battese (2005). But, it has been observed (Ogundele and Okoruwa, 2006) that the impact of household size on productivity depends on the quality and capabilities of the household members, rather than on the sheer magnitude of the household size. However, level of inefficiency is reduced with increased number of capable household members.

Farmers' level of formal education (δ_1): Education has a negative coefficient (-0.0750) and a significant relationship ($P<0.05$) with technical inefficiency. This means that the higher the farmers' level of formal education, the higher the technical efficiency. This finding agrees with those of Onyeweaku and Effiong (2005), Battese and Coelli (1995) and Seyoum, Battese and Fleming (1998). It plays a significant role in skill acquisition and technology transfer. It enhances technology adoption and the ability of farmers to plan and take risks. In other words, farmers with higher levels of education are likely to be more efficient in the use of inputs than their counterparts with little or no education. Low level of education no doubt affects the level of technology adoption and skill acquisition. It can also constitute a block to the effectiveness of extension activities.

Farming experience (δ_2): Farming experience is negative (-0.0210) and statistically significant (P<0.1). Based on the sign of the coefficient, the implication is that farmers with more years of farming experience tend to be more efficient in acha production, hence reduced inefficiency.

Table 6: Stochastic frontier production function estimates showing the inefficiency effects of acha farmers

Variable	Parameter	Coefficient	SE	T- statistics
Inefficiency effects				
Constant	δ_0	-1.5061	1.3585	1.1085
Household size	δ_1	-0.6791***	0.1237	-5.4899
Level of formal education	δ_2	-0.0750**	0.0289	-2.5953
Farming experience	δ_3	-0.0210*	0.0109	1.9214
Extension contacts	δ_4	-0.8631***	0.1538	-5.6129
Off- farm income	δ_5	0.251E-05*	0.121E-05	2.1172
Threshing cost	δ_6	-0.288E-04*	0.0002	1.7939
Harvesting cost	δ_7	0.0001	0.0001	0.8123
Storage cost	δ_8	-0.0036***	0.0007	-5.1712
Transportation cost	δ_9	0.0012***	0.0003	3.8640
Farm distance	δ_{10}	3.0900***	0.6159	5.0169
Variance Parameters				
Sigma Squared	δ^2	1.4792***	0.2198	6.7168
Gamma	Γ	0.9892***	0.0216	44.7895
Mu	μ	0.7883		
Log Likelihood Function		-3.8421		
Likelihood Ratio test		94.0080		

**** P<0.01, ** P<0.05, * P<0.10*

This conforms to the findings of Battese and Coelli (1995) who reported negative production elasticity with respect to farming experience for farmers in two villages in India, but disagrees with that of Rahman and Umar (2009) and Onyeweaku and

Nwaru (2005). The longer a person stays on a job, the more likely the person is to become an expert. Hence the saying "experience is the best teacher". Farming involves a lot of risks and uncertainties; hence, to be competent enough to handle all the vagaries of farming, a farmer must have stayed on the farm for quite some time. A farmer who has been growing acha for say, ten years is likely to be more knowledgeable about the pattern of rainfall, the incidence of pest and diseases, and other agronomic conditions of the area than a farmer who is just coming into the business irrespective of their level of education.

Contact with extension agents (δ_3): The result reveals that the estimated coefficient of farmers' contact with extension agents had a negative sign (-0.8631) and is statistically significant ($P<0.01$). It implies that farmers with high number of extension contacts tend to reduce inefficiency, thereby, increasing technical efficiency. This is consistent with several other studies that have found a positive connection between farm level efficiency and availability of extension services (Awoyinka, 2009; Bravo-Ureta and Evenson, 1994; Bifarin *et al.*, 2010). The introduction of Agricultural Development Projects (ADPs) in all states of the federation has boosted extension activities in Nigeria. The ADPs often reach the peasant farmers with various agricultural technologies, which are demonstrated to them through their various programmes by the extension agents. Through the activities of these extension agents, some varieties of other crops developed on experimental farms are now being grown by the peasant farmers. The high number of visits recorded by the farmers is an indication of the deliberate attempt by the government to promote new technologies.

Off farm income (δ_4): The coefficient of this variable has a positive sign and is significant ($P<0.10$). Although the sign is contrary to expectation, the magnitude of the coefficient is very small (0.21E-05). This implies that farmers that engage in off farm activities have higher inefficiency. It is expected that the amount of money or its money value equivalent of a facility obtained outside farm income (such as wages/salaries, borrowed funds, gifts from friends and relatives) by the farmer will help him to sustain and improve management of his farm through the purchase of inputs and the hiring of labour. However, with respect to acha farmers in the study area, the positive relationship suggests that involvement in non-farm work are accompanied by reallocation of time away from farm related activities, such as adoption of new technologies and gathering of technical information that is essential for enhancing production efficiency and they tend to diversify in the production of other commodities. Other researchers that made similar findings include Awudu and Eberlin (2001); and Liu and Jizhong (2000).

Threshing/processing cost (δ_5): Threshing cost has a negative coefficient (-0.28E-04) and a significant relationship ($P<0.10$) with technical efficiency. This agrees with a priori expectation, meaning that the higher the farmers' cost of processing, the less the inefficiency. This means that when money is available for farmers to hire the services of labour in terms of processing, technical efficiency will be increased. This is so because farmers get this done through pounding manually to remove the chaff before selling. Although the magnitude of the coefficient is very small (-0.5E-05), it significantly influences technical efficiency.

Harvesting cost (δ_6): Harvesting cost has a positive coefficient (0.0001) and a not significantly related to technical efficiency. However, the positive relationship means that the higher the farmers' cost of harvesting the grain, the greater the inefficiency effect. This is contrary to expectation simply because increased costs of production inputs lead to high allocative efficiency. As such, the cost of harvesting crops can also be seen as part of labour cost.

Storage cost (δ_7): Storage cost has a negative coefficient (-0.0036) and a significant relationship ($P<0.01$) with technical efficiency, meaning that the higher the farmers' cost of storage, the lesser the inefficiency effect. This means that when farmers spend more on storage, inefficiency will be reduced and hence, increase in efficiency especially with respect to handling. With increased efficiency, this will help farmers in making decision towards increasing production. Although the relationship is not significant, the magnitude of the coefficient is small and hence negligible.

Transportation cost (δ_8): Transportation has a positive coefficient (0.0012) and a significant relationship ($P<0.01$) with technical efficiency, meaning that the higher the farmers' cost of transportation, the higher the inefficiency effect. The result can be attributed to the fact that a farm located far from the market incurs more costs to transport farm inputs from the market to farm and cost of transporting output to the market, compared to the one closer to the market. This result is in line with empirical findings from Omamo (1998), Key *et al.* (2000) and Stifel and Minten (2008), that transportation cost is statistically significant to the quantity produced and supplied of crops .

Farm distance (δ_9): Distance from farmers' residences to the farm has a direct (3.0900) relationship with technical inefficiency of acha production and is statistically significant (P<0.01), meaning that the longer the distance, the higher the inefficiency effect. This is not surprising because farmers will have to trek a long distance and would have been tired before reaching the farm, such that labour input is reduced. This in turn hinders the effective application of farm inputs and leads to technical inefficiency. The findings are consistent with results found by Bagamba *et al.* (2007) among smallholder banana producers in Uganda. They observed that households located nearer to the factor markets showed higher technical efficiency than those located in remote areas. According to the authors, proximity (nearness) to the factor market increased farmers' ease of accessing farm inputs and extension trainings from which they could attain information and skills for better crop management hence increasing their productivity.

4.6 Profitability Analysis

Table 7 shows the average costs and returns of acha farmers. Acha farming may not be for the purpose of only satisfying the household food need or subsistence. The farmers may be interested in selling their outputs to raise income. Thus, the farmers like any other entrepreneur would be interested in the profitability of the farm enterprise. For this reason, efforts were made to determine the costs associated with acha farming and also revenue that accrues to the farmers' efforts. Only the variable costs of production were considered while the profitability was measured as the gross margin. Of all variable items, labour-related activities put together take the largest share (55.89%) of the short-run cost of production.

On the average, it costs N33, 085.00 to cultivate one hectare of acha farmland in the study area. An average of N60, 005.59 accrues to a farmer as revenue and N27, 920.59 is left as the gross margin. This level of profit translates to about N2, 300 per month as income to the farmers. Although this amount is lower than the national minimum wage of N18, 000 in Nigeria during the period of study, it is clear that acha farming is profitable enough to sustain an average farmer since although grown sole, it is not the only crop produced by the farmers in the area.

Table 7: Costs and returns structure of acha farmers

Item	**Unit Price (₦)**	**Value (₦/ha)**	**Percentage**
A. Gross Returns			
Value of output	130.00/kg	60,005.59	100.00
B. ***Cost of Variable Inputs***			
Cost of seeds	125.00/kg	8,075.14	24.41
Cost of labour	500.00/man-day	18,492.24	55.89
Fertilizer	100.00/kg	6,168.79	18.65
Herbicides	950.00/litre	348.36	01.05
C. ***Total Variable Cost***		33,085.00	100.00
D. Gross Margin = (A-C)		27,920.59	
E. Profit Margin = (D/A*100)			47.00
F. Gross Ratio = (C/A*100)			55.00
G. Return on Investment = (A/C)			1.81

Profitability ratios showed profit margin, gross ratio and rate of return to be 47%, 55% and 81%, respectively. This means that for every one naira invested by acha farmer, a profit of 81 kobo is made. This ratio reflects the return available to investments. It shows the returns to the capital investment over the production period, that is, a measure of the profitability of the investment capital (Engle and Neira, 2005). It reflects the true value of profit or gain that can be realized for every ₦1 investment made to the business. These ratios not only indicate substantial return to the enterprise, but also a high level efficiency in the use of capital.

4.7 Hypothesis Testing for Profitability

Table 8 shows the result of the hypothesis test comparing the means of farmers' cost and returns. The result proved a significant difference between cost and returns of acha farmers.

Table 8: Test of hypothesis on difference between costs and returns of acha farmers

Variables	Mean	N	SD	SE	t-value	t-critical
Returns	60092.731	194	8276.064	5911.147	36.671**	2.015
Cost	33810.461	194	3613.516	2613.520		

***P<0.05, SD=Standard Deviation, SE= Standard Error*

Since the average return is greater than average cost with a significant t- value at 5%, the null hypothesis which states that acha production is not profitable is therefore not accepted.

4.8 Constraints to Acha Production

Among the constraints encountered by acha farmers in the study area (table 9), high cost of labour, inadequate capital and high cost of inputs were identified as the major problems encountered by acha farmers.

Ninety seven percent of the respondents identified high cost of labour as a problem, hence, was ranked the 1st constraint. This is in accordance with the fact that labour includes the total cost of weeding, harvesting and processing. As a result of scarcity of labour, it is very expensive such that it reveals why labour accounts for about 55% of the variable cost of production. High cost of labour could extend production period, thereby, reducing the yield which in turn affects revenue.

Inadequate capital ranked 2nd among the constraints faced by acha farmers. About fifty eight percent of the respondents stated they are facing this problem. This confirms why some of the respondents engage in off farm activities so as to get financial support for their farms. This could also be the reason why off farm income had positive effect on farmers' output.

Table 9: Constraints encountered by acha farmers

Constraint	**Frequency**	**Percentage**	**Rank**
Scarcity and high cost of labour	189	97.42	1st
Inadequate capital	133	58.24	2nd
High cost of inputs	97	50.00	3rd
Unavailability of market	69	35.57	4th
Inadequate market information	44	22.68	5th
High cost of transportation	41	21.13	6th
Bad/poor roads	16	08.24	7th
Inadequate storage facilities	14	07.22	8th
Total	**603***	**301***	

**Total frequency is more than 194 and total percentage more than 100 due to multiple responses*

High cost of inputs such as fertilizer and agro-chemicals was identified by about fifty percent of the farmers as a major problem. Hence, it was ranked the 3rd constraint. Even when the inputs are available and accessible, the farmers cannot afford due to high prices. This explains the positive and significant influence that fertilizer and herbicides had on the output of acha farmers (table 2).

Thirty five percent of the respondents identified unavailability of market as a problem, hence ranked the 4th constraint. However, it cannot be unconnected to the non-availability of markets in the area. Markets are located in far areas which induce the farmers to sell at give away prices if buyers are not much as well as incurring high transportation cost to convey the grains to the market.

Inadequate market information ranked 5th of the constraints faced by acha farmers in the study area. Twenty two percent of the respondents identified this as a problem. Access to information on price and market demand for the commodity is vital to producers, as it can help farmers to know the extent to which the crop is needed as well as the quantity. This low market information could be attributed to the inadequate extension service experienced in the study area of which not all respondents had at least one contact with extension agents (Table 1) during the farming season.

High cost of transportation ranked 6th position among the constraints faced by acha farmers with twenty one percent of the sampled farmers highlighting this constraint. The roads in the study area are mostly un-tarred feeder roads, hence, sometimes inaccessible by motorist during the rainy season leading to difficult and high cost of transportation which invariably influences the farmers' decision to produce more of the crop.

Bad road ranked 7th position among the constraints faced by acha farmers with eight percent of the sampled farmers highlighting this constraint. Farmers in the study area mostly trek to their farms because the roads are bad most especially during the rainy season leading to difficulties in transportation. This can also be related to farm distance where farmers will have to go through a longer way if the usual roads are bad. Similar result was obtained by Gibson and Rozelle (2003) that bad road is a determinant of poverty.

The sampled farmers identified inadequate storage facilities as a constraint; hence, it was ranked the 8th constraint as seven percent of the sampled farmers identified it as a problem. Generally, farmers do store their grains in bags and kept in various places such as homes and stores which may not have enough space. Therefore, during the peak season, when price of acha is usually low as a result of glut, farmers are forced to sell at even unwilling prices to avoid spoilage.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study analyzed the productivity of acha using structured questionnaire administered to 194 acha farmers in Kaduna State. The data were subjected to analysis using the stochastic frontier production function and the gross margin analysis to achieve the set specific objectives.

The maximum likelihood error estimates of the stochastic frontier production function revealed a positive relationship between output and farm size which was found to be significant at 1% level, which could mean that it is possible to expand acha farming activity in the study area. The magnitude of the coefficient of farm size shows that output is inelastic to land or farm size, meaning that there is still some scope for increasing output per plot by expanding farmland. The coefficient of labor was significant and had a positive sign, implying the importance of labour in farming in the study area. In the study area, farming is still at the subsistence level generally. This involves the use of traditional farming implements such as hoe, machete and manual weeding. The production elasticity of output with respect to quantity of fertilizer is 0.042, which is highly statistically significant at 1% level. The coefficient of planting materials was positive but not significant. This implies that planting materials are important in crop production in acha farms in the study area.

The result further revealed the variance parameters; the sigma squared (δ^2) which indicates the goodness of fit and correctness of the distributional form assumed for the composite error term and the gamma (γ) which indicates the systematic influences that are un-explained by the production function and the dominant sources of random errors. This means that the inefficiency effects contribute to the technical efficiencies of acha farmers. Though the result shows the presence of inefficiency effects with some of the included variables being significant, gamma is also significant and shows about 98% of the variation in technical efficiency to be caused by the inefficiency variables captured in the model.

The input elasticities showed that output is inelastic to all inputs (land, labour, seed rate, fertilizer and agrochemicals). The scale coefficient (1.42) indicates that the farmers were operating at increasing returns to scale, that is, stage one of the production phase. The implication of such a result is that a proportional increase of all the factors of production leads to a more than proportional increase in production. Therefore, farmers should continue to increase the use of all inputs until the rational stage is reached in order to boost production.

The technical efficiency score of each respondent revealed that the most efficient farmer operated at 96% efficiency while the least efficient farmer was found to operate at 38% efficiency level. The mean technical efficiency score was 81%, indicating that farmers still have room to increase the efficiency in their farming activities as about 19% efficiency gap from the optimum (100%) is yet to be attained by all farmers.

The technical inefficiency model revealed that of the selected variables; contact with extension agent, household size, level of education, off farm income, processing cost, harvesting cost, transportation cost and farm distance influenced farm inefficiency.

Although the significant value of gamma indicates that 98% of the inefficiency can be explained by the selected variables, others might have been accounted for by other natural and environmental factors that were not captured in the model. These factors could be land quality, weather, labour quality, diseases and pests infestation. Hence, the null hypothesis which states that the selected variables have no influence on their technical efficiency of farmers was rejected.

The profitability analysis result showed significant difference between farmers' cost and returns with an average gross margin of ₦27,920.59 per hectare, a profit margin of 47% and a return on investment of 1.81. This implies that for every one naira invested in acha production, a profit of 81 kobo is made. It further shows that labour related activities accounts for about 56% of the total cost of acha production in the study area.

Most important constraints encountered by acha farmers include high cost of labour ranking 1^{st}, followed by inadequate capital, then high cost of inputs (97.42%, 58.24% and 50%) respectively.

5.2 Conclusion

Within the limit of productivity analysis, farm size, seed rate, labour and fertilizer were the important factors influencing acha production in the study area. This means that increase productivity and income can be acheived through more efficient utilization of resources. The estimated mean technical efficiency of 81 percent implies that there is substantial difference in technical efficiency by farmers in acha production and that there is opportunity for increased efficiency in acha production in the future. Thus, the study establishes that productivity can be increased by increasing the use of the resources.

The technical inefficiency effects appear to be crucial, as many of the included variables proved significant and have therefore contributed to the technical efficiency gap obtained. The parameter estimates of the socio-economic and transaction costs variables confirm that most variables are significant and thus, should not be neglected in estimating production structures. Acha production in the area is profitable at a rate of 81 kobo made for every ₦1 invested. The study therefore, concluded that input use, household characteristics and transaction costs variables have influence on acha production in the study area and thus, should not be neglected in estimating production structures.

5.3 Recommendations

Based on the findings of this study, the following suggestions are made to help solve acha crisis in Nigeria.

a) Since the farms are mainly small scale, productivity can easily be increased by timely and adequate supply of fertilizer and agrochemicals by the government. Also, the production of new and improved seed variety which is high yielding will be of greater help in increasing productivity.

b) Increase in seed rate and in more labour intensification in the farming activities by the farmers will be appropriate for the increase in productivity of acha.

c) Farmers too should strengthen themselves financially by forming co-operative groups, whereby members could have access to loans at a very low rate and farm inputs could be purchased in bulk to be shared among members at a reduced cost. The produce could also be sold in bulk, thereby lowering the average transactions costs.

d) Since cost of threshing as a component of labour cost had significant influence on farmers' efficiency, farmers can as well pool resources together to purchase a threshing machine as it will help solve the problem of labour scarcity and cost.

e) Government should continue to increase its support for public investment in research and extension. The extension activities of the extension agents should be revived so that farmers will make better technical decision and also help in allocating their production inputs effectively and follow appropriate farm management practices so that resources will be efficiently utilised.

f) Government should invest in key non-price factors such as improved technology, provision of farm capital and irrigation facilities so as to help continuous and sustainable production of acha.

g) Government should provide adequate rural infrastructure such as markets, feeder roads and other social amenities to discourage rural-urban drift by youths who can provide labour to the industry in order to promote good investment climate for the commercial production of acha in the study area.

5.4 Contribution of the Study to Knowledge

The study established the following:

i. Acha farmers in the study area were 81% technically efficient in production, implying that increase in productivity and income can be acheived through more efficient utilization of resources.

ii. The socio-economic and transaction costs variables were responsible for 98% of the farmers' inefficiency.

iii. Acha production in the study area was profitable with an average gross margin of ₦27, 920.59 /ha. The farmers were operating at a return on investment of 1.81, that is, a profit of 81kobo made for every ₦1 invested.

iv. Acha farmers in the study area were constrained to production as 97.42%, 58.24% and 50% of the farmers responded positively to high cost of labour, inadequate capital and high cost of inputs (fertilizer and agrochemicals) respectively as the major constraints.

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QUESTIONNAIRE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY
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AHMADU BELLO UNIVERSITY, ZARIA

Questionnaire on Research titled: Productivity of Acha in Selected Local Government Areas of Kaduna State.

INSTRUCTION: Please tick or fill in the spaces provided where necessary

Date…………….........………………………………………………………………

Questionnaire No: ……………..…………………………………………………….

Village………….....……………………………………………………………………

Local Government Area……..……………………………………………………….

A. Background Information

1. Name……………………………………………………………………………….

2. Sex………………………………………………….Male [ ] Female [ ]

3. Age……………………………………………………………………………..…

4. Marital Status (a) Single [ ] (b) Married [ ] (c) Widow/ Widower [ ]…....…

5. Household size (a) Number of males 12 years and above ……………………….....

(b) Number of female 12 years and above………………………..

(c) Number of children below 12 years …………………………..

(d) Number of wives ………………..

6. Level of Education

(a) No formal education (years)……… (b) Adult education (years)…………………

(c) Primary education (years)………… (d) Secondary education (years)……………..

(e) College education (years)………….(f) University education (years)……………...

7. Major occupation of respondent……………………………………………………..

8. Farming experience on acha production (years)…………………………………….

9. Total annual income from (a) off-farm activities…..……(b) farm activities............

10. How many times did you or any member of your household had contact with extension agent on acha production related activities in the past 12 months? (Face to face/film show/field demonstration/media)…..

11. How was the rainfall distribution last cropping season? Normal [ ] Deviation [ ]

12. Are you a member of any farmers' cooperative? Yes [ ] No [ ]
If yes, for how long have you been a member? .... years

13. Access to credit

Row	Source of borrowed money	How much did you borrow in the last 12 months (in Naira)	Purpose of borrowing
1	Relatives and friends		
2	Informal savings or credit groups		
3	Money lenders		
4	Government credit schemes		
5	NGO/Church		
6	Bank or Micro finance institution		

B. Land Ownership and Size Cropped to Acha Production

Plot No	Plot Area (ha)	Distance from home(km)	Tenure type	Used in the cropping season of 2011?

Tenure type: 1= gift, 2=customary, 3=leased, 4=purchased

C. Production Information on Inputs and Output in 2011

1. Seed / Planting Materials and Cost

Plot No	Crops grown (if mixed)	Did you use improved varieties?	Source of seeds for planting	Quantity of seeds planted in kg	Amount in Naira

Sources: 1= market 2= owned seeds 3=obtained from extension agents/ association

2. Information on the use of labour

Plot No	Land preparation method	Total family labour for land preparation in days	Total hired labour for land preparation in days	Total cost (amount) of land preparation in naira	Number of weeding	Total family labour for weeding in days	Total hired labour for weeding in days	Total cost/ amount of weeding in naira	Total cost of other labour activities

3. Information on the use of fertilizer and other chemicals

Plot No	Type of fertilizer used	Quantity used in kg	Total cost in naira	Used pesticides /chemicals?	Quantity used in kg	Total cost in naira	Total cost of other inputs used in naira

D. Income from acha and other related crops in 2011

Plot No	Did you sell?	If yes, quantity sold (kg)	Type of market sold	How far is the market?(km)	Price per unit in the market	In what form did you sell?	How did you sell?	Time/ Month of sales
Other Important Crops (cereals, tubers, legumes, vegetables)								

(a)Type of market: 1=farm gate, 2=village market, 3=town market

(b) In what form: 1= Fresh, 2=Dried, 3=threshed/processed

(c)How did you sell? : 1= Individually, 2= Collectively

E. Information on transaction cost

Transaction cost variables	Cost / Amount in Naira			
	Plot 1	Plot 2	Plot 3	Plot 4
Harvesting				
Processing				
Storage				
Transportation				
Bargaining/ middle men				
Assembling				
Others (Specify)				

F. Constraints to production and marketing of acha

Row	Constraints to Production	Rank	Constraints to marketing	Rank
1	Low soil fertility		Low quality of produce	
2	Pests and diseases		Low market price at time of selling	
3	Lack of improved varieties		Unavailability or of markets	
4	Low access to inputs		Lack of market information	
5	High cost of inputs		Difficulties in processing	
6	Insecure land tenure		Difficulties in storage	
7	Small land holdings		Transportation to market	
8	Lack of labour during peak season		Difficulties in setting prices	
9	Lack of / high cost of equipments		Government policy	
10	Others (Specify)		Others (Specify)	

G. Solutions to problems in (F) above.

What do you think could be the possible solutions to these problems?

(i)…....................……………………………………………………………………

(ii)………..……………………………………………………………………………..

(iii)…………………………………...………………………………………………….

(iv)…………………………...…………………………………………………………….

(v)………………....………………………………………………………………….

Thank you.