

# **ANALYSIS OF PRODUCTION EFFICIENCY AMONG RAINFED RICE FARMERS IN NORTHERN TARABA STATE, NIGERIA**

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**DECEMBER, 2019**

## **CHAPTER ONE INTRODUCTION**

### **1.1 Background of the Study**

There are more than 50, 000 edible plant species in the world, only a few hundreds contributes significantly to our food supplies. Almost the world's entire food energy intake is satisfied by just a few crop plants. Rice, maize and wheat make up two-third of this already small group of foods. These three grains are the staple food for more than four billion people both as a source of nutrition and income. A staple crop, by definition, dominates the major part of our energy and nutrient need. If staple crops are threatened by drought, pests or nutrients-poor soils, hunger

and poverty can rise dramatically (International Atomic Energy Agency, Bulletin, 2012). Out of these three crops, rice (*Oryza sativa*) is gradually taking the lead in terms of economic importance. Rice is consumed by more than 4.8 billion people in 176 countries and is the most important food crop for over 2.89 billion people in Asia, over 40 million people in Africa and over 150.3 million people in America (Biyi, 2005).

The total rice harvested globally in 2010 equated to approximately 154 million tons. The majority of this amount was harvested in Asia (137 million tons which is 88% of the rice harvested globally), 31% of which or about 48 million tons was harvested in the Southeast Asia alone. The global figure (154 million tons) however, experienced an increase which amounted to 494.4 million tons, 494.8 million tons, decreased to 491.6 million tons and then increased to 499.4 million tons in 2013/14, 2014/15, 2015/16 and 2016/17, respectively, and it is forecast to be 504.0 million tons in 2017/18 (FAO, 2017).

The largest three rice exporting countries are Thailand (26%), Vietnam (15%) and the United States (11%). The largest three rice importers are China (4,700 metric tons), Nigeria (3,000 metric tons) and Philippines (1,800 metric tons). (www.worldatlas.com, 2015). Rice production and consumption are of global importance providing more than 20.0% of caloric needs of millions of people on daily basis (Yang and Zhang, 2010). In terms of annual world production and consumption of major cereals, rice is the third most produced and consumed cereals after maize and wheat (FAO, 2012). In Nigeria, the agricultural sub-sector parades a large array of staple crops made possible by the diversity of agro-ecological production system, out of these staple crops, rice has risen to a position of preeminence. The country is the highest producer and consumer of rice in the West African sub-region, the total paddy rice production in Nigeria stood at about 4.0 million metric tons representing about 44% of the total production in the West African sub-region (FAOSTAT, 2008).

Rice production occurs in all agro-ecological zones in Nigeria with the middle belt enjoying a comparative advantage in production over the other parts of the country. Production is primarily by small-scale producers, with average farm size of 1-2 hectares. Yield per hectare is low due to production systems, aging farming population and low competitiveness with imported rice. Rice growing environment in Nigeria are usually classified into five ecosystems namely: Rain-fed upland, Rain-fed lowland, Irrigated lowland, Deepwater and Mangrove swamp (Biyi, 2005).

The annual consumption of milled rice in Nigeria increased from 0.4 million metric tons in 1960 to approximately 5.2 million metric tons in 2013, reflecting an annual average growth rate of 7.2% (International Rice Research Institute(IRRI), 2013). In Nigerian household consumption, rice is the fifth most common food after tubers, vegetables, beans, sorghum and other cereals representing about 5.8% of the household spending (Johnson *et al.*, 2013).

The per capita annual consumption of rice in Nigeria has also accelerated from 1.6kg in 1960 to approximately 31.6kg per annum in 2013; this increase is driven by growth in population, urbanization, increase in per capita income and changes in preference for rice meals (Omojola *et al.*, 2006). For instance, average annual growth rate of population has fluctuated between 2.2% in 1960s to 2.9% in 2013 (World Bank, 2014). However, in recent years, rice production has been expanding at the rate of 6% per annum in Nigeria, with 70% of the production increase due mainly to land expansion and only 30% being attributed to an increase in productivity (Okoruwa *et al.*, 2007).

Similarly, since 1970, Nigeria has consistently experienced increases in per capita income due to inflows of petro-dollars, which have pushed up food per capita consumption in general and rice per capita consumption in particular. These increases in per capita income were also responsible for some of the changes that have occurred in Nigeria for consumers' taste and preferences for rice (Abayomi *et al.*, 2010). Nigeria has about 4.8 million hectares of potential land area for rice production but only about 36% is under cultivation (Ilevbaoje and Ingawa, 2008; and NFRA, 2008) with the rice farmers cultivating average farm size of less than 2 million hectare annually (Biyi, 2005).

However, it was further stated that domestic production has never been able to meet the demand leading to considerable imports which stands at about 1,000,000 metric tons yearly. These imports are procured at the world market with Nigeria spending annually over US\$300 million on rice imports alone, been the largest importer of rice in Africa and the second importer in the globe after China (FAOSTAT, 2008). The supply-demand gap keeps widening due to the increasing population growth and shift in consumers' preference towards rice (Achike and Okoye, 2004; and Uguwanyi *et al.*, 2008).

The rice industry has showed a rising trend in milled rice supply deficit in Nigeria, from 1,100 metric tons in 1960s to 2.3 million metric tons in 2013. Between 1960 and 2013, Nigeria has persistently imported foreign milled rice to augment local supply deficit. This was an average

of 2.3 million metric tons of imported rice per annum. Self-sufficiency ratio has also declined from 99.6% in 1960s to 55.3% in 2013. The long-run self-sufficiency ratio of rice between 1960 and 2013 stood at 55.1%. The balance of 44.9% during this period was imported to meet local demand for rice. Thus, despite recorded increase in international price of rice, the country in the past few decades has experienced rice import surges between 1970 and 2013 (IRRI, 2013). The inability of the Nigerian rice sector to meet the domestic demand may be due to low hectares under cultivation and inefficiency of the farmers in the use of production resources among others. Thus, according to Okuruwa *et al.* (2009), the issue of efficiency of the rice farmers in the use of resources is central to explaining why domestic rice production lags behind the demand for the commodity in Nigeria. Since increased productivity is directly related to production efficiency, it is very important to raise productivity of the farmers through government intervention of the provision of active extension agents, delivery of improved seeds varieties, and prompt delivery of fertilizer to farmers, provision of credits facilities among others.

## 1.2 Statement of the Problem

Although Nigeria is the largest producer and consumer of rice in West Africa and in the sub-Saharan Africa, it is yet to meet its local supply-demand gap making her the largest importer of rice in Africa (FAOSTAT, 2008). Even though there has been increase in the local rice production since 1990s but the increase has not been sizeable enough to satisfy domestic demand (Johnson *et al.*, 2013) which is shown in Table 1.

**Table 1:** Selected Indicators of Nigeria’s Rice Economy

Indicators	Average	Average	Average	Average
	1960-1979	1980-1999	2000-2010	2011-2013
Milled rice production (mmt)	0.3	1.3	2.2	2.9
Growth rate of production (%)	2.9	11.3	3.6	4.0
Milled rice consumption (mmt)	0.4	1.9	3.9	5.2
Growth rate of consumption (%)	8.0	8.4	5.0	3.5
Self-sufficiency ratio (%)	75.0	68.4	56.4	53.8

Source: Samuel (2016)

From Table 1, locally milled rice production increased from an average of 0.3 million metric tons per annum in 1960 to an average of 2.9 million metric tons in 2013, representing an average annual growth rate of 6.1%. The growth rate consumption of rice decreased from 8.0% in the 1960s to an average of 3.5% which is a reflection of decline in Nigeria been self-sufficient in its rice production from 75% in 1960-1979 which dropped to 68.4% in 1980s and 1990s and this also trimmed down to 53.8% in 2011-2013. However, local demand for milled rice products has increased much faster from an average of 0.4 million metric tons per annum in 1960 to an average of 5.2 million metric tons in 2013, representing an average annual growth rate of 7.2%. This imbalance between Nigeria rice cultivation and consumption is a significant long-term concern. Therefore, there is a need to bridge the gap (Samuel, 2016).

According to an outlook from Food and Agricultural Policy Research Institute (FAPRI) database 2007, the local demand for rice and allied products is projected to rise to 7.2 million metric tons by 2018, while local production of milled rice is projected to reach only 3.7 million metric tons. By implication, local supply gap of 3.5 million metric tons deficit which must be filled by importation of rice in order to avoid hunger and disease by 2018. Thus, Nigeria will need to allocate more of foreign exchange earnings for importation of rice in order to meet local supply gap in the future (Samuel, 2016).

However, importation of rice into Nigeria has been banned by the current administration in 2016 with its economic policy of diversifying the economy where major attention has been diverted into agricultural sector with the aim of been self-sufficient in domestic food production. Studies have revealed that low output realized by rice farmers is an indication of poor performance due to insufficient technical-know-how on use of fertilizer, improved and inadequate extension agents (Tijjani and Bakari, 2014). There is therefore a need for farmers to be efficient in their use of farm resources.

Farm production efficiency is the ability of a farm to produce a given level of output with the lowest amount of resources. The efficient method of producing a product is the one which uses the least amount of resources to get a given amount of output. Efficient farms make better use of existing resources to produce maximum output or incur the lowest cost thereby achieving food security objective. There are six features of efficient farm which includes; zero waste, least cost, minimum risk, maximum output, best quality produce and maximum profit (Rahman, 2013).

This research work, examined rice production efficiency (allocative, technical and economic efficiency) in Northern part of Taraba State as most of the related published research works carried out in Taraba State were skewed to determinants of technical efficiency such as Ahmadu and Arhabor (2012), allocative efficiency of rain-fed rice production in Taraba State by Tijjani and Bakari (2014), resource use efficiency in Niger and Taraba States by Isah *et al.* (2012) and Moses (2012) on the analysis of production efficiency of rice in Adamawa and Taraba States. Therefore, the justification for undertaking this research study in the area. And as such, the study answered the following research questions:

- (i) What are the socio-economic characteristics of rice farmers in rice production in Northern part of Taraba state?
- (ii) Is rice production profitable in the study area?
- (iii) What are the determinants of production efficiency?
- (iv) What are the constraints of rice production in Northern part of Taraba State?

### **1.3 Aim and Objectives of the Study**

The broad objective of the study was to analyze the production efficiency among rain-fed rice farmers in Northern Taraba State. The specific objectives were to:

- (i) examine the socio-economic characteristics of rice farmers in Northern part of Taraba State;
- (ii) determine the profitability of rice farmers;
- (iii) estimate the technical, allocative and economic efficiency of rice farmers and;
- (iv) identify constraints associated with rice production in the study area.

### **1.4 Hypothesis**

Ho: there is no presence of inefficiency effects among rice farmers in the study area.

### **1.5 Significance of the Study**

The analysis of production efficiency among rain-fed rice farmers in Northern Taraba State assessed farmers' performance in terms of the use of production resources and determined their level of profitability among others. The study would be relevant to:

- i. Government organizations, to know the level of rice farmers performance in the study area;

- ii. Non-governmental organizations (NGOs) that are actively involved in providing incentives to rice farmers, so that it can serve as direction for their activities;
- iii. Students and researchers as source of new literature for future;
- iv. guide for better policy formulation by both governmental organizations and non-governmental organizations (NGOs); and
- v. present and potential farmers, so that they can be acquainted with knowledge on how to improve their productivity

### **1.6 Scope and Limitation of the Study**

This study was conducted in Northern Taraba State namely; Ardo-kola, Jalingo and Yorro Local Government Areas as a study area. It collected data solely from rain-fed rice farmers in the study area for the 2017/ 2018 farming season. Data on socio-economic characteristics of the farmers such as marital status, level of education, sex, age, occupational status, improved seed variety, household size and years of experience were considered. In an attempt to determine production efficiency of rain-fed rice, information on the level of output (kg), farm size (ha), labour (Mandays), fertilizer (kg), seed quantity (kg), agrochemicals (lt), and years of experience were considered. However, in carrying out the research work the following drawbacks were encountered:

- i. Inadequate finance and time constraint.
- ii. Some of the respondents misunderstood the objectives of the research, as they thought the research was aimed at providing them with financial assistance for their rice farming activities.
- iii. Some of the respondents were unable to read or write in English, therefore additional effort was provided by interpreting the questions and answers provided were written by the researcher.
- iv. It was difficult to gain access to farmers, as some of the farmers claimed to be busy on their farms.

However, despite these limitations, the results of the study was not invalidated, that is, data were validly collected and analyzed to a logical conclusion.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

A comprehensive review of literatures regarding different aspects of production efficiency of rice farmers in Nigeria as well as other countries has been done.

#### **2.1 Theoretical Framework**

##### **2.1.1 *Production function***

Production function in microeconomics theory is defined in terms of the maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms involved (Batesse, 1991). In production economics, the most fundamental relationship is that between the factors of production and the product. Hence, production function is defined as the mathematical model which expresses the technical relationship between inputs and the resulting outputs (Olayemi, 1998).

The commonly known types of production functions as identified in “Introduction to the Economics of Agricultural Economics” by Sankhayan (1988) are five namely; linear production, quadratic production function, square root production function, Cobb-Douglas production function and the constant elasticity of substitution function.

Generally, a function states the relationship between variables as expressed below:

$$Y_i = f(X_{ij}, X_{ik}, \dots, X_n) \dots \text{eqn. (1)}$$

where;

Y= total output of the ith farmer

X<sub>ij</sub>= jth input of ith farmer

X<sub>ik</sub>= kth input of the ith farmer

X<sub>n</sub>= n inputs

f()= functional relationship

### **2.1.2 Production efficiency**

Farrell (1957) remains the pioneer of the concept of production efficiency as cited by Iqbal *et al.* (2013). Farrell’s seminal article has led to the development of several techniques for the measurement of efficiency of production. Farrell (1957) defined efficiency as the success with which a farm best utilizes its available resources to produce maximum levels of potential outputs. He posit that the efficiency of a firm is its success in producing as large quantity of output as possible from the given sets of inputs.

Production efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs (an output oriented measure), or uses the minimum feasible level of inputs to produce a given level of output (an input oriented measure). The most popular approach to the measurement of efficiency is the use of stochastic frontier production function (Rahman, 2003). A farm is efficient if and only if it is not possible to increase output (or

decrease inputs) without more inputs (or without decreasing output) (Cooper *et. al.*, 1995). Any failure to obtain this potential maximum output results in inefficiency.

Ali and Chaudhary (1990) stated that the crucial role of efficiency in increasing agricultural output has been widely recognize by researchers and policy makers; it remains an area of important research both in developed and developing countries. This is particularly so in developing economies where resources are meager and opportunity for developing and adopting better technology are dwindling. The reason behind measurement of efficiency is that, if farmers are not making efficient use of existing resources, then efforts designed to improve efficiency would be more cost effective than introducing a new technology as a means of increasing output (Shapiro, 1983). It is important because it lead to a sustainable resource savings which have important implication for both policy formulation and farm management.

Farrell (1957) proposed that efficiency of a farm consists of two components: technical efficiency and allocative efficiency. Technical efficiency represents the ability of a farm to obtain maximum output from a given set of inputs, or the ability to minimize input use in the production of a given output vector. Thus, the production frontier is associated with the maximum attainable level of output, given the level of inputs, or the minimum level of inputs required to produce a given output. In other words, it is the locus of maximum attainable output for each input mix. Technical inefficiency is attributed to a failure of the farm to produce the frontier level of output, given the quantities of inputs (Kumbhakar, 1993). It can be estimated using either of these; deterministic parametric estimation, stochastic parametric estimation and non-parametric mathematical programming (Udoh and Akintola, 2001). Parametric frontier approach assumes functional form on the production function and makes assumptions about the data. The most common functional forms include the Cobb-Douglas, Constant Elasticity of Substitution (CES) and Trans-log production functions. Deterministic frontiers assume that all the deviations from the frontier are a result of firms' inefficiency, while stochastic frontiers assume that part of the deviation from the frontier is due to random events (reflecting measurement errors and statistical noise) and part is due to farm specific inefficiency (Forsund *et al.*, 1980). On the other hand, non-parametric frontier assumes no functional form on the production frontiers and does not make assumptions about the error term. It uses linear programming approaches. The most popular non-parametric approach is the Data Envelopment Analysis (DEA).

Allocative efficiency reflects the ability of a farm to use inputs in optimal proportions, so as to maximize profit, given their respective prices. Alternatively, allocative inefficiency arises if a farm fails to allocate inputs which minimize the cost of production of an output, given relative input prices. Failure in allocating resources optimally results in increased cost and decreased profit. (Johnson *et al.*, 2013)

In particular, a farm is said to be allocatively inefficient if the marginal rate of technical substitution (MRTS) between any two inputs is not equal to the corresponding ratio of input prices, that is, allocative inefficiency exists when the farm fails to use cost-minimizing input mixes.

The distinction between technical and allocative efficiency provides four ways for explaining the relative performance of farms. First, a farm might be technically and allocatively inefficient, secondly; it may be technically efficient, but allocatively inefficient; thirdly, it may show allocative efficiency, but technical inefficient; finally, it may be both technically and allocatively efficient. These two measures, that is, technical efficiency and allocative efficiency- are then combined to provide a measure of economic efficiency, which reflects the ability of a farm to produce output at minimum cost. Thus, either one of the efficiencies may be necessary but not sufficient conditions to ensure economic efficiency for a farm. The simultaneous attainment of both efficiencies gives the sufficient condition to ensure economic efficiency (Ellis, 1993).

### **2.1.3 Stochastic frontier approach (SFA)**

The stochastic frontier production function independently proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) has two error components, viz: the symmetric error term ( $V_i$ ) which accounts for noise (factors beyond the control of the farmers in production) and the non-negative asymmetric error ( $U_i$ ) accounting for the technical inefficiency of the farmers. In model specification, the stochastic production frontier is expressed as:

$$Y_i = f(X_{ij} B) + V_i - U_i \dots \text{eqn. (2)}$$

where;

$Y_i$  = Output of the  $i$ th farmer

$X_i$  = Vector of actual  $j$ th input used by the  $i$ th farmer.

$B$  = Vector of the unknown parameters to be estimated

$V_i$  =the symmetric noise associated with random factors, assumed to be independent of  $U_i$ , identically and normally distributed with zero mean and constant variance  $N(0, \delta^2_{v_i})$ , intended to capture events beyond the control of farmers.

$U_i$  = the non-negative error term representing deviations from frontier production function, which is attributed to controllable factors (technical inefficiency), assumed to be half normally, independently and identically distributed with zero mean and constant variance  $N(0, \delta^2_{U_i})$

The stochastic frontier production function was established using the maximum Likelihood Estimate (MLE). The technical efficiency can be empirically measured by decomposing the deviation into a random component ( $V_i$ ) and efficiency component ( $U_i$ ). According to Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977), the technical efficiency of the farmers is expressed as:

$$TE_i = Y_i/Y_i^* \dots \text{eqn. (3)}$$

Where;

$TE_i$  = Technical efficiency of the  $i$ th farmer

$Y_i$  = Observed output of the  $i$ th farmer

$Y_i^*$  = Frontier output

Other vital parameters of a stochastic function includes the sigma squared ( $\delta s^2$ ), gamma ( $\gamma$ ) and the log-likelihood ratio test. The  $\delta s^2$  indicates the goodness of fit of the model used. The gamma gives the proportion of the deviation of output from the production frontier caused by technical inefficiency. If  $\gamma = 0$ , it means  $U_i$  is absent from the model and hence, all deviations from the frontier are attributed to noise. If  $\gamma = 1$ , it means all deviations from the frontier are due to technical inefficiency. The log-likelihood ratio test is used to test for the significant presence of technical inefficiency effects in the production process. Therefore, technical efficiency of a farm lies between 0 and 1

## **2.2 Empirical Studies on Rice Production**

### **2.2.1 Socio-economic characteristics of rice farmers**

Ahamdu and Erhabor (2012) in their study of determinants of technical efficiency of Rice farmers in Taraba State using descriptive statistics discovered that young males within the age bracket of 20-49 years dominated the rice production industry. Majority of them (77%) were married with high family size. The study also revealed that majority of the respondents were literate with 54% of them having secondary education, most of them had over 9 years of farming experience (64%). The farmers relied more on the use of local rice varieties (79%) for cultivation as against improved varieties (21%).

Similarly, in a study conducted by Tijani and Bakari (2014) on the economics of rain-fed rice production in Taraba State using descriptive statistics revealed that majority (82%) of the respondents were males because they are the household heads and mostly involved in strenuous activities while their female counterpart handles food processing and marketing activities. Majority (84%) of them were aged between 21-50 years old, suggesting that they are predominantly youths and hence might be vibrant and economically productive. Also, majority (62%) are married with a mean family size of seven persons. This could enhance the release of family labour, thus making more hands available for productive activities. Furthermore, 88% of the respondents had one form of education or the other, hence will possibly be innovative. Similarly, 64% of them had more than five years of experience and 85% were small scale farmers cultivating less than five (5) hectares of land. This may not encourage mechanization system of farming and thus, production may continue to be minimal in the area.

Manum (2013) studied on the comparative analysis of resource use efficiency in rice production among *Fadama III* and non-*Fadama III* beneficiary rice farmers in Niger State, the study showed that majority of respondents, from both the *Fadama III* and non-*Fadama III* beneficiary rice farmers, fall within the productive age of 20-50 years. The mean age of *Fadama III* beneficiary rice farmers was 43 years while the mean age of non-*Fadama III* beneficiary rice farmers was 42 years, 95(%) of the *Fadama III* beneficiary rice farmers were males and 5(%) were females, while 100(%) of the non-*Fadama III* beneficiary rice farmers were males. Most of the rice farmers (96.6% of the *Fadama III* beneficiaries and 100% of the non-beneficiaries) were married. The mean household size of 9.42 and 7.95 were recorded for the *Fadama III* and non-*Fadama III* rice farmers, respectively. The result showed that 16.7% of the *Fadama III* beneficiary rice farmers, against 11.7% of the non-*Fadama III* beneficiary rice farmers, had farming experience of 1-5 years; while 35.0% of the *Fadama III* beneficiary rice farmers against 36.7% of the non-*Fadama III* beneficiary rice farmers, had farming experience of more than 21 years, the mean farming experience of the *Fadama III* and non-*Fadama III* beneficiary rice farmers are 19.8 and 18.28, respectively. The implication of this finding is that sampled respondents have had a considerable amount of farming experiences and should be able to use resources optimally and produce profitably. It also showed 68.4% and 45.0% of the *Fadama III* and non-*Fadama III* beneficiary rice farmers, respectively, had no formal education, leaving only 31.6% of the *Fadama III* beneficiaries against 55.0% of the non-*Fadama III* beneficiary rice farmers as the ones that

have acquired various levels of formal education. Since level of education plays a significant role in skill acquisition and in application of new ideas, the implication of this finding is that most rice farmers in the study area will accept and adopt new ideas slowly. Also 100% of the *Fadama* III beneficiary rice farmers had crop farming as a major occupation against 83.4% for the non-*Fadama* III rice farmers.

Akinbode *et al.* (2011), in a study on the examination of technical, allocative and economic efficiencies in *Ofada* rice farming in Ogun State, Nigeria showed that the average age of farmers was 44.6 years with majority completing primary school education with an average years of rice farming experience of 23. An average farmer in the study area realized an output of 1.47 tones per hectare. This is far below the average yield of 4 t/ha which is known in literature. The farmers cultivate relatively small areas of land with a mean value of 0.86 ha. They used much of family labor than hired labor. The level of fertilizer use was very low (an average of 169 kg on an average farm size of 0.86 ha) which was shown to reduce output of *Ofada* rice substantially. None of the farmers use herbicide; therefore farmers relied on manual weeding, which may result in labor wastage and decrease efficiency. Their findings also showed that, majority (60%) of the farmers had contact with extension workers, while there is need for urgent control measures against bird invasion in rice farms in the study area. An attempt either by technological invention aimed at controlling bird invasion on rice farms is capable of raising rice output substantially.

The study on the analysis of economic efficiency of irrigation water-use in Mwea Irrigation Scheme, Kirinyaga district, Kenya by Owilla (2006) revealed that, the main economic activity in the Scheme is farming, with 120 (99.2%) respondents fully dependent on farming as their main occupation, against 1 (0.8%) respondent who relied on business. Similarly, 118 (97.5%) of the farmers had more than ten years of experience in irrigation farming. Household size ranged from 2 to 38 persons, with a median size of 8 persons. Labour in the Scheme was found to be fully commercial, even at household level. The mean land size was 3.769 acres per farmer. The farmers are therefore classified as small-scale farmers. The farming activities rely on irrigation and rice is the main crop grown (99.2%).

A study on technical efficiency of rice farmers in Northern Ghana by Seidu (2008), he studied on two categories of rice farmers which are the irrigators and non-irrigators. The study revealed that the mean age of sampled farmers is 42 years. There is a four-year difference between the mean ages of irrigators (39 years) and non-irrigators (43 years). The mean ages of rice farmers

suggest that rice farming is dominated by the youth. The farmers had 8 years as average years of formal education for both farm groups. The mean years of education shows that on average the highest level of education attained by a farmer is primary school, which revealed some literacy level among rice farmers, revealing that literacy standards are low in Northern Ghana. Average household size is high for the sampled farmers (10 persons). The results revealed that the main reason for maintaining large household sizes is to ensure adequate supply of family labour for rice production activities. Larger families also enable household members to earn additional income from non-farm activities. Average farm size also differs between irrigators (1.3 ha) and non-irrigators (2 ha). Thus, non-irrigators own bigger plots. They also received greater number of extension contacts (four times) as compared with irrigators (three times). The results show that there is limited supply of irrigated land in the study area as against demand. Thus, land fragmentation characterizes the irrigation system of farming in the study area. In terms of experience in rice cultivation, the findings show that non-irrigators had an average of 14 years of accumulated rice farming as compared to ten years for irrigators. This shows that non-irrigated rice farmers use their accumulated farming experience to guide them in planting and in the application of fertilizers and weeding. Result on the credit facilities indicates that average credit availability to rice farmers appeared to be inadequate compared with the input requirements of rice farming which is 1.5 Cedis for non-irrigators and 1.7 Cedis for irrigators. The mean yield for sampled farmers was 1,984 kg/ha. It is high for non-irrigators (2,115 kg/ha). However, this finding suggests a difference in the quantities of inputs used. For example, average use of fertilizer is 321 kg/ha and 227 kg/ha, respectively, for non-irrigators and irrigators. The difference could also be attributed to the longer rice farming experience of the non-irrigators as well as the possession of large family sizes that offers them various forms of labour (children and adults, both men and women) for rice activities.

Tashikalma *et al.* (2014) studied on swamp rice production in Ogoja Local Government Area of Cross River State, Nigeria; an imperative for rice value chain of the agricultural transformation agenda. The study revealed that majority of the respondents (69.10 %) are aged between 41-60 years with a mean age of 47 years. The farmers are relatively older and their productivity is expected to decline. Rice cultivation is dominated by males (93.30%) and majority of them are married (78.30%). Rice farmers are educated (88.40%) and education has been found to be a catalyst in farmers' adoption and productivity. Furthermore, 91.70 % of the respondents

cultivated between 1 and 3 hectares with a mean holding of 1 hectare. Similarly, majority (58.90%) of the respondents are well experienced in the range of 11 years and above in rice farming. Rice farmers are characterized by small family sizes of 1-5 members with a mean family size of 6 people, a repository of labour for production activities. Also, 74.20 % of the respondents had farming as their major occupation and majority (72.50%) of them obtained their farm land for rice production through purchase.

Ogundari (2008) determined resource-productivity, allocative efficiency and determinants of technical efficiency of rain-fed rice farmers: A guide for food security policy in Nigeria; the result of the farmer's socio-economic variables shows that an average age, years of schooling, number of contact with extension agents and access to credit are approximately 42 years, 10 years, 6 and 0.64 respectively were obtained from the analysis. This shows that the farmers were relatively young. Similarly, numbers of the extension contacts and access to credit shows that an average farmer has access to extension message and credit (over 60 percent have access to credit). An average credit amount of ₦ 68, 300 was accessed by the over 60% of the respondents ranging between ₦ 20, 000 and ₦ 150, 000 with 8% interest rate payable within a year.

Kadiri *et al.* (2014) studied on resource-use and allocative efficiency of paddy rice production in Niger- Delta region of Nigeria and result on the socio-economic characteristics of the rice farmers in the region revealed that, most of the respondents fell within the age group of 36 – 55years which was about 62.66% of the total sample, with a mean of 49 years. This implied that rice farming is being practiced by middle aged farmers. This showed that rice farmers who belong to the middle age classes, who are physically fit to withstand the stress and risks involved in rice production, and are more mentally alert to embrace new techniques of rice production. Also, rice production in the study area was dominated by male farmers who comprised 64.33% of the sampled farmers. The result also showed that 69% of rice farmers were part time farmers and 70.00% were married; this implied that rice farmers were people with high responsibility who needed income from other sources to meet up with their financial obligations. The study also showed that rice farming has been a long time practice amongst the farmers in the study area which on the average was 17 years. The level of education attained was (6 – 10 years) on the average and the experience attained over the years will assist the farmers to be able to adopt new technologies. The result showed that farmers in the study area were small – scale farmers (2.32 hectare) and this

small farm size make mechanization difficult thereby limiting output of rice to subsistence level leaving little for commercial.

A study on relative economic efficiency of farms in rice production: a profit function approach in North Central Nigeria was carried by Okoruwa *et al.* (2009); it focused on the production efficiencies of small and large scale rice farmers revealed that, small scale farmers were relatively younger than the large scale farmers. A striking result is that no female was found among the large farmers which may be attributed to lack of access to productive resources. No significant difference existed in the educational status and the farming experience among the two farming categories. The average educational levels for both the small scale farmers and the large scale farmer are 7 years and 8 years, respectively, while the average farming experience for both small scale and large scale farmers are 23 years and 27 years, respectively. However, the extent of resource use differed significantly; 109 man-days were required for the large farmers compared to 79 man-days in the case of small farmers per hectare. This is expected due to farm size difference but the same was observed in the choice of seed variety. This could be as a result of non-availability of improved seed to smaller farms and where available is usually costly.

The result on the socio-economic characteristics of rice farmers as studied by Ataboh *et al.* (2014) on the determinants of technical efficiency among rice farmers in Kogi State, Nigeria revealed that the mean age of farmers was 43 years. This suggests that most of the farmers are young people who are still strong and full of energy to make meaningful impact in agricultural production. Also, the average household size was five persons while the average farming experience was 17.8 years. The farmers had a low level of education as their average years of formal educational attainment were about 6.3 years. This will likely limit the farmers' ability to seek deciphers and make good use of information on inputs. The farmers had a farm size of 2.3 hectares on an average, implying small scale rice farming in the study area. Furthermore, the rice farmers in the study area has little access to improved rice varieties as only about 10.4% used improved varieties.

Enwerem and Ohajianya (2013) studied on farm size and technical efficiency of rice farmers in Imo State, Nigeria. They focused on large and small scale rice farmers; their findings revealed that 89.70% of the large scale farmers and 71.60% of the small scale farmers were males, respectively, while only 10.30% of the large scale and 28.40% of the small scale farmers were females respectively. The larger proportion of respondents was male, indicating that rice

production was dominated by males in the study area. Majority (74.10%) of large scale and (77.50%) of small scale rice farmers falls in the age bracket of 41-51 years, which could be classified as the active and productive age. Also 55.20% of large scale and 50% of small scale farmers had household sizes of 9-12 persons, which implies that most of the labour force would be supplied by the household members. Educationally, 56.90% of the large scale and 57.90% of the small scale farmers spent 7-12 years in formal education, which implies that the rate of adoption of innovation is expected to be high in the study area. Also, 48.30% of the large scale and 46.10% of the small scale farmers have been in rice production for 11-15 years, which implies that many of the farmers have acquired enough experience in rice production to enable them earn higher profit and allocate resources more efficiently in rice production. On extension contact, 60.30% of the large scale and 48% of the small scale farmers had 1-2 visits per annum, which implies that extension visits to the rice farmers were poor in the study area. It was found that 96.50% of the large scale and 95.10% of the small scale farmers were married, which indicates how responsible the farmers were to their various households. The study showed that 39.70% of the large scale and 28.50% of the small scale farmers obtained funds for their production activities through their personal savings, which implies that the formal credit institutions were not being utilized possibly due to their stringent loan conditions.

### **2.3 Profitability of Rice Farmers**

Isa *et al.* (2012) studied on resource use efficiency and rice production in Guma Local Government Area of Benue State: An Application of Stochastic Frontier Production Function, examined three categories of rice farmers which includes the small, medium and large scale rice farmers. They found out that the average total variable cost of small, medium and large scale rice farmers per hectare were ₦56, 566.510, ₦50, 056.620 and ₦41, 545.351, respectively. Per hectare cost of rice production for the scale category were: Labour cost accounted for ₦40, 915.660, ₦32, 825.000 and ₦19, 172.188, respectively of the total variable cost, large scale farmers spent less money on labour compared with farmers in small and medium scale farms. This suggests that large scale farmers employed the use of machine (tractor) to compliment labour in the process of production. The results also revealed that, on the average, small and medium scale farmers produced 2,433kg and 2,601kg of rice, while large scale rice farmers produced 2,640.6kg of rice/ha, a figure greater than that of small and medium scale rice farmers. The gross margin obtained for small, medium and large was ₦13, 382.600; ₦24, 722.148 and ₦34, 371.899

respectively, total revenue for small, medium and large scale farmers was ₦43,183.910, ₦ 25,334.472 and ₦7,173.452 respectively. The return on gross margin, which is a measure of financial success or failure for small, medium and large scale, was 0.24, 0.49 and 0.83 indicating that, on the average a gross margin of 24 kobo, 49 kobo and 83 kobo.

Manum (2013) studied on the comparative analysis of resource use efficiency in rice production among *Fadama III* and non-*Fadama III* beneficiary rice farmers in Niger state. He used gross margin, net farm income and return on naira invested and found out that, farmers who sold their produce early received lower price than those who sold later. Paddy rice sold at farm gate is the cheapest in a season. The results showed that *Fadama III* beneficiary rice farmers produce an average yield of 2.16 tons per hectare and sold at an average price of ₦49,808.07 per ton while the non-*Fadama III* beneficiary rice farmers produce an average yield of 1.17 tons per hectare and sold at an average price of ₦48,957.15. The results also revealed that the total cost of production for *Fadama III* beneficiary rice farmers was ₦40,025.52 per ha against ₦28,729.6 per ha for the non-*Fadama III* beneficiary rice farmers. The total variable cost for the *Fadama III* rice farmers was ₦38,297.06 against ₦27,095.51 per ha for the non-*Fadama III* rice farmers. The total variable cost constitutes 95.68% and 94.08% of the total cost for the *Fadama III* and non-*Fadama III* rice farmers, respectively. This reflects the small scale nature of rice production in Niger State with fixed costs accounting for only 4.32% and 5.92% of the total costs for the *Fadama III* and non-*Fadama III* beneficiary rice farmers respectively. *Fadama III* rice farmers had a total revenue of ₦107,585.43, made a gross margin of ₦69,288.37 per ha and a net farm income of ₦67,559.91 per ha while the non-*Fadama III* rice farmers had a total revenue of ₦57,279.86, made a gross margin of ₦30,250.36 per ha and a net farm income of ₦28,550.26 per ha. The *Fadama III* rice farmers recorded a return on Naira invested of ₦1.81 while the non-*Fadama III* rice farmers made a return on Naira invested of ₦1.21. This means that on every Naira invested, the *Fadama III* rice farmers made 1.181 Naira while the non- *Fadama III* beneficiary rice farmers made 1.121 naira.

Kadiri *et al.* (2014) studied on resource-use and allocative efficiency of paddy rice production in Niger Delta region of Nigeria using Gross Margin and Net Farm Income analysis and discovered that the average total revenue (paddy rice) was ₦653,963.44 per hectare obtained from 4713.25kg of paddy rice. Total operating cost amounted to ₦334,916.60 or 95.18% of the total cost of production, out of which labor cost was ₦324,663.00 or 96.93% of total production cost while fixed cost (₦16,975.00) accounted for 4.82% of the total cost of production. The net

farm income of rice farmers as revealed from the research was ₦300, 071.84 per hectare which indicated that rice production is profitable. Rice farmers on the average made a net return of ₦264, 063.22 per hectare that resulted in a return of 0.80k for every one naira invested. The average gross margin of rice enterprise as found in the study was ₦319, 046.84 per hectare; this positive gross margin showed that rice enterprise is profitable.

Tashikalma *et al.* (2014) studied on swamp rice production in Ogoja Local Government Area of Cross River State, Nigeria. An analysis of the budgetary techniques based on per hectare of rice production revealed associated cost and revenue. They revealed that swamp rice production generate a total revenue of ₦121,327.06 per hectare, while variable and fixed cost were ₦29, 723.05 and ₦2, 618.00 per hectare, respectively. The gross margin and net farm income were ₦91, 604.01 and ₦88, 986.01, respectively. The result shows that rice production was a profitable venture in the study area.

#### **2.4 Technical, Allocative and Economic Efficiency of Rice Farmers**

Akinbode *et al.* (2011), in a study on the examination of technical, allocative and economic efficiencies in *Ofada* rice farming in Ogun State, Nigeria revealed that all the estimated coefficients of the variables of the production function were positive. The positive coefficient of farm size, hired labor, seed, fertilizer and insecticide implies that rice output increases with increase in these variables. However, the t-ratio value of family labour and insecticide were found not to exert any significant effect on rice output. The implication of this is that increase in the level of use of family labor and insecticide will not increase output of rice in the study area. The Return to Scale (RTS) parameter (1.209) was obtained from the summation of the coefficients of the estimated inputs (elasticities) which indicates that rice production in the study area was in stage II of the production surface. Stage II is the stage of increasing positive return to scale This implies that efforts should be made by the farmer to expand the present scope of rice production to actualize the potential in it. More of the variable inputs could be employed to obtain more output. Efficiency analysis of rice production in the area revealed that technical inefficiency effects existed in rice production in the study area as confirmed by the gamma value of 0.979 at 1% level of significance, this implies that about 98% variation in the output of rice farms was due to differences in the technical efficiencies of the rice farmers; the sigma-square had a value of 0.061 which is significant at 1% level, indicating that there is 6.1% presence of technical inefficiencies. The Technical efficiencies (TE) ranged between 0.371 and 0.996 with a mean of 0.726 as revealed in

their study. The wide variation shows possibility for improvement by some farmers. The study posit that if the average farmer in the study area was to achieve the technical efficiency of his most efficient counterpart, then the average farmer could realize a 27.1% cost saving (that is,  $1 - (0.726/0.996)$ ) or increase in output. Similarly, they also discovered that the most technically inefficient farmer will increase output by 62.8%, that is,  $1 - (0.371/0.996)$ .

Further, economic efficiency result revealed that there was economic inefficiency effect as shown by the gamma value of 0.969 in the cost function which was significant at 1% level. This implies that about 96.9% of the total variation in total cost of production incurred by each farmer was due to differences in their cost efficiencies. The predicted economic efficiency (EE) of the farmers ranged between 0.409 and 0.85 with a mean value of 0.674. This implies that if the average farmer is to achieve the economic efficiency of his most efficient counterpart, the average farmer could realize a 20.7% cost saving, that is,  $1 - (0.674/0.85)$ . This also means a cost saving of 51.9% for the most economically inefficient farmer (that is,  $1 - (0.41/0.85)$ ). Allocative efficiency result ranged between 0.74 and 0.985 with a mean value of 0.928. This means that if the average farmer was to achieve the allocative efficiency level of his most efficient counterpart, the average farmer could realize a cost saving of about 5.8% while the most allocatively inefficient farmer could realize a cost saving of about 24.9%.

Shehu and Mshelia (2007) studied on productivity and technical efficiency of small-scale rice farmers in Adamawa State, Nigeria. Their findings showed that land factor appears to be the most important factor of production with an elasticity of 0.828 which implies that a unit increase in farm size will result in 0.828% in output, followed by labour (0.364), fertilizer (0.141). The RTS as revealed by the study was 1.06 indicating increasing return to scale and that production was in stage 1. The variance ratio ( $\gamma$ ) was 0.893, suggesting that systematic influences that are unexplained by the production function are the dominant sources of random errors. This means that 89.3% of the total variability of rice output for the farmers was due to differences in technical efficiency, while a sigma-square ( $\delta^2$ ) value of 0.302 was obtained, suggesting the goodness of fit and correctness of the distributional form assumed for the error term, which indicates 30.2% technical inefficiency. The estimated coefficients of the variables of the inefficiency model tells about the contribution of the variables to technical efficiency, for example age was estimated to be positive indicating that age led to technical inefficiency of the rice farmers, household size was likewise positive which led to technical inefficiency, the coefficient of education was estimated to be

negative which entail greater technical efficiency. The study revealed the predicted value of technical efficiencies for the farmers range from 0.740 to 0.989 with a mean of 0.957. This mean that, on the average, the efficiency of farmers fall 4.3% short of the maximum possible level and 1.1% from the best practice farmer. They also found out that more than 93% of the rice farmers had technical efficiencies above 90% suggesting that majority of the sampled rice farmers had high technical efficiency in rice production given the prevailing technology.

In another study conducted by Shehu *et al.* (2007) on the analysis of technical efficiency of small-scale rain-fed upland rice farmers in North-West Agricultural Zone of Adamawa State, Nigeria. The maximum-likelihood estimates (MLE) for the parameters of the Cobb-Douglas production function revealed that all except the labour variable had the expected positive signs, suggesting that more rice output would be obtained from the use of additional quantities of these variables. The coefficient of land was found to be positive and statistically significant at 5% level of significance this was because of its importance in crop production in the sense that its shortage would not only have a direct negative effect on production but also an indirect negative effect on output through reducing the marginal productivity of non-land inputs. The elasticities with respect to land, seed and fertilizer were positive and between 0 and 1 which indicates that allocation and use of the resources were in the rational stage of production process. The RTS was 0.37 suggesting decreasing returns to scale. This indicates that a unit increase in the quantities of the production resources would lead to less than proportionate increase to the output of rice.

The variance ratio ( $\gamma$ ) was estimated to be 0.935 suggesting that some systematic influences were unexplained by the production function which were the dominant sources of random error. This indicated that 93.5% of total variability of rice output for the farmers was due to differences in technical efficiency, but model variance that is sigma-square ( $\delta^2$ ) was estimated to be 0.053 indicating the goodness of fit of the model. Their analysis of technical inefficiency revealed that all the included variables except age had the expected sign. The coefficient of age was estimated to be positive which suggested that age leads to technical inefficiency of the rice farmers. The predicted Technical Efficiencies (TE) of the farmers ranged from 0.56 to 0.99. The mean TE of 0.93 indicated that the average farmer produced about 93% maximum attainable output for given input with a short fall of 7%. Also, they found out that more than 88% of the respondents were more than 80% technically efficient. The best practice farmers operated at about 99% efficiency

with also a short fall of 1%, while the least practice farmers were found to operate at about 56% efficiency level.

Isa *et al.* (2012) studied on resource use efficiency and rice production in Guma Local Government Area of Benue State: an application of stochastic frontier production function. The variance parameters for  $\delta^2$  and  $\gamma$  as revealed are 0.2237, 0.2913, 0.3902 and 0.5209, 0.5999, 0.6634 for small, medium and large scale farms, respectively. They were significant at 1% level. The sigma squared,  $\delta^2$  indicate the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma ( $\gamma$ ) indicates the systematic influences that are unexplained by the production function as dominant sources of random errors. This means that the inefficiency effects make significant contribution to the technical inefficiencies of rice farmers. The result further shows that inefficiency effects were present and significant as labour appears to be the most important factor of production with an elasticity of 0.8406, 0.8999 and 0.9319 for small, medium and large scale farm sizes respectively, showing the labour intensive nature of farming in the study area. Farm size coefficient was found to be positive and significant at 1% level in all the farms operations, i.e., 0.5485, 0.5499 and 1.2222 for small, medium and large scale farms respectively. Statistically, the magnitude of the coefficient of the farm size shows that output is inelastic to small and medium scale farms. The production elasticity of output with respect to quantity of fertilizer was 0.1796, 0.6665 and 0.8099 for small, medium and large farms scale respectively. Planting materials and pesticides from all the farm sizes was positive and significantly different from zero. This implies that planting materials and pesticides are important in rice production in the study area.

The sources of inefficiency was examined and result revealed that the coefficient of education variable in small scale farm was estimated to be negative, that is (-0.4558) and statistically significant at 1% level. The implication is that farmers with more years of formal schooling tend to be more efficient in rice production. Household size coefficients of the small scale farm indicates negative sign (-0.2990), this implies that small scale farm household sizes are more technically efficient since small scale farmers do not make use of hired labour, hence, the cost of hiring labour is saved. The positive coefficient for age (0.6667) variable in small farm sizes implies that the older farmers are more technically inefficient than the younger ones. The coefficient of farming experience in small scale farms was shown to be negative, that is (-0.6912) and statistically significant at the 1% level. The implication is that farmers with more years of

farming experience tend to be more efficient in rice production. While the coefficients of education (-0.7011), household size (-0.8493), age (-0.7009) and farm experience (-0.9373) in medium farm sizes have negative sign. This implies that farmers' personal characteristics do not contribute to farm inefficiency. The large scale inefficiency coefficients indicate negative scores for education (-0.7741), age (-0.8380) and farm experience (-0.9373), except household size which have positive sign (0.5279), the positive coefficient for the household size implies that the large scale farm constitute small household sizes as such the farmers embark on hired labour. The technical efficiency rating of the farmers revealed that more than 50% of the respondents in small, medium and large scale farms were found to be more than 32.8%, 54.4% and 68% technically efficiency, while 67.2%, 45.6% and 32% of the respondents in small, medium and large scale farms were found to be less than 50%. The most efficient farmer operated at 59%, 69% and 79% for the small, medium and large scale farms, while the least efficient farmer was found to operate at 11%, 39% and 49% efficiency level for small, medium and large scale farms. Rice farmers on average were found to be technically efficient at 35%, 47% and 54% for small, medium and large scale farms, respectively.

Fadil and Mitsuyasu (2011) studied on the evaluation of technical, allocative, and economic efficiency in rice production; a case study on rice farmers in Brunei Darussalam. From the estimated gamma ( $\gamma$ ) value is 0.64, suggesting that systematic influences that are unexplained by the production function were the dominant sources of random errors. This indicated that 64 percent of the total variability of rice yield for the farmers was due to differences in technical efficiency among farmers. In other words, rice output can be optimized if the technical efficiencies among farmers are minimized while model variance estimate was 0.38 which indicate the goodness of fit and correctness of the distributional form of the composite errors. Result on frequency and percentage distribution of Technical, Allocative and Economics Efficiencies of rice farmers in the study area shows that TE of rice farmers range from 23.3% to 99.7% and the mean of TE is 76.3%. This indicates that the 'best' practice farmer operated at 99.7 percent efficiency, while the 'least' practice farmers were found to operate at about 23.2% level. Also, from the result more than 48% of the farmers were more than 80% technically efficient. The AE indices of rice farmers range from the lowest of 1.8% percent to the highest of 85.3% with a mean AE of 65.7%. The mean EE was 53.1%, with indices ranging from 0.4% to 77.5%.

In a study conducted by Tijani and Bakari (2014) on the determinants of allocative efficiency of rain-fed rice production in Taraba State, they recorded 0.69 as the average measure of allocative efficiency in the area. This suggests that respondents were about 69% allocatively efficient while the remaining (31%) short fall was attributed to their allocative inefficiencies. The minimum and maximum measures of allocative efficiencies were 0.51 and 0.90, respectively. This implies that the least allocatively efficient farmer was 51% efficient whereas, the most allocatively efficient farmer was 90% efficient. Thus, if the average rice farmers in the area were to achieve the level of allocative efficiency shown by the most efficient farmer, then they would realize a cost saving of 23.33%. They further revealed that about 83% of the farmers had allocative efficiency from 0.61 and above, indicating that on the relative term most of the respondents were fairly efficient in allocating their cost structure in course of rice production.

## **2.5 Constraints Associated with Rice Production**

Tashikalma *et al.* (2014) in their study on swamp rice production in Ogoja Local Government Area of Cross-river state identify that high cost of labour (75.80%), land tenure problem (67.50%), poor market system (63.30%), lack of finance (60.00%), poor storage facility (55.80%) and inadequate supply of inputs (53.30%) were major constraints experienced by the respondents.

Rice farmers in Niger State face various types of constraints that have not allowed them to operate more profitably and optimally. Manum (2013), in his study on comparative analysis of resource use efficiency in rice production among *Fadama* III and non-*Fadama* III beneficiary rice farmers in Niger state found out that lack of tractor hiring service, low soil fertility, lack of finance, low price of local rice, competition from imported rice, high cost of fertilizer and inadequate storage facilities were regarded as very serious constraints by both *Fadama* III and non-*Fadama* III beneficiary rice farmers. In addition, *Fadama* III beneficiary rice farmers also see poor credit accessibility as a very serious constraint while the non-*Fadama* III beneficiaries in addition see lack of high yielding seeds as a very serious constraint. Both groups regarded high production cost as a serious constraint. In addition, the non-*Fadama* III beneficiary rice farmers also see land acquisition as a serious constraint, a constraint that the *Fadama* III rice farmers regarded as not serious.

A study carried out in Southern Thailand by Sirirat (2008) on ‘assessing economic and environmental efficiency of rice production systems in southern Thailand’ found out that the most severe problems of rice production in southern Thailand were; high cost of chemical inputs (chemical fertilizer and pesticide), water shortage or drought, which was related to the rainfall statistics in the study area, low output price, which was related to low negotiation power of the farmers, low land productivity, ineffective extension services, low seed quality, lack of technical knowledge and labour shortage.

In Cross River State, Ajoma *et al.* (2016) studied on allocative efficiency of rice production in Cross River State, Nigeria. The study revealed constraints militating against rice production in the study area to include; high cost of fertilizer (99.1%), pest and disease attack (96.3%), high cost of labour (95.9%), weeds control (90.0%), inadequate capital (89.0%), inadequate supply of farm input and lack of modern farm equipment (86.3%), lack of credit facilities (84.5%), poor access roads (83.1%), risk and uncertainties (79.0%) and land tenure system (78.1%). From the result it is depicted that high cost of fertilizer, pest and disease attack, and high cost of labour constitute the major production constraints farmers in the study area faced.

Matanmi *et al.* (2011) studied on perceived factors limiting rice production in Patigi Local Government Area of Kwara State, Nigeria discovered that perceived factors limiting rice production include lack of rice processing machines (59.1%), financial constraints (42.7%), illiteracy (30.0%), poor access to input (22.7%), pest and disease (21.0%), poor transportation (11.8%), fluctuation in climate (11.8%), lack of extension service (10.9%) and lack of storage facilities 10.9%, respectively

Tiku *et al.* (2017) studied on socioeconomic factors affecting local rice production in Biase Local Government Area of Cross River, Nigeria and revealed they following constraints: lack of good road infrastructure, high cost of labour, lack of adequate investment capital, land fragmentation and tenure, poor storage and processing facilities, high cost of agricultural inputs and pests and diseases infestation. However, lack of adequate investment capital (23.73%), poor storage and processing facilities (20.33%) and high labour cost (16.95%) are the key constrains of the rice farmers in the area.

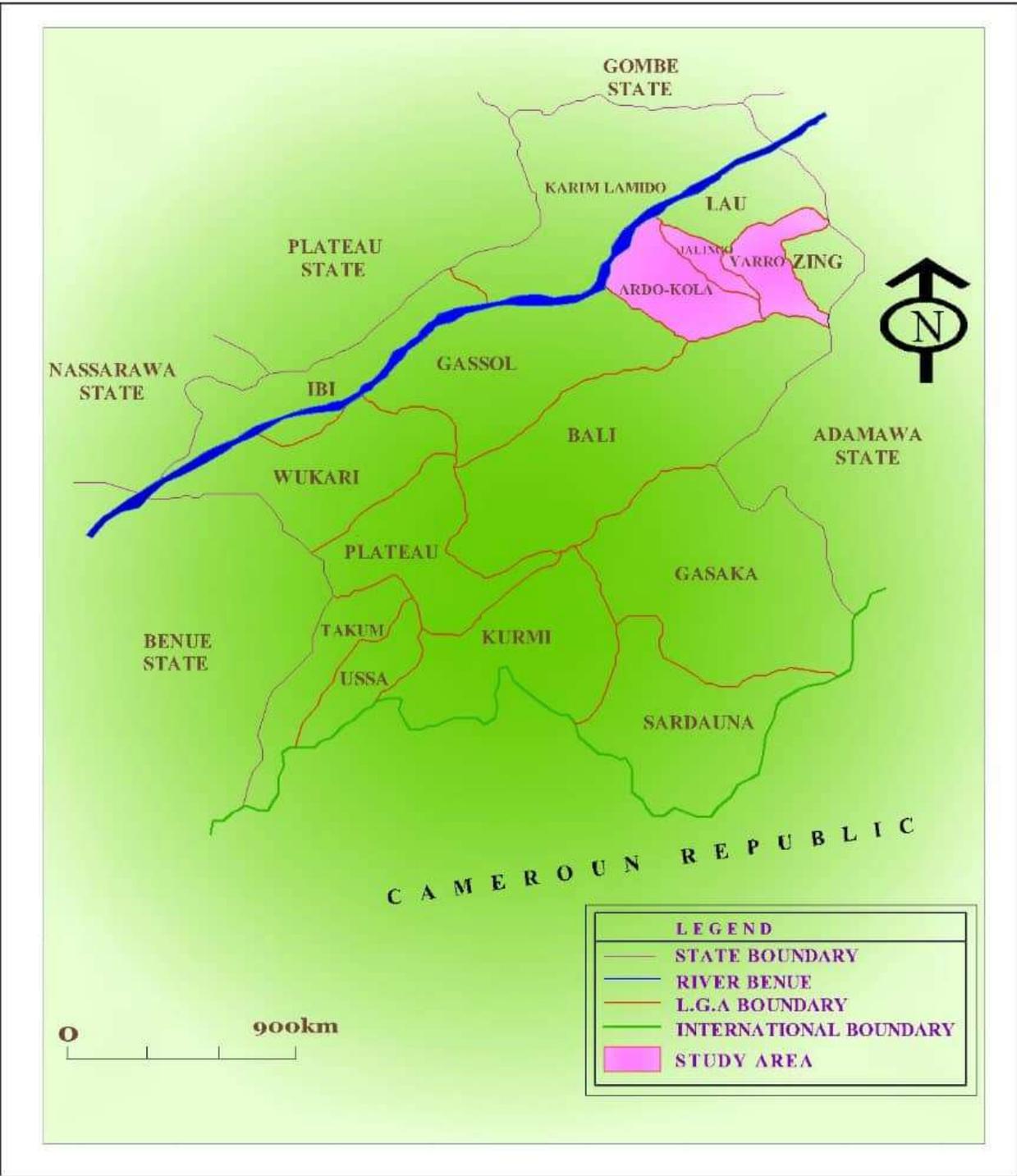
## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 The Study Area**

The study was conducted in Northern Taraba State, Nigeria namely Ardo-kola, Jalingo and Yorro. The choice of the study area was informed by the fact that they are among the major rice producing local government areas of Taraba State. Taraba State comprises of 16 Local Government Areas. It is located in the North-eastern part of Nigeria (Figure1). The State lies between latitudes  $6^{\circ} 30'$  and  $9^{\circ} 36'$  North of the equator and between longitudes  $9^{\circ} 10'$  and  $11^{\circ} 50'$  East of the Greenwich meridian (Taraba State Diary, 1999). The State has a land area of 59,400 km<sup>2</sup> with a population of 2,300,736 people and projected to be 2, 875, 920 people at 2.5% by the end of 2019 (Federal Republic of Nigeria Official Gazette, 2006). The state shares a common boundary with Bauchi State in the north and Gombe State in the north east, Adamawa State in the east and Plateau State in the North West. The state is further bounded to the West by both Nasarawa and Benue states, while it shares an international boundary with the republic of Cameroun to the south and south east (Taraba State Diary, 1999).

The State has two distinct climatic seasons-rainy and dry seasons. The rainy season starts in April and ends in October. The wettest months are August and September. The mean annual rainfall ranges from 800mm in the north to over 1800mm in the south. The dry season, on the other hand, starts in November and ends in April. The mean daily temperature ranges between 14.8°C and 34.4°C. The State is predominantly agrarian in nature, with majority (80%) of its inhabitants depending on subsistence agricultural practices mainly in food production. The climate, soil and hydrology of the study area provide good atmosphere for the cultivation of most staple food crops, grazing of animals, fresh water fishing and forestry. The dominant soil groups in the state are ferruginous (gleric, luvisol, eutric, regosol and ferric luvisol) found in the north and entisols along the southern parts. The central parts of the state are covered with vertisol and ultisol groups. The main vegetation cover of the state is the guinea savanna, the topography is essentially marked with mountainous land transverse by large river valley such as Benue, Taraba, Donga and Bibinu. The valleys of Mambila and Fali mountains form part of this undulating landscape of the state.



**Figure 1: Map of Taraba State showing Jalingo, Ardo-kola and Yorro Local Government Areas (Study Area)**

**Source: GIS, Laboratory, Geography Department MAUTECH, 2017**

The rich alluvian tract of the soil found in most part of the state makes Taraba state conducive for growing various food and cash crops. Examples of food crops grown includes; maize, rice, yam, cassava etc., while livestock reared includes cattle, goats, sheep, poultry birds etc. The main farming system practiced in the area is either mono cropping or mixed cropping. The ethnic groups found in Taraba State are Jukun, Wurkun, Jenjo, Hausa-Fulani, Mumuye, Chamba, Ichen, Kuteb and Tiv among others (Tijjani, 2010).

With regard to infrastructural facilities, the state has federal, state and private Universities as well as colleges of Education and Agriculture, and Polytechnic. Banks facilities are also available, but restricted only to major towns such as Jalingo, Wukari, Takum towns among others in the State. Similarly, urban and village markets are found within the State where agricultural produce and other commodities are transacted. In fact, almost all the villages within the State have market outlets. Some rice markets include Yelwan Tau, Yelwan Abbare, Mayo-Lope, Mutum-Biyu, Mararraba Gassol, Gassol, Tella, Sabon Gida, Dan Anacha, Bantaje, Gareji, Chanchaji, Mai-Hula, Gazabu. The State is connected by major road network linking Benue State with Adamawa State through Jalingo and Wukari Local Government Areas. However, five (5) out of the Local Government Areas have difficult terrain due to poor access roads. These are Karim Lamido, Lau, Yorro, Donga and Kurmi Local Government Areas. In terms of electricity, there is mostly an epileptic power supply that jeopardize economic activities in the state that led the few rice milling industries found in the State to use individual generators. However, milling industries for rice are found in urban areas, but they are inadequate considering the production output in the state.

### **3.2 Sampling Techniques and Sample Size**

The study combined both purposive and simple random sampling techniques for the selection of respondents. The purposive sampling technique was employed to select Ardo-kola, Jalingo and Yorro LGAs and six (6) rice farmers' association in the study area popularly known as 'clusters' in Sunkani, Mayo-Ranewo, Kona, Wuro sambe, Koffai and Lankaviri 'cluster' for the study. This is because these areas are well identified with rice production. A total of 180 respondents were selected at random, that is, the samples was drawn one at a time, giving every respondent equal chance of being represented based on their proportionate size. Table 2 indicates the sampling procedure and selection of farmers.

**Table 2:** List of Registered Rice Farmers in the Study Area

S/N	Local Government Areas	Rice Farmer Cluster	Membership	No. of Farmers Selected
1	Ardo-kola	Mayo Ranewo Rice Cluster	152	22
		Koffai Rice Cluster	235	33
		Sunkani Rice Cluster	397	56
2	Jalingo	Kona Rice Cluster	134	19
		Wuro Sambe Cluster	176	25
3	Yorro	Lankaviri Cluster	175	25
		Total	1269	180

Source: Taraba State Agricultural Development Programme (TADP), 2017

However, the selection of the farmers was based on this formula as adopted by Kehinde, *et al.* (2012):  $n_1 = \frac{n}{N} \times N_1 \dots$  eqn. (4)

Where;

$n_1$ = number of farmers selected

$n$ = sample size

$N$ = total population of the rice farmers

$N_1, N_2, N_3, N_4, N_5, N_6$ = population of rice farmers in each cluster

### 3.3 Methods of Data Collection

This study made use of primary data from the sampled farmers. Collection of data for the study was achieved by using a set of well-structured questionnaire which was administered through personal interview by the researcher and two other enumerators. The enumerators are those who were conversant with the respondents. The use of the enumerators was to ensure that access to the right respondents is achieved. The researcher ensured strict monitoring of the enumerators in the administration of the questionnaires. Data on the socio-economic characteristics of the farmers included; marital status, level of education, sex, age, occupational status, improved seed variety, household size, years of experience, extension contact and access to credit. In an attempt to determine production efficiency of rain-fed rice, information on the level of output (kg), farm size (ha), family labour (mandays), hired labour (mandays), fertilizer (kg), seed quantity (kg) and agrochemicals (Lt) were collected.

### 3.4 Analytical Techniques

#### 3.4.1 Descriptive Statistics

Descriptive statistics such as means, frequency distribution and percentages were used to describe the socioeconomic characteristics of rice farmers and constraints confronting rice farming in the study area.

##### 3.4.1.1 Gross Margin Analysis

Gross margin analysis which involves the profitability of an individual rice farm, so that comparison can be made between farms. The purpose of this analysis is to identify the cost, returns and profitability of the farmers. It is given as:

$$GM = TR - TVC \dots \text{eqn. (5)}$$

where:

GM = Gross Margin (₦)

TR = Total Revenue (₦)

TVC = Total Variable Cost (₦) i.e. the cost incurred in the use of variable inputs.

**3.4.1.2 Net Income Analysis:** this is given as the difference between gross margin (GM) and total fixed cost (TFC) of production. It is given as:

$$NI = GM - TFC \dots \text{eqn. (6)}$$

where:

GM= Gross Margin (₦)

TFC= Total Fixed Cost (₦)

TC= Total Cost (₦)

#### 3.4.2 The Stochastic Production Function

A Cobb-Douglas functional form was employed to model rice production technology in the study area to estimate the rice production efficiency, based on the following reasons: (a) the functional form has been used in many empirical studies, particularly, those relating to developing country agriculture (Ajibefun, 2002; and Bravo-Ureta and Pinheiro, 1997); (b) the functional form also meets the requirement of being self-dual, that is, allowing an examination of farm efficiency.

The Cobb-Douglas functional form for the rice farms in the study area is specified as follows for the production functions:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + V_i - U \dots \text{eqn. (7)}$$

where;

$Y_i$  = Output of rice (kg);

$X_1$  = Farm Size in hectares

$X_2$  = Family labour (mandays)

$X_3$  = Hired labour (mandays)

$X_4$  = Seed in kg

$X_5$  = Fertilizer in kg

$X_6$  = Agrochemicals in litres

$V_i$  = Random variable which is assumed to be independently and identically distributed  $N(0, \delta^2_{V_i})$  and independent of  $U$ ;  $U_i$  = Non-negative random variable associated with technical inefficiency in production, and is assumed to be independently and identically distributed  $N(0, \delta^2_{U_i})$ .

The inefficiency model is specified thus:

$$\mu = \delta_0 + \delta_1 W_1 + \delta_2 W_2 + \delta_3 W_3 + \delta_4 W_4 + \delta_5 W_5 + \delta_6 W_6 + \delta_7 W_7 \dots \text{eqn. (8)}$$

where;

$\mu$  = Technical inefficiency effect

$\delta$  = Parameters to be estimated

$W_1$  = Age of farmer in years

$W_2$  = Educational level of farmer (number of years spent in school)

$W_3$  = Household Size

$W_4$  = Years of Rice farming experience

$W_5$  = Extension contact (1 if the farmer has extension contact, 0 if otherwise)

$W_6$  = Access to credit (1 if farmer has access to credit, 0 if otherwise)

$W_7$  = Sex of farmer (1 if male, 0 if otherwise).

### 3.4.2.1 Stochastic Cost Function

In order to estimate economic and allocative efficiencies of the rice farmers, a Cobb-Douglas cost frontier function for rice farms in the study area is specify as follows:

$$\ln C_i = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + \alpha_3 \ln P_{3i} + \alpha_4 \ln P_{4i} + \alpha_5 \ln P_{5i} + \alpha_6 \ln P_{6i} + V_i + U_i \dots \text{eqn. (9)}$$

where;

C = total production cost rice per farmer for the season

P<sub>1</sub>= the rental value of land per hectare

P<sub>2</sub>= the wage rate of family labor per manday

P<sub>3</sub>= the wage rate of hired labor per manday

P<sub>4</sub>= the cost of rice seed per kilogramme

P<sub>5</sub>= the cost of fertilizer per kilogramme

P<sub>6</sub>= the cost of agrochemicals per liter

$\alpha$  = parameters to be estimated.

Cost inefficiency effects thus as:

$$\mu = \delta_0 + \delta_1 W_1 + \delta_2 W_2 + \delta_3 W_3 + \delta_4 W_4 + \delta_5 W_5 + \delta_6 W_6 + \delta_7 W_7 \dots \text{eqn. (10)}$$

where;

$\mu$ = cost inefficiency effect

$\delta$ = Parameters to be estimated

W<sub>1</sub> = Age of farmer in years

W<sub>2</sub> = Educational level of farmer (number of years spent in school)

W<sub>3</sub> = Household Size

W<sub>4</sub> = Years of Rice farming experience

W<sub>5</sub> = Extension contact (1 if the farmer has extension contact, 0 if otherwise)

W<sub>6</sub> = Access to credit (1 if farmer has access to credit, 0 if otherwise)

W<sub>7</sub> = Sex of farmer (1 if male, 0 if otherwise).

### 3.4.2.2 Test of Hypothesis

To test for the presence of inefficiency effects, Log likelihood ratio test was used as adopted by Battese and Coelli (1995).

It is given by:

$$LR = -2 \left\{ l(H_0) - L(H_1) \right\} \dots \text{eqn. (11)}$$

where;

LR=Log likelihood Ratio test

L (H<sub>0</sub>) = Log likelihood function of restricted model

L (H<sub>1</sub>) = Log likelihood function of unrestricted model

## CHAPTER FOUR RESULTS AND DISCUSSION

### 4.1 Socio-economic Characteristics of the Respondents

#### 4.1.1 Age of the Respondents

The age distribution of the respondents is presented in Table 3; the mean age of the rice rain-fed rice farmers in the study area is 36.32 years. Rain-fed rice farmers that were within the age group of 21 – 30 years constituted 26.7% and those that were within the age group of 31- 40 and 41-50 years constituted 47.7% and 22.6%, respectively, while 3% of the respondents are within the age group of 51-60 years. The minimum age of the farmers is 22 years and the maximum age is 60 years with a standard deviation of 7.49 years. The standard deviation value shows that there is great inequality in the age of the respondents as shown by the large dispersion around the mean age.

These indicated that the majority of the respondents (74.4%) are within the age group of 21-40 years respectively. This shows that rain-fed rice farmers in the study area are at their most active age; therefore they are more energetic to participate in farming activities. The types of activities to be performed by the farmers depends on the age of the farmers, with younger farmers, they are more likely to be involved in farm operations such as threshing, harvesting, planting, herbicide application, planting, land clearing, bagging and weeding.

The result as revealed is similar to the findings of Tijjani and Bakari (2014) who reported that majority (84%) of the rice farmers in Taraba state are within the age bracket of 21-50 years, implying that majority of the respondents were predominantly youths who are vibrant and within the economically active age. Ataboh *et al.* (2014) also revealed that majority of rice farmers in Kogi State, Nigeria has a mean age of 43 years.

**Table 3:** Age Distribution of Respondents

Age (years)	Frequency	Percentage
21-30	48	26.7
31-40	86	47.7
41-50	41	22.6
51-60	5	3
Total	180	100
Mean	36.32	
Std. deviation	7.49	
Minimum age	22	
Maximum age	60	

Source: Field Survey, 2018

#### 4.1.2 Sex of the Respondents

Result on the sex distribution of rice farmers in the study area is presented on Table 4 showed that, majority (147) of the respondents were males which constituted 81.7%, while 18.3% (33) of the respondents were females. This findings indicated that male dominated the rice farming enterprise in the study area as they are mostly household heads and also involved with strenuous activities, while the female counterparts handles food processing and marketing activities.

This was similar to the finding of Manum (2013) who studied on the comparative analysis of resource use efficiency in rice production among *Fadama* III and non-*Fadama* III beneficiary rice farmers in Niger State, Nigeria, and revealed that, majority of *Fadama* III beneficiaries (95%) were male; with only 5% who were females, while 100% of the non-*Fadama* III beneficiary were males. Similarly, Tijjani and Bakari (2014), on their study of the economics of rain-fed rice production in Taraba state revealed that majority (82%) of the farmers were males, while only 18% were females. Also Tashikalma *et al.* (2014) studied on swamp rice production in Ogoja Local Government Area of Cross River State, Nigeria revealed that most (93.30%) of the respondents were males, while females constituted the minority (6.7%).

**Table 4:** Sex Distribution of Respondents

Sex	Frequency	Percentage
Male	147	81.7
Female	33	18.3
Total	180	100

Source: Field Survey, 2018

#### 4.1.3 Marital Status of the Respondents

Marital status of the respondents as presented in Table 5, shows that majority (84.6%) of respondents who constituted 152 were married, while 15.4% (28) of the respondents were singled. The result further revealed that none of the farmers were either divorced or widowed. This implies that most of the respondents have dependents. This was in line with the result of Kadiri *et al.* (2014) who studied on resource-use and allocative efficiency of paddy rice production in Niger-Delta region of Nigeria which revealed that majority (70%) of the respondents were married, while only 30% were females. Also, Enwerem and Ohajianya (2013) studied on farm size and technical

efficiency of rice farmers in Imo State, Nigeria and found out that 96.50% of the large scale and 95.10% of the small scale farmers were married.

**Table 5:** Distribution of Marital Status of the Respondents

<b>Marital status</b>	<b>Frequency</b>	<b>Percentage</b>
Married	152	84.6
Single	28	15.4
Total	180	100

Source: Field Survey, 2018

#### **4.1.4 Educational Level of the Respondents**

An analysis of the educational level of the respondents as presented in Table 6, shows that 6.1% of the respondents have no formal education, majority of the respondents which constitute 88 of them (49%) have tertiary education. Among which 13.2% and 31.7% have primary and secondary education respectively. Therefore, the study revealed that majority (93.9%) of the respondents have attained one form of formal education or the other, hence are expected to have acquired the required knowledge to increase efficiency for their production.

Similarly, report of a study by Seidu (2008) on technical efficiency of rice farmers in Northern Ghana, revealed that the farmers had 8 years as average years of formal education which implies low literacy level among the respondent. Also Okoruwa *et al.* (2009) report on their study on relative economic efficiency of farms in rice production shows that the average year of educational level among small and large scale rice farmers are 7 years and 8 years, respectively which is similar to the finding of Seidu (2008).

**Table 6:** Distribution of Educational Level of the Respondents

<b>Level of Education</b>	<b>Frequency</b>	<b>Percentages</b>
No formal education	11	6.1
Primary education	24	13.2
Secondary education	57	31.7
Tertiary education	88	49
Total	180	100

Source: Field Survey, 2018

#### 4.1.5 Household Size of the Respondents

The distribution of the household size of the respondents is presented in Table 7; 57.3 % of the rice farmers had a household size of 1-5 persons which constituted the majority in the study area, followed by 28.9% who had a household size of 6-10 persons. The lowest proportion of the respondents (0.6%) had a household size of 21-35 persons. The mean household size of the farmers in the study area is about six persons with a minimum household size of 1 person and maximum of 30 persons with a standard deviation of about five persons. This implies that there is reduced inequality in household size distribution as seen by the value of mean.

Enwerem and Ohajianya (2013) studied on farm size and technical efficiency of rice farmers in Imo State, Nigeria. They focused on large and small scale rice farmers; their findings revealed that, 55.20% of large scale and 50% of small scale farmers had household sizes of 9-12 persons. Their report is similar to this findings of the study which revealed that majority (86.2%) of the farmers had household size of 1-10 persons.

**Table 7:** Distribution of Respondents According to Household Size

Household size (number)	Frequency	Percentage
1-5	103	57.3
6-10	52	28.9
11-15	19	10.5
16-20	2	1.1
21-25	1	0.6
26-30	3	1.7
Total	180	100
Mean	5.76	
Std. Deviation	5.00	
Minimum	1	
Maximum	30	

Source: Field Survey, 2018

#### 4.1.6 Primary Occupation of the Respondents

Result on primary occupation of rice farmers in the study area revealed that most (62.30%) of respondent's primary occupation is farming. Business was found to be the next occupation of the farmers. However, 6.67% were applicants, 11.12% were civil servants and 5.56% were found to be motorcyclists. This result is similar to that of Ahamdu and Erhabor (2012) who found out that farming was the primary occupation of rice farmers in Taraba State, Nigeria.

**Table 8:** Distribution of Respondents According to Primary Occupation

Primary occupation	Frequency	Percentage
Farming	112	62.30
Civil servant	20	11.12
Applicant	12	6.67
Businessmen/ women	26	14.35
Motorcyclist	10	5.56
Total	180	

Source: Field Survey, 2018

#### 4.1.7 Farm Size of the Respondents

The result in Table 9 revealed that 2.8% of the respondents had farm sizes of less than 1 hectare; 63.8% had farm sizes of 1-2 hectares, while 26.7% had farm sizes of 3-4 hectares. This implies that majority (93.3%) of the rice farmers in the study had farm size less than 5 hectares. This result is similar to the findings of Tijjani and Bakari (2014) who found out that majority (85%) of rice farmers in Taraba State are small scale rice farmers cultivating less than 5 hectares. However, only 6.7% of the rice farmers had farm size of 5-6 hectares. The mean farm size is 2.2 hectares which is less than the mean farm size of 3.3 hectares of *Fadama* III beneficiary rice farmers and 2.6 hectares of Non-*Fadama* III beneficiary rice farmers in Niger State as revealed by Manun (2013). This implies that majority of rice farmers in the study area are small scale rice farmers that will require access to more land to be effectively transformed into large scale rice farming.

**Table 9:** Farm Size of Respondents

<b>Farm size</b>	<b>Frequency</b>	<b>Percentage</b>
< 1	5	2.8
1-2	115	63.8
3-4	48	26.7
5-6	12	6.7
Total	180	100
Mean	2.2	
Minimum	0.5	
Maximum	6	

Source: Field Survey, 2018

#### **4.1.8 Number of Extension Contact of the Respondents**

Table 10 shows the result on the respondents' number of contacts with extension agent, which revealed that 33.3% of the farmers had no contact with extension agent, 43.3% had 1-2 contacts in the 2017/2018 production season. This indicate that extension visit in the study area is poor, hence the farmers will not be well informed about modern production practices. However, 23.4% had 3-6 extension contact in the production season. Enweren and Ohajianya (2013) also reported poor extension contact among majority (60.3%) of rice farmers in Imo State, Nigeria.

**Table 10:** Distribution of Respondents According to Number of Extension Contact

<b>Number of visit</b>	<b>Frequency</b>	<b>Percentage</b>
0	60	33.3
1-2	78	43.3
3-4	38	21.1
5-6	4	2.3
Total	180	100

Source: Field Survey, 2018

#### **4.1.9 Source of Credit of the Respondents**

The study revealed that most (66.7%) of rice farmers in the study area obtained funds for their farming activities through their personal savings (Table 11). However, only 33.3% obtained assistance from family members and relative. This implies that the formal credit institutions were not being used probably because of their stringent loan conditions. The finding is similar to the

findings of Enweren and Ohajianya (2013), who also reported that farmers in Imo State, Nigeria had no access to formal credit institutions.

**Table 11:** Distribution of Respondents According to Source of Credit

Source of income	Frequency	Percentage
Personal saving	120	66.7
Family/relatives	60	33.3

Source: Field Survey, 2018

#### **4.1.10 Membership of Cooperative of the Respondents**

Table 12 shows the result of respondents based on membership of cooperative organizations. It revealed that majority (80.6%) of rice farmers in the study area belongs to one form of cooperative society or the other. This implies that farmers in the study area are organized and can effectively assist themselves with information required that will better their performance especially in the farm production

**Table 12:** Distribution of Respondents Based on Cooperative Membership

Membership of cooperative	Frequency	Percentage
Yes	145	80.6
No	35	19.4
Total	180	100

Source: Field Survey, 2018

#### **4.1.11 Land Acquisition of the Respondents**

An analysis of land acquisition of respondents in the study area as shown in Table 13 revealed that most (63.3%) rice farmers acquired their farm land through inheritance. However, 36.7% of them acquired farm land by rent (hiring) where they pay after every farming season. This means that most of the farmers inherited farm land from their ancestors thus rice farmers have available land for rice cultivation to ensure food security.

**Table 13:** Land Acquisition Distribution of the Respondents

Land acquisition	Frequency	Percentage
Inheritance	114	63.3
Hired	66	36.7
Total	180	100

Source: Field Survey, 2018

#### 4.1.12 Farming Experience of the Respondents

Result obtained from the analysis of farming experience as shown in Table 14 is characterized by farmers with 1-10 years of farming experience i.e. 86.1%, while 12.7% had 11-20 years of rice farming experience. However, 1.2% of the respondents had over 20 years of farming experience. This implies that farmers in the study area are experienced, hence they can be able to manage their farms efficiently.

**Table 14:** Farming Experience Distribution of Respondents

Years of Experience	Frequency	Percentage
1-10	155	86.1
11-20	23	12.7
21-30	1	0.6
31-40	1	0.6
Total	180	100

Source: Field Survey, 2018

#### 4.2 Profitability of Rain-fed Rice Farmers in the Study Area

Analysis of the budgetary techniques as contained in Table 15 based on per hectare of rice production reveals associated cost and revenue. Rain-fed rice production in the study area revealed a total revenue of ₦710,385.57 while variable and fixed cost were ₦213,068.58 and ₦10,791.40 per hectare, respectively. The gross margin and net farm income were ₦497,316.99 and ₦486,457.01 per hectare, respectively, while the return per naira investment is estimated to be ₦2.22. The result shows that rice production is a profitable venture in the study area. This study is in conformity with the works of Manum (2013), Tashikalma *et al.* (2014) and Kadiri *et al.* (2014) who reported that rice production is a profitable venture among rice farmers in Nigeria.

**Table 15:** Average Cost and Return Analysis (per Ha) of Rain-fed Rice Farmers for 2017/2018 in the Study Area

Item	Value (₦) per Hectare
<b>a. Variable costs:</b>	
Cost of seed	7, 017. 22
Cost of fertilizer	45, 386. 08
Cost of agrochemicals	11, 505. 32
Cost of family labour	49, 845. 10
Cost of hired labour	57, 002. 43
Market tax	3, 831. 24
Cost of transportation	7, 662. 49
Cost of ploughing	30, 818. 70
Total Variable cost (TVC)	<b>213, 068. 58</b>
<b>b. Fixed costs</b>	
Rent on farm land	10, 791. 40
Total fixed cost (TFC)	<b>10, 791. 40</b>
Total cost (TC) = TVC+TFC	<b>223, 859.98</b>
<b>c. Income</b>	
Total revenue (TR)	<b>710, 385. 57</b>
Gross margin (GM)= TR-TVC	<b>497, 316. 99</b>
Net farm income (NFI)= GM-TFC	<b>486, 457. 01</b>
Return per Naira investment=NI/TC	2.22

Source: Field Survey, 2018

### 4.3 Estimate of Technical, Allocative and Economic Efficiencies of Rice Farmers in the Study Area

#### 4.3.1 Estimate of Stochastic Frontier Production Function

The maximum likelihood estimate of the Cobb-Douglas stochastic frontier production function as presented in Table 16 indicates the relative importance of factor inputs used in rice production in the study area. Other vital estimates include the sigma squared ( $\sigma^2$ ), gamma ( $\gamma$ ) and the log likelihood function. The sigma squared indicates the goodness of fit of the model, while gamma gives the proportion of the deviation of output from the production frontier. From the result, the coefficients of factor inputs have the expected positive sign except the coefficient of fertilizer input ( $\beta_5$ ) which has a negative sign. The coefficient of seed ( $\beta_4$ ) appears to be the most important factor of production with an elasticity of 0.155. The coefficient is positive and significant at 1% level, this confirms to *a priori* expectation. The elasticity of 0.155 suggest that a unit increase in the quantity of seed will result in 0.155% increase in rice output. The coefficient of agrochemical ( $\beta_6$ ) is the second most important factor with an elasticity of 0.128 and statistically significant at 5%. This implies that agrochemical is also an important significant factor which

influences change in the output of rice production in the study area. Thus, a unit increase in the use of agrochemical will result in 0.128% increase in the yield of rice production in the study area. The predicted coefficient of hired labour ( $\beta_3$ ) is estimated to be 0.113 and is positive and statistically significant at 5% level. This suggest that hired labour is a significant factor that influences changes in the output of rice, such that a unit increase in hired labour significantly contribute to the output of rice. The coefficient of farm size ( $\beta_1$ ) was estimated to be 0.101 and statistically significant at 1%. The implication is that farm size is also an important factor which influences rice production. Thus a unit increase in farm size will result to 0.101% increase in output. Family labour ( $\beta_2$ ) was estimated to be 0.006 and not significant even at 10% level. However, the coefficient of fertilizer ( $\beta_5$ ) was estimated to be negative and not significant.

Diagnostic statistics as revealed by the analysis revealed that gamma ( $\gamma$ ) also known as the variance ratio was estimated to be 0.835 and highly significant at 1% level, suggesting that systematic influence which were unexplained by the production function were the main sources of random errors. This implies that about 84% of the variation in rice output is due to differences in technical efficiency among the farmers. Sigma squared ( $\sigma^2$ ) was estimated to be 0.020 and highly significant at 1% level. This indicate a good fit and correctness of the specified distributional assumption of the model particularly about the error term. Thus, the result of the diagnostic statistics confirmed the relevance of stochastic frontier production using maximum likelihood estimates.

Analysis of the estimated coefficient of the technical inefficiency variables tells us the contribution of the variables to technical efficiency. The coefficient of age ( $\delta_1$ ) is estimated to be negative as it conforms to a priori expectation and significant at 5% level, indicating that age lead to or increase technical efficiencies of the rice farmers in the study area. This conforms to the findings of Ataboh *et al.* (2014) who reported that older rice farmers are more technically efficient than younger farmers. The implication is that increase in age of farmers increases their experience in acquiring and handling inputs thereby making them more efficient. The predicted coefficient of education ( $\delta_2$ ) was negative and it is in consonance with *a priori* expectation and statistically significant at 5% level. The possible explanation could be that farmers with greater years of formal schooling tends to be more technically efficient. This agrees with the findings of Shehu *et al.* (2007) who studied on analysis of technical efficiency of small scale rain-fed upland rice farmers in North-west Agricultural Zone of Adamawa State, Nigeria; and Amaza and Maurice (2005) who

studied on identification of factors that influence technical efficiency in rice based production system in Nigeria. The implication is that with more years of formal education, new technologies could be better understood and adopted, which will subsequently make it possible to move close to the production frontier. The predicted coefficient of household size ( $\delta_3$ ) is predicted to be positive and not significant even at 10% level, this does not conform to a priori expectation. This is in conformity to the findings of Shehu *et al.* (2007). The estimated coefficient of farming experience ( $\delta_4$ ) is predicted to be negative and statistically significant at 1% level. This shows that increase in experience in rice production would reduce technical inefficiency. The implication is that farmers' experience could be associated with skill accumulation which could enhance productivity and thereby reduce technical inefficiency. This also is in conformity with the findings of Binuyo *et al* (2016). The coefficient of the extension contact ( $\delta_5$ ) variable as an efficiency factor is estimated to be positive and not statistically significant even at 10% level. The estimated coefficient of gender ( $\delta_6$ ) is negative and not significant even at 10% level. The possible explanation as revealed in Table 4 earlier indicates that male dominated the rice farming enterprise in the study area as they are mostly household heads and also involved with strenuous activities, while the female counterparts handles food processing and marketing activities. This tend to decrease technical inefficiencies of the rice farmers.

**Table 16:** Maximum-likelihood Estimates for parameters of the Cobb-Douglas Stochastic Frontier production function for Rice Farmers During the 2017/2018 farming season in the Study Area.

Variable	Parameter	Coefficient	Standard Error	t-ratio
<b>Production factors</b>				
Constant	$\beta_0$	3.537	0.190	18.590***
Farm size ( $X_1$ )	$\beta_1$	0.101	0.031	3.217***
Family labour ( $X_2$ )	$\beta_2$	0.006	0.005	1.123
Hired labour ( $X_3$ )	$\beta_3$	0.113	0.052	2.173**
Seed ( $X_4$ )	$\beta_4$	0.155	0.059	2.607***
Fertilizer ( $X_5$ )	$\beta_5$	-0.078	0.053	-1.466
Agrochemicals ( $X_6$ )	$\beta_6$	0.128	0.054	2.383**
<b>Inefficiency model</b>				
Constant	$\delta_0$			
Age ( $Z_1$ )	$\delta_1$	-0.037	0.015	-2.514**
Education ( $Z_2$ )	$\delta_2$	-0.125	0.061	-2.058**
Household size ( $Z_3$ )	$\delta_3$	0.094	0.082	1.141
Farming experience ( $Z_4$ )	$\delta_4$	-0.150	0.055	-2.711***
Extension contact ( $Z_5$ )	$\delta_5$	0.049	0.070	0.704
Sex ( $Z_6$ )	$\delta_6$	-0.051	0.067	-0.762
<b>Diagnostic statistics</b>				
Sigma squared	$\sigma^2$	0.020	0.003	6.920***
Gamma	$\gamma$	0.835	0.289	2.887***
Log likelihood function		125.16		
LR test		7.95		
Number of observations		180		

\*\*\* Significant at 1% level \*\* significant at 5% level

Source: Field Survey, 2018

#### 4.3.2 Rice Farmers' Technical Efficiency

The predicted technical efficiencies of farmers ranged from 0.47-0.97 (Table 17). Majority (76.2%) of the farmers operated at a technical efficiency of between 0.67-0.97. On the average, a farmer operated at a technical efficiency 0.75. This implies that, if the average rice farmers in the area were to achieve the level of technical efficiency as shown by the most efficient farmer, then they would realize an increase in output of 25.77%, that is  $(1-0.75/0.97)$ . Majority (51.5%) of the farmers were found to be efficient below the mean value, while 47.9% were above the average technical efficiency. Hence, in the short run there is still scope of increasing the technical efficiency of rice farmers in Northern part of Taraba State through better use of available resources. This finding do not agreed with Shehu and Mshelia (2007) who studied on productivity and

technical efficiency of small-scale rice farmers in Adamawa State, Nigeria which revealed a mean technical efficiency of 0.96%, which ranged from 0.74 to 0.99.

**Table 17:** Frequency Distribution of the Technical Efficiencies of Rice Farmers During the 2017/2018 Cropping season in the Study Area

Ranges	Frequency	Percentage of farms
0.47- 0.51	4	2.2
0.52-0.56	14	7.8
0.57-0.61	10	5.5
0.62-0.66	15	8.3
0.67-0.71	27	15.0
0.72-0.76	24	13.3
0.77-0.81	23	12.8
0.82-0.86	26	14.5
0.87-0.91	22	12.2
0.92-0.96	14	7.7
0.97-1.00	1	0.6
Total	180	100
Mean efficiency	0.75	
Minimum efficiency	0.47	
Maximum efficiency	0.97	

Source: Field Survey, 2018

#### 4.3.3 Estimate of Stochastic Frontier Cost Function

The maximum likelihood estimate of the Cobb-Douglas stochastic frontier cost function shows the relative importance of cost of input as used during rice production in the study area. These estimates include the sigma squared ( $\sigma^2$ ), gamma ( $\gamma$ ) and the log likelihood. The sigma squared indicates the goodness of fit of the model, while gamma gives the proportion of the deviation of output from the cost frontier.

The estimates of the stochastic frontier cost function are presented in Table 18. The results revealed that all the independent variables conform to the a priori expectations as all the estimated coefficients gave positive coefficients. This implies that the variables used in the regression analysis have direct relationship with total cost of rice production. The cost of production increases by the value of each coefficient as the quantity of each variable input is increased by one percent. The estimated coefficient of cost of land ( $\beta_1$ ) is 0.500 and not statistically significant even at 10% level. The cost of family labour ( $\beta_2$ ) was estimated to be 0.152 and statistically significant at 5%

level. This implies that a unit increase in the cost of family labour will result to 0.152% significant increase in the total cost of rice production in the study area. However, hired labour ( $\beta_3$ ) estimate (0.069) was not significant. The estimated coefficient of cost of seed ( $\beta_4$ ) was revealed to be 0.277 and statistically significant at 1% level. The implication is that a unit increase in the cost of seed will result to 0.277% significant increase in the total cost of production. The result was contrary to the findings of Akinbode *et al*, (2011) which revealed that increase in price of seed did not significantly contribute to total cost of rice production in Ogun State, Nigeria. The cost of fertilizer ( $\beta_5$ ) was estimated to be 0.436 and statistically significant at 1%. This means that a unit increase in the cost of fertilizer will result to 0.436% significant increase in the total cost of rice production. The implication is that rice farmers in the study area rely more in the use of fertilizer. The estimated coefficient of agrochemical ( $\beta_6$ ) was revealed to be 0.184 and significant at 5% level. This means that a unit increase in the cost of agrochemical will result in 0.184% significant increase in total cost of production. The result of the diagnostic statistics revealed that both sigma squared and gamma are significant at 1% level. The gamma estimate (0.856) shows that about 86% of the variation in rice production cost among the respondents is due to differences in allocative efficiency. Sigma squared was estimated to be 0.191. This indicate a good fit and correctness of the specified distributional assumption of the model or about the error term. Thus, the result of the diagnostic statistics confirmed the relevance of stochastic frontier cost function using maximum likelihood estimates.

An analysis of allocative inefficiency variables as shown in Table 18 revealed the coefficient of age ( $\delta_1$ ) to be negative and statistically significant at 1% level. This implies that aged farmers tends to attach high importance to minimizing production costs when compared with younger farmers thereby increasing cost efficiency. This findings is contrary to the findings of Tijjani and Bakari (2014) where age was estimated to be positive and decrease cost efficiency (0.0003). The coefficient of education ( $\delta_2$ ) was estimated to be negative and significant at 5% level. This means that farmers with more years of education tends to be more efficient in the allocation of factor inputs which minimize production cost and better managerial ability. Farming experience ( $\delta_4$ ) was estimated to be negative, but not significant. This findings does not agrees with that of Tijjani and Bakari (2014) who reported that rice farmers in Taraba State with more years of education and farming experience are good in resource allocation that minimizes cost thereby increasing cost efficiency. However, the estimated coefficient of household size ( $\delta_3$ ) is revealed to

be positive and not significant. This could be attributed to the fact that large family size could cause diversion of fund from farming activities to home consumption thereby increasing cost inefficiency. The coefficient of extension contact ( $\delta_5$ ) have the desired negative sign and statistically significant at 5% level. This means that farmers with more extension contact are better informed with good farming practices and technology. The estimated coefficient of gender ( $\delta_6$ ) is negative and also significant at 5% level of significance; this implies that most males are aged; have more years of education and are experienced household heads, thus, have better managerial ability than the female counterpart.

**Table 18:** Maximum-likelihood Estimates for parameters of the Stochastic Frontier Cost Function for Rice Farmers During the 2017/2018 Farming Season in the Study Area

Variables	Parameter	Coefficient	Standard Error	t-ratio
<b>Cost factors</b>				
Constant	$\beta_0$	1.221	0.990	1.233
Cost of land( $X_1$ )	$\beta_1$	0.500	0.691	0.724
Cost of family Labour( $X_2$ )	$\beta_2$	0.152	0.066	2.286**
Cost of Hired Labour( $X_3$ )	$\beta_3$	0.069	0.651	0.106
Cost of seed( $X_4$ )	$\beta_4$	0.277	0.085	3.272***
Cost fertilizer( $X_5$ )	$\beta_5$	0.436	0.077	5.637***
Cost of Agrochemicals( $X_6$ )	$\beta_6$	0.184	0.084	2.191**
<b>Inefficiency model</b>				
Constant	$\delta_0$			
Age( $Z_1$ )	$\delta_1$	-0.286	0.099	-2.899***
Education( $Z_2$ )	$\delta_2$	-0.159	0.066	-2.405**
Household size( $Z_3$ )	$\delta_3$	0.049	0.620	0.079
Farming experience( $Z_4$ )	$\delta_4$	-0.043	0.099	-0.433
Extension contact( $Z_5$ )	$\delta_5$	-0.240	0.099	-2.405**
Sex( $Z_6$ )	$\delta_6$	-0.345	0.168	-2.049**
<b>Diagnostic statistics</b>				
Sigma squared	$\sigma^2$	0.191	0.046	4.109***
Gamma	$\gamma$	0.856	0.239	3.574***
Log likelihood function		176.92		
LR test		1.93		
Number of observations		180		

\*\*\* Significant at 1% level \*\* significant at 5% level

Source: Field Survey, 2018

#### **4.3.4 Rice Farmers' Allocative Efficiency**

The frequency distribution of allocative efficiencies of the respondents is presented in Table 19. The mean measure of allocative efficiency in the area was estimated to be 0.89. This suggests that respondents were about 89% allocatively efficient while the remaining (19%) short fall can be attributed to their allocative inefficiencies. Majority (82.2%) of the respondents were efficient below the mean, whereas 17.3% were efficient above the mean value. The minimum and maximum measures of allocative efficiencies were 0.60 and 0.96, respectively. This implies that the least allocatively efficient farmer was 60% efficient, whereas the most allocatively efficient farmer was 96% efficient. Thus, if the average rice farmers in the area were to achieve the level of allocative efficiency shown by the most efficient farmer, then they would realize a cost saving of 11.46% that is  $(1-0.89/0.96)$ . The table further shows that majority (69%) of the farmers had allocative efficiency from 0.78 and above, indicating that on the relative term most of the respondents were very efficient in allocating their cost during the 2017/2018 rice production in the study area. However, there is room for improvement of their allocative inefficiency. The finding do not agreed with that of Akinbode *et al.* (2011) who examined technical, allocative and economic efficiencies in *Ofada* rice farming in Ogun State, Nigeria reported a mean allocative efficiency of 0.93 that ranged between 0.74 and 0.99 which implies that if the average farmer was to achieve the allocative efficiency level of his most efficient counterpart, the average farmer could realize a cost saving of about 5.8%. Similarly, the findings of Fadil and Mitsuyasu (2011) evaluated technical, allocative and economic efficiency in rice production a case study of rice farmers in Brunei Darussalam reported that farmers' allocative efficiency ranged between 0.018 to 0.85 with a mean of 0.66 which is below rice farmers' performance in Northern Taraba State, Nigeria.

**Table 19:** Frequency Distribution of the Allocative Efficiencies of Rice Farmers During the 2017/2018 Cropping Season in the Study Area.

Range	Frequency	Percentage
0.60- 0.65	16	8.8
0.66-0.71	15	8.4
0.72-0.77	25	13.9
0.78-0.83	40	22.2
0.84-0.89	53	29.5
0.90-0.95	26	14.5
0.96-1.00	5	2.7
Total	180	100
Mean efficiency	0.89	
Minimum efficiency	0.60	
Maximum efficiency	0.96	

Source: Field Survey, 2018

#### **4.3.5 Rice Farmers' Economic Efficiency**

The frequency distribution of economic efficiencies of the respondents is presented in Table 20. The table revealed the mean measure of economic efficiency to be 0.61 in the area. This suggests that respondents were about 61% economically efficient while the remaining (39%) short fall can be attributed to their economic inefficiencies. Majority (57.2%) of the farmers were efficient below the mean, whereas 41.2% performed above the mean. The minimum and maximum measures of allocative efficiencies were 0.29 and 0.88, respectively. This implies that the least economically efficient farmer was 29% efficient, whereas the most economically efficient farmer was 88% efficient. Thus, if the average rice farmers in the area were to achieve the level of economic efficiency as shown by the most efficient farmer, then they would realize a cost saving of 44.32% that is  $(1-0.61/0.88)$ . The table further shows that majority (73.4%) of the farmers had economic efficiency from 0.53- 0.88, indicating that that there is scope for improving their economic efficiencies by 12% during the 2017/2018 rice production in the study area. The finding do not agreed with that of Akinbode *et al.* (2011) who examined technical, allocative and economic efficiencies in *Ofada* rice farming in Ogun State, Nigeria reported a mean economic efficiency of 0.0.67 that ranged between 0.41 to 0.85 which implies that if the average farmer was to achieve the economic efficiency level of his most efficient counterpart, the average farmer could realize a cost saving of about 20.7%. Similarly, the findings of Fadil and Mitsuyasu (2011) evaluated technical, allocative and economic efficiency in rice production a case study of rice farmers in

Brunei Darussalam reported that farmers' economic efficiency ranged between 0.04 to 0.78 with a mean of 0.53 which is below rice farmers' performance in Northern Taraba State, Nigeria.

**Table 20:** Frequency Distribution of the Economic Efficiencies of Rice Farmers During the 2017/2018 Cropping Season in the Study Area.

Range	Frequency	Percentage of farms
0.29- 0.34	2	1.1
0.35-0.40	5	2.8
0.41-0.46	17	9.5
0.47-0.52	24	13.3
0.53-0.58	33	18.2
0.59-0.64	25	13.9
0.65-0.70	29	16.1
0.71-0.76	26	14.5
0.77-0.83	14	7.8
0.84-0.89	5	2.8
Total	180	100
Mean efficiency	0.61	
Minimum efficiency	0.29	
Maximum efficiency	0.88	

Source: Field Survey, 2018

### 4.3.6 Test of Hypothesis

#### 4.3.6.1 Technical Inefficiency Effects

$H_0$ = there is no presence of technical inefficiency among rice farmers in the study area

$$H_0: (y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0)$$

$H_i$ : there is presence of technical inefficiency among rice farmers in the study area

$$H_i: (y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 \neq 0)$$

The Likelihood ratio test statistics for the presence of technical inefficiency effects is presented in Table 21. The generalized likelihood ratio statistics was used to test the null hypothesis  $H_0: (y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0)$  that there was no presence of technical inefficiency effects against the alternative hypothesis  $H_i: (y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 \neq 0)$  that inefficiency effects were present. The computed test statistics for the presence of technical inefficiency was estimated at 27.94 (Appendix IV), while the critical value at 7 degree of freedom as obtained from Kodde and Palm is 13.401. Since the computed test statistic value is greater than the critical value, the null hypothesis is therefore rejected indicating that technical inefficiency effects exist among the rice farmers in Northern part of Taraba State.

#### 4.3.6.2 Allocative Inefficiency Effects

H<sub>0</sub>= there is no presence of allocative inefficiency among rice farmers in the study

H<sub>0</sub>: Ho: (y=  $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6=0$ )

H<sub>i</sub>: there is presence of allocative inefficiency among rice farmers in the study area

H<sub>i</sub>: (y= $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 \neq 0$ )

The Likelihood ratio test statistics for the presence of allocative inefficiency effects is presented in Table 21. The generalized likelihood ratio statistics was used to test the null hypothesis Ho :( y=  $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6=0$ ) that there was no presence of allocative inefficiency effects against the alternative hypothesis Hi: (y= $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 \neq 0$ ) that inefficiency effects were present. The computed test statistics for the presence of allocative inefficiency was computed as 39.26 (Appendix IV), while the critical value as obtained from Kodde and Palm is 13.401. Since the computed test statistic value is greater than the critical value, the null hypothesis is therefore rejected indicating that allocative inefficiency effects exist among the rice farmers in the study area.

**Table 21:** Generalized Likelihood Ratio Test for Inefficiency Effects

Efficiency	Null hypothesis	DF	LR	X <sup>2</sup> (critical value)	Decision rule
Technical	H <sub>0</sub> : y= $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6=0$	7	27.94	13.401	Reject Ho
Allocative	H <sub>0</sub> : y= $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6=0$	7	39.26	13.401	Reject Ho

Source: Field Survey, 2018

#### 4.4. Constraints Associated with Rice Production in Northern part of Taraba State

Table 22 highlighted the problems faced by rice farmers as they carry out their rice farming activities in the study area. The constraints were ranked based on the degree of severity as identified by the respondents. The first three constraints identified by the farmers as very serious constraints were; unavailability of credit facility (35.03%), shortage of farm labour (21.68%) and shortage and high cost of land rentage (16.12%). The possible implication may be that most financial institutions are not ready to provide credit facility to farmers possibly because of lack of payback by the farmers. Therefore, they rely on personal savings, family and friends for funds. This is in conformity with the findings of Tashikalma *et al*, (2014) who identified lack of finance as a major problem faced by swamp rice farmers in Ogoja Local Government Area of Cross River State, Nigeria. Shortage of farm labour could be associated to the fact that the major occupation in the study area is farming thus, majority of the labour force may be engage in their personal farms

rather than been hired during the production season. Also, 11.12% of the respondents identified shortage of materials as a serious constraint, this means that the farmers had difficulty in farming inputs such as fertilizer, seed, herbicide, etc. for their farms. However, inadequate infrastructure (example poor road network), inadequate extension service, marketing problems, pests and disease incidence, and high cost storage facility were identified as not a serious constraints. This could possibly mean that respondents improvised storage facility that is cost effective such as bags and rhumbus and there is ready market for their farm produce.

**Table 22:** Distribution of Respondent Based on Constraints associated with Rice Production in Northern part of Taraba state.

<b>Identified problems</b>	<b>Frequency</b>	<b>Percentage</b>	<b>Rank</b>
Shortage of material inputs	20	11.12	4
Farm land shortage and high cost of rent	29	16.12	3
Farm credit unavailability	63	35.03	1
Farm labour shortage	39	21.68	2
Pest and disease incidence	4	2.24	8
Inadequate infrastructure (example poor, road network)	10	5.56	5
Marketing problems	5	2.78	7
Inadequate extension service	8	4.46	6
High cost of storage facility	2	1.11	9
<b>Total</b>	<b>180</b>	<b>100</b>	

Source: Field Survey, 2018

## CHAPTER FIVE

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 5.1 Summary

The study analyzed production efficiency among rainfed rice farmers in Northern Taraba State, Nigeria. Primary data formed the basis of the study and were collected with the help of structured questionnaire administered to the respondents. The objectives of the study were to examine the socio-economic characteristics of rice farmers in Northern Taraba State; determine the profitability of rice farmers in the study area; estimate the technical, allocative and economic efficiency of rice farmers and; identify constraints associated with rice production in the study area. Purposive and simple random sampling techniques were used to collect data from 180 respondents. Descriptive statistics, stochastic frontier analysis, gross margin analysis, and net income analysis were employed to analyze the data.

The study revealed that most (81.7%) of the respondents were males; the findings revealed that, majority (74.4%) of the rice farmers were within the age group of 21-40 years; majority (84.6%) of respondents were married; majority (93.9%) of the respondents have one form of formal education or the other; majority (57.3 %) of the respondents had household size of 1-5 persons. Result on the distribution of respondents based on respondents primary occupation showed that majority (62.30%) of the respondent's primary occupation is farming. The study revealed that most (93.3%) of the respondents are small scale farmers, with farm size of less than 5 hectares.

The profitability analysis from the study showed an estimated gross margin and net farm income of ₦497, 316. 99 and ₦486, 457. 01 per hectare, respectively, with total revenue of ₦710, 385. 57, total variable cost of ₦213, 068. 58 and total fixed cost of ₦10, 791.40 per hectare, respectively, while the return per naira invested is estimated to be ₦2.2.

The result on the stochastic frontier production function analysis revealed that, all the six factors inputs have the expected signs except the coefficient of fertilizer input which has a negative sign. Gamma ( $\gamma$ ) was estimated to be 0.835 and highly significant at 1% level, while Sigma squared was estimated to be 0.020 and highly significant at 1% level.

The study further revealed that all the six (6) estimated coefficient of the technical inefficiency parameters have the expected sign except household size ( $z_3$ ) and extension contact

(z<sub>5</sub>). The predicted technical efficiencies of the farmers ranged from 0.47-97 with mean efficiency of 0.75%.

The estimates of the stochastic frontier cost function revealed that all the six variables had the *a priori* expectations as all the estimated coefficients gave positive coefficients. In addition, the study present the frequency distribution of the farmers efficiency levels, it revealed that majority (69%) of the respondents had allocative efficiency from 0.78 and above, with the most efficient farmer operating at 0.96% level of allocative efficiency.

The estimate of allocative inefficiency model revealed the coefficient of age ( $\delta_1$ ) to be negative and statistically significant at 1%. Estimate of educational level ( $\delta_2$ ) is negative and significant at 5% level; farming experience ( $\delta_4$ ) has the *a priori* sign, but not significant. However, the estimated coefficient of household size ( $\delta_3$ ) was revealed to be positive and not significant. The coefficient of extension contact ( $\delta_5$ ) was estimated to be negative and also significant at 5% level. The coefficient of sex ( $\delta_6$ ) was estimated to be negative and significant at 5% level. The research also revealed farmers had economic efficiency range of 0.53- 0.88, with a mean measure of 0.6.

The result of the hypothesis testing revealed the presence of technical and allocative inefficiency effects among farmers in the study area. Therefore, the null hypothesis is rejected in both cases.

The most severe constraints faced by rice farmers in the study area were: farm credit unavailability, farm labour shortage, and shortage of farm land shortage and high cost of rent.

## **5.2 Conclusion**

The study revealed that young married males with formal education dominated the rice farming enterprise in Northern part of Taraba State, majority of whom are small scale farmers who had positive gross margin and net farm income of ₦497, 316. 99 and ₦486, 457. 01 per hectare respectively. The result of the Stochastic Frontier Approach revealed that basic production variables included in the production function had positive relationship with rice output except fertilizer. In the same vein, the maximum likelihood cost function showed that cost of variable inputs contributed significantly to the total cost of production. The means of TE, AE and EE values were 0.75, 0.89, and 0.61 respectively. Given the shortfall of 25% in the technical efficiencies of farmers, 11% in the allocative efficiencies and 39% in the economic efficiencies of farmers, there is therefore potential to improve output of an average farm without the need for any change in existing technology. Moreover, the means for TE, AE and EE also implies that rice farmers in the

study area still have the potential to achieve some level of cost savings or increase in output if certain corrective measures are taken as inefficiency effects still existed among the sampled rice farms. However, most (35.03%) of the farmers were faced with the constraint of unavailability of credit to enable them perform their farming activities efficiently; 21.68% had shortage of farm labour; 16.12% experienced land shortage and high cost of rent, while 11.12% of the farmers were faced with shortage of material inputs.

### **5.3 Recommendations**

Based on the findings of the study, the following recommendations are made for high efficiencies and increased local production of rice in the study area:

- i. More agricultural extension effort should be intensified to ensure dissemination of modern agricultural information especially on the use of fertilizer.
- ii. In order to raise efficiency level, there is need for the commitment of government and non-governmental organizations in the provision of farm inputs such as agrochemicals, seeds and farm implements at affordable rates.
- iii. Rice farmers in the study area are faced with problems of unavailable access to credit. Therefore, government and other non-governmental organizations should make credit accessible to farmers through its *anchor borrower scheme*.
- iv. Government should open more road network to ensure easy and reduced cost of movement of rice from the rural area to markets; and
- v. Taraba State government should make policy that will encourage more participation of women in rice production as it is also a major employer of labour among young males in the study area.

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## APPENDICES

### APPENDIX I: QUESTIONNAIRE

Modibbo Adama University of Technology, Yola.  
Department of Agricultural Economics and Extension,  
P. M. B. 2076, Yola  
Adamawa State.  
--/--/2018

Dear respondents,

I am a postgraduate student of the above institution conducting a research study entitled:  
**“Analysis of Production Efficiency Among Rain-fed Rice Farmers in Northern Taraba State, Nigeria.”**

You are kindly requested to provide the necessary information in the study questionnaire by filling or ticking as appropriate. The information provided would be treated with confidentiality and be used strictly for research purpose

Thanks for your anticipating cooperation

Yours Faithfully  
HASSAN, Christopher Kefas  
M.Sc/AGE/16/0395  
Researcher

## RESEARCH QUESTIONNAIRE

**TITLE: Analysis of Production Efficiency among Rain-Fed Rice Farmers in Northern Taraba State, Nigeria**

### **A. Socio-economic Characteristics of Rice Farmers in the Study Area**

1. Sex: (a) male  (b) female
2. Age (years)-----
3. Marital status: (a) single  (b) married  (c) divorced  (d) widowed
4. Total number of people in the household
  - (a) Number of adult male
  - (b) Number of adult female
  - (c) Number of children less than 18 years
  - (d) Total number in the household-----
5. Main occupation
  - a) Civil servant
  - b) Farmer
  - c) Applicant
  - d) Business man/ woman
6. Other occupation(s) please specify (if any)-----
7. Educational level: (a) no-formal education  (b) primary school education  (c) secondary school education  (d) tertiary education  (e) others-----  
-----

### **B. Rice Farming Activities 2017/2018 Production Season**

8. How long have you been farming rice? -----
9. What cropping system do you use in cultivating rice? (a) sole cropping  (b) mixed cropping  both
10. What is the size of your rice farm?-----hectare
11. How do you acquire your rice farm land? (a) inheritance  (b) hired at ₦-----per production season or if the hire was kind what was the approximate value ₦-----  
(c) gift  (d) purchase at ₦----- (e) others (specify)-----

12. Have you ever had contact with extension agent during the 2017/2018 production season?  
(a) yes [ ] (b) no [ ]
13. If yes, in question 12 how many contacts have you had with extension workers during the  
2017/2018 production season? -----times
14. Did you use family labour on your rice farm? (a) yes [ ] (b) no [ ]
15. If yes, in question 14 kindly fill the Table below:

Table 1: Family Labour Use on Rice Farm, 2017/2018 Production Season

Operation	Adult male			Adult female			Children less than 18 years		
	No. of person engaged per day	Approx. hours worked per day	Approx. days worked in the season	No. of person (s) engaged per day	Approx. Hours worked per day	Approx. days worked in the season	No. of person (s) engaged	Approx. Hours worked per day	Approx. days worked in the season
Land clearing									
Planting									
Weeding									
Herbicide application									
Harvesting									
Threshing									
Bagging									
Bird scaring									
Others (if any)									

16. Did you use hired labour on your farm? (a) yes [ ] (b) no [ ]

17. If yes, please fill the Table below:

Table 2: Hired Labour Use on Rice Farm 2017/ 2018 Production Season

Operation	Adult male				Adult female				Children less than 18 years			
	No. of person(s) engaged	Approx. hours worked per day	Approx. days worked in the season	Wage rate per day (₦)	No. of person(s) engaged	Approx. hours worked per day	Approx. days worked in the season	Wage rate per day (₦)	No. of person(s) engaged	Approx. hours worked per day	Approx. days worked in the season	Wage rate per day (₦)
Land clearing												
Planting												
Weeding												
Herbicide application												
Harvesting												
Threshing												
Bagging												
Others (if any) i. ii. iii.												

18. What was the approximate cost of hiring one man to work on your rice farm for one day only in 2017/ 2018 production season? ₦-----  
-----

19. What are the costs of the following inputs? Please, fill the Table below:

Table 3: Production Inputs Used on Rice Farm, 2017/ 2018 Production Season

Service/ input	Total cost (₦) and quantity used
Tractor service	i. Total cost of ploughing ₦----- ii. Total cost of harrowing ₦-----
Animal traction	iii. Total cost of ploughing ₦-----
Manual labour	Total cost of ploughing
Rice Seed	i. Quantity used ----- (kg) ii. Total cost of seed (₦)----- iii. Transporting cost (₦)----- iv. Planting cost (₦)----- v. Sources of seed----- vi. Type of seed-----
Herbicide	i. Quantity used -----(liter) ii. Cost of herbicide (₦)----- iii. Transporting cost (₦)----- iv. Sources of herbicide----- v. Type of herbicide-----
Fertilizer	i. Quantity used -----(bags) ii. Cost of fertilizer (₦)----- iii. Transporting cost (₦)----- iv. Sources of fertilizer----- v. Types of fertilizer
Others (if any) Security (watching)	

20. How did you get money to use in your rice farm business? Please, fill in the Table below:

Table 4: Source of Income for Rice Farm for 2017/2018 Production Season

Source of finance (money)	Amount borrowed/ used (₦)	Amount paid as interest (if any) (₦)
Personal savings		
Friends/ relatives		
Bank of Agriculture		
Commercial bank		
Non-governmental organizations (NGOs)		
Others source (specify)		

**C. Data on Rice output for 2017/2018 Production season**

21. What was the total output (yield) realized from your rice farm? -----  
-kg/bag

22. What type of bags did you use? (a) 50kg [ ] (b) 100 kg [ ] (c) other (specify) -----  
-----

23. What was the cost of empty sack used? -----

24. What was the cost of evacuating your produce (rice) from? :

a) Farm to your home ₦ -----

b) Home to market ₦ -----

25. How much did you pay for market tax for?

a) Each bag ₦ -----

b) All bags ₦ -----

26. Where did you sell your rice produce? (please tick)

a) Market (consumer) [ ]

b) Middlemen [ ]

c) Cooperatives [ ]

27. At what price did you sell your produce (rice)?

Bag type	Selling price/ bag (₦)	Number of bags sold	Months of sales
50kg			
100kg			
Others (specify)			

28. How much of your produce was consumed, sold or given out?

Bag type	Number of bags consumed	Number of bags given out	Number of bags sold
50kg			
100kg			
Others (specify)---			

29. Do you store your rice before selling? a) Yes [ ] No [ ]

30. If yes, how do you store your rice?

a) Local storage facility (rumbu) [ ]

b) Silos [ ]

c) Bags [ ]

d) Others (specify)-----

31. How do you store your Rice output? -----

32. Do you belong to a cooperative society?----- yes [ ]

No [ ]

33. If yes, what privilege do you get from the society? -----  
-----

**D. Data on Constraints Faced in Rice Production during 2017/2018 production season**

Indicate whether the given option is a constraint or not and also indicate the degree of severity of the constraint on a 3-points scale by ticking the appropriate option (s)

		Very serious	Serious	Not serious
S/N	Constraints	3	2	1
1	Shortage of material inputs			
2	Farm land shortage			
3	Farm credit unavailability			
4	Farm labour shortage			
5	Pest and disease incidence			
6	Inadequate infrastructure example poor road network			
7	Marketing problems			
8	Others (specify) i. ii. iii. iv.			

Suggests ways on how to solve the problems: -----  
-----  
-----

**APPENDIX II**  
**Technical Efficiency Model Effect**

Output from the program FRONTIER (Version 4.1c)

Instruction file = CG1-ins.txt

Data file = CG1-dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the ols estimates are:

	coefficient	standard-error	t-ratio
beta 0	0.34749395E+01	0.19752554E+00	0.17592355E+02
beta 1	0.10136493E+00	0.19512100E-01	0.51949779E+01
beta 2	0.61887570E-02	0.56765269E-02	0.10902365E+01
beta 3	0.16988561E-01	0.10001913E-01	0.16985312E+01
beta 4	0.23936054E-01	0.82187449E-01	0.29123734E+00
beta 5	-0.70532505E-01	0.55809855E-01	-0.12638002E+01
beta 6	0.12448861E+00	0.58042941E-01	0.21447675E+01

Sigma-squared 0.17709569E-01

Log likelihood function = 0.11118946E+03

The estimates after the grid search were:

beta 0	0.34985954E+01
beta 1	0.10136493E+00
beta 2	0.61887570E-02
beta 3	0.16988561E-01
beta 4	0.23936054E-01
beta 5	-0.70532505E-01
beta 6	0.12448861E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00

Sigma-squared 0.17580467E-01

Gamma 0.50000000E+00

Iteration = 0 func evals = 20 llf = 0.11105046E+03

0.34985954E+01 0.10136493E+00 0.61887570E-02 0.16988561E-01 0.23936054E-01  
-0.70532505E-01 0.12448861E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00  
0.00000000E+00 0.00000000E+00 0.00000000E+00 0.17580467E-01 0.50000000E+00

Gradient step

Iteration = 5 func evals = 45 llf = 0.11343498E+03

0.34990876E+01 0.10129577E+00 0.57352785E-02 0.15370275E-01 0.23467887E-01  
-0.70330735E-01 0.12381665E+00 -0.77451399E-03 -0.19026677E-01 -0.49918397E-02  
-0.49396023E-03 0.39679404E-01 -0.30585559E-01 0.16501569E-01 0.68240405E+00

Iteration = 10 func evals = 67 llf = 0.11399701E+03

0.35715989E+01 0.10231806E+00 0.51577755E-02 0.10304035E-01-0.27139516E-01  
 -0.69652372E-01 0.15397201E+00-0.32981235E-02-0.75352260E-01 0.30427028E-01  
 -0.59506859E-01 0.21926499E-01-0.54629507E-01 0.18580214E-01  
 0.66538681E+00  
 Iteration = 15 func evals = 86 llf = 0.11422155E+03  
 0.35710604E+01 0.10215581E+00 0.52958950E-02 0.79784710E-01-0.21090496E-01  
 -0.72493325E-01 0.15322407E+00 0.11180278E-01-0.10770394E+00 0.73567998E-01  
 -0.12928785E+00 0.21364553E-01-0.53028611E-01 0.19670056E-01  
 0.83066303E+00  
 Iteration = 20 func evals = 148 llf = 0.11515682E+03  
 0.35368662E+01 0.10112398E+00 0.61339149E-02 0.11297129E+00 0.15554232E-01  
 -0.77536028E-01 0.12765788E+00-0.36074723E-01-0.12448300E+00 0.93946932E-01  
 -0.14813361E+00 0.49283849E-01-0.50967677E-01 0.20690968E-01  
 0.83467458E+00  
 Iteration = 25 func evals = 179 llf = 0.11516245E+03  
 0.35368967E+01 0.10112363E+00 0.61311053E-02 0.11298269E+00 0.15496532E-01  
 -0.77529903E-01 0.12768632E+00-0.36556031E-01-0.12466482E+00 0.94019320E-01  
 -0.15039932E+00 0.49519851E-01-0.51148621E-01 0.20693067E-01  
 0.83484811E+00

The final mle estimates are:

	coefficient	Standard-error	t-ratio
beta 0	0.35368967E+01	0.19025594E+00	0.18590204E+02
beta 1	0.10112363E+00	0.31435180E-01	0.32168936E+01
beta 2	0.61311053E-02	0.54575731E-02	0.11234124E+01
beta 3	0.11298269E+00	0.51999249E-01	0.21727754E+01
beta 4	0.15496532E+00	0.59441198E-01	0.26070356E+01
beta 5	-0.77529903E-01	0.52873462E-01	-0.14663292E+01
beta 6	0.12768632E+00	0.53589365E-01	0.23826802E+01
delta 1	-0.36556031E-01	0.14538644E-01	-0.25144043E+01
delta 2	-0.12466482E+00	0.60564400E-01	-0.20583844E+01
delta 3	0.94019320E-01	0.82393284E-01	0.11411042E+01
delta 4	-0.15039932E+00	0.55468841E-01	-0.27114199E+01
delta 5	0.49519851E-01	0.70299506E-01	0.70441250E+00
delta 6	-0.51148621E-01	0.67133188E-01	-0.76189770E+00
Sigma-squared	0.20693067E-01	0.29901251E-02	0.69204688E+01
Gamma	0.83484811E+00	0.28921614E+00	0.28865889E+01

Log likelihood function = 0.12516245E+03

LR test of the one-sided error = 0.79459901E+01  
 With number of restrictions = 7  
 [Note that this statistic has a mixed chi-square distribution]  
 Number of iterations = 25  
 (Maximum number of iterations set at: 100)  
 Number of cross-sections = 180  
 Number of time periods = 1  
 Total number of observations = 180  
 Thus there are: 0 obsns not in the panel

Covariance matrix:

```

0.36197323E-01 0.12173569E-01 -0.17436283E-03 -0.22756039E-03 -0.98877481E-
02
-0.72505200E-02 -0.83435927E-04 -0.21138275E-02 -0.53515526E-03 -0.13688450E-
02
0.22011561E-02 -0.21447099E-02 -0.28218641E-02 0.30580701E-04 0.29662737E-
02
0.12173569E-01 0.69055790E-02 -0.97176135E-04 -0.12932989E-03 -0.29260553E-
02
-0.21337124E-02 -0.18790715E-02 -0.21566883E-02 0.33043547E-03 -0.12699617E-
02
0.29569540E-02 -0.12291906E-02 -0.17187610E-02 0.19400910E-04 0.17589951E-
02
-0.17436283E-03 -0.97176135E-04 0.29785104E-04 0.21393322E-04 0.29780138E-
04
0.35154101E-04 0.72826437E-06 0.89910387E-04 -0.21018416E-04 0.42538327E-
04
-0.99322533E-04 0.53511501E-04 0.72580553E-04 -0.83657468E-06 -0.31658981E-
04
-0.22756039E-03 -0.12932989E-03 0.21393322E-04 0.92809861E-04 -0.82839518E-
06
0.68643988E-04 -0.68794699E-04 0.18304315E-03 0.13814103E-03 -0.10837284E-
03
-0.86069235E-04 0.16533087E-03 0.15475059E-03 -0.59075746E-05 -0.37756606E-
03
-0.98877481E-02 -0.29260553E-02 0.29780138E-04 -0.82839518E-06 0.59615458E-
02
0.20348888E-03 -0.11068552E-02 0.15138033E-02 0.47678625E-04 0.72224465E-
03
-0.22715701E-02 0.10577870E-02 0.11746062E-02 0.14627323E-04 0.47754039E-
03
-0.72505200E-02 -0.21337124E-02 0.35154101E-04 0.68643988E-04 0.20348888E-
03
0.27956030E-02 -0.24072477E-03 0.23144528E-04 0.32635546E-03 -0.41612891E-
04

```

0.46559093E-03 0.13558365E-03 0.34691771E-03 -0.13630196E-04 -0.11631538E-02  
-0.83435927E-04 -0.18790715E-02 0.72826437E-06 -0.68794699E-04 -0.11068552E-02  
-0.24072477E-03 0.28718201E-02 -0.37783286E-03 -0.52433941E-03 0.33199838E-03  
0.55107539E-03 -0.42045129E-03 -0.19189511E-03 -0.28307734E-05 0.16387661E-03  
-0.21138275E-02 -0.21566883E-02 0.89910387E-04 0.18304315E-03 0.15138033E-02  
0.23144528E-04 -0.37783286E-03 0.12164860E-01 0.22824302E-04 0.17885782E-02  
-0.12184584E-01 0.10531405E-02 0.54628287E-02 -0.10213738E-03 -0.28749507E-02  
-0.53515526E-03 0.33043547E-03 -0.21018416E-04 0.13814103E-03 0.47678625E-04  
0.32635546E-03 -0.52433941E-03 0.22824302E-04 0.36680465E-02 -0.34823991E-02  
0.56402399E-02 -0.84081279E-03 0.37305342E-03 -0.10925369E-03 -0.47004924E-02  
-0.13688450E-02 -0.12699617E-02 0.42538327E-04 -0.10837284E-03 0.72224465E-03  
-0.41612891E-04 0.33199838E-03 0.17885782E-02 -0.34823991E-02 0.67886532E-02  
-0.80585701E-02 0.20711200E-02 0.20990897E-02 0.83463270E-04 0.36397126E-02  
0.22011561E-02 0.29569540E-02 -0.99322533E-04 -0.86069235E-04 -0.22715701E-02  
0.46559093E-03 0.55107539E-03 -0.12184584E-01 0.56402399E-02 -0.80585701E-02  
0.28685783E-01 -0.37858833E-02 -0.37421133E-02 -0.63564480E-04 -0.60843822E-02  
-0.21447099E-02 -0.12291906E-02 0.53511501E-04 0.16533087E-03 0.10577870E-02  
0.13558365E-03 -0.42045129E-03 0.10531405E-02 -0.84081279E-03 0.20711200E-02  
-0.37858833E-02 0.49420206E-02 0.22366560E-02 -0.47166779E-04 -0.13289602E-02  
-0.28218641E-02 -0.17187610E-02 0.72580553E-04 0.15475059E-03 0.11746062E-02  
0.34691771E-03 -0.19189511E-03 0.54628287E-02 0.37305342E-03 0.20990897E-02  
-0.37421133E-02 0.22366560E-02 0.45068649E-02 -0.80052639E-04 -0.34577707E-02  
0.30580701E-04 0.19400910E-04 -0.83657468E-06 -0.59075746E-05 0.14627323E-04

-0.13630196E-04 -0.28307734E-05 -0.10213738E-03 -0.10925369E-03 0.83463270E-04  
-0.63564480E-04 -0.47166779E-04 -0.80052639E-04 0.89408481E-05 0.29307656E-03  
0.29662737E-02 0.17589951E-02 -0.31658981E-04 -0.37756606E-03 0.47754039E-03  
-0.11631538E-02 0.16387661E-03 -0.28749507E-02 -0.47004924E-02 0.36397126E-02  
-0.60843822E-02 -0.13289602E-02 -0.34577707E-02 0.29307656E-03 0.15495999E-01

Technical efficiency estimates :

firm	year	eff.-est.
1	1	0.69128821E+00
2	1	0.73274234E+00
3	1	0.88688185E+00
4	1	0.89047919E+00
5	1	0.78667401E+00
6	1	0.72058749E+00
7	1	0.62049991E+00
8	1	0.78674457E+00
9	1	0.86037212E+00
10	1	0.80039810E+00
11	1	0.71079136E+00
12	1	0.53098577E+00
13	1	0.66000729E+00
14	1	0.73043812E+00
15	1	0.84077038E+00
16	1	0.57041758E+00
17	1	0.64057693E+00
18	1	0.93019523E+00
19	1	0.88682994E+00
20	1	0.75041107E+00
21	1	0.83762020E+00
22	1	0.74030408E+00
23	1	0.52293277E+00
24	1	0.69013420E+00
25	1	0.71030011E+00
26	1	0.96066629E+00
27	1	0.87033542E+00
28	1	0.84067168E+00
29	1	0.68005477E+00
30	1	0.80656981E+00
31	1	0.58672398E+00
32	1	0.78066183E+00
33	1	0.91715323E+00
34	1	0.87682827E+00

35	1	0.78242521E+00
36	1	0.65605532E+00
37	1	0.74055288E+00
38	1	0.81034866E+00
39	1	0.96668300E+00
40	1	0.65934171E+00
41	1	0.75108996E+00
42	1	0.63024579E+00
43	1	0.86095904E+00
44	1	0.90040393E+00
45	1	0.67125794E+00
46	1	0.90138341E+00
47	1	0.78783338E+00
48	1	0.69144404E+00
49	1	0.72153222E+00
50	1	0.81152337E+00
51	1	0.88842345E+00
52	1	0.50149150E+00
53	1	0.82134298E+00
54	1	0.75832207E+00
55	1	0.79078234E+00
56	1	0.57136433E+00
57	1	0.92847013E+00
58	1	0.96148815E+00
59	1	0.85074968E+00
60	1	0.66104651E+00
61	1	0.78806305E+00
62	1	0.68831620E+00
63	1	0.89157283E+00
64	1	0.83127805E+00
65	1	0.93116798E+00
66	1	0.58143951E+00
67	1	0.77085265E+00
68	1	0.56937227E+00
69	1	0.78886878E+00
70	1	0.88708744E+00
71	1	0.69085803E+00
72	1	0.76106692E+00
73	1	0.86136477E+00
74	1	0.75274550E+00
75	1	0.82138299E+00
76	1	0.58717443E+00
77	1	0.69083324E+00
78	1	0.56197481E+00
79	1	0.78151483E+00
80	1	0.69079013E+00

81	1	0.93151026E+00
82	1	0.58158947E+00
83	1	0.85131005E+00
84	1	0.77481614E+00
85	1	0.55568822E+00
86	1	0.68708505E+00
87	1	0.91119946E+00
88	1	0.56074234E+00
89	1	0.63429996E+00
90	1	0.60336815E+00
91	1	0.90120815E+00
92	1	0.75359167E+00
93	1	0.88208840E+00
94	1	0.73271967E+00
95	1	0.93120122E+00
96	1	0.83531558E+00
97	1	0.53119194E+00
98	1	0.86424040E+00
99	1	0.83519501E+00
100	1	0.80115215E+00
101	1	0.67551491E+00
102	1	0.68783518E+00
103	1	0.59107033E+00
104	1	0.89339430E+00
105	1	0.96119268E+00
106	1	0.94801083E+00
107	1	0.85089394E+00
108	1	0.50150311E+00
109	1	0.66320907E+00
110	1	0.51210421E+00
111	1	0.67434326E+00
112	1	0.56221136E+00
113	1	0.87578340E+00
114	1	0.66407903E+00
115	1	0.73223855E+00
116	1	0.88746618E+00
117	1	0.67502199E+00
118	1	0.55730944E+00
119	1	0.83203477E+00
120	1	0.78919339E+00
121	1	0.52729633E+00
122	1	0.68219856E+00
123	1	0.76999564E+00
124	1	0.70531562E+00
125	1	0.89130231E+00
126	1	0.95296474E+00

127	1	0.66552986E+00
128	1	0.74197825E+00
129	1	0.82419143E+00
130	1	0.87696135E+00
131	1	0.78305099E+00
132	1	0.68791769E+00
133	1	0.56360776E+00
134	1	0.67385040E+00
135	1	0.87331966E+00
136	1	0.83108043E+00
137	1	0.74241729E+00
138	1	0.70411182E+00
139	1	0.85266172E+00
140	1	0.82360277E+00
141	1	0.75608160E+00
142	1	0.59236847E+00
143	1	0.75681552E+00
144	1	0.86735273E+00
145	1	0.82006033E+00
146	1	0.80285749E+00
147	1	0.94753385E+00
148	1	0.67455925E+00
149	1	0.64580567E+00
150	1	0.56215928E+00
151	1	0.46580505E+00
152	1	0.75448501E+00
153	1	0.94467963E+00
154	1	0.90929561E+00
155	1	0.73111619E+00
156	1	0.87124055E+00
157	1	0.67842557E+00
158	1	0.85220839E+00
159	1	0.86245918E+00
160	1	0.76461996E+00
161	1	0.80205940E+00
162	1	0.84171120E+00
163	1	0.64378989E+00
164	1	0.68201681E+00
165	1	0.75331896E+00
166	1	0.82361715E+00
167	1	0.54244272E+00
168	1	0.68826469E+00
169	1	0.96216409E+00
170	1	0.65439703E+00
171	1	0.71087929E+00
172	1	0.75253305E+00

173	1	0.82175257E+00
174	1	0.54896861E+00
175	1	0.78808372E+00
176	1	0.76069352E+00
177	1	0.81493069E+00
178	1	0.54637628E+00
179	1	0.63923992E+00
180	1	0.62722242E+00

mean efficiency = 0.75213890E+00

**APPENDIX III**  
**Allocative Efficiency Effect Model**

Output from the program FRONTIER (Version 4.1c)

Instruction file = CA1-ins.txt

Data file = CA1-dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a cost function

The dependent variable is logged

The ols estimates are:

	Coefficient	standard-error	t-ratio
beta 0	0.13329813E+01	0.18066237E+00	0.73783006E+01
beta 1	0.49057579E+00	0.25696343E+00	0.19091269E+01
beta 2	0.17677057E+00	0.24324026E-01	0.72673239E+01
beta 3	0.18183672E-01	0.43245064E-01	0.42047971E+00
beta 4	0.28336866E+00	0.49984349E-01	0.56691477E+01
beta 5	0.43342088E+00	0.38600324E-01	0.11228426E+02
beta 6	0.18542851E+00	0.37637321E-01	0.49267190E+01

Sigma-squared 0.10611030E-01

Log likelihood function = 0.15728845E+03

The estimates after the grid search were:

beta 0	0.12233161E+01
beta 1	0.49057579E+00
beta 2	0.17677057E+00
beta 3	0.18183672E-01
beta 4	0.28336866E+00
beta 5	0.43342088E+00
beta 6	0.18542851E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00

Sigma-squared 0.22224832E-01

Gamma 0.85000000E+00

Iteration = 0 func evals = 20 llf = 0.16199825E+03

0.12233161E+01 0.49057579E-02 0.17677057E-01 0.18183672E-02  
0.28336866E+00

0.43342088E+00 0.18542851E+00 0.00000000E+00 0.00000000E+00  
0.00000000E+00

0.00000000E+00 0.00000000E+00 0.00000000E+00 0.22224832E-01  
0.85000000E+00

Gradient step

Iteration = 5 func evals = 42 llf = 0.16691753E+03

0.12211591E+01 0.50008075E+00 0.15182367E+00 0.69178229E-01  
0.27730752E+00  
0.43619721E+00 0.18376202E+00-0.28623065E+00-0.15887933E+00 0.49886277E-  
01  
-0.42940224E-01-0.24017670E+00-0.34541793E+00 0.19129048E-01  
0.85645270E+00  
pt better than entering pt cannot be found  
Iteration = 6 func evals = 50 llf = 0.16691753E+03  
0.12211591E+01 0.50008075E+00 0.15182367E+00 0.69178229E-01  
0.27730752E+00  
0.43619721E+00 0.18376202E+00-0.28623065E+00-0.15887933E+00 0.49886277E-  
01  
-0.42940224E-01-0.24017670E+00-0.34541793E+00 0.19129048E-01  
0.85645270E+00

The final mle estimates are:

	Coefficient	standard-error	t-ratio
beta 0	0.12211591E+01	0.99072860E+00	0.12325869E+01
beta 1	0.50008075E+00	0.69026734E+00	0.72447401E+00
beta 2	0.15182367E+00	0.66422041E-01	0.22857423E+01
beta 3	0.69178229E-01	0.64980216E+00	0.10646045E+00
beta 4	0.27730752E+00	0.84747282E-01	0.32721701E+01
beta 5	0.43619721E+00	0.77376817E-01	0.56373114E+01
beta 6	0.18376202E+00	0.83867082E-01	0.21911102E+01
delta 1	-0.28623065E+00	0.98743762E-01	-0.28987213E+01
delta 2	-0.15887933E+00	0.66066981E-01	-0.24048220E+01
delta 3	0.49886277E-01	0.63347947E+00	0.78749635E-01
delta 4	-0.42940224E-01	0.99158527E-01	-0.43304621E+00
delta 5	-0.24017670E+00	0.99870043E-01	-0.24048924E+01
delta 6	-0.34541793E+00	0.16852850E+00	-0.20496113E+01
Sigma-squared	0.19129048E+00	0.46553965E-01	0.41090051E+01
Gamma	0.85645270E+00	0.23962548E+00	0.35741303E+01

Log likelihood function = 0.17691753E+03

LR test of the one-sided error = 0.19258152E+02

With number of restrictions = 7

[Note that this statistic has a mixed chi-square distribution]

Number of iterations = 6

(Maximum number of iterations set at: 100)

Number of cross-sections = 180

Number of time periods = 1

Total number of observations = 180

Thus there are: 0 obsns not in the panel

Covariance matrix:

```
0.98154317E+00 -0.99344680E-02 -0.20044463E-02 0.70485164E-02 -0.70160701E-01
-0.85204088E-01 -0.70550573E-01 -0.36582803E-02 0.14927874E-03 0.24441367E-01
-0.65388444E-04 0.13213166E-02 0.11551971E-01 0.64471458E-02 -0.40058637E-02
-0.99344680E-02 0.47646900E+00 0.94745106E-01 -0.27448741E-01
0.17135694E-01
-0.78649685E-02 0.34941441E-01 0.18009872E-01 0.28475130E-01
0.35827234E+00
0.36176103E-01 0.55421569E-02 0.11053808E+00 -0.30772499E+00
0.17105150E-01
-0.20044463E-02 0.94745106E-01 0.19553542E-01 -0.51765207E-02
0.54698825E-02
-0.55637880E-02 0.78279468E-02 0.96061151E-02 0.12351489E-01
0.70399582E-01
0.96863606E-02 -0.21266636E-01 0.15365905E-01 -0.63557167E-01 -
0.36223731E-02
0.70485164E-02 -0.27448741E-01 -0.51765207E-02 0.42224285E-02 -
0.70778301E-03
0.61681773E-02 -0.16997408E-01 0.25057546E-01 0.22641135E-02 -
0.16128437E-01
0.11550279E-01 -0.23450007E-02 -0.36769440E-01 0.14533095E-01
0.20871857E-01
-0.70160701E-01 0.17135694E-01 0.54698825E-02 -0.70778301E-03
0.71821018E+00
-0.33479161E+00 -0.28832999E+00 -0.28924584E-01 -0.14657146E-01
0.26819888E-02
-0.14547733E-01 0.88979210E-02 0.17713731E-01 -0.52276591E-02 -
0.15114390E-01
-0.85204088E-01 -0.78649685E-02 -0.55637880E-02 0.61681773E-02 -
0.33479161E+00
0.59871718E+00 -0.34029865E+00 -0.27665504E-01 -0.10280300E-01
0.48632136E-01
-0.10523283E-01 0.88443710E-02 0.34528298E-01 0.56037042E-02 -
0.18191915E-01
-0.70550573E-01 0.34941441E-01 0.78279468E-02 -0.16997408E-01 -
0.28832999E+00
-0.34029865E+00 0.70336875E+00 -0.33602797E-01 -0.19486082E-01 -
0.25849027E-01
-0.19035370E-01 0.10104911E-01 0.92837438E-02 -0.14147507E-01 -
0.15037597E-01
-0.36582803E-02 0.18009872E-01 0.96061151E-02 0.25057546E-01 -
0.28924584E-01
-0.27665504E-01 -0.33602797E-01 0.97503305E+00 -0.21583824E-01 -
0.94756083E-01
-0.19618135E-01 0.71902329E-02 -0.23839339E-01 -0.10050189E+00
0.78260414E-03
```

0.14927874E-03	0.28475130E-01	0.12351489E-01	0.22641135E-02	-
0.14657146E-01				
-0.10280300E-01	-0.19486082E-01	-0.21583824E-01	0.98012404E+00	-
0.97116491E-01				
-0.18090767E-01	0.61377383E-02	-0.26371820E-01	-0.82835793E-01	
0.14082708E-02				
0.24441367E-01	0.35827234E+00	0.70399582E-01	-0.16128437E-01	
0.26819888E-02				
0.48632136E-01	-0.25849027E-01	-0.94756083E-01	-0.97116491E-01	
0.40129624E+00				
-0.92374298E-01	0.23126777E-01	-0.17442852E+00	-0.21201184E+00	
0.32092871E-02				
-0.65388444E-04	0.36176103E-01	0.96863606E-02	0.11550279E-01	-
0.14547733E-01				
-0.10523283E-01	-0.19035370E-01	-0.19618135E-01	-0.18090767E-01	-
0.92374298E-01				
0.98324135E+00	0.53248873E-02	-0.25013064E-01	-0.65978291E-01	
0.60030118E-03				
0.13213166E-02	0.55421569E-02	-0.21266636E-01	-0.23450007E-02	
0.88979210E-02				
0.88443710E-02	0.10104911E-01	0.71902329E-02	0.61377383E-02	
0.23126777E-01				
0.53248873E-02	0.99740254E+00	0.55539552E-02	0.34042578E-01	-
0.66042392E-03				
0.11551971E-01	0.11053808E+00	0.15365905E-01	-0.36769440E-01	
0.17713731E-01				
0.34528298E-01	0.92837438E-02	-0.23839339E-01	-0.26371820E-01	-
0.17442852E+00				
-0.25013064E-01	0.55539552E-02	0.94695242E+00	-0.49121460E-01	
0.20667804E-02				
0.64471458E-02	-0.30772499E+00	-0.63557167E-01	0.14533095E-01	-
0.52276591E-02				
0.56037042E-02	-0.14147507E-01	-0.10050189E+00	-0.82835793E-01	-
0.21201184E+00				
-0.65978291E-01	0.34042578E-01	-0.49121460E-01	0.21672716E+00	
0.26070295E-01				
-0.40058637E-02	0.17105150E-01	-0.36223731E-02	0.20871857E-01	-
0.15114390E-01				
-0.18191915E-01	-0.15037597E-01	0.78260414E-03	0.14082708E-02	
0.32092871E-02				
0.60030118E-03	-0.66042392E-03	0.20667804E-02	0.26070295E-01	
0.99776118E+00				

Cost efficiency estimates:

firm	year	eff.-est.
1	1	0.13833244E+01
2	1	0.11834735E+01
3	1	0.12342818E+01
4	1	0.12170678E+01
5	1	0.12079655E+01
6	1	0.13690403E+01
7	1	0.11156115E+01
8	1	0.11558229E+01
9	1	0.11398086E+01
10	1	0.15839144E+01
11	1	0.12481347E+01
12	1	0.11232062E+01
13	1	0.12196863E+01
14	1	0.11354474E+01
15	1	0.11188789E+01
16	1	0.13821780E+01
17	1	0.11818711E+01
18	1	0.12360423E+01
19	1	0.14437556E+01
20	1	0.11878691E+01
21	1	0.12621573E+01
22	1	0.13182375E+01
23	1	0.11406660E+01
24	1	0.13616131E+01
25	1	0.11760161E+01
26	1	0.12325114E+01
27	1	0.15412590E+01
28	1	0.11690495E+01
29	1	0.12390204E+01
30	1	0.11363849E+01
31	1	0.11652068E+01
32	1	0.14572438E+01
33	1	0.13393442E+01
34	1	0.12946317E+01
35	1	0.12844276E+01
36	1	0.11436939E+01
37	1	0.12298157E+01
38	1	0.12011442E+01
39	1	0.11037482E+01
40	1	0.11419818E+01
41	1	0.13729666E+01
42	1	0.12889447E+01
43	1	0.10974094E+01
44	1	0.10630016E+01

45	1	0.11927684E+01
46	1	0.11024465E+01
47	1	0.13955903E+01
48	1	0.16559707E+01
49	1	0.10879212E+01
50	1	0.12791093E+01
51	1	0.12274536E+01
52	1	0.15436266E+01
53	1	0.11409142E+01
54	1	0.10541073E+01
55	1	0.11108326E+01
56	1	0.11528268E+01
57	1	0.12466090E+01
58	1	0.14840176E+01
59	1	0.13743240E+01
60	1	0.11242814E+01
61	1	0.12989374E+01
62	1	0.12175829E+01
63	1	0.11831850E+01
64	1	0.10432078E+01
65	1	0.13489920E+01
66	1	0.11212066E+01
67	1	0.12669304E+01
68	1	0.11111736E+01
69	1	0.10617534E+01
70	1	0.11378148E+01
71	1	0.14348666E+01
72	1	0.11652107E+01
73	1	0.14446279E+01
74	1	0.10995916E+01
75	1	0.11275715E+01
76	1	0.12565825E+01
77	1	0.12838876E+01
78	1	0.11181512E+01
79	1	0.10935783E+01
80	1	0.15737790E+01
81	1	0.13841248E+01
82	1	0.12860883E+01
83	1	0.11338475E+01
84	1	0.11348687E+01
85	1	0.13769880E+01
86	1	0.10600500E+01
87	1	0.11292487E+01
88	1	0.12380988E+01
89	1	0.14240359E+01
90	1	0.11567513E+01

91	1	0.13256099E+01
92	1	0.14537381E+01
93	1	0.15817469E+01
94	1	0.16647311E+01
95	1	0.12690304E+01
96	1	0.15602144E+01
97	1	0.10570613E+01
98	1	0.11454031E+01
99	1	0.15474195E+01
100	1	0.12200005E+01
101	1	0.10542669E+01
102	1	0.14872994E+01
103	1	0.12332582E+01
104	1	0.14482747E+01
105	1	0.11412610E+01
106	1	0.11821561E+01
107	1	0.14775563E+01
108	1	0.11324657E+01
109	1	0.10505848E+01
110	1	0.11380085E+01
111	1	0.14568566E+01
112	1	0.13956666E+01
113	1	0.11095292E+01
114	1	0.11769637E+01
115	1	0.12295087E+01
116	1	0.12290923E+01
117	1	0.10649702E+01
118	1	0.11329416E+01
119	1	0.15406929E+01
120	1	0.11495423E+01
121	1	0.13532807E+01
122	1	0.11819022E+01
123	1	0.11464841E+01
124	1	0.12467108E+01
125	1	0.14863905E+01
126	1	0.11212671E+01
127	1	0.13325743E+01
128	1	0.11044560E+01
129	1	0.14944263E+01
130	1	0.11421019E+01
131	1	0.15718375E+01
132	1	0.14587746E+01
133	1	0.13887905E+01
134	1	0.11598893E+01
135	1	0.11045122E+01
136	1	0.11084093E+01

137	1	0.13116557E+01
138	1	0.10852070E+01
139	1	0.11287646E+01
140	1	0.13360437E+01
141	1	0.15741721E+01
142	1	0.10693455E+01
143	1	0.11502210E+01
144	1	0.11489030E+01
145	1	0.12618535E+01
146	1	0.11463035E+01
147	1	0.12060812E+01
148	1	0.12321731E+01
149	1	0.12456110E+01
150	1	0.13602195E+01
151	1	0.16287549E+01
152	1	0.15721808E+01
153	1	0.11026962E+01
154	1	0.13521385E+01
155	1	0.11040594E+01
156	1	0.11132587E+01
157	1	0.11275325E+01
158	1	0.12406217E+01
159	1	0.11053608E+01
160	1	0.12615017E+01
161	1	0.11437212E+01
162	1	0.11030087E+01
163	1	0.15734447E+01
164	1	0.12561146E+01
165	1	0.12124954E+01
166	1	0.11147672E+01
167	1	0.14799131E+01
168	1	0.12686337E+01
169	1	0.11743806E+01
170	1	0.16419891E+01
171	1	0.11416420E+01
172	1	0.11350655E+01
173	1	0.11939415E+01
174	1	0.12486548E+01
175	1	0.13639730E+01
176	1	0.12640129E+01
177	1	0.11279423E+01
178	1	0.12060987E+01
179	1	0.11095925E+01
180	1	0.11947207E+01

Mean efficiency = 0.12521656E+01

**APPENDIX IV**  
**Log-likelihood Ratio Test**

To test the hypothesis, Log-likelihood Ratio Test was used given as:

$$LR = -2 \left\{ L(H_0) - L(H_i) \right\}$$

Where:

LR=Log likelihood Ratio test

L (H<sub>0</sub>) = Log likelihood function of restricted model

L (H<sub>i</sub>) = Log likelihood function of unrestricted model

The result obtained from the production function, Log likelihood function of restricted model was predicted to be 111.19 while Log likelihood function of unrestricted model was predicted as 125.16. Therefore,

$$LR = -2(111.19 - 125.16) = 27.94$$

H<sub>0</sub>: there is no presence of technical inefficiency among the rice farmers in the study area

H<sub>0</sub>:  $y = \delta = 0$

The generalized likelihood ratio statistics was used to test the null hypothesis (H<sub>0</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0$ ) that there was no presence of technical inefficiency effects against the alternative hypothesis (H<sub>i</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 > 0$ ) that inefficiency effects were present. The computed test statistics for the presence of technical efficiencies was 27.94, while the critical value was obtained from Kodde and Palm at 7 df as 13.401. Therefore, since the computed test statistics value is greater than the critical value, the null hypothesis (H<sub>0</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0$ ) is rejected and we accept the alternative (H<sub>i</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 > 0$ ). Thus, rice farmers in Ardo-Kola, Jalingo and Yorro Local Government Areas of Taraba state are technically inefficient in the use of their production.

To test the hypothesis for the presence of allocative inefficiency in the study area, Log likelihood Ratio Test was used given as:

$$LR = -2 \left\{ L(H_0) - L(H_i) \right\}$$

Where:

LR= Log likelihood Ratio test

L (H<sub>0</sub>) = Log likelihood function of restricted model

L (H<sub>i</sub>) = Log likelihood function of unrestricted model

From the result obtained from the production function, Log likelihood function of restricted model was predicted to be 157.29 while Log likelihood function of unrestricted model was predicted as 176.92

$$LR = -2(157.29 - 176.92) = 39.26$$

H<sub>0</sub>: there is no presence of allocative inefficiency among the rice farmers in the study area

H<sub>0</sub>:  $y = \delta = 0$

The generalized likelihood ratio statistics was used to test the null hypothesis (H<sub>0</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0$ ) that there was no presence of allocative inefficiency effects against the alternative hypothesis (H<sub>1</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 > 0$ ) that inefficiency effects were present. The computed test statistics for the presence of allocative efficiencies was 39.26, while the critical value was obtained from Kodde and Palm at 7 df as 13.401. Therefore, since the computed test statistics value is greater than the critical value, the null hypothesis (H<sub>0</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0$ ) is rejected and we accept the alternative (H<sub>1</sub>:  $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 > 0$ ). Thus, they rice farmers are allocatively inefficient. Since, the rice farmers in the study area are technically and allocatively inefficient, hence the presence of economic inefficiency exist.

Table 21: Generalized Likelihood Ratio Test

Efficiency	Null hypothesis	LR	DF	X <sup>2</sup>	Decision rule
Technical	H <sub>0</sub> : $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0$	27.94	7	13.401	Reject
Allocative	H <sub>0</sub> : $y = \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 = 0$	39.26	7	13.401	Reject

Source: Field Survey, 2018