ECONOMIC EFFICIENCY OF RAIN-FED UPLAND RICE PRODUCTION IN OSUN AND OYO STATES OF NIGERIA

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CERTIFICATION

This work has not been presented elsewhere for the award of a degree or any other purpose.

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This thesis is dedicated to the Glory of **God** who has made it possible for me to obtain this higher degree.

ABSTRACT

Rice (*Oriza sativa)* is one of the food crops by which successive Nigerian governments had desired to boost food production since the early 1970s without much progress. Thus, this study examined the socio-economic characteristics of rain-fed upland rice growers in Osun and Oyo States of Nigeria; estimated their profitability, technical, allocative and economic efficiencies; determined resource-use efficiency and the influence of growers' socio-economic characteristics on technical efficiency on rain-fed upland rice production in the study areas. Data collected from 300 rice growers in the two States through a combination of purposive and multi-stage random sampling techniques were analyzed, using descriptive statistics, gross margin analysis and the stochastic frontier production function analysis.

Results showed that the mean ages of the rice farmers were 44.3 years and 37.5 years while the mean rice farm sizes were 1.3 ha and 1.9 ha for Osun and Oyo States respectively. Paddy outputs averaged 1,679.48kg/ha in Osun while that of Oyo State was 1,158.11kg/ha. Paddy growers in Osun State earned average gross margin/ha of ₦34,181.38 while their counterparts in Oyo State received ₦25,448.84 with average profit per grower being ₦41,132.74 and ₦44,476.8 respectively.

Results of the stochastic frontier production function analysis showed that the value of the estimated sigma squared of 0.008 which was significant at the 5.0% level indicated that the estimated production function for Osun State fitted the data very well. The estimated coefficients of included regressors were 0.961 (for farm size); 0.016 (family labour); -0.036 (hired labour); 0.534

(fertilizer); -0.063 (rice seed); 0.037 (cost of agro-chemicals) and -0.047 (cost of implements). For Oyo State, the estimated value of sigma squared of 0.018 which was also significant at 5.0% showed that the estimated production function fitted the data quite well. The estimated coefficients of the explanatory variables were 0.314 (for farm size); 0.142 (family labour); 0.284 (hired labour); 0.001 (fertilizer); 0.026 (rice seed); 0.010 (cost of agro-chemicals) and 0.051 (cost of implements). Land was the most productive resource with elasticity of production of 0.961 and 0.314 for Osun and Oyo States respectively. With the exception of the estimated coefficient of family labour which was insignificant, the estimated coefficients of other explanatory variables were significant at the 5.0% level for Osun State. In Oyo State, the coefficients of farm size, family labour and hired labour were significant while those of the quantity of fertilizers, rice seed, costs of agrochemicals and implements were not statistically different from zero at the 5.0% level. The computed RTS for paddy production in Osun State was 1.40 while that of Oyo State was 0.83. Results of efficiency measurements showed an average of 90.1% in technical efficiency, 92.0% in allocative efficiency and 83.4.0% in economic efficiency for Osun State. On the other hand, Oyo State paddy producers recorded an average of 94.3% in technical efficiency, 88.9% in allocative efficiency and 84.0% in economic efficiency.

It was concluded that although rice enterprise was profitable in the two States, rain-fed upland rice farmers were not fully economically efficient in the use of production resources available to them.

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CHAPTER ONE

1. INTRODUCTION

1.1 Background Information

In spite of the dominance of petroleum as the major revenue earner in Nigeria, agriculture still constitutes a very significant sector of nation's economy. Collier, (1987); Olayemi and Dittoh, (1995) discussed extensively the contributions of agriculture to the Nigerian economy. Amongst the contributions of the agricultural sector are the provision of food for the teeming population; contribution of over 30% of the total Gross Domestic Product (GDP) of the country (CBN, 1999); provision of employment opportunities for over 65.0% of economically active population of the country; provision of raw materials for agro-allied industries and the generation of foreign exchange earnings. Food crops account for the bulk of the crop' sub-sector of the nation's agriculture and comprise broadly of cereals, pulses, roots and tubers, plantains, oil seeds and nuts, vegetables and fruits. Food was relatively adequate in Nigeria at independence because of high farming activities and productivity level within the food crop sub-sector and the situation remained the same during the first few years that followed. However, effects of the subsequent neglect of the agricultural sector started to take its toll on the nation's food supply in the early 1970s (Oni, 1998).

The Federal Office of Statistics (FOS), Lagos (1986) claimed that between 1970 and 1985, there was an average decline of 1.3% per year in crop production while food production declined by 0.4 percent on the average. The factors which contributed to the decline in food production since the early 1970s included:

(i) low level of production technology;

(ii) aftermath of Nigerian civil war;

(iii) upsurge in petroleum revenues;

(iv) huge government expenditure in financing large construction projects in urban centres and,

(iv) neglect of agriculture attendant upon the discovery and exploitation of crude petroleum in large quantities.

The downward trend in food crop output influenced the sub-sector's contribution to GDP as its contribution to the GDP shrank to about 21.0% by the early 1980s (FOS, 1986). As a result, Nigeria began to experience food supply deficits while food import bills began to rise astronomically. From a level of ₦88.3 million in 1971, representing 8.2 percent of total imports, food import bills rose to ₦1.8 billion in 1981, representing 14.4percent of total imports for that year; instability in food production was higher between 1986 and 1994 than between 1981 and 1985. Generally, the annual coefficient of variation was between 20 and 45 percent for most major food crops in Nigeria (World Bank, 1996).

1.2 The Importance of Rice in the Nigerian Economy

Rice, *Oryza sativa,* has been cultivated in parts of the Northern parts of Nigeria since the sixteenth century but its importance in the food economy of the nation dates back to the early 20th century (Agboola, 1979). According to WARDA (1993), rice has become a staple food of considerable strategic importance in many rapidly growing African cities where its consumption among urban poor households has increased substantially. It is one of the most popular food commodity in Nigeria being widely accepted and consumed in one form or another by households across all ethnic, religious, and geopolitical zones in the country. Its economic importance is also strengthened by the fact that unlike other cereals rice is less proned to storage pest attacks and as such, may be stored over a relatively longer period (Aderinola, 1997). Rice also has been identified as an important raw material in the production of starch and alcohol (Akinsanmi, 1975) while its bran is an important source of protein in the production of livestock feeds in Nigeria (IRRI, 1974 & Bamiro *et al*, 2001). Rice has not only become a very important menu in virtually all Nigerian households, it became a 'political' food commodity when in 1981, a 'Presidential Task Force' (PTF) was set up to import it by the Federal Government of Nigeria (Aderinola, 1997).

Aderinola (1997) also claimed that although rice has been cultivated in Nigeria for more than three hundred years, its production and consumption did not gain much attention until the early 1970s when the supply of traditional food stuffs such as yam, maize, sorghum and millet suffered acute shortages due to the civil war of 1967 to 1970 and the Sudano-Sahelian drought of 1973/74 in the northern parts of the country. However, by the mid-1970s, the consumption of parboiled, milled rice had assumed a prominent feature in Nigerian homes as rice was eaten at least once in every three meals even among the "iyan-eating" people in Southwestern parts of the country (Alao *et al*, 1979). The deficit in domestic rice production necessitated its importation in large volumes, which did not only drain the nation's foreign exchange reserves but almost virtually crippled the domestic rice industry. The South-Western Nigeria which was noted for its large land area (916,380 ha), suitable for rice production, had the highest indices of productive efficiency in rice in the country (Aderinola, 1997). However, much of the estimated potential hectarages suitable for upland rice production had not been put into productive use (Adesimi and Fabiyi, 1995).

Rice has grown in importance as a component of Nigerian diet. The average per capita consumption of rice per annum in Nigeria is about 24.8kg, representing 9.0% of total calorie intake and 23.0% of total cereal consumption (FAO Statistics, 2004). Since the mid-1980s, rice consumption has increased at an average annual rate of 11.0%, due to increasing population, rising income levels, rapid urbanization and changes in family occupational structures (Akande, 2004). FAO (2004) estimated that over 2.1 million tonnes of rice were consumed annually in Nigeria.

Available statistics indicate that domestic rice production in Nigeria increased from about 1,090 thousand tones in 1980 to about 3,373 thousand in 2003 (Table 1). These increases were due partly to increases in the area cultivated (Akande, 2004) and partly to remunerative producer prices of paddy rice which resulted from the ban on rice importation at the introduction of the Structural Adjustment Programme (SAP) in 1986 (Aderinola, 1997). Nevertheless, FAO (2004) claimed that an estimated 0.4 million tonnes of rice continued to enter Nigeria annually in spite of the ban! Since food importation constitutes a drain on the nation's foreign exchange reserves, greater efforts should be geared-up to boost domestic production of this staple food. In addition, a nation that cannot feed her citizens cannot be said to be truly independent.

Table 1: Domestic Rice Production, Imports and Aggregate Supply in Nigeria

Year	Domestic Production ('000 tonnes)	Imports ('000 tonnes)	Total Supply ('000 tonnes)	Self-Sufficiency Ratio
1980	1,090.0	450.0	1540.0	70.78
1981	1,241.0	656.8	1897.8	65.40
1982	1,250.0	539.4	1789.4	69.86
1983	1,280.0	543.5	1823.5	70.20
1984	1,300.0	365.0	1665.0	78.08
1985	1,430.0	356.1	1786.1	80.06
1986	1,416.3	320.0*	1736.3	81.57
1987	1,780.0	400.0*	2180.0	81.65
1988	2,081.0	200.0*	2281.0	91.23
1989	3,303.0	300.0*	3603.0	91.67
1990	2,500.0	224.0*	2724.0	91.78
1991	3,226.0	296.0*	3522.0	91.60
1992	3,260.0	350.0*	3610.0	90.30
1993	3,065.0	350.0	3415.0	89.75
1994	2,427.0	350.0	2777.0	87.40
1995	2,920.0	300.0F	3220.0	90.68
1996	3,122.0	345.5	3467.5	90.04
1997	3,268.0	699.0	3967.0	82.38
1998	3,275.0	594.0	3869.0	84.65
1999	3,277.0	812.4	4089.4	80.13
2000	3,298.0	740.0	4038.0	81.67
2001	2,752.0	1,765.0	4517.0	60.93
2002	3,192.0	1,232.4	4424.4	72.15
2003	3,373.3	1,600.0	4923.3	67.83
2004	3,542.0	1,350.0	4892.0	72.40

Notes: F = FAO estimates.
* = Unofficial figures.

Source: FAO Statistical Database (2004).

Apart from the possibility of being held to ransom by the food exporting country(ies), the food importing country may (unwittingly) subject her self to the vicissitudes of the former in addition to destroying her agricultural economy (Aderinola, 1983).

Table 2 shows estimates of rice hectarages, output and yield per hectare for rain-fed upland rice farmers in Osun and Oyo States from year 2000 to 2004. In Osun State, the area cultivated to rice increased from 1074 thousand hectares in year 2000 to 2119 thousand hectares in 2004. Although, the output of paddy rice increased from 1616 thousand tonnes in the year 2000 to 1736 thousand tonnes in 2004 in Osun State, there was a decrease in yield from 1.50 tonnes per hectares in year 2000 to 0.82 tonne per hectare in 2004. In Oyo State similar trend was also observed for paddy rice production during production years 2000 through 2004. According to FAOSTAT(2004),the observed slow rate of paddy rice production, low yield and productivity in the last five years shown in Table 2 has been largely attributed to a combination of factors such as the use of unimproved seed varieties, poor agronomic and post-harvest handling practices as well as the use of low external inputs.

Other programmes embarked upon by the Federal Government of Nigeria (FGN) since 1999 to boost local rice production include:

(i) restoration of fertilizer subsidies at 25.0%(1999);

(ii) establishment of Department of fertilizer(1999);

(iii) restoration of producer price support scheme for grains (rice inclusive)(1999), and the,

(iv) National Poverty Eradication Programme (NAPEP)(1999).

Table 2: Estimated Hectarages, Output and Yields of Rice in Osun and Oyo States, 2000-2004

	Osun			Oyo		
Year	Area ('000 Ha)	Output ('000 tonnes)	Yield (T/ha)	Area ('000 Ha)	Output ('000 tonnes)	Yield (T/ha)
2000	1074	1616	1.50	110	165	1.50
2001	1081	1348	1.23	110	138	1.25
2002	1527	1564	1.02	156	160	1.03
2003	1792	1653	0.92	183	169	0.92
2004	2119	1736	0.82	216	177	0.81

Source : Computed from FAO Statistical Data Base, 2004.

1.3 The Research Problem Statement

In order to prevent the depletion of the nation's foreign exchange earnings (through huge food import bills) and achieve a satisfactory level of self-sufficiency in domestic food production, concerted efforts should be made to improve individual factor productivity. The low level of productivity in food grains' production is a reflection of the low levels of technical, allocative and economic efficiencies in the sub-sector. Therefore, one approach at solving this problem is to investigate the efficiencies of resource-use in grain crop production. Towards this end, there will be a need to conduct empirical studies on the measurement of factor efficiencies in the production of grain crops in the country with a view to making appropriate policy (-ies) for improvements.

Thus, this study was planned to examine the economic efficiency of rain-fed upland rice production in Osun and Oyo States of Nigeria. The study attempted to provide answers to the following research questions:

(a) what is the level of profitability of rain-fed upland rice enterprises in the study areas?

(b) are there differences in the technical efficiencies among rain-fed upland rice farmers in the study areas?

(c) how efficiently do rain-fed upland rice farmers use available farm resources in the study areas?

(d) what are the determinants of technical efficiency among rain-fed upland rice farmers in the study areas?

By providing answers to these questions, this study intended to supply empirical information on resource-use efficiency among rain-fed upland rice farmers in Osun and Oyo States to Policy-makers in their bid to boost the output of the grain crop in the country.

1.4 Objectives of the Study

The overall objective of the study was to examine the economic efficiency of upland rice production in Osun and Oyo States of Nigeria. The specific objectives were:

(i) to examine the socio-economic characteristics of rain-fed upland rice growers in Osun and Oyo States of Nigeria;

(ii) to estimate the profitability of rain-fed upland rice production in the study areas;

(iii) to determine resource-use efficiency of rain-fed upland rice production in the study areas;

(iv) to estimate the technical, allocative and economic efficiencies of rain-fed upland rice production in the study areas;

(v) to examine the influence of some farmers' socio-economic variables on their technical efficiency and

(vi) to draw inferences from the findings on the appropriate farm management policy formulation capable of leading to optimal allocation of scarce resources in rain-fed upland rice production in the study areas.

1.5 Hypotheses of the Study

In order to achieve the objectives stated above, the following hypotheses in the null form were tested:

(i) H_0: RTS = Stage II; that is, rice crop farmers are operating in the efficient region of the production surface.

(ii) H_0: $\gamma = 0$; that is, there are no (a) technical and (b) allocative inefficiency effects in rice crop production in the study areas.

(iii) H_0:μ_Π = 0; that is, profitability level of rice crop farmers is not significantly different from zero.

(iv) H_0: δ = 0; Socio-economic characteristics of rice crop farmers have no significant effect on the farmer technical efficiencies.

(v) H_0: TE $(AE)_{(OS)}$ = $TE(AE)_{(OY)}$; there is no significant difference between the mean technical and allocative efficiencies of rice farmers in Osun and Oyo States.

1.6 Justification for the Study

There is the need to increase agricultural production if there is going to be any appreciable development in the agricultural sector. This could be achieved by making efficient use of the available scarce resources of agricultural production. The amount of output a farmer will produce depends to a large extent on how efficiently he is able to combine such resources. Quantitative analysis of agricultural production systems has become an important step in the formulation of agricultural policy. A number of empirical studies include attempts to estimate economies of scale, to investigate producer responsiveness to product and input price changes, and to measure relative efficiency. The latter, which is the subject of this study, is necessary because the analysis of efficiency helps in identifying the possibilities of increasing output while conserving resource use. The role of increased efficiency may be viewed as a complement to any set of policies to stimulate domestic production and/or to promote resource conservation.

Thus, the study of efficiency in agricultural production at the farmers' level is carried out judging from the standpoint of the vital information, which may be gained from the study. First, by carrying out micro-study on the farm and conditions confronting the farmers, one may be able to indicate the course of action profitable for farmers to take and hence profitable and efficient use of resources. Second, such efficiency of agricultural production study would give the basis for predicting the consequences of changes in economic condition of production of farm and in turn upon the aggregative amount of products that will be available for consumption. If the production of individual farm increases from a given amount of resources, society gains in that a greater quantity of product is available for distribution among the people.

From the problem statement above, this study is justified in the role it could play in finding solution to the food problem occasioned by the increase in population in the country. This study is also justified in that the measurement of efficiency (technical, allocative and economic) is very important because it is a factor for productivity growth. Such study will benefit Nigerian economy by determining the extent to which it is possible to raise productivity with the existing resource base and the available technology, thereby conserving foreign exchange, which would have been used for imports. It would also help in deciding whether to improve efficiency first or develop a new technology in the short run. If efficiency of food grain production is improved, resources can be made available for non-agricultural development and other needs beyond the essentials of food and fibre.

CHAPTER TWO

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 The Theory of Production

In economic analysis, the major concern is with the technical, allocative and economic efficiencies of resource transformation (Seitz, 1970). Therefore, the theoretical framework for this study stands on the theory of production. Production is the process by which variable and fixed factors are combined to produce outputs. Factors of production used in agriculture include land, labour, capital, management and water (irrigation). The relationship between the input used and maximum possible output produced is expressed by the production function (Henderson and Quandt, 1980). Production function can be used in the measurement and or the computation of the following important economic magnitudes: total physical product (TPP), average physical product (APP), marginal physical product (MPP), marginal rate of technical substitution (MRTS), elasticity of production (ε_p) and returns-to-scale (RTS). Thus, the analysis of the production function curve with the knowledge of the metrics given above could be used as a frame of reference to undertake a quantitative interpretation of the three stages of the production surface. Each stage is important from the view point of economic analysis and efficient resource use. Stage I is an irrational zone of production. There is a positive increasing return to factor and scale. Production is inefficient at this stage. Therefore, the economic decision at this stage is that if the product being produced has any value at all, input use once started should be continued until stage II is reached where the productivity of such input would reach its peak.

Stage II is the stage of positive decreasing returns to scale and the RTS is less than unity but greater than zero. It is the economic relevant stage in the production function analysis because it is there that such issues as output and profit maximization, optimization of input level combination and cost minimization are addressed. The exact point of optimal input combination and output production is determined when the choice indicators (input and output prices) are known together with the physical concept underlying the production function analysis.

Stage III has no economic relevance and production is not advisable in this stage. Efforts should be made to readjust production back to stage II once it gets to stage III. Total product decreases with each additional input use and the RTS exhibits negative decreasing returns to scale.

There are three basic physical relationships between a set of inputs and the output streams they generate. These are factor-product, factor–factor and product-product. These relationships could result into increasing, constant or decreasing returns to scale (Olayide and Heady, 1982). Figure 1 shows the typical factor - product relationship and the parameters derivable from the relationship.

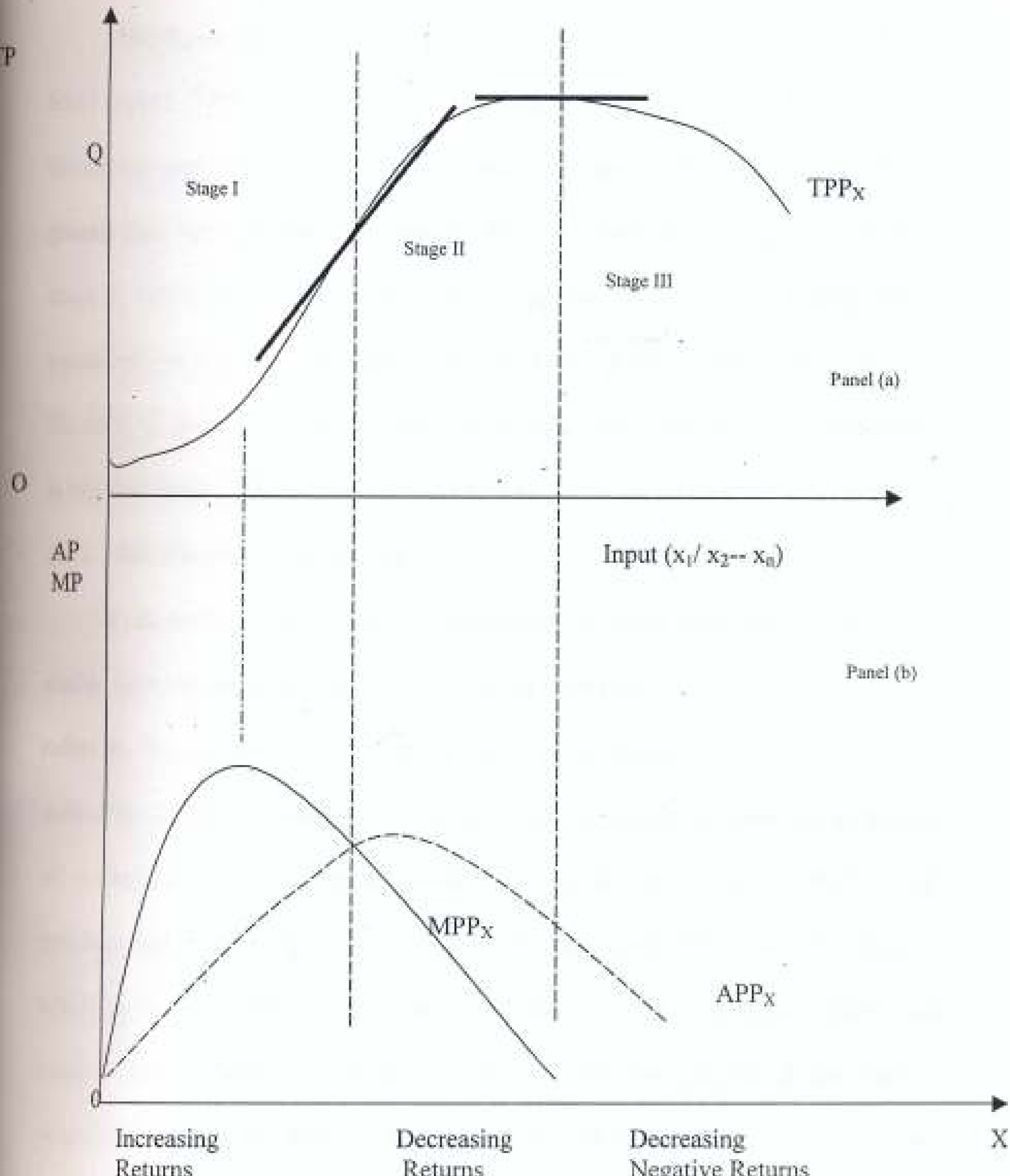

Figure 1: Total, Average, Marginal, Product Curves and the Three Stages of Production

Source: Olayide and Heady (1982), p 55.

The figure shows that as a variable input is being added to one or more fixed inputs, TPP_X increases at an increasing rate, and then it increases at a decreasing rate before it finally decreases. In stage I of production, MPP_X is greater than APP_X while MPP_X equals APP_X at boundary of stages I and II. In stage II, MPP_X is less than APP_X and it is falling. APP_X is also falling. MPP_X equals zero at boundary of stages II and III while APP_x is still positive. In stage III, APP_x is greater than MPP_x, APP_x is positive (greater than zero) while MPP_X is negative (lesser than zero). Both APP_x and MPP_x are falling.

2.1.2 The Theory of Farm Cost

Cost concepts are of great importance in farm business because they enable farm operators to make choices among present alternative actions. Cost refers to the expenditures on inputs used in production. Cost functions are defined as the mathematical presentation of the relationships between total cost of production and the output produced (Olayide and Heady, 1982). Cost functions help the producer to determine the most profitable level of output at which production must cease. Costs generally are of two types: fixed and variable costs. Fixed costs are those costs that exist irrespective of the level of production. They are those costs incurred on inputs which do not change as production changes. Fixed costs exist only in the short run because in the long run, all costs are variable since occasion may demand changing all the factors of production. Therefore, fixed costs are not part of production decision in the short run. Variable costs are those costs that relate directly to the level of production. The level of variable costs depends on the level of output. Total costs of production are obtained by summing up the total fixed and variable costs production. In the short run, it will increase only as total variable cost increases, as total fixed cost is a constant value.

Marginal cost is the additional cost necessary to produce one more unit of output or the change in total cost associated with producing an extra unit of output. The marginal cost is a function of the nature of the production function and the cost per unit of the variable inputs.

Cost functions are derived from production functions. Various cost concepts used in economics are: Total Cost (TC), Total Fixed Cost (TFC), Total Variable Cost (TVC), Average Fixed Cost (AFC), Average Variable Cost (AVC), Average Total Cost (ATC), and the Marginal Cost (MC).

As noted above, total cost (TC) is a function of total output (Y) which implies that the greater the output, the greater will be the total cost. Symbolically,

$$TC = f(Y) \quad \text{------------------------------------} \quad (1)$$

Where: Y = quantity produced (kg)

The various cost concepts are defined as follows:

$$TC = TFC + TVC \quad \text{------------------------------------} \quad (2)$$

$$TVC = X_1P_1 + X_2P_2 \ldots, + X_n P_n \quad \text{------------------------------------} \quad (3)$$

From equation (2),

$$\frac{TC}{Y} = \frac{TFC}{Y} + \frac{TVC}{Y} \quad \text{------------------------------------} \quad (4)$$

$$ATC = AFC + AVC \quad \text{------------------------------------} \quad (5)$$

$$\frac{dTC}{dY} = MC \quad \text{------------------------------------} \quad (6)$$

Thus, marginal cost is the first derivative of the total cost function with respect to quantity produced (Y). The MC has inverse relationship to MPP when output is maximum, MC = AVC and MPP = 0.

$$AVC = \frac{TVC}{Y} = \frac{P_iX_i}{Y} = P_i/APP_i \quad (7)$$

Where: P_i is the unit price of input X_i and APP_i is average physical product. The AVC is inversely related to APP and as APP increases the AVC decreases. When APP is maximum, AVC is minimum. Average and marginal measures are employed in efficiency measurement analysis while the analyses of the revenue and cost functions are very important in budgetary analysis (Doll and Orazem, 1984).

2.1.3 The Concepts of Productivity and Efficiency

Agricultural productivity may be defined as the ratio of total farm output to total inputs used in farm production. Increases in agricultural productivity will contribute to the well-being of the economy as a whole (Olayide and Heady, 1982). Productive efficiency means the attainment of production goal without waste. Beginning with this basic idea of 'no waste', economists have built up a variety of theories on efficiency. However, the fundamental idea underlying all efficiency measures is the relationship between the quantity of goods and services produced per unit of input.

Thus, efficiency in economics is usually defined in terms of the optimality conditions associated with the perfectly competitive norm, that is, for efficiency to exist, the marginal rates of substitution between any two commodities or factors must be the same in all their different uses (Pasour, 1981). Efficiency is often used synonymously with that of productivity which relates output to input. In agriculture, the analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or certain level of output at least- cost.

Three components of efficiency have been distinguished in the economic literature (Farrell, 1957). They are:

(i) technical efficiency,

(ii) allocative efficiency and,

(iii) economic efficiency.

(i) Technical Efficiency

Technical efficiency is defined as the ability to produce maximum output from a given set of inputs, given the available technology (Yao and Liu, 1998). This definition indicates that differences in technical efficiency exist between farms. According to Mijindadi and Norman (1982) the observed differences might be attributed to at least four sets of factors, viz:

(i) differences in management ability;

(ii) the employment of different levels of technology ---- indicated by the qualities and of types of inputs used;

(iii) different environmental factors-soil quality, rainfall, solar radiation, and,

(iv) non-economic and non-technical factors such as family structure and motivational differences which can prevent some farmers from working hard enough on their plots thus failing to achieve the highest level of farm output.

In a factor-product relationship, the production function presupposes technical efficiency whereby maximum output is obtained from a given level of input combination. One important assumption that relates to efficiency is that efficient farms operate on the outer bound of the production function, that is, on their frontier, while inefficient farms are those operating below the production frontier. The amount by which a farm lies below its production frontier is regarded as the measures of inefficiency. For such inefficient farms, improvements in technical efficiency may be achieved through improved production techniques. This may imply a change in factor proportions through factor substitution under a given technology.

(ii) **Allocative Efficiency**

While the technical efficiency is concerned with the physical relationship between input and output, allocative efficiency takes into account price relationship in addition to the physical relationship. Thus, allocative efficiency is the optimum allocation of resources taking into account the prices of the resources. In other words, it is the ability of choosing optimal input levels for given factor prices.

A farm is allocatively efficient when production occurs at point where the marginal value product (MVP) is equal to the marginal factor cost (MFC) (Apezteguia and Garate, 1997). Allocative inefficiency occurs if the ratio of the marginal physical products of two inputs does not equal the ratio of their prices.

(iii) **Economic Efficiency**

Economic efficiency combines technical efficiency with allocative efficiency and marries them with unit prices of inputs. Thus, the presence of either technical efficiency or allocative efficiency is a necessary but not a sufficient condition to achieve economic efficiency. When technical efficiency and allocative efficiency are present together, then sufficient condition for achieving economic efficiency is provided (Yotopoulous and Nugent, 1976).

Economic efficiency refers to the choice of the best combination of inputs for a particular level of output which is determined by both input and output prices. According to Xu and Jeffrey (1998), an economically efficient input-output combination would be on both the frontier production function and the expansion path which they claimed implied that both the necessary and sufficient conditions for optimal combination of inputs and outputs were met. Applying the basic ideas underlying Farrell's (1957) approach to the measurement of the three types of efficiencies, Singh *et al*, (2000) used the diagram presented in figure 2 for illustration.

The diagram shows the efficient unit isoquant (SS^1) for a farm which uses the least amounts of inputs {labour (X_1) and land (X_2)} to produce a unit of output. In Figure 2, production unit operating at point P utilizes two input factors, labour (X_1), and land (X_2) to produce a single output. SS^1 is the efficient isoquant estimated with an available technique. Point Q on the isoquant represents the efficient reference of observation P. The technical efficiency (TE) of a production unit operating at P is measured by the ratio specified by equation (8):

$$TE = OQ/OP \quad (8)$$

which is equal to 1-QP/0Q. It will take a value between zero and one, and hence an indicator of the degree of technical inefficiency of the production unit. A value of one indicates the firm is fully technically efficient. For instance, the point Q is technically efficient because it lies on the efficient isoquant. If the inputs price ratio, represented by the slope of the iso-cost line SS' in figure 2 is

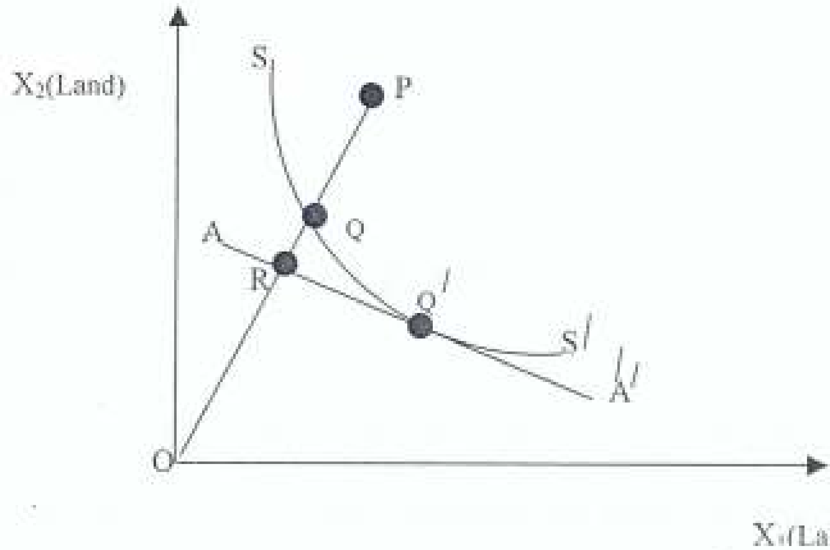

Figure 2: Technical and Allocative Efficiencies in Input-oriented Measures

Source: Singh *et al* (2000).

also known, allocative efficiency can be inferred. This is because in economic theory, the optimal level of input combination is that at which the ratio of the marginal physical product of the two inputs X_1 and X_2 is equal to the ratio of their prices, that is:

$$MPP_{x1}/\ MPP_{x2} = P_{x1}/\ P_{x2} \quad \text{--} \quad (9)$$

The allocative efficiency (AE) of a firm operating at point P is defined to be the ratio specified in equation (10):

$$AE = OR/OQ \quad \text{--} \quad (10)$$

Since the distance RQ represents the reduction in production costs that would occur if production were to occur at the allocatively and technically efficient point Q' which is the point of minimum cost, instead of the technically efficient, but allocatively inefficient point Q (where $MPPx_1/\ MPP_{x2} \neq P_{x1}/\ P_{x2}$).

The total economic efficiency (TEE) is the product of technical efficiency and allocative efficiency as specified in equation (11):

TEE = (OQ/OP) X (OR/OQ) = OR/OP .... (11)

Where the RQ can also be interpreted in terms of a cost reduction. In ensuring optimal combination of factors of production, farms should aim at production at point Q'.

The explanation above represents an overview of input-based radial measures of economic efficiency. These measures are input-based in so far as they measure differences in input use between farms for standardized (unit) output. The radial nature of Farrell's (1957) measures is taken along a ray from origin in input-input space. This defines the TE standard as a point on efficient isoquant SS' having identical input proportions to the farm whose efficiency is being measured and allows a simplified cost interpretation of the AE measure.

Farell (1957) also proposed an output based measure which focuses on differences in output between farms when input levels are standardized. These and other measures are examined in detail by Timmer (1971), Fare and Lovell (1978). They pointed out that the input-based measure is equivalent to the output based measure only in the case of homogenous technology with constant returns to scale and that both measures break down when technology is non-homothetic. Thus, Battese (1992) showed a more general presentation of Farrell's concept of the production function (or frontier) as depicted in figure 3 involving the original input and output values. The horizontal axis represents the (vector of) inputs, X, associated with producing the output, Y.

The observed input-output values are below the production frontier, given that farms do not attain the maximum output possible for the inputs involved, given the technology available, A measure of the technical efficiency of the farm which produces output, Y, with inputs, X, denoted by point A, is given by Y/Y^*, where Y^* is the "frontier output" associated with the level of inputs, X (see point B). This is a measure of technical efficiency which is conditional on the levels of the inputs involved.

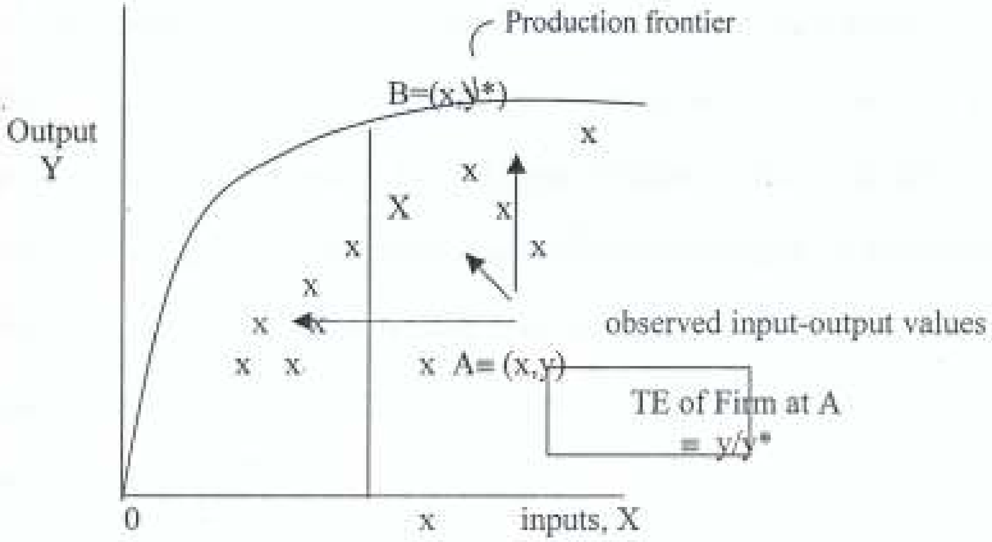

Figure 3: Technical Efficiency of Firms in Input-Output Space.

Source: Battese, 1992.

2.1.4 Techniques of Efficiency Measurement

There are two basic methods of measuring efficiency; the classical method and the frontier method.

a. The Classical Method

This method is based on ratio of output to a particular input. This method is termed partial productivity measure because output is related to a single input at a time, for example, measure of labour productivity given by output per man-hour; land productivity given by crop yield per unit of farmland. Measures such as tones per hectare are deficient in the sense that they only consider the land input and ignore all other inputs, such as labour, machinery, fertilizer and chemicals. The use of this measure in the formulation of management and policy advice is likely to result in excessive use of those inputs which are not included in the efficiency measure.

b. The Frontier Method

The frontier method was developed as a result of the inadequacy of the classical method. This method involves the use of econometric, statistical and linear programming techniques for analyzing efficiency related issues. The frontier method implies that efficient farms are those operating on the production frontier, while inefficient farms are those operating below the production frontier. The amount by which a farm lies below the production frontier is regarded as the measure of inefficiency. The earliest work on the frontier approach dates back to Farell(1957).According to Coelli(1995),the two main benefits of estimating frontier functions rather than average(for example Ordinary Least Squares) functions are that:

(i) estimation of an average function will provide a picture of the shape of technology of an average firm, while the estimation of a frontier function will be most heavily influenced by the best performing firms and hence reflect the technology they are using

(ii) the frontier function represents a best-practice technology against which the efficiency of firms within the industry can be measured. It is this second use of frontier which has provided the greatest impetus for the estimation of frontier functions in recent years. The frontier method can be:

(i) **Non-Parametric Approach**

This is a mathematical programming approach often referred to as Data Envelopment Analysis (DEA). The mathematical programming method focused mainly on the development of DEA methods engaged with multiple-input and multiple-output production technologies. DEA approach was first applied by Charnes *et al*, (1978). In their study, they proposed a model which assumes constant returns to scale (CRS). DEA applies operational programme to construct a non- parametric piecewise linear production frontiers over the data. One of the advantages of DEA approach is that it removes the necessity for the definition or specification of the functional form of the production frontiers and their assumptions regarding the distributional form of the U_i. DEA studies producers' behaviour by the efficient frontier and the distance between a production unit and the frontier. The basic DEA models are deterministic. The criticisms of this model are that it takes no account of the possible influence of measurement error and other noise in the data.

(ii) **Parametric or Econometric Approach**

The econometric or parametric approach has been motivated to develop stochastic frontier models based on the deterministic parameter frontier of Aigner and Chu (1968). The Stochastic Frontier Analysis (SFA) recognizes the existence of the random noise around the estimated production frontier. In a simple case of a single output and multiple inputs, the approach predicts the outputs from inputs by the functional relationships;

$$Yi = f(X_i, \beta) + \varepsilon_i \text{ --(12)}$$

Where "i" denotes the production unit being evaluated and β 's are the parameters to be estimated. The residual ε_i is composed of a random error V_i and inefficiency component U_i. If we assume that Vi = 0, then SFA is reduced to the Deterministic Frontier Analysis (DFA). If we assume that Ui = 0, SFA will be reduced to central tendency analysis or average response analysis. The relative merits of the Stochastic Frontier Analysis of parametric approach are that it can account for noise as well as allowing the tests of hypotheses to be conducted (Coelli, 1995; Coeli *et al*, 1998; Kumbhackar and Lovell, 2000).

The econometric approach and the non-parametric approach differ in many ways, but the essential differences, and the sources of the advantages of one approach to the other boil down to two characteristics:

(a) the econometric approach is stochastic, and so attempts to distinguish the effects of noise from the effects of inefficiency. The programming approach is non stochastic, and lumps noise and inefficiency together and calls the combination inefficiency.

(b) the econometric approach is parametric, and confuses the effects of misspecification of functional form (of both technology and inefficiency) with inefficiency. The programming approach is non parametric and less prone to this type of specification error.

2.2 Stochastic Frontier Production Function: Technical and Allocative Efficiency

Empirical estimation of efficiency is normally done with the methodology of stochastic frontier production function. The stochastic frontier production model has the advantage of allowing simultaneous estimation of individual technical and allocative efficiencies of the respondent farmers as well as determinants of technical efficiency (Battese and Coelli, 1995).

The stochastic frontier production function independently proposed by Aigner *et al* (1977) and Meeusen and Van Den Broeck (1977) assumes that maximum output may not be obtained from a given input or a set of inputs because of the inefficiency effects. It can be written as:

$$Y_i = f(X_{ai}; \beta) + \varepsilon_i \quad \text{...} \quad (13)$$

Where:

Y_i = the quantity of agricultural output,

X_{ai} = a vector of input quantities and,

β = a vector of parameters

ε_i is an error term defined as:

$$\varepsilon_i = V_i - U_i \quad i = 1, 2, \ldots n \text{ farms} \quad \text{..............................} \quad (14)$$

V_i is a symmetric component that accounts for pure random factors on production, which are outside the farmers' control such as weather, disease, topography, distribution of supplies, combined effects of unobserved inputs on production etc. and U_i is a one-sided component, which captures the effects of inefficiency and hence measures the shortfall in output Y_i from its maximum value given by the stochastic frontier $f(Xa;\ \beta) + V_i$. The model is expressed as:

$$Y_i = \exp(X_i\beta + V_i - U_i) \quad \text{...} \quad (15)$$

2.2.1 Technical Efficiency

The technical efficiency of production of the i[th] farmer in the appropriate data set, given the levels of his inputs, is defined by:

$$TE_i = \frac{\exp(X_i\beta + V_i - U_i)}{\exp(X_i\beta + V_i)} = \exp(-U_i) \quad \text{.......} \quad (16)$$

From equations (13) and (14) above, the two components V_i and U_i are assumed to be independent of each other, where V_i is the two-sided, normally distributed random error ($V_i \sim N(0, \sigma_v^2)$), and U_i is the one-sided efficiency component with a half normal distribution ($U_i \sim IN(0, \sigma_u^2)$). Y_i and X_i are as defined earlier. The β's are unknown parameters to be estimated together with the variance parameters.

The variances of the parameters, V_i and U_i, are σ_v^2 *and* σ_u^2 respectively and the overall model variance given as σ^2 are related thus:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad \text{.......} \quad (17)$$

The measures of total variation of output from the frontier, which can be attributed to technical efficiency, are lambda (λ) and gamma (γ) (Battese and Corra, 1977) while the variability measures derived by Jondrow, *et al* (1982) are presented by equations (18) and (19):

$$\lambda = \frac{\sigma_u}{\sigma_v} \quad \text{.......} \quad (18)$$

and,

$$\gamma = \frac{\sigma_u^2}{\sigma^2} \quad \text{.......} \quad (19)$$

On the assumption that V_i and U_i are independent and normally distributed, the parameters β, σ^2, σ_u^2, σ_v^2, λ *and* γ were estimated by method of Maximum Likelihood Estimates (MLE), using the computer program FRONTIER Version 4.1 (Coelli, 1996). This computer program also computed estimates of technical and allocative efficiencies.

Following Olowofeso and Ajibefun, 1999, a three-step procedure in estimating the MLE estimates of the parameters of the stochastic frontier production function was then used. The steps are:

Step I: The OLS estimates of the production function were obtained.

Step II: A two-phase grid search for the gamma (γ) and meu (μ) parameters were conducted with the β parameters, excepting the β_0, which was set to the OLS values and the β_0 and σ^2 parameters were suitably adjusted.

Step III: The values selected in the grid search were used as starting values to obtain the maximum likelihood estimates.

The farm specific technical efficiency (TE) of the i^{th} farmer was estimated using the expectation of U_i conditional on the random variable (ε_i) as shown by Battese and Coelli (1988). The TE of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology, that is:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{\exp(X_i\beta + V_i - U_i)}{\exp(X_i\beta + V_i)} = \exp(-U_i) \quad \text{.........} \quad (20)$$

(Tadesse and Krishnamoorthy, 1997); so that O ≤ TE ≤ 1.

2.2.2 Allocative Efficiency

Allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, given their respective prices. A production process is said to be allocatively efficient if it equates the marginal rate of substitution between each pair of inputs with the input price ratio. According to Ajibefun and Daramola (2003) departure from this optimality condition can be explained by:

(a) under-utilization or over-utilization of inputs resulting from the failure to minimize cost exactly because of some institutional, structural or managerial problems and,

(b) uncontrolled random exogenous shocks such as uncertainty in input and output prices, quality of inputs, etc.

Allocative efficiency is modelled as:

$$MP_{Xi}/MP_{Xj} = K_i W_i/W_j e^{hi} \quad \text{...} \quad (21)$$

$i = 1, 2\ldots, n$

Where factors of proportionality, K_i are firm and input specific, h_i are random errors; MP_{XI} are marginal products of X_i and W_i input prices. Hence, exact cost minimization is a special case when $K_i = 1$ ($i = 1, 2\ldots, n$) and K_i represents allocative inefficiency in the input pair (j, i).

When $h_i = 0$ for all i, the production process is allocatively efficient. On the other hand, if $h_i > 0$ for some i, input X_i is relatively under-utilized, given W_i and W_j. Similarly, input X_i is over-utilized if $h_i < 0$ (Ajibefun and Daramola, 2003).

2.2.3 Concept of Dual Technology Approach to Efficiency Measurement

In efficiency modeling, an alternative method of estimation of frontier production is the cost or profit function. Coelli (1995) gave three main reasons for the consideration of alternative dual forms of the production technology, such as the cost or profit function.

The reasons are:

(a) to reflect alternative behavioural objectives, such as cost minimization;

(b) to account for multiple outputs;

(c) to simultaneously predict both technical and allocative efficiency

The dual form of technology in stochastic frontier production modeling can be illustrated as follows:

Consider a firm employing *n* inputs $X = (X_1, X_2, \ldots X_n)$, available at fixed prices $W = (W_1, W_2, \ldots W_n) > 0$, to produce a single output y that can be sold at fixed price; $P > 0$. Efficient transformation of inputs into output is characterized by the production function f(x), which shows the maximum output obtainable from various input vectors.

Alternatively, an equivalent representation of efficient production technology is provided by the cost function,

$$C(y, w) = \min x \{w'x / f(x) \geq y, x \geq 0\} \quad \ldots\ldots (22)$$

which shows the minimum expenditure required to produce output y at input prices W. Equivalently, a third representation of efficient production technology is given by the profit function,

π (P, W) = max y, x {Py-W'x/f(x) $\geq$y, x $\geq$0, y$\geq$0} .... (23)

which specifies the maximum profit available at output P and input prices W.

The functions f (x), C (y,w) and π (P, W) are typically referred to as frontiers in economic literature. The reason is that they characterize optimizing behaviour on the part of an efficient producer, and thus place limits on the possible values of their respective dependent variable (Forsund *et al*, 1980; Battese, 1992).

Suppose the firm is observed at production plan (y^0, x^0), such plan is said to be technically efficient if y^0 = f(x^0), and technically inefficient if y^0<f(x^0). A measure of the technical efficiency of this plan is provided by the ratio 0$\leq y^0/f(x^0) \leq$1. Technical inefficiency is due to excessive input usage, which is costly, and so w'$x^0 \geq$C (y^0, W). The plan (y^0, x^0) is said to be allocatively efficient if *fi*{ (x^0)/fj (x^0) = Wi/Wj} and allocatively inefficient if *fi*{(x^0)/fj(x^0) $\neq$ Wi/Wj}

Allocative inefficiency results from employing inputs in the wrong proportions, which is costly and so W' X^0>C (y^0, w). Since cost is not minimized, profit is not maximized, and so (Py^0–W'x^0) $\leq \pi$(P, W). The observed expenditure W'X^0 coincide with minimum cost C(y^0, w) if, and only if, the firm is both technically and allocatively efficient. If W' X^0>C (y^0, w), this difference may be due to technical inefficiency alone, or some combination of the two. It also follows that observed input usage X^0 coincides with cost-minimizing input demand X(y^0, w) if and only if the firm is both technically and allocatively efficient (Ajibefun and Daramola, 2003).

2.2.4.0 Stochastic Frontier Cost Function

The stochastic *frontier cost function* (SFCF) can be used to determine: Cost efficiency and consequently allocative efficiency. If the functional form of the production frontier is self-dual, for example Cobb-Douglas, then the corresponding stochastic cost frontier can be expressed as:

$$C_i = g(P_i, Y_i, \alpha) + L_i + M_i \quad \text{.......} \quad (24)$$

Where C_i represents the minimum cost of the ith farmer associated with the production of Y_i, P_i is a vector of input prices measured in Naira; α is the vector of parameters to be estimated. Li is an error term which is assumed to be independent and identically normal distribution $N(0, \sigma_U^2)$. While the efficiency error term, Mi is assumed to be independent and identically truncated half normal distribution $N^+(0, \sigma_{M}^2)$. Note that in this case, because inefficiencies are assumed to always increased costs, both of the error terms are preceded by positive signs (Webester *et al*, 1998). M_i provides information on the level of cost efficiency of the ith farm (Coelli, *et al*, 1998). This may be calculated as the ratio of the frontier (predicted) minimum cost (with M_i = 0) to observed cost. This is expressed as:

$$\text{Cost Efficiency } (CE_i) = \exp(-M_i) \quad \text{.......} \quad (25)$$

In this cost function, the non-negative random variable, M_i, which is assumed to account for the cost of inefficiency, defines how the farm operates above the cost frontier (Coelli, 1995). In other words, it measures the cost of producing below the production frontier-that is, of technical inefficiency

(Schmidt and Lovell, 1979). Thus, if allocative efficiency is assumed (Coelli, 1996), the non-negative random variable, M_i, is closely related to the cost of technical inefficiency. Both technical and allocative efficiency measures are bounded by zero and one. Hence efficiency estimates would range between zero and one (Ajibefun and Daramola, 2003).

Following Farrell (1957), equations (20) and (25) can be combined to obtain the economic efficiency (EE) index:

$$EE = (AE) \times (TE) \quad \text{.......... (26)}$$

2.2.4.1 Computation of Allocative Efficiency from the Frontier Cost Function

Stochastic frontier calculates cost efficiency (CE) predictions as the inverse of Economic Efficiency (EE) (Coelli *et al*, 1998).

Thus: EE = 1/CE

If EE = AE X TE

Then: AE = EE/TE = 1/CE(1/TE) .... (27)

Jondrow *et al* (1982) have shown that inferences about technical inefficiency of individual farmers can be made by considering the conditional distribution of U_i given the fitted values of ε_i and the respective parameters. In other words, given the distribution assumed for V_i and U_i, and assuming that these two components are independent of each other, the conditional mean of U_i given ε_i is defined as:

$$E(U_i / \varepsilon_i) = \sigma^* \left[\frac{f^*\left(\varepsilon_i \lambda / \sigma\right)}{1 - F^*\left(\varepsilon_i \lambda / \sigma\right)} - \frac{\varepsilon_i \lambda}{\sigma} \right] \quad \text{.......... (28)}$$

Where $\lambda = \frac{\sigma_u}{\sigma_v}, \sigma^2 = \sigma_v^2 + \sigma_u^2, \gamma = \frac{\sigma_u^2}{\sigma^2} = \frac{\lambda}{[1+\lambda^2]}$, f^* is the standard normal density function and F^* is the cumulative distribution function of a standard normal where both functions being evaluated at $\varepsilon_i \lambda/\sigma$.

Therefore, equations (13) and (28) provide estimates for U_i and V_i after replacing $\varepsilon_i, \sigma, and\ \lambda$ by their estimates. If V is now subtracted from both sides of the equation (13), we obtain the stochastic production frontier:

$$Y^* = f(X\alpha; \beta) - U = Y - V \quad \text{.......... (29)}$$

Where Y^* is the farm's observed output adjusted for statistical noise captured by V (Bravo-Ureta and Pinheiro, 1997).

2.2.5 Inferential Statistical Analysis

The following statistical methods were used to achieve the stated hypothesis.

a. Generalized Likelihood Ratio Test

The generalized likelihood ratio test statistic is defined by:

$$\chi_c^2 = -2\, ln(L(H_0) - L(H_a)) \quad \text{.......... (30)}$$

Where L (H_0) is the value of the log-likelihood function under the null hypothesis (i.e., the restricted model likelihood function) and L (H_a) is the value of the log-likelihood function under the alternative hypothesis (that is, the unrestricted model likelihood function). If the null hypothesis is true, the log-likelihood ratio test has a mixed Chi-square distribution (χ^2) with degree of freedom equals the number of parameters excluded in the traditional average response function.

The generalized likelihood ratio test defined by the test statistic in equation (30) is used to test for the presence of inefficiency effects in the frontier models and the half normal distribution of the inefficiency effects. The decision rule is that the null hypothesis is accepted if the computed Chi-square is less than the tabulated Chi-square at 5.0% level of significance and a given degree of freedom.

b. Student t-Ratio Test

In order to test for the significance of the estimated coefficients of socio-economic variables on the predicted inefficiency function, t-ratio test was used.

The test statistic is given by equation (31):

$$tc = \beta j - 0 / S_{\beta j} = \beta j / S_{\beta j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

Where the β_js are the estimated coefficients and $S_{\beta js}$ are the standard errors of the estimated coefficients. The test stipulates that the null hypothesis (H_0), H_0: $\beta_j = 0$ that is, the explanatory variable is not significant in explaining the variation in the dependent variable. The decision rule is that Ho is accepted if t-computed is less than t-tabulated at a given level of significance and degree of freedom while it is rejected, otherwise. This test was used to test the fourth hypothesis at the 5.0% level of significance.

The t-ratio test is used where the population variance (σ^2) is unknown and the sample size is less than 30--- a condition which renders the distribution of sample means no longer normally distributed. For this study, the student's t-ratio was used on the assumption that the population of variable X was normally distributed instead of using the Z-statistic. Student's t-test was also used to test the third hypothesis.

c. **Student's t-Test for the Difference of Two Means**

The student's t-test for the difference of two means is a statistical tool used to test the significance of difference between two sample means. Thus, the test was used to test for the significant difference between the means of technical efficiencies (TE) and allocative efficiencies (AE) between the rice farmers in Osun and Oyo States (fifth hypothesis). The t-ratio was computed using the formula specified by equation (31):

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S_{\overline{X}1 - \overline{X}2}} \quad \text{...} \quad (32)$$

Where: t = the test statistic;

$\overline{X}_1$ and $\overline{X}_2$ are the sample means of TE (AE) for Osun and Oyo States respectively;

$S_{\overline{X}1-\overline{X}2}$ = the estimated standard error of the difference, and it is computed using the formula specified by equation (33):

$$S_{\overline{X}1-\overline{X}2} = \sqrt{\frac{S^2}{n_1} + \frac{S^2}{n_1}} \quad \text{...} \quad (33)$$

Where S^2, the pooled variance is computed as specified by equation (34):

$$S^2 = \frac{(n_1 - 1)S_1^{\ 2} + (n_2 - 1)S_2^{\ 2}}{n_1 + n_2 - 2} \quad \text{...} \quad (34)$$

(Blalock, 1972 & Oloyo, 2001).

Where: n_1 and n_2 are sample sizes for variables 1 and 2 respectively; S_1^2 and S_2^2 are the variances for variables 1 and 2 respectively; and $n_1 + n_2 - 2$ is the degree of freedom. Hence,

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad \ldots\ldots\ldots\ldots \quad (35)$$

The variables are as defined earlier.

2.2.6 Productivity Measurement

The partial influence of the explanatory variables on the dependent variable measures the addition to total product due to the addition of one unit of the explanatory variable. This is the marginal physical product (MPP).

$$MPP = \frac{dY}{dX} \quad \ldots\ldots\ldots\ldots \quad (36)$$

The elasticity of production measures the proportional change in output with respect to proportionate change in input. It is defined thus:

$$\varepsilon_i = \frac{dY_i}{dX_i} \bigg/ \frac{Y}{X} \quad \ldots\ldots\ldots\ldots \quad (37)$$

$$= \frac{MPP}{APP} \quad \ldots\ldots\ldots\ldots \quad (38)$$

So that:

$$MPP_{xi} = \varepsilon_j \frac{Y}{X_i} \quad \ldots\ldots\ldots\ldots \quad (39)$$

(Henderson and Quandt, 1980; Ozsabuncuoglu, 1998; and Alimi, 2001)

Where:

ε_j = coefficient of the variable (X_i) obtained from Cobb-Douglas production function = (direct elasticity)

Y= quantity of output;

X = quantity of variable X_i;

$$\frac{Y}{X} = APP \quad \ldots\ldots \quad (40)$$

2.3 Review of Empirical Studies on Allocative and Technical Efficiencies

Available studies on crop production efficiency such as Norman (1973a); Onyenweaku (1987); Olagoke (1991) (in Nigeria); (Huang and Bagi (1984); Kalirajan and Shand (1985) (in India); (Lingard, Castillo and Jayasuriya (1983) (in Phillipines); (Ekayanake, 1987) (in Srilanka); (Kalirajan and Shand (1986) (in Srilanka) and, (Taylor and Shonkwiler, 1986) (in Brazil) were concerned exclusively with the measurement of technical efficiency. They ignored the gains that could be obtained by improvements in allocative and economic efficiencies of the crop enterprises in the short-run.

Olayide and Heady (1982) and Ghatak and Ingersent (1984) gave some insight into resource-use efficiency or resource productivity. In their own case, Olayide and Heady (1982) defined resource productivity in terms of individual resource inputs or in terms of a combination of them. They also defined land, labour, capital, water and management productivities as the ratio of total output to inputs of land, labour, capital, water and management respectively. Also, they inferred that resource productivity implied achieving the maximum possible output from the minimum possible set of inputs. In this context, optimal productivity of resources implies efficient use of resources in the production process.

Available studies on resource use efficiency in agriculture dwelt on the knowledge of marginal productivity. For examples, Ogunfowora *et al* (1975); Ladipo (1977); Dhawan and Bansal (1977) and Osuntogun (1980) in their studies determined the most economical and optimum means to maximize net output in agriculture. Thus, for a given level of technology and prices of both output and inputs, marginal value productivity (MVP) is the yardstick for judging the efficiency of resource use when related to the input price (opportunity cost) known as the marginal factor cost (MFC). With this principle, a resource is said to be most efficiently used if its MVP is just equal to its MFC. In other words, such resource is said to be allocativelly efficient in its use (Durojaiye and Adekoya, 1999). The MVP of a particular resource represents the expected addition to the gross returns caused by an addition of one unit of that resource, while other inputs are held constant. The price used is the prevailing average market price over the entire production season. The magnitude of MVP has to be compared with the MFC to determine the "worthwhileness" of increasing the level of resource use. Economic theory states that a firm maximizes its profit with respect to an input if the ratio of its MVP to its MFC is one (Kay, 1981).

If the MVP is greater than MFC, it implies under utilization of such resource and that there is scope for raising output profitably by increasing the use of that particular resource. On the other hand, when MVP is less than MFC, it shows over utilization of the resource in question and that output can be increased by reducing the use of such resource. The differential between MVP and MFC indicates the scope of resource adjustment necessary to attain economic optimum (Omotosho *et al*. 1993; Ayanwale, 1995; Aderinola, 1997; Alimi, 2000 and Alimi, 2001).

In Nigeria, past studies on resource use efficiency using production function have come up with various conclusions. For example, the results of study conducted by Durojaiye and Adekoya (1999) on resource use efficiency by women maize farmers in Ogun state using the Cobb-Douglas production function analysis to analyse the data showed that the sampled women maize farmers were allocative inefficient in the utilization of all the production inputs considered.

In a study of efficiency of resource-use in rice production systems by Olagoke (1991), he analysed the activities of 45 randomly selected rice farmers in Uzo-Uwani Local Government Area (LGA) of Anambra State. The study showed that swamp rice farms had the highest average returns per hectare, followed by irrigated and least by upland rice. It was also discovered that scarcity of land, financial constraints, unfavourable rainfall patterns and the inefficient distribution of irrigation water limited production of rice during the survey period.

In his study on the economic efficiency of rice farmers in Kwara State, Nigeria, Olayemi (1974) reported that returns to scale varied widely. Marginal returns to modern input as well as land were higher than their marginal cost. Also, Ogunfowora *et al* (1975) fitted linear and Cobb-Douglas production function for rice farmers in Kwara State and reported inefficient resource use in the various rice growing areas in the State.

Aderinola's (1997) study on economics of upland rice production in Ondo State, Nigeria, estimated costs and returns for upland rice production and determined efficiency of resource utilization of upland rice farms in the State. He estimated production function and computed MVP of resources to indicate the level of efficiency. Also, he found that land, hired labour and purchased inputs were underutilised while rice seeds and family labour were over-utilised and that farmers operated at diminishing positive returns to scales.

In their own study, Seyoum, *et al* (1998) used the stochastic frontier production analysis to estimate the technical efficiency and productivity of maize farmers within and outside the Sasakawa –Global 2000 project in Ethiopia. They assumed that the technical inefficiency effects of the farmers were a function of their ages, levels of education and the time spent with them by extension advisers to assist them in their agricultural production operations. The Cobb-Douglas stochastic frontier function was found to give a good fit to the data -- given the specifications of the translog stochastic frontiers for farmers within and outside the project. The empirical results indicated that farmers within the SG 2000 project were more technically efficient than farmers outside the project, relative to their respective technologies. The mean frontier output of maize for farmers within the SG-2000 project was significantly greater than that for the farmers outside the project.

Ajibefun *et al* (2002), employed a stochastic frontier production function to analyse technical efficiency and technological change in Japanese rice industry. The results of the study showed that the technical inefficiency effects were statistically significant but time invariant. There was evidence of neutral technological change. Technical efficiencies of the average rice farm households in the prefectures were only moderately high and the mean technical efficiency was estimated to be 74.5 percent. It was also shown that the returns –to- scale parameter was not significantly greater than unity, indicating constant returns to scale, at the average levels of the inputs used by the rice farmers.

In a study by Onyenweaku (1991), he compared resource-use efficiency between irrigated and non-irrigated farms in Nigeria. The results showed that technical efficiency was higher on irrigated farms compared with non-irrigated farms. However, both groups underutilized land, capital and other forms of input, but labour and irrigation services were over utilised.

Also, in his study of wheat farmers in Pakistan, Battese *et al* (1996) applied a single stage model for estimating technical efficiencies. The inefficiency variables were identified as age of the farmer, maximum years of schooling and ratio of adult males to the total household size and were incorporated along with the production variables of land, labour, dummy variables for fertilizers, land preparation, number of ploughs and quantity of seeds. The technical inefficiency effects were highly significant meaning that the traditional production function model was inadequate for the analysis of wheat production in the four districts involved. The technical efficiency of wheat farmers displays considerable variation over time within each district such that the mean technical efficiencies ranged from 57 percent to 79 percent in the four districts.

In their study of grain production in China, Yao and Liu (1998) specified the dependent variable as the total output of grain while the independent variables were land, labour, machinery, fertilizer and irrigation. The inefficiency variables in their model included research and development, disaster index, rural population share and crop labour share. The results of the study revealed that considerable regional differences existed in grain yields and that there was still a vast potential for increasing grain output. The short-term solution was to use more land augmenting inputs such as fertilizer and irrigation in the medium and low-yield region. The low diminishing returns however were applied to shrinking land. Growth in grain output in the long-term must, therefore, rely on improvement in technical efficiency.

Adewuyi and Okunmadewa's (2001) study attempted to capture the economic efficiency of yam and cassava farmers in Kwara State of Nigeria. The effects of socio-economic factors on the efficiency level were also determined. The budgetary technique, non-parametric (linear programming) frontier and Tobit regression were applied to the cross sectional farm level data. Their study observed a range of economic efficiency across the 226 farms sampled with the best farm being 99.7% while the least was 1.7%. The mean efficiency of 52.7% showed that on the average, crop output falls 47.3% below the frontier, which suggests that there is a scope for increasing crop production by 47.3% by adopting the techniques and technology used by the most efficient farmer. The Tobit regression analysis revealed that the economic efficiency of farmers was significantly affected by household size, farming experience, farm distance and extension services. Their study concluded that most of the farmers in the area were inefficient.

In a study of gender and relative production efficiency in food crop farming in Abia State of Nigeria, Nwaru (2003), food crop farmers were disaggregated on gender-basis. Their production efficiencies and returns to scale were derived and compared. The additive multiplicative dummy variable approach was used to compare the technical efficiencies between the farmer groups. The study fitted separate production functions on the data obtained for each group in order to derive their respective allocative efficiencies and returns to scale. Results of the study showed that none of the farmer groups achieved absolute allocative efficiency in the use of any of the resources. The female farmers achieved a lower level of technical efficiency, over utilised fertilizer and under utilised other farm inputs, labour, farmland and capital. The male farmers over utilised labour and fertilizer and under utilised other farm inputs, capital and farmland. The study concluded that redistributing available scarce resources in favour of the female gender would be uneconomical. Rather agricultural policies and programmes that could enable both farmer groups optimise their current levels of resource endowments should be implemented.

Onyenweaku and Nwaru's (2005) was designed to measure the level of technical efficiency and its determinants in food crop production in Imo State, Nigeria using the stochastic frontier production function methodology. Results showed that the estimated farm level technical efficiency ranged from 31.1% with a mean of 57.1%. Results also showed that the observed wide variation in the level of technical efficiency indicated that ample opportunities existed for the farmers to increase their productivity and income through improvements in technical efficiency. Credit, education, farming experience, farm size and membership of farmers' associations/cooperative societies were positively and significantly related to technical efficiency while ages of farmers and their household sizes were negatively but significantly related to technical efficiency. There was no relationship between gender and technical efficiency.

The foregoing review of empirical studies revealed that farmers in general allocated their productive resources inefficiently and that considerable scope existed for raising their income by improving the level of their production efficiency. It could also be observed that with the exception of the works of Durojaiye and Adekoya (1999) all other studies focused exclusively on the measurement of technical efficiency to the utter neglect of allocative and economic efficiencies --- thereby creating a gap that needs to be filled. Thus, this study, while learning from the lessons gained through the studies reviewed in the preceding paragraphs, attempted to extend the frontiers of knowledge in economic analysis of grain crop production by estimating the technical, allocative, economic efficiencies of rain-fed upland rice production in Osun and Oyo States, Nigeria.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 The Study Areas

The study was conducted in Osun and Oyo States of Nigeria. The States are among the six States constituting the South-Western Zone of Nigeria. The other four States are Ekiti, Lagos, Ogun and Ondo States. The Old Oyo State was created in 1976 out of the old Western State and the State was divided into two in 1991 when Osun State was created from it. Although, some parts of the region are fairly urbanized, majority of the population still live in the rural areas.

Oyo State covers an area of 28,454 square kilometers (2,845,400 Ha) while Osun State covers an area of 9,251 square kilometers (925,100 Ha) (FOS, 1997). According to the National Population Commission (1991), Oyo State has a population of 3,488,789 people with females being 1,743,069 people and males being 1,745,720 people while Osun State has a population of 2,203,016 with female being 1,123,592 and male being 1,079,424. The States have two distinct ecological zones: The moist forest to the south and the intermediate savannah to the north. Oyo State shares borders with Peoples' Republic of Benin in the West, Kwara State in the North, Osun State in the East and Ogun State in the South while Osun State shares borders with Oyo State in the West, Kwara State in the North, Ekiti and Ondo States in the East and Ogun State in the South. Osun State is currently made up of thirty Local Government Areas while Oyo State is currently made up of thirty –three Local Government Areas (Figures 4 and 5).

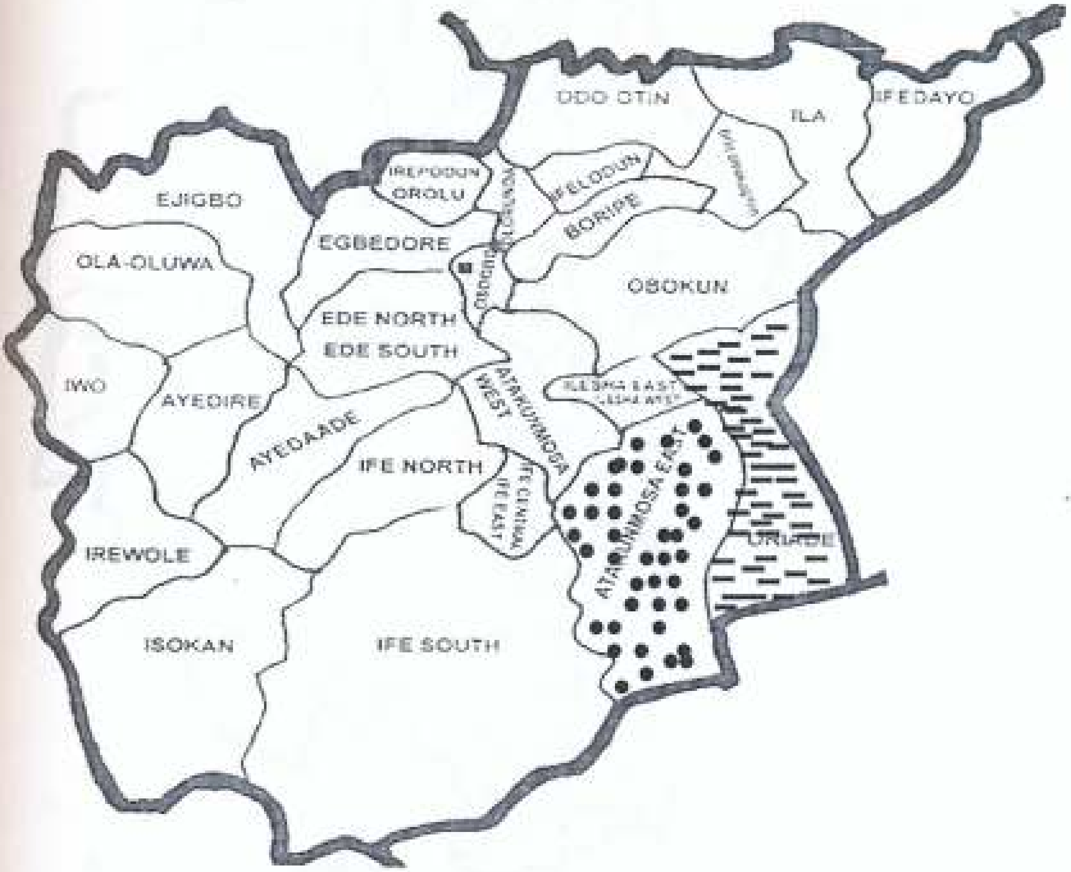

Figure 4: Map of Osun State showing the Study Areas

Source : Ministry of Lands and Physical Planning, Survey Department, Osogbo

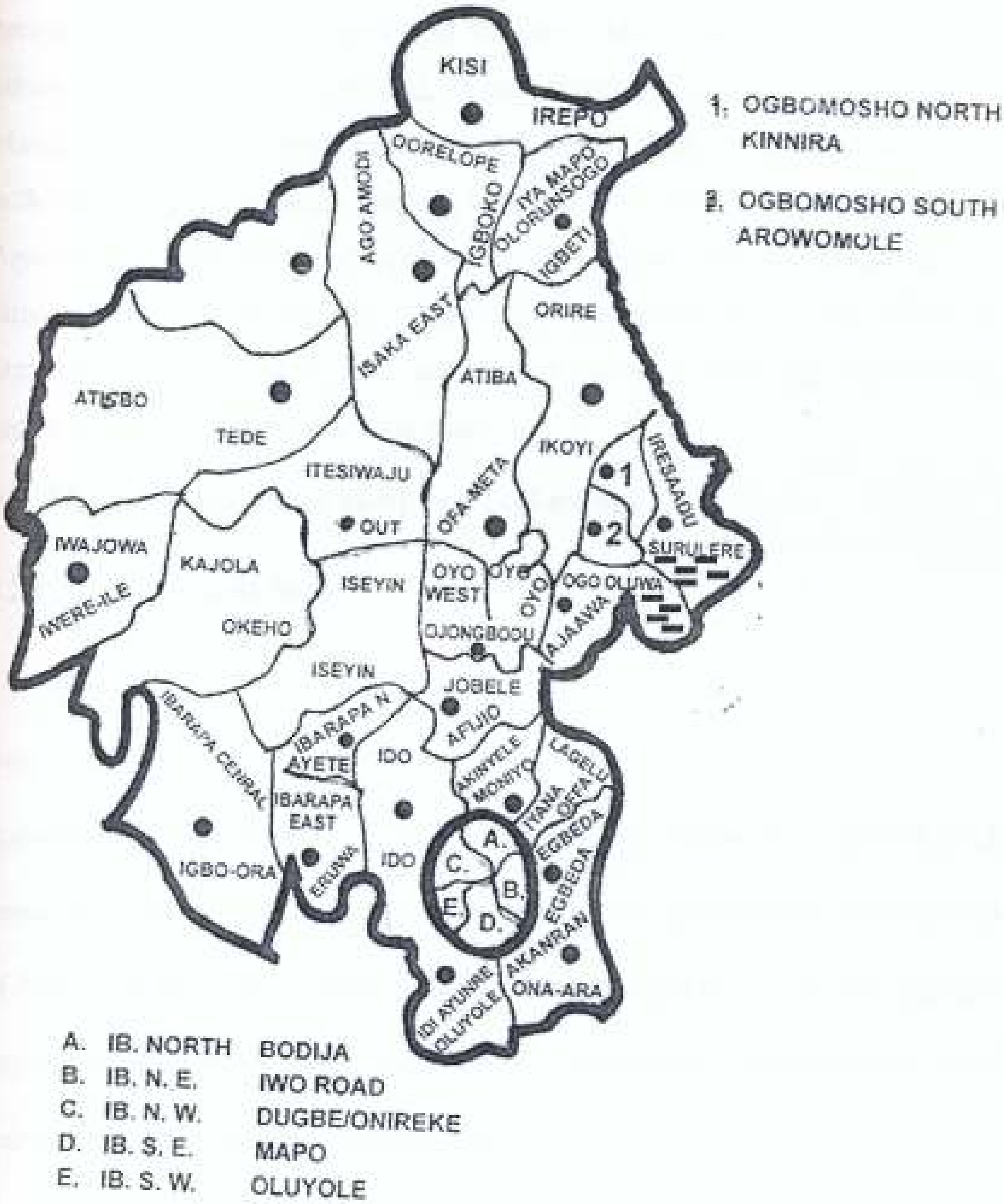

Figure 5: Map of Oyo State showing the Study Areas

Source : Ministry of Lands, Housing and Survey, Ibadan

The climates in the States are of tropical type with two distinct rainfall patterns. The rainy season, which marks the agricultural production season is normally between the months of April and October. The heaviest rainfall is recorded between the months of June and August while driest months are November to March. The average total annual rainfall ranges between 1000mm and 1500mm with high daily temperature ranging between 28^{0}C and 30^{0}C (FAOSTAT, 2004). Agriculture is the main occupation of the people and small-scale traditional farming system predominates in the area. The major food crops grown in the States include maize, rice, yam, cassava and cocoyam while the major cash crops grown are: cocoa, kolanut and oil palm.

3.2 Sources of Data and Sampling Techniques

3.2.1 Sources of Data

This study used primary data which were supplemented with secondary data. The primary data were obtained through sample survey using structured questionnaire, administered by trained enumerators under the supervision of the researcher. The secondary data were obtained from publications of Central Bank of Nigeria (CBN), the Federal Office of Statistics (FOS), Food and Agricultural Organization (FAO), State Agricultural Development Programmes (ADPs), journals and other relevant publications.

3.2.2 Sampling Techniques

The study used a combination of purposive and multi-stage random sampling techniques. The first stage involved purposive selection of the two Local Government Areas (LGAs) noted for rice cultivation in each of Osun and Oyo States. These are Atakunmosa East and Oriade LGAs from the Ife/Ijesa agricultural zone in Osun State and Ogo-Oluwa and Surulere LGAs from Ogbomoso agricultural zone in Oyo State. The second stage involved random selection of six towns/villages from the list of rice-growing towns/villages obtained from the Information Unit of each LGA-making a total of twenty–four villages that is, twelve villages from each State.

The towns/villages sampled are: Ijido, Iperindo, Iwaro, Kajola, Odogbo and Temidire in Atakunmosa East LGA of Osun state while those sampled in Oriade LGA are: Erinjesa, Erinoke, Ijebu-jesa, Ijeda, Ikeji-arakeji and Iloko-Ijesa in Osun state. The towns/villages sampled in Oyo State are: Aba-Oke, Agbeja, Ajaawa, Elemu, Ojutaye and Olorunda in Ogo-Oluwa LGA while the towns/villages sampled in Surulere LGA are: Ebila, Ijado, Iresaadu, Iresaapa, Mayin and Surulere(Table 3). The last stage involved a random sampling of thirteen rice farmers from each of the 24 villages in both States. Thus, a total of 312 farmers out of all the population of rain-fed upland rice farmers were interviewed, using a structured questionnaire with interview schedule. However, 300 well-completed copies of the questionnaire were used for analysis while the remaining 12 copies were rejected due to inconsistencies and inadequate information. The survey was done between the months of April and August, 2004.

Table 3: Distribution of Towns/Villages Sampled

State	Local Government Area	Towns/ Villages	Copies of Questionnaire		
			Distributed	Retrieved	Rejected
Osun	Atakumosa East	Ijido	13	13	-
		Iperindo	13	13	-
		Iwaro	13	13	-
		Kajola	13	13	-
		Odogbo	13	13	-
		Temidire	13	10	3
	Ori ade	Erinjesa	13	13	-
		Erinoke	13	13	-
		Ikeji-Arakeji	13	10	3
		Ijebu-Jesa	13	13	-
		Ijeda	13	13	-
		Iloko-Ijesa	13	12	1
Oyo	Ogo-Oluwa	Aba-Oke	13	11	2
		Agbeja	13	13	-
		Ajaawa	13	13	-
		Elemu	13	13	-
		Ojutaye	13	12	1
		Olorunda	13	13	-
	Surulere	Ebila	13	12	1
		Ijado	13	13	-
		Iresaadu	13	12	1
		Iresaapa	13	13	-
		Mayin	13	13	-
		Temidire	13	13	-
		Total	**312**	**300**	**12**

Source: Computed from data obtained from the Field Survey.

3.2.3 Types of Data Collected

Data collected included socio-economic characteristics of farmers such as age, gender, educational level, marital status, household size, years of experience in farming, income level, off-farm activities, income sources and amount of farm credit and loans, expenditure and problems encountered in upland rice production in the area of study. Information was also collected on the quantities of paddy rice harvested and their market prices while input data included size of rice farms, quantities of hired labour; family labour, fertilizers, seeds; chemicals and their unit prices and the number and amount spent on farm implements.

3.4.0 Methods of Data Analysis

The analytical techniques used in this study are a combination of: descriptive statistics, budgeting technique and stochastic frontier production and cost functions.

3.4.1 Descriptive Statistics

The descriptive statistics used are: frequency distribution, mean, standard deviation, mode, minimum and maximum values. They were used to discuss the socio-economic and production data of the rice farmers.

3.4.2 Budgeting Technique

The budgeting technique involved the use of gross margin (GM) to determine the profitability of the rice cultivation. The GM was specified as presented by equations (41) and (42)

$$GM_i = TR_i - TVC_i \quad \text{...} \quad (41)$$

$$GM = \sum PQ - \sum_{k=1}^{4} C_k X_k \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (42)$$

Where: GM = Gross margin (₦/farmer);

TR = Total revenue from the sale of paddy rice (₦);

TVC = Total variable cost (₦);

P = Paddy price/kg;

Q = Rice output (kg);

C_1 = Cost of seeds/kg;

C_2 = Cost of fertilizer/kg;

C_3 = Cost of labour/man-day;

C_4 = Cost of agrochemicals/litre;

X_1 = Quantity of seeds used (kg);

X_2 = Quantity of fertilizer used (kg);

X_3 = Quantity of labour used (man-days);

X_4 = Quantity of agrochemicals used (litre).

In order to calculate the GM for this study, inputs costs were valued at prices paid by the farmers or at village market prices. Values were imputed for such seeds the farmers planted from their stocks using the average of market prices at the time of planting. The prices paid by each farmer (including transportation costs) were used to determine expenditure on fertilizers. Labour input was measured in mandays as well as monetary values. A manday is the work done by an adult male in eight hours. Considering the number of people performing each operation and the duration of time such operation take, the man-equivalents of both family and hired labour were worked out. Operations performed by women was taken to be 0.75 of a man-equivalent and those by children to be 0.5 of a man-equivalent (Norman, 1973b). Labour was valued at wage rate paid by farmers for the operations in the villages. However, costs were imputed for family labour utilization at the wage rates paid hired hands. The TR from the sale of paddy rice was the value of total sales and imputed value (also at average of sales prices) of paddy used for home consumption.

3.4.3. Efficiency Determination

The econometric methods, using the stochastic frontier production and cost functions were used to estimate the technical and cost efficiencies. They were used to determine the resource-use efficiency of resources used in rain-fed upland rice production and used in examining the influence of some socio-economic variables on technical efficiency respectively. This method was chosen because in agricultural economics literature, the approach has generally been preferred due to the following reasons:

(i) the inherent variability of agricultural productions due to weather, pest and diseases and,

(ii) because many farms are small family –owned enterprises, where accurate records are not always kept, hence, available data on production are subject to measurement errors.

3.4.3.1 Models Specification

For the purpose of this study, the stochastic frontier production functions where the functional form of the production frontier is Cobb-Douglas proposed by Battese and Coelli (1995) and used by Yao and Liu (1998) was applied in the analysis of data to capture the efficiency of rice grain farmers. The Cobb-Douglas functional form is easily adaptable for most agricultural productions. It has been widely used in many empirical studies in agriculture especially in developing countries (Xu and Jeffrey, 1998). According to Heady and Dillon (1966), Cobb-Douglas functional form possesses some unique characteristics which make it easy to work with. These characteristics include:

(i) when the input and output quantities are transformed to their logarithms, the resultant function is linear in the log, hence it is easy to fit data with the Cobb-Douglas form;

(ii) the estimated co-efficients are the direct elasticities of production and,

(iii) the sum of estimated coefficients are used to deduce returns to scale (RTS) directly.

The model of the stochastic frontier production for the estimation of the TE is specified as:

$$Y_i = f(X_i, \beta) + V_i - U_i \quad \text{.......................................} (43)$$

Which is log-linearised as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + V_i - U_i \quad \text{.......................................} (44)$$

Where subscript i refers to the observation of the i^{th} farmer, and

Y = output of rice grain (kg);

X_1 = land area devoted to rice cultivation (ha);

X_2 = family labour used (man-days);

X_3 = hired labour used (man-days);

X_4 = quantity of fertilizer used (kg);

X_5 = quantity of rice seed planted (kg);

X_6 = amount spent on agrochemicals (₦);

X_7 = amount spent on implements (₦);

β_i's = the parameters to be estimated.

ln's = natural logarithms.

V_i = the two-sided, normally distributed random error.

U_i = the one-sided inefficiency component with a half-normal distribution.

The model of the stochastic frontier cost function for the estimation of the cost efficiency is specified as:

$$C = f(P_{ij}, Y, \varphi) + \varepsilon_{ij} \quad \text{.......(45)}$$

Which is log-linearised as:

$$\ln C_i = \varphi_0 + \varphi_1 \ln P_{1i} + \varphi_2 \ln P_{2i} + \varphi_3 \ln P_{3i} + \varphi_4 \ln P_{4i} + \varphi_5 \ln Y^* + L_i + M_i \quad \text{........ (46)}$$

Where:

Subscript, "i" is as previously defined

C = cost of rice production per farm (₦);

P_1 = price of rice seed/kg;

P_2 = labour wage rate/man day;

P_3 = price of agrochemicals/litre;

P_4 = price of implements/quantity;

Y^* = annual rice output adjusted for any statistical noise as previously specified in (29).

φ_i's = the parameters to be estimated.

ln's = natural logarithms.

L_i = the two-sided, normally distributed random error.

M_i = the one-sided inefficiency component with a half-normal distribution.

3.4.3.2 The Inefficiency Model

For this study, it is assumed that the technical inefficiency measured by the mode of the truncated normal distribution (i.e. U_i) is a function of socio-economic factors (Yao and Liu, 1998). Thus, the technical efficiency in equation (44) was simultaneously estimated with the determinant of technical efficiency defined by:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} \quad \text{.......} \quad (47)$$

Where:

U_i = technical inefficiency of the i^{th} farmer;

Z_1 = age of farmer (years);

Z_2 = years of education;

Z_3 = number of contacts with extension agent;

Z_4 = years of farming experience;

Z_5 = amount of credit available;

$\delta_i s$ = the parameters to be estimated.

Equation (47) was used to examine the influence of some farmers' socio-economic variables on their technical efficiency. Therefore, the socio-economic variables in equation (47) were included in the model to indicate their possible influence on the technical efficiencies of the rice farmers.

In the presentation of estimates for the parameters of the above frontier production, two basic models were considered. Model 1 is the traditional response function in which the inefficiency effects (U_i) are not present. It is a special case of the stochastic frontier production function model in which the parameter $\gamma = 0$. Model 2 is the general frontier model where there is no restriction in which γ, $\sigma^2 s$ are present.

The estimates of the stochastic frontier production function and cost function were appraised using the generalized likelihood ratio test, and the T-ratio for significant econometric relevance.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Upland Rice Production Practices in Osun and Oyo States

The rain-fed upland rice production season in the two States begins from April/May and ends in August/September every year. Land preparation is done either manually or mechanically. The land is cleared and stumped, and at times, burning is done if required. This is followed by plowing, harrowing and planting of seeds. The seeds are sown at the rate of 8-10 seeds per hole which is 2-4cm deep, dug with a pointed implement or a stick. The farmer covers the seed hole with earth which is then firmed with his foot. Some growers prefer seed broadcasting. Although the seed broadcasting method is faster than sowing, it often leads to poor seed germination and makes hand-weeding difficult.

The popular varieties of rice planted in the two States are ITA 150 (FARO 46) and OS6. Majority of the rice growers plant the ITA 150 variety because it is early maturing (100-105days) while only a few of the rice grower plant 0S6 which is late maturing (135days). Weeding is done manually at the third and seventh week after planting. Only few of the farmers apply fertilizers at varying degrees which are far below recommended rates.

Pests that attacked rice in the study areas include insects, rodents and birds. Rice farms are sprayed with *gammalin 20* to control insect pests while trapping is employed to control rodents. A number of methods are used by farmers in the study areas for bird scaring. These include tapping the farm with unused cassette tapes, erecting human statues at strategic locations around the farm, and use of catapults and stones as well as whistle-blowing around the rice farms by children.

Harvesting of rice paddy is done manually by cutting the panicles with knives and sickles. The harvested panicles are put together in bundles, suspended under a well-ventilated shelter and later threshed.

4.2 Socio-Economic Characteristics of Rice Farmers

The summary statistics of socio-economic characteristics of the rice farmers is presented in table 4 to give a broad view of selected socio-economic variables. The minimum and maximum age of rice farmers in Osun State were 21 and 70 years respectively with the mean age of about 44years, while the minimum and maximum age of rice farmers in Oyo State were 20 and 62 years respectively with the mean age of about 38 years. The respondents had about 3 years of formal education in Osun State and 4 years of formal education in Oyo State. The average household size per farming family was 3 persons in Osun State and about 7 persons in Oyo State. The mean amount of credit available to rice farmers in Osun State was about ₦6.101 while the mean amount of credit available to their counterpart in Oyo State was about ₦10,967. The mean output of rice paddy production was about 2183kg from an average of 1.3ha of farmland in Osun State and 2200kg from an average of 1.9ha of farmland in Oyo State, while the average revenue was about ₦65,486 in Osun State and ₦74,349 in Oyo State. Average profit made by rice farmers in Osun State was about ₦41,132.74 and about ₦44,476.8 in Oyo State.

Table 4: Summary Statistics of Socio-Economic Variables of Rain-fed Upland Rice Farmers in the Study Area

Variable	Osun State					Oyo State				
	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Age (Years)	150	21	70	44.3	11.3	150	20	62	37.5	6.7
Education (Years)	150	1	15	3.2	3.4	150	1	17	4.2	3.9
Experience (Years)	150	2	52	14.1	9.9	150	1	34	10.5	7.0
Household Size (No)	150	1	15	3.2	3.4	150	1	20	6.7	3.2
Farm Size (Ha)	150	0.3	6.0	1.3	0.9	150	0.1	13.0	1.9	1.7
Amount of Credit (₦)	150	1000	60000	6100.7	8838.3	150	500	45000	10966.9	10232.3
Output (kg)	150	500	9500	2183.3	1387.97	150	150	10000	2200.4	1516.7
Revenue (₦)	150	18000	285000	65486.4	41650.14	150	600	455000	74349.3	51078.6
Profit (₦)	150	-2675	208050	41132.74	34393.6	150	-19600	237700	44476.8	32602.5

N = sample size; Min = minimum values; Max = maximum values; SD = standard deviation.

Source: Computed from data obtained from the Field Survey.

4.2.1 Age Distribution

The age distribution is presented in table 5. The Table 5 shows that the modal age-group for paddy farmers in Osun and Oyo States was the 30-39 age brackets into which 46 (30.7%) and 78 (52.0%) respondents fell in the former and latter states respectively. The Table 5 also shows that 87.4% of the pooled rice farmers in Osun State was below the retirement age of 60 years in the Nigerian Civil Service while the same proportion for Oyo State was 98.7% - showing that rice farmers in Oyo State were relatively younger than their counterparts in Osun State. The age distribution in both States suggested that in addition to being energetic, rice farmers in the two States would be receptive to innovations to boost rice production, all other factors remaining unchanged.

Table 5: Age Distribution of Upland Rice Farmers in Osun and Oyo States, Nigeria.

Age (Years)	Osun		Oyo	
	Frequency	%	Frequency	%
20-29	11	7.3	16	10.7
30-39	46	30.7	78	52.0
40-49	37	24.7	50	33.3
50-59	37	24.7	4	2.7
≥ 60	19	12.6	2	1.3
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

4.2.2 Level of Education

The level of education is presented in table 6. The Table 6 shows that the modal level of education for paddy farmers in Osun and Oyo States was the non-formal/adult education into which 99(66.0%) and 76 (50.7%) respondents fell in the former and latter States respectively. The Table 6 also shows that 34.0% of the farmers in Osun State had their level of education ranged between primary and post primary education while the same proportion for Oyo State was 49.3%. The level of education attained by a farmer is known to influence the adoption of innovation, better farming decisions making including efficient use of inputs. The finding implied that the literate farmers would be more innovative than the non-literate farmers there by boosting rice production all other factors remaining unchanged.

Table 6: Level of Education of Upland Rice Farmers in Osun and Oyo States, Nigeria.

Education Levels	Osun		Oyo	
	Frequency	%	Frequency	%
Non-formal/adult	99	66.0	76	50.7
Primary	41	27.3	59	39.3
Secondary	7	4.7	9	6.0
ND/NCE	3	2.0	4	2.7
HND/B.Sc	-	-	2	1.3
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

4.2.3 Farming Experience

Farming experience is presented in table 7. The Table 7 shows that the modal farming experience-group for paddy farmers in Osun and Oyo States was 14 years and above into which 72 (48.0%) and 48(32.0%) respondents fell in the former and latter States respectively. The Table 7 also showed that 81.33% of the pooled rice farmers in Osun State had 5 years and above of farming experience while the same proportion for Oyo State was 79.33%. It is expected that the farmers should have experience in farming. The more the number of years a farm operator is engaged in farming, the more his experience will be. The farming experience distribution in both States suggested that the rice farmers were well experienced enough in rice cultivation to boost rice production, all other factors remaining equal.

Table 7: Farming Experience of Upland Rice Farmers in Osun and Oyo States, Nigeria.

Years of Experience	Osun		Oyo	
	Frequency	%	Frequency	%
≤1.99	0	0.00	1	0.67
2.00 – 4.99	28	18.67	30	20.00
5.00 – 7.99	24	16.00	34	22.67
8.00 – 10.99	18	12.00	26	17.33
11.00 – 13.99	8	5.33	11	7.33
≥14.00	72	48.00	48	32.00
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

4.2.4 Gender Distribution

In Osun State, majority of the respondents (79.0%) were men, while 21.0% of the respondents were women. However, in Oyo State about 99.0% of the respondents were men which constituted the majority while 1.0% was female. The pooled data showed that 89.33% of all the farmers in the two States were male while 10.67% of them were female. This analysis shows that rice production was dominated by men in the area covered by the study. This might likely be connected with the difficulties associated with rice production most especially the yearly attack of birds on rice fields.

4.2.5 Marital Status

Analysis of the marital status of pooled paddy rice farmers showed that 97.3% and 94.7% of them were married in Osun and Oyo States respectively.

The highest proportion of single paddy growers (5.3%) was found in Oyo State as compared with 2.7% in Osun State. The pooled data showed that 96.0% of all the farmers in the two States were married while 4.0% of them were singles. These results have implications for rice production. Married rice growers are more likely to be stable in their places of domain to carry on farming activities than the single ones. Also, married rice farmers are more likely to enjoy assistance provided by family labour to boost rice production than single rice farmers, all other factors remaining unchanged.

4.2.6 Household Size

The household size is presented in table 8. The Table 8 shows that the modal household size-group for paddy farmers in Osun and Oyo States was the 5-6 household size into which 42 (28.0%) and 41 (27.33%) respondents fell in the former and latter States respectively. The Table 8 also shows that 40.0% and 35.34% of the respondents in Osun and Oyo States respectively had family sizes of between 7 to 10 members. About 17% and 13% of the respondents in Osun and Oyo States respectively had more than 10 members per family. The size of the household affects the amount of farm labour, determines the food and nutritional requirements of the household, and often affects household food security. The Table 8 shows that the respondents in Osun State had moderately small household sizes while their counterparts in Oyo State had large household sizes. It is expected that the family members of a farm operator will contribute labour to farm work, thus, the farmer's family in the study areas assisted in planting, weeding, bird scaring and harvesting of rice.

Table 8: Household Size of Upland Rice Farmers in Osun and Oyo States, Nigeria.

Household Sizes	Osun		Oyo	
	Frequency	%	Frequency	%
≤2	7	4.67	10	6.67
3 – 4	15	10.00	27	18.00
5 – 6	42	28.00	41	27.33
7 – 8	37	24.67	37	24.67
9 – 10	23	15.33	16	10.67
>10	26	17.33	19	12.66
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

4.2.7 Major Occupation

Major occupation of the respondents is presented in table 9. The Table 9 shows that 93.3% and 94.7% of the respondents in Osun and Oyo States respectively were full time rice farmers. The remaining 6.7% and 5.3% for Osun and Oyo States respectively were involved in other businesses. The major occupational distribution has direct effects on the level and degree of supervision of the farm business and economic efficiency of the farm operations.

4.2.8 Farm Size

Farm size is presented in Table 10. The Table 10 shows that the modal farm size-group for paddy farmers in Oyo State was the 1.10-3.00 hectares of farm size into which 72(48.0%) respondents fell while the modal farm size group for paddy farmers in Osun State was ≤1.09 farm size into which 87(58.01%) respondents fell. The Table 10 also shows that 99.34% of the

Table 9: Major Occupation of Upland Rice Farmers in Osun and *Oyo* States, Nigeria.

Major Occupations	Osun		Oyo	
	Frequency	%	Frequency	%
Farming	140	93.3	142	94.7
Business/Trading	3	2.0	1	0.7
Artisans (Driving, Tailoring, Mechanic)	6	4.0	2	1.3
Public/Civil Servant	1	0.7	5	3.3
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

Table 10: Farm Size of Upland Rice Farmers in Osun and Oyo States, Nigeria.

Farm Sizes (Ha)	Osun		Oyo	
	Frequency	%	Frequency	%
≤1.09	87	58.00	55	36.67
1.10 – 3.09	58	38.67	72	48.00
3.10 – 5.09	4	2.67	19	12.67
5.10 – 7.09	1	0.66	2	1.33
7.10 – 9.09	0	0.00	0	0.00
≥9.10	0	0.00	2	1.33
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

pooled rice farmers in Osun State had their farm size ranged between 0.1 and 5.0 hectares while the same proportion for Oyo State was 97.34%. The crop output of any farmer depends on the size of farm he operates. It is revealed from the analysis that farm sizes cultivated are generally small scale in nature (Olayide, 1980).

4.2.9 Land Acquisition

Modes of land acquisition by the rain-fed upland rice farmers is presented in table 11. The nature of access gained to a particular parcel of farmland largely determines the quantum of use right and privileges of the farmers. Table 11 shows the mode of land acquisition predominant in the study area. It could be seen that majority of the respondents (57.3%) in Osun State owned their rice farmland while 42.7% of the respondents hired their farmland. However, in Oyo State, majority (98.0%) of the respondents hired their rice farmland while only 2.0% were the owners of their farmlands. This result indicated that non-natives were the major rice farmers in Oyo State.

4.2.10 Access to Extension Services

The extension services include dissemination of proven research technology to rice farmers with the aim of improving rice production. 98.7% and 69.3% of rice farmers in Osun and Oyo States respectively had access to extension services implying that majority of the farmers gained more knowledge to improve their rice production, all other factors remaining unchanged.

Table 11: Land Acquisition of Upland Rice Farmers in Osun and Oyo States, Nigeria.

Modes of Land Acquisition	Osun		Oyo	
	Frequency	%	Frequency	%
Owned (Gift, inheritance, purchased)	86	57.3	3	2.0
Hired (rented, leased)	64	42.7	147	98.0
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

4.2.11 Sources of Credit

Availability of credit helps in the procurement of inputs on a timely basis. It also helps in the adoption of yield increasing innovation, thereby increasing the efficiency of farmers.

Table 12 indicates the sources of credit available to the rice farmers in the study area. It is shown by the table that the respondents obtained their funding from informal sources. This might be an indication of the fact that it is easy to obtain credit from non-institutional sources than institutional sources.

Table 12: Sources of Credit Facilities Available to Upland Rice Farmers in Osun and Oyo States, Nigeria.

Sources of Credit	Osun		Oyo	
	Frequency	%	Frequency	%
Personal Savings	99	66.0	107	71.3
Cooperative Societies	24	16.0	19	12.7
Friends/Relatives	16	10.7	15	10.0
Rice Buyers	11	7.3	9	6.0
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

4.2.12 Amount of Credit Obtained

The amount of credit obtained is presented in table 13. The Table 13 shows that the modal amount of credit obtained for paddy farmers in Osun and Oyo States was equal or less than ₦9,999 into which 129 (86.0%) and 86 (57.3%) respondents fell in the former and latter States respectively. It is expected that the larger the amount of credit available to rice farmers, the greater the encouragement of these farmers in the adoption of improved technologies to enhance rice productivity. The Table 13 also shows that 6.0% of the pooled rice farmers in Osun State obtained amount of credit of ₦20,000 and above while the same proportion for Oyo State was 26.7%-showing that most rice farmers will adequately manage loan amount of less than ₦20,000 to purchase improved technologies which might enhance rice production, all other factors remaining unchanged.

4.3 Costs and Revenues Analysis

The costs and revenues are presented in table 14. The Table 14 showed that average total variable costs per hectare were ₦16,192.77 and ₦13,682.35 for paddy farmers in Osun and Oyo States respectively. Cost of labour accounted for 57.86% and 71.76% of average total variable costs per hectare of paddy farmers in Osun and Oyo States respectively. The average total revenue per hectare were ₦50,374.15 and ₦39,131.19 for paddy farmers in Osun and Oyo States respectively.

The analysis of gross margin per hectare to determine the profitability of rice production in Osun and Oyo States is also presented in table 14. The gross margin per hectare is defined as the difference between gross revenue per hectare and total variable costs of production per hectare.

Table 13: Amount of Credit Obtained By Upland Rice Farmers in Osun and Oyo States, Nigeria.

Amount of Credit received (₦)	Osun		Oyo	
	Frequency	%	Frequency	%
≤9999	129	86.0	86	57.3
10000 – 19999	12	8.0	24	16.0
20000 – 29999	6	4.0	25	16.7
30000 – 39999	1	0.7	13	8.7
≥40000	2	1.3	2	1.3
Total	150	100.0	150	100.0

Source: Computed from data obtained from the Field Survey.

The average gross margin per hectare for farmers in Osun State was ₦34,181.38 while it was ₦25,448.84 in Oyo State. These results, which are in line with the findings of Aderinola (1997); Agbamu and Fabusoro (2001) suggested that rice production was profitable in the two States. However, it was more profitable to produce rice in Osun State than Oyo State because of the highest level of gross margin per hectare obtained in the State; all other factors remaining unchanged.

Table 14: Average Costs and Returns per Hectare of Upland Rice Production in Osun and Oyo States, Nigeria.

Items/Variables	Mean Figure	
	Osun	Oyo
Farm size (ha)	1.30	1.90
Rice output (kg)	2183.3	2200.4
Rice yield(kg/ha)	1679.48	1158.11
Total Revenue (₦)	65486.40	74349.26
Total Revenue/ha (₦/ha)	50374.15	39131.19
Variable Cost		
Cost of seeds (₦)	4879.68	1286.32
Cost of fertilizer (₦)	1315.79	3366.79
Cost of labour (₦)	12179.60	18656.09
Cost of agrochemicals (₦)	2675.53	2687.27
Total Variable Cost (₦)	21050.60	25996.47
Total Variable Cost/ha(₦/ha)	16192.77	13682.35
Gross Margin (₦)	44435.80	48352.79
Gross Margin/ha (₦/ha)	34181.38	25448.84
Fixed Cost		
Rent on land(₦)	1376.99	1689.11
Depreciation on tools(₦)	1926.07	2187.20
Total Fixed Cost(₦)	3303.06	3876.31
Total Fixed Cost/ha (₦/ha)	2540.82	2040.16
Total Cost (₦)	24353.66	29872.78
Total Cost/ha (₦/ha)	18733.58	15722.52
Net Farm Income (₦)	41132.74	44476.48
Net Farm Income/ha (₦/ha)	31640.57	23408.67

Source: Computed from data obtained from the Field Survey.

CHAPTER FIVE

5 THE STOCHASTIC FRONTIER PRODUCTION FUNCTION AND COST FUNCTION ANALYSIS

5.1 Estimates of Stochastic Frontier Production and Stochastic Frontier Cost Functions

The ordinary least squares estimates (OLS) (Model 1) and the maximum likelihood parameter estimates (MLE) (Model 2) of the stochastic production and cost frontier models for Osun and Oyo States are presented in tables 15 through 18.

The coefficients of the variables are very important in discussing the results of the analysis of data. For Osun State, farm size had the highest coefficient with a value of 0.949 and 0.961 (Table 15) for the two models respectively. Farm size, family labour, quantity of fertilizer and amount spent on agrochemicals carried positive sign for the two models while hired labour, quantity of rice seed planted and expenditure on implements carried negative signs. The variables with positive coefficients implied that any increase in such a variable would lead to an increase in rice output, while an increase in the value of the variable with a negative coefficient would lead to a decrease in output of rice. Negative coefficient on a variable might indicate an excessive utilization of such a variable. In Oyo State, however, all the variables carried positive signs (Table 16) while the coefficients of the farm size and hired labour are significant at 5.0% level of significance across the two States.

Table 15: Maximum Likelihood Estimates for the Parameters of the Stochastic Frontier Production Function for Rice Farmers in Osun State.

Variables	Model 1	Model 2
General Model (Production Function)		
Constant	2.703 (7.720)	2.943 (11.31)
Farm Size	0.949* (18.95)	0.961* (22.24)
Family Labour	0.011 (0.803)	0.016 (1.459)
Hired Labour	-0.014 (-0.435)	-0.036* (-2.136)
Quantity of Fertilizer	0.240 (0.808)	0.534* (2.479)
Quantity of Rice Seed Planted	0.024 (0.525)	-0.063* (-2.098)
Amount spent on Agrochemicals	0.068* (4.354)	0.037* (2.788)
Expenditure on Implements	0.020 (0.067)	-0.047* (-2.506)
Inefficiency Model		
Constant	0	0.3947 (7.301)
Age of Farmer	0	-0.007* (-4.139)
Years of Education	0	-0.003 (-0.869)
Contact With Extension Agents	0	-0.014* (-1.993)
Years of Farming Experience	0	0.001 (0.935)
Amount of Credit Available to Farmers	0	0.007 (1.152)
Variance Parameters		
Sigma Squared	0.004	0.008* (8.260)
Gamma	0	0.999* (236.2)
Log Likelihood Function	199.2	217.4

Notes: * indicates estimated coefficients which were significant at 5.0% level.

Figures in parentheses are t-ratio values.

Source: Computed from data obtained from the Field Survey.

Table 16: Maximum Likelihood Estimates for the Parameters of The Stochastic Frontier Production Function for Rice Farmers in Oyo State

Variable	Model 1	Model 2
General Model (Production Function)		
Constant	2.093 (9.676)	2.376 (9.603)
Farm Size	0.306* (3.692)	0.314* (3.933)
Family Labour	0.162* (2.943)	0.142* (2.563)
Hired Labour	0.308* (3.783)	0.284* (3.588)
Quantity of Fertilizer	0.010 (0.556)	0.001 (0.044)
Quantity of Rice Seed Planted	0.065 (0.846)	0.026 (0.346)
Amount spent on Agrochemicals	0.007 (0.323)	0.010 (0.437)
Expenditure on Implements	0.079 (1.239)	0.051 (0.794)
Inefficiency Model		
Constant	0	0.061 (0.609)
Age of Farmer	0	0.001 (0.573)
Years of Education	0	0.008 (1.526)
Contact with Extension Agents	0	-0.067 (-1.195)
Years of Farming Experience	0	-0.002 (-0.491)
Amount of Credit Available to Farmers	0	-0.00001 (-1.471)
Variance Parameters		
Sigma Squared	0.019	0.018* (8.047)
Gamma	0	0.159 (1.613)
Log Likelihood Function	90.16	93.65

Notes: * indicates estimated coefficients which were significant at 5.0% level.

Figures in parentheses are t-ratio values.

Source: Computed from data obtained from the Field Survey.

From the ML estimates for the cost frontier, Table 17 shows that coefficient of price of agrochemicals was negative in Osun State. All other variables had positive coefficients. The coefficients of all variables including output were statistically significant at 5.0% level of significance. In Oyo State, all the variables had positive coefficients. However, only the coefficients of price of seed and output were statistically significant at 5.0% level of significance (Table 18).

5.1.1 Goodness of Fit

The estimated sigma square (σ^2) of each of the farms were 0.008 and 0.018 for farmers in Osun and Oyo States respectively. The values were large and significantly different from zero (Tables 15 and 16). This was an indication of a good fit of the model and the correctness of the specified distributional assumptions.

The σ^2 of the estimated cost function were 0.013 and 0.023 respectively for farms in Osun and Oyo States. The σ^2 value for farms in Osun State was statistically significant at 5.0% level of significance and was not significantly different from zero in Oyo State (Tables 17 and 18). The large values of sigma squared indicated a good fit of the model.

5.1.2 The estimated Gamma (γ) Parameter

The estimated gamma (γ) parameter of farms in Osun State was 0.99 and highly significant at 5.0% level of significance. This means that 99% of the variation in rice output among the farms in Osun State was due to the differences in their technical efficiencies. This result is consistent with the findings of Yao

Table 17: Maximum Likelihood Estimates for the Parameters of the Stochastic Frontier Cost Function for Rice Farmers in Osun State

Variable	Model 1	Model 2
General Model (Cost Function)		
Constant	-1.856 (-2.649)	-2.037 (-3.068)
Price of Seed (N)	1.498* (7.652)	1.635* (8.108)
Daily Wage Rate (N)	0.463* (1.929)	0.466* (2.072)
Price of Agrochemical (N)	-6.922* (-3.468)	-0.064* (-3.345)
Price of Implement (N)	0.129* (3.548)	0.105* (2.906)
Output of Rice (kg)	0.608* (16.78)	0.598* (17.78)
Sigma Squared	0.007	0.013* (4.194)
Gamma	0	0.734* (4.958)
Log Likelihood Function	159.1	160.4

Note: * indicates estimated coefficients which were significant at 5.0% level.

Figures in parentheses are t-ratio values.

Source: Computed from data obtained from the Field Survey.

Table 18: Maximum Likelihood Estimates for the Parameters of the Stochastic Frontier Cost Function for Rice Farmers in Oyo State

Variable	Model 1	Model 2
General Model (Cost Function)		
Constant	1.2349 (2.231)	1.254* (2.278)
Price of Seed (N)	0.833* (20.97)	0.835* (22.24)
Daily Wage Rate (N)	-0.001 (-0.021)	0.011 (0.198)
Price of Agrochemical (N)	0.153 (0.810)	0.165 (0.923)
Price of Implement (N)	0.041 (1.003)	0.047 (1.124)
Output of Rice (kg)	0.055* (2.684)	0.056* (2.870)
Sigma Squared	-0.015	0.023 (1.471)
Gamma	0	0.715* (4.029)
Log Likelihood Function	106.4	107.7

Note: * indicates estimated coefficients which were significant at 5.0% level.

Figures in parentheses are t-ratio values.

Source: Computed from data obtained from the Field Survey.

and Liu (1998); Seyoum *et al* (1998); Ajibefun *et al* (2002); Ajibefun and Aderinola (2004). In the case of the farms in Oyo State however, it was only about 16% of variation in their rice output that was accounted for by differences in technical efficiency.

The γ parameter of the estimated cost function measures the total variation of output from the frontier, which can be attributed to allocative inefficiency. The estimated γ parameters of farms were 0.73 and 0.72 for Osun and Oyo States respectively (Tables 17 and 18). This means that about 73% and 72% of the of the variation in total cost among the farmers in Osun and Oyo States respectively were due to the differences in cost efficiency or allocative efficiency (Bravo – Ureta and Pinheiro, 1997).

5.2 Inefficiency Effects Analysis of Stochastic Frontier Production Function

The estimated parameters of the inefficiency model in the stochastic frontier models of the farms in Osun and Oyo States are presented in tables 15 and 16 respectively. The analysis of the inefficiency model shows that the signs and significance of the estimated coefficients in the inefficiency model had important policy implications on the technical efficiency (TE) of the farmers.

In Osun State, the coefficients of age, years of education, and contact with extension agents were negative while the coefficients of years of experience and amount of credit available to farmers were positive. Those variables with positive coefficients lead to increase in technical inefficiency or decrease in TE while variables with negative coefficients lead to decrease in technical inefficiency or increase in TE (Ajibefun and Aderinola, 2004). The negative signs obtained for variables such as age, years of education and contact with extension agent for Osun State conformed with *a priori* expectation (Coelli and Battese, 1996) and were similar to the findings of Ajibefun and Daramola (1999); Ojo (2003) and Seyoum *et al* (1998). The results indicated that younger and more educated farmers tend to be highly receptive to modern and newly introduced agricultural technology. However, the positive signs obtained for years of experience and amount of credit did not conform to *a priori* expectation and were consistent with the findings of Adewuyi and Okunmadewa (2001). One reason adduced for the positive sign carried by years of experience was an indication of the fact that new entrants into farming might be more knowledgeable about recent development in technology (for example, information technology), which can improve agricultural production than their older counterparts. The coefficients of age and contact with extension agents were significant at 5.0% level of significance.

In Oyo State, the coefficients of age and years of education were positive against *a priori* expectation (Coelli and Battese, 1996) while the coefficients of contact with extension agent, years of experience, and amount of credit available to farmers were negative, *a priori*. The positive sign on age variable indicated that increasing age would lead to increase in technical inefficiency, based on the fact that ageing farmers would be less energetic to work on the farm, hence, they were supposed to have low TE. The positive sign on years of education indicated that more educated farmers in Oyo State were probably involved in other enterprises and occupations and had less time for efficient supervision of their rice farms. The coefficients of contact with extension agents, years of experience and amount of credit available obtained were negative and conformed with *a priori* expectation. The negative coefficients on the amount of credit available conformed with the findings of Onu *et al* (2000), and the result implied that availability of more credit enhances TE of farmers in rice production because availability of credit will facilitate easy procurement of fertilizers, agrochemicals and other yield-improving inputs on timely basis.

5.3 Productivity Analysis

The estimated productivity parameters such as elasticities of production and returns to scale are discussed in this section.

The elasticity of production of each input indicates the proportion by which the quantity of output will change with one percent change (increase) in the quantity of the input when the quantities of other inputs are kept constant. Returns-to-scale indicate the proportions by which quantity of output will change with one percent change (increase) in the quantities of all the inputs simultaneously.

The estimated elasticities of production (ε_P) and returns to scale (RTS) for all the farms in the study areas are presented in table 19.

5.3.1 Elasticities of Production (ε_P)

In Osun State, the estimated elasticities of the explanatory variables of the preferred model (Model 2) show that farm size, family labour, quantity of fertilizer and amount spent on agrochemicals were positive decreasing functions to the factors. This indicated that the use and allocation of those variables were in stage II (the stage of economic relevance) of the production function. The elasticities of hired labour, quantity of rice seed and expenditure on implements

Table 19: Elasticities and Returns-to-Scale (RTS) of Rice Farms in Osun and Oyo States, Nigeria

Elasticity of Production	Osun	Oyo
Farm size	0.961	0.314
Family labour	0.016	0.142
Hired labour	-0.036	0.284
Quantity of fertilizer	0.534	0.001
Quantity of rice seed	-0.063	0.026
Amount spent on agrochemicals	0.037	0.010
Annual expenditure on implement (depreciation)	-0.047	0.051
Returns-to-scale	1.40	0.83

Source: Computed from data obtained from the Field Survey.

were negative decreasing functions to the factors, indicating over-use of such variables and in stage III of the production function.

In Oyo State, the estimated elasticities of all the explanatory variables were positive decreasing functions to the factors, indicating that the use and allocation of those variables were in stage II of the production function. The economic implications of the positive ε_{Ps} obtained for resources such as farm size, family labour, quantity of fertilizer and amount spent on agrochemicals suggested that the use of these resources should be increased in order to increase rice output while the negative ε_{Ps} obtained for hired labour, quantity of rice seed and expenditure on implement suggested that their use should be reduced in order to increase rice output.

The elasticity of rice output with respect to farm size had the highest value across the two States (0.961 for Osun and 0.314 for Oyo). This was an indication of the fact that land was the most important factor in the production of rice; hence, there was the need for the farmers to increase their farm size in order to increase the output of rice. Other variables that were of significant importance in increasing rice output were hired labour, quantity of fertilizer, amount spent on agrochemical and family labour.

5.3.2 Returns-to-Scale (RTS)

From table 19, it could be observed that the RTS for the farms were 1.40 and 0.83 in Osun and Oyo States respectively. This indicated that farms in Osun State had increasing returns to scale and that the rice farmers were operating in the irrational zone of production (Stage I). However, in Oyo State, returns to scale parameter had a value between 0 and 1 (0.83), which showed that the rice farmers were operating in the rational zone of production (Stage II) and that the resources were being efficiently used in rice production in Oyo State. The overall economic implication of these results is that farmers in Osun State can improve on their productivity by employing more resources while farmers in Oyo State can only improve their productivity by reducing their current level of resource-use.

5.4.0 Efficiency Analysis

5.4.1 Cost Efficiency Analysis

Separate Stochastic frontier cost function based on equation (46) was estimated for upland rice farmers in Osun and Oyo States in order to quantify allocative efficiency measures. Thus, from equation (27) allocative efficiency estimate was obtained by finding the reciprocal of the product of cost and technical efficiency estimates. Tables 17 and 18 give the parameter estimates of the stochastic frontier cost function for Osun and Oyo States respectively. Estimates of gamma parameter were statistically significant at 5.0% level of significance suggesting that one–sided error component, related to farm specific inefficiency, dominated the random error term in the determination of $\varepsilon_i = L_i + M_i$. Thus, the deviation of observed minimum cost from the frontier cost was due to both technical and allocative inefficiency.

In Osun State, all the parameters were significant at 5.0% level of significance and had the expected positive signs except price of agrochemical which was negatively signed. This suggested that an increase in the daily wage rate and other inputs such as seed and implement would increase cost and an increase in output would also increase cost. However, increase in price of agrochemical would decrease cost (Table 17). In Oyo State, price of seed and output were significant at 5.0% level of significance and had the correct signs; that is, price of seed and output parameters were positive, suggesting that an increase in the price of seed and output would increase cost. In Oyo State although the daily wage rate, price of agrochemical and price of implement had the expected positive signs they were not statistically significant (Table 18). The implication of the significant variables was that such variables had important influence on cost structure of rice enterprise and hence profitability.

5.4.2 Estimates of Technical, Allocative and Economic Efficiencies Analysis of Rain-fed Upland Rice Farms in Osun State

The predicted technical, allocative and economic efficiencies estimates obtained for the individual farms in Osun and Oyo States are presented in tables 20 through 23.

Table 20 shows the predicted technical, allocative and economic efficiencies estimates in Osun State. The predicted rice farm specific technical efficiency (TE) indices ranged from a minimum of 66.8% to a maximum of 99.8% for the farms, with a mean of 90.1% and a standard deviation of 6.6%. Thus, in the short run, there was a scope for increasing rice production of an average farmer by about 10.0% by adopting the technology and techniques used by the best practiced (most efficient) rice farmers. Such farmers could also realize a 9.7% cost savings (i.e., $1-\left[{}^{90.1}/_{99.8}\right]$) in order to achieve the TE level of his most efficient counterpart (Bravo-Ureta and Evenson, 1994; Bravo-Ureta and Pinheiro, 1997). A similar calculation for the most technically inefficient farmer reveals a cost saving of about 33.0% (i.e., $1-\left[{}^{66.8}/_{99.8}\right]$) as shown in Table 21. This could be achieved by addressing the issue of negative elasticities of hired labour, quantity of rice seed planted and expenditure on implement (Table 19). The decile range of the frequency distribution of the TE indicates that about 1.0% of the rice farmers had TE of less than 71.0% while about 99.0% had TE of equal or greater than 71.0% (Table 20).

The predicted rice farm specific allocative efficiency (AE) indices ranged from a minimum of 77.8% to a maximum of 97.8% for the farms in the sample, with a mean of 92.0% and a standard deviation of 8.5%. The figures obtained

Table 20: Decile Range of Frequency Distribution of Technical, Allocative and Economic Efficiencies of Rice Farmers in Osun State

Decile Range (%)	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	No	%	No	%	No	%
> 90	73	48.67	123	82.0	31	20.7
81 – 90	66	44.00	25	16.7	79	52.7
71 – 80	10	6.67	2	1.3	35	23.3
61 – 70	1	0.66	0	0.0	5	3.3
Total No of Farms	150	100.0	150	100.0	150	100.0
Mean %	90.1		92.0		83.4	
Minimum %	66.8		77.8		63.1	
Maximum %	99.8		97.8		95.0	
Standard Deviation	6.6		8.5		6.8	

Source: Computed from data obtained from the Field Survey.

showed that if the average farmer in the sample was to achieve the AE level of his most efficient counterpart, then the average farmer could realize a 5.9% cost savings (i.e., $1-\left[\frac{92}{97.8}\right]$) (Table 21) (Bravo-Ureta and Evenson, 1994; Bravo-Ureta and Pinheiro, 1997). A similar calculation for the most allocatively inefficient farmer reveals a cost savings of 20.4% (i.e., $1-\left[\frac{77.8}{97.8}\right]$). The decile range of the frequency distribution of the AE showed that 82.0% of the rice farmers had AE of over 90.0% and 18.0% had AE ranging between 61.0% and 90.0%.

Table 21: Summary of Cost Savings According to Efficiency Indicator by Farmers in Osun State

Efficiency Indicator		Value of Savings (%)
	Most Technically Efficient	9.7
TE	Most Technically Inefficient	33.0
	Most Allocatively Efficient	5.9
AE	Most Allocatively Inefficient	20.4
	Most Economically Efficient	12.2
EE	Most Economically Inefficient	33.6

Source: Computed from data obtained from the Field Survey.

The combined effect of technical and allocative efficiencies indicated that mean economic efficiency (EE) level for the sampled farms was 83.4% and ranged from a minimum of 63.1% to a maximum of 95.0% with a standard deviation of 6.8%. The figures obtained imply that if the average farmer in the sample was to achieve the EE level of his most efficient counterpart, then the average farmer could realize a 12.2% cost savings (i.e., $1-\left[{}^{83.4}/_{95}\right]$) (Table 20) (Bravo-Ureta and Evenson, *op cit*; Bravo-Ureta and Pinheiro, *op cit*).

A similar calculation for the most economic inefficient farmers reveals a cost saving of 33.6% (i.e.$1-\left[{}^{63.1}/_{95}\right]$). The analysis showed that EE could be increased substantially, and that technical inefficiency constituted a more serious problem than allocative inefficiency (Table 21). The decile range of the frequency distribution of the EE shows that about 21.0% of the rice farms had EE f over 90.0% while about 79.0% of the rice farms had EE ranging between 1.0% and 90.0%.

This study showed that about 90.0% mean TE obtained is lower than the findings of Bagi (1982), but higher than the findings of Ali and Chaudry (1990), Bravo-Ureta and Evenson (1994), Bravo-Ureta and Pinheiro (1997), who reported a mean TE estimates of 93.0%, 80.0%, 52.0% and 70.0% respectively for rice in developing countries elsewhere. The average AE and EE of 92.0% and about 83.0% obtained respectively in this study is higher than a similar study conducted by Bravo-Ureta and Pinheiro (1997), who obtained an average AE and EE of 44.0% and 31.0% respectively, implying that farmers in Osun State are both allocativelly and economically efficient in resource allocation in the production of rice.

5.4.3: Estimates of Technical, Allocative and Economic Efficiencies Analysis of Rain-fed Upland Rice Farms in Oyo State

Table 22 shows the predicted technical, allocative and economic efficiency estimates in Oyo State. The predicted farm specific TE indices ranged from a minimum of 84.4% to a maximum of 99.4% for the farms in the sample, with a mean of about 94.0% and a standard deviation of 4.3%. Thus, in the short run, there is a scope for increasing rice production of an average rice farmer by about 6.0% by adopting the technology and technique used by the best-practiced (most efficient) rice farmer. Such a farmer could also realize a 5.1% cost savings (i.e., $1-\left[94.3/99.4\right]$) (Bravo-Ureta and Evenson, *op cit*; Bravo-Ureta and Pinheiro, *op cit*). A similar calculation for the most technically inefficient farmer reveals a

Table 22: Decile Range of Frequency Distribution of Technical, Allocative and Economic Efficiencies of Rice Farmers in Oyo State

Decile Range (%)	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	No	%	No	%	No	%
> 90	124	82.67	72	48.0	31	20.7
81 – 90	25	16.67	64	42.7	74	49.3
71 – 80	1	0.66	14	9.3	41	27.3
61 – 70	-	-	-	-	4	2.7
Total No of Farms	150	100.0	150	100.0	150	100.0
Mean %	94.3		88.9		84.0	
Minimum %	84.4		73.0		70.3	
Maximum %	99.4		97.0		95.9	
Standard Deviation	4.3		5.5		6.5	

Source: Computed from data obtained from the Field Survey.

cost savings of about 15.1% ((i.e., $1-\left[{}^{84.4}/_{99.4}\right]$) as shown in Table 23. This could be achieved by addressing the issue of low elasticities obtained for quantity of fertilizer, amount spent on agrochemicals and expenditure on implements. The decile range of the frequency distribution of the TE indicates that about 83.0% of the rice farms had TE of over 90.0% and about 17.0% had TE ranging between 71.0% and 90.0%.

Table 23: Summary of Cost Savings According to Efficiency Indicator by Farmers in Oyo State

Efficiency Indicator		Value of Savings (%)
	Most Technically Efficient	5.1
TE	Most Technically Inefficient	15.1
	Most Allocatively Efficient	8.4
AE	Most Allocatively Inefficient	24.7
	Most Economically Efficient	12.4
EE	Most Economically Inefficient	26.7

Source: Computed from data obtained from the Field Survey.

The predicted rice farm specific AE indices ranged from a minimum of 73.0% to a maximum of 97.0% for the farms in the sample, with a mean of 88.9% and a standard deviation of 5.5%. The figure obtained showed that if the average farmer in the sample was to achieve the AE level of his most efficient counterpart, then the average farmer could realize a 8.4% cost savings (i.e., 1- $\left[{}^{88.9}/_{97}\right]$) (Table 23) (Bravo-Ureta and Evenson, *op cit*; Bravo-Ureta and Pinheiro, *op cit*). A similar calculation for the most allocatively inefficient farmer reveals a cost savings of about 24.7% ((i.e., 1 - $\left[{}^{73}/_{97}\right]$). The decile range of the frequency distribution of the AE showed that 48.0% of the rice farms had AE of over 90.0% and 52.0% had AE ranging between 61.0% and 90.0%.

The combined effect of technical and allocative efficiencies indicated that mean economic efficiency (EE) level for the sampled farms was 84.0% and ranged from a minimum of 70.3% to a maximum of 95.9% with a standard deviation of 6.5%. The figures obtained in Table 23 imply that if the average farmer in the sample was to achieve the EE level of his most efficient counterpart, then the average farmer could realise a 12.4% cost savings (i.e., 1-$\left[\frac{84}{95.9}\right]$) (Bravo-Ureta and Evenson, *op cit*; Bravo-Ureta and Pinheiro, *op cit*). A similar calculation for the most economically inefficient farmer reveals a cost savings of 26.7% (i.e., 1-$\left[\frac{70.3}{95.9}\right]$). The analysis shows that EE could be increased substantially, and that allocative inefficiency constituted a more serious problem than technical inefficiency (Table 23). The decile range of the frequency distribution of the EE shows that about 21.0% of the rice farms had EE of over 90.0% while about 49.0% of the rice farms had EE ranging between 81.0% and 91.0%. The remaining 30.0% had EE ranging between 61.0% and 80.0%.

5.5. Test of Hypotheses

The results of the test of the hypotheses are presented in tables 24 through 31.

5.5.1 Test of hypotheses that rice farmers are operating in Stage II of the Production Surface

The null hypothesis states that rice farmers are operating in the efficient region (stage II) of the production surface where RTS should be between zero and unity that is, O< RTS<1.

H_{01}: RTS = Stage II

The null hypothesis was rejected for farmers in Osun State because for Osun State RTS = 1.40 and accepted for farmers in Oyo State, where RTS = 0.83.

5.5.2 Test of Hypothesis of Absence of Inefficiency Effects

The null hypothesis specifies that rice farmers were technically efficient in the production of rice and that the variation in their output was only due to random effects, which are beyond the control, of the decision maker and as such the average response function (OLS) was adequate to estimate the production function parameters. The hypothesis is defined thus:

H_{02}: $\gamma = 0$

The test used was the generalized likelihood ratio test and the test statistic computed was the Chi-square (χ^2) distribution.

Table 24 shows the results of the generalized likelihood ratio test for the absence of technical inefficiency effects. The results showed that the null hypothesis, $\gamma = 0$, was rejected for farmers in Osun State. This implied that the traditional average response function was not an adequate representation of the rice production in the State and there were inefficiency effects in the production processes of the farmers. However, in Oyo State, the null hypothesis was accepted. This implied that the technical inefficiency effects were not strong in the production of rice in the State and that variation in their production processes was only due to random effects.

Table 25 shows the results of the generalized likelihood ratio test for the absence of cost inefficiency effects. The results of the test showed that the null hypothesis of full cost efficiency was accepted for the two States, implying that rice farmers in two States were efficient in the allocation of their cost of production and thus were allocativelly efficient.

Table 24: Test of Hypothesis on Technical Efficiency

H_{02}: Rice farmers are fully technically efficient ($\gamma = 0$)						
State	**L (H_0)**	**L (H_a)**	$\chi^2_{Computed}$	**d.f**	$\chi^2_{7, 0.05}$	**Decision**
Osun	199.2	217.4	36.4	7	14.07	Reject H_0
Oyo	90.16	93.65	6.98	7	14.07	Accept H_0

Source: Computed from data obtained from the Field Survey.

Table 25: Test of Hypothesis on Cost Efficiency

H_{02}: Rice farmers are fully cost efficient ($\gamma = 0$)						
State	**L (H_0)**	**L (H_a)**	$\chi^2_{Computed}$	**d.f**	$\chi^2_{7, 0.05}$	**Decision**
Osun	159.0	160.4	2.8	2	5.99	Accept H_0
Oyo	106.4	107.6	2.4	2	5.99	Accept H_0

Source: Computed from data obtained from the Field Survey.

5.5.3 Test of Significance of Profitability Level of Paddy Farmers

The null hypothesis states that profitability level of paddy farmers in the study areas is not significantly different from zero.

The hypothesis is defined thus:

$$H_0: = \mu_{\Pi} = 0$$

Where: μ_{Π} is the separate mean profit level for farmers in Osun and Oyo States respectively. The test used was the Student t-ratio test and was conducted at $\alpha = 0.05$ and a degree of freedom of 148. The results of the t-tests are presented by tables 26 and 27 respectively. Results showed that the null hypothesis that the profitability level of paddy farmers in the study areas was not significantly

Table 26: Test of Hypothesis that Profitability Level is not significantly different Zero in Osun State.

Osun State				
Items	**Value**	**tc**	$t_{0.05,148}$	**Decision**
Number of farms	150			
Mean gross margin	44435.80	15.82	1.96	Reject H_0
Standard deviation	34394.22			

Source: Computed from data obtained from the Field Survey.

Table 27: Test of Hypothesis that Profitability Level is not Significantly Different from Zero in Oyo State.

Osun State				
Items	**Value**	**tc**	$t_{0.05,148}$	**Decision**
Number of farms	150			
Mean gross margin	48352.79	16.18	1.96	Reject H_0
Standard deviation	36610.47			

Source: Computed from data obtained from the Field Survey.

different from zero was rejected. This implied that the average profit level of paddy farmers was significantly different from zero.

5.5.4 Test for the Significance of Coefficients of the Socio-Economic Variables of the Inefficiency Model

The null hypothesis specifies that each of the estimated coefficients of the explanatory variables of the inefficiency model of the stochastic frontier production function is not statistically significant at 5.0% level of significance that is, the socio-economic variables do not have any significant relationship with TE. The hypothesis is defined thus:

H_{03}: $\delta_i = 0$ where δ_i is the individual explanatory coefficient of the inefficiency model. The test used was the t-ratio test and was conducted at $\alpha = 0.05$ and a degree of freedom 148.

The results of t-ratio tests for the coefficients of the inefficiency model of the stochastic frontier production function for Osun and Oyo States are presented by tables 28 and 29 respectively. It could be seen from table 28 that in Osun State, the coefficient of age and contact with extension variables were significant, hence, the null hypothesis was rejected in the case of each of these variables. However, the coefficients of years of education, years of farming experience and amount of credit available to farmers were not significantly different from zero, hence; the null hypothesis was accepted for each of these variables.

In Oyo State however, it was evident that all the individual coefficients of the inefficiency variables were not significantly different from zero. Hence, the null hypothesis was accepted in the case of each of these variables. Therefore, it can be concluded that only the age of rice farmers and contact with extension agents were the factors that significantly determined TE in Osun State while only the production function variables determined TE in Oyo State.

Table 28: T-Ratio Test for the Significance of Coefficients of the Socio-Economic Variables of the Inefficiency Model in Osun State.

$H0_3$: Socio-economic variables have no significant relationship on the farmers' TE(δ_i=0)				
Variables	**Coefficients**	t_c	$t_{0.05,148}$	**Decision**
Age of farmer	-0.047*	-4.139	-1.960	Reject H_o
Years of education	-0.003	0.869	-1.960	Accept H_o
Number of contacts with Extension Agents	-0.014*	-1.993	-1.960	Reject H_o
Years of farming experience	0.001	0.935	1.960	Accept H_o
Amount of credit received	0.007	1.152	1.960	Accept H_o

Source: Computed from data obtained from the Field Survey.

Table 29: T-Ratio Test for the Significance of Coefficients of the Socio-Economic Variables of the Inefficiency Model in Oyo State.

$H0_3$: Socio-economic variables have no significant relationship on the farmers' TE(δ_i=0)				
Variables	**Coefficients**	t_c	$t_{0.05,148}$	**Decision**
Age of farmer	0.001	0.573	1.960	Accept H_o
Years of education	0.008	1.526	1.960	Accept H_o
Number of contacts with Extension Agents	-0.067	-1.195	-1.960	Accept H_o
Years of farming experience	-0.002	-0.491	-1.960	Accept H_o
Amount of credit received	-0.00001	-1.471	-1.960	Accept H_o

Source: Computed from data obtained from the Field Survey

5.5.5 Test of Hypotheses of Significant Differences in Mean Technical and Allocative Efficiencies

The null hypothesis states that the mean TE and AE of farms in Osun and Oyo States are not different and as such rice farmers in the two States have the same productivity, the same technical and allocative efficiencies. The hypothesis is defined thus:

$H_{04}: U_a = U_b$

Where: U_a and U_b are the population means of TE (or AE) of farms in Osun and Oyo States respectively. The test used was the test of significance for difference of means for large samples ($n>30$). The results of the test are presented in tables 30 and 31. The results of the test rejected the null hypothesis that there was no significant difference between the mean technical efficiency of rice farmers in Osun and Oyo States (Table 30). Therefore, the mean TE of rice farmers in Osun State were significantly different from the mean TE of rice farmers in Oyo State.

Similarly, the results of the test of the null hypothesis that there was no significant difference of mean AE between rice farms in Osun and Oyo States was rejected (Table 31). Therefore, the mean AE of rice farmers in Osun State were significantly different from the mean AE of rice farmers in Oyo State.

Table 30: Test of Significant Differences of Mean Technical Efficiencies between the Rice Farmers in Osun and Oyo States

Items	Osun State	Oyo State	t-Computed	t-Critical	Decision
No of farms	150	150	-	-	-
Mean TE	0.9011	0.9428	6.48	1.96	Reject H_0
Standard deviation	0.066	0.043	-	-	-

Source: Computed from data obtained from the field survey.

Table 31: Test of Significant Differences of Mean Allocative Efficiencies between the Rice Farmers in Osun and Oyo States

Items	Osun State	Oyo State	t-Computed	t-Critical	Decision
No of farms	150	150	-	-	-
Mean AE	0.9263	0.8887	4.56	1.96	Reject H_0
Standard deviation	0.0848	0.0548	-	-	-

Source: Computed from data obtained from the Field Survey.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Major Findings

This study examined the socio-economic characteristics of rain-fed upland rice growers in Osun and Oyo States of Nigeria; estimated the profitability, technical, allocative and economic efficiencies; determined resource-use efficiency and the influence of growers' socio-economic characteristics on technical efficiency on rain-fed upland rice production in the study areas. Data collected from 300 rice growers in the two States through a combination of purposive and multi-stage random sampling techniques were analyzed, using descriptive statistics, gross margin analysis and the stochastic frontier production function analysis. The results can be summarized as follows:

1. The mean ages of rice farmers were 44.3 years and 37.5 years for Osun and Oyo States respectively. This revealed that rice growers in Oyo were younger than their counterparts in Osun State;

2. The mean rice farm sizes were 1.3 ha and 1.9 ha for Osun and Oyo States respectively – indicating that the mean farm size for rice farms in Oyo was higher than that of Osun State;

3. Majority (97.3%) of the farmers in Osun State was married with average family size of 3 while 94.7% of them in Oyo State was married with average family size of 7 members – indicating that family sizes of rice growers in Oyo was much larger than those in Osun State;

4. Paddy outputs averaged 1,679.48kg/ha and 1,158.11kg/ha for farmers in Osun and Oyo States respectively. This result indicated that paddy yield/ha was higher in Osun than in Oyo State;
5. TVC/ha of rice farms which averaged ₦16,192.77 accounted for 86.4% of TC/ha of ₦18,733.58 in Osun State while that for Oyo State was ₦13,682.35 which accounted for approximately 87.0% of TC/ha of ₦15,722.52;
6. The average TR/ha for paddy production were ₦50,374.15 and ₦39,131.19 for Osun and Oyo States respectively;
7. Paddy growers in Osun State earned average gross margin/ha of ₦34,181.38 while their counterparts in Oyo State received ₦25,448.84;
8. The mean revenue/rice farmer in Osun and Oyo States were ₦65,486.4 and ₦74,349.3 while the average profit were ₦41,132.74 and ₦44,476.8 respectively. Thus, rain-fed upland rice production could be said to be profitable among small-scale farmers in Osun and Oyo States.
9. Results of the stochastic frontier production function analysis showed that:
   (i) the value of the estimated sigma squared of 0.008 which was significant at the 5.0% level indicated that the estimated production function for Osun State fitted the data very well. The estimated coefficients of included regressors were 0.961 (for farm size); 0.016 (family labour); -0.036 (hired labour); 0.534 (fertilizer); -0.063 (rice seed); 0.037 (cost of agro-chemicals) and -0.047 (cost of implements);

(ii) for Oyo State, the estimated value of sigma squared of 0.018 which was also significant at 5.0% showed that the estimated production function fitted the data quite well. The estimated coefficients of the explanatory variables were 0.314 (for farm size); 0.142 (family labour); 0.284 (hired labour); 0.001 (fertilizer); 0.026 (rice seed); 0.010 (cost of agro-chemicals) and 0.051 (cost of implements);

(iii) land was the most productive resource with elasticity of production of 0.961 and 0.314 for Osun and Oyo States respectively;

(iv) with the exception of the estimated coefficient of family labour which was insignificant, the estimated coefficients of other explanatory variables were significant at the 5.0% level for Osun State;

(v) in Oyo State, coefficients of farm size, family labour and hired labour were significant while those of the quantity of fertilizers, rice seed, costs of agrochemicals and implements were not statistically different from zero at the 5.0% level;

(vi) the computed RTS for paddy production in Osun State was 1.40 while that of Oyo State was 0.83. The former value of RTS indicated inefficiency in the use of available resources in rice production while the RTS value of the latter showed otherwise;

(vii) the results of efficiency measurements showed an average of 90.1% in technical efficiency, 92.0% in allocative efficiency and 83.4% in economic efficiency for Osun State. On the other hand, Oyo State paddy producers recorded an average of 94.3% in technical efficiency, 88.9% in allocative efficiency and 84.0% in economic efficiency. This showed that there was a scope for increasing paddy production by 9.9% technical efficiency, 8.0% allocative efficiency and 16.6% economic efficiency in Osun State. Similarly, in Oyo State there was scope for increasing paddy output by 5.7% technical efficiency, 11.1% allocative efficiency and 6.0% economic efficiency --- using the present technology. There was also a scope for decreasing cost of paddy production given the existing technology.

6.2 Conclusions

From the foregoing findings, the following conclusions could be made concerning rain-fed upland rice production in Osun and Oyo States of Nigeria:

a) the enterprise was profitable in both States;

b) the farmers are not fully economically efficient in the use of production resources available to them;

c) land was more productive than other resources in paddy production in the two States;

d) paddy production was being undertaken at Stage I of the production surface in Osun State while it was at Stage II in Oyo State;

e) age of growers and their contact with Extension Agents had significant positive influence on technical efficiencies of the farmers.

6.3 Policy Implications and Recommendations

The findings of this study have a number of policy implications and recommendations for boosting the output of rain-fed upland rice in Osun and Oyo States in particular and in Nigeria as a whole. The policy implications and recommendations are presented in the paragraphs that follow.

(1) The finding that approximately 63.0% and 96.0% of paddy growers in Osun and Oyo States respectively were within the productive age groups of 20-49 years suggested that they would be receptive to modern rice production practices which were capable of boosting rice production in the areas. It is therefore, recommended that price/tonne of the commodity be made sufficiently remunerative in order to provide incentive for those growing the crop and to attract more youth into the enterprise in both States. It is also strongly recommended that the ban on importation of parboiled milled rice be kept in place to protect expansion of local production.

(2) The non-availability of credit from formal sources probably had a set-back of the production activities of paddy farmers in the two States. Credit, which was available only from informal sources, was very small and unreliable. It is recommended, therefore, that efforts should be made to make credit available to rice farmers in the State, more so, because of the profitability of the enterprise in both States.

(3) The finding that rice growers' contact with Extension Agents had positive impact on their technical efficiency suggested that the farmers were benefiting from the technical advisory services

(especially in the areas of training and adoption of improved technology) of the States' Agricultural Extension Services. In this connection, it is recommended that the existing Agricultural Extension Services of the two States be strengthened through the provision of funds, improved logistics and more manpower.

6.4 Suggestions for further Studies

The scope of study has been limited by time and availability of funds! It is, therefore, suggested that future studies on rain-fed upland production should examine risk factors; trends in productivity and efficiency; the determination of technical change, efficiency and productivity change. Also, the relative impacts of environmental factors on economic efficiency of rain-fed upland rice production could also be examined.

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APPENDIX A

THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE
(Department of Agricultural Economics and Extension)

Questionnaire on "Economic Efficiency in Upland Rice Production in Osun and Oyo States of Nigeria".

A. PERSONAL INFORMATION ON THE RESPONDENT

State ………; LGA ……………..; Name of village/town.............................

Name of respondent (optional)	Age (years)	Marital status	Gender (M/F)	Household size	Size of rice farm (ha)

2. What is your highest educational qualification? (Please, tick only one).

(a) No formal education...

(b) Primary six ....

(c) SSCE/Technical Certificate...

(d) ND/NCE..

(e) HND/B.SC...

(f) Others (please specify)..

1. Is farming your main occupation? Yes No

2. If farming is not your main job, please state your main occupation.

(a) Trading------------------- (c) Tailoring -------------------

(b) Driving ------------------- (d) Automobile mechanic -------------------

(e) Others (specify) -------------------

3. State the amount realized from non-farming activity per month N...........

4. How long have you been involved in farming? (Years)...........................

5. How long have you been involved in rice production? (Years)..............

6. Your main objective for rice cultivation is: (Please tick one only)

(i) For family consumption --------------------------------------

(ii) For the market---

B. FARM TENANCY

7. What is the total size of your farm? ....

8. What is the size of your farm under rice production? ....

9. Sources of land acquisition and hectarages of land owned through the sources.

Sources	Size (specify units)
Family inheritance	
Rented	
Leased	
Purchased	
Gift	
Any other (specify)	

10. (a) If rented, how much per unit / year? ....

(b) If leased, how much per unit / year? ....

(c) If purchased, how much per unit / year.......................................

11. How easily can you obtain additional farmland if you want to increase the size of your farm? (Please tick one only).

(i) Easily......... (ii) Very easily...... (iii) Difficult ...... (iv) Very difficult

(v) I don't know ......

C. RICE PRODUCTION PRACTICES

12. What type of rice production system do you practice in 2003? (please tick one):

(i) Rain-fed Upland........ (ii) Lowland rice....... (iii) Irrigated rice ....

13. What variety (ies) of rice did you grow in 2003?

(i) OS6 (Ofada).... (ii) ITA 128.... (iii) ITA 150 ... (iv) FARO 43.........

(v) Any others (Please, specify) ....

14. Which of the following land preparation methods do you use for rice cultivation?

(i) Slashing and burning the bush ...... (ii) Plowing and harrowing.........

15. How do you plant the rice seed?

(i) By hand........ (ii) By broadcasting using the harrow.............

D. INFORMATION ON RICE OUTPUT, SALES AND REVENUES FOR 2003 PRODUCTION SEASON

16. Please provide the following information on the amount of crops produced on your farm in year 2003

Crops	Hectarage cultivated	Quantity produced	Estimated Value of Production	Total Sold (kg, tuber)	Estimated Value (₦)	Total Returns (₦)
Rice						
Maize						
Cassava						
Yam						
Cocoyam						
Beans						
Sorghum						
Others (specify)						

17. Please, complete the Table below on rice paddy harvest from your farm last season.

Items	Price per unit (₦)	Estimated revenue (₦)
Quantity sold (kg/bag*)		
Quantity consumed by family (kg/bag		
Quantity given to friends/relatives (kg/bag)		
Quantity reserved (kg/bag)		

* Indicates that average weights of the bags were obtained for conversion.

18 What was the portion of rice paddy sold to the following categories of buyers?

Categories	Unit of quantity sold (kg, baskets, bags)	Price per unit of sale (₦)	Total amount (₦)	Total transportation cost (₦)
Wholesalers				
Middlemen				
Retailers				
Industries				
consumers directly				
Others (specify)				

19 What difficulties did you face in selling your rice paddy?

(i) --

(ii) --

(iii) --

(iv) --

20 For how much did you sell each bag (100kg) of your rice paddy?

(i) at harvest: N ---

(ii) three months after harvest: N --

(iii) six months after harvest: N--

21 How much did you spend in transporting your rice paddy?

(i) From farm to home? N --

(ii) From home to market? N---

22 What are your source(s) of information on prices of crops?

Crops	Sources of Information	Current unit price (kg,bags, baskets)	Last year's price per unit (kg,bags, baskets)
(i)			
(ii)			
(iii)			
(iv)			

E. INFORMATION ON INPUTS USED

23 Rice seeds acquired for production

Varieties	Qty bought (kg)	Source(s)	Qty from previous harvest (kg)	Price per unit (₦)	Total cost (₦)
(i)					
(ii)					
(iii)					
(iv)					

24 What difficulties did you face in obtaining seed materials?

(i) --

(ii) --

(iii) --

(iv) --

25 Fertilizer Usage

Types	Qty bought (kg, bag)	Source	Unit Cost (₦)	Transport cost (₦)	TC (₦)
NPK					
Urea					
Single Super Phosphate					

24 What difficulties did you face in obtaining fertilizer?

(i) --

(ii) --

(iii) --

(iv) --

25. Herbicides used for production

Types	Qty bought (kg/l)	Source(s)	Price per unit (₦)	Total cost (₦)	Transport cost (₦)	TC (₦)
Ransteal						
Weed-off						
Atrazine						
Risane						
Gramozone						
2,4-5D						

26. What difficulties did you face in obtaining herbicide?

(i) --

(ii) --

(iii) --

(iv) --

25 Pesticide Usage

Types of Pesticide	Qty bought (kg/l)	Source(s)	Price per unit (₦)	Transport cost (₦)	TC (₦)
Karate					
Monocrotophos					
Cymbush					
Nuvacron					
Cypermetian					
Aldrex 40					

26 What difficulties did you face in obtaining pesticide?

(i) --

(ii) --

(iii) --

(iv) --

27 Give the quantity and cost of the following cultivating tools and implements you bought.

Type of tool	Qty bought	Price per unit (₦)	Year bought
i. Tractor			
ii. Hoe			
iii. Cutlass			
iv. Rake			
v. Pruning implement			
vi. Spraying can			
vii. Others (specify)			

28. What difficulties did you face in obtaining farming tools?

(i) --

(ii) --

(iii) --

(iv) --

29. Please give the following details on the hired labour employed by you on your farm:

Operation	Category of Workers						Amount Paid per Adult Worker (₦)
	Children		Female adult		Male adult		
	No	No of days	No	No of days	No	No of days	
i. Land Preparation/clearing							
ii. Harrowing							
iii. Planting							
iv. Thinning							
v. Weeding							
vi. Bird Scaring							
vii. Spraying							
viii. Fertilizer Application							
ix. Harvesting							

30. What difficulties did you face in getting hired labour?

(i) --

(ii) --

(iii) --

(iv) --

31. Please give the following details on the family labour employed by you on your farm.

Operation	Category of Workers						Amount Paid per Adult Worker (₦)
	Children		Female adult		Male adult		
	No	No of days	No	No of days	No	No of days	
i. Land Preparation/ clearing							
ii. Harrowing							
iii. Planting							
iv. Thinning							
v. Weeding							
vi. Bird Scaring							
vii. Spraying							
viii. Fertilizer Application							
ix. Harvesting							

32 Did you hire machinery (tractor etc) for your farm operations in years 2003?

i. Yes.................................. (ii) No................................

If yes, kindly give the following details

Types of operation by tractor	Number of hectares	Number of days worked	Amount of rent per day (N)	Total amount paid for rent (N)	Total amount paid for rent on total hectare (N)
i. clearing					
ii. ploughing					
iii. Harrowing					
iv. Application of herbicides					
v. Planting					

33. Where did you obtain the machinery from?

(i) Local ADP's office ....

(ii) Government tractor hiring services ....

(iii) Private tractor hire services ....

34. What difficulties did you face in obtaining machinery?

(i) too costly................ (ii) not available on time ......

35.(i) Did you store your rice paddy until lean season before you sell them?

Yes..................................; No..

(ii) If yes, what quantity did you store and what are the costs incurred in storage?

(a) Building N...

(b) Specified container*e.g silo, metal bin) N...

(c) Chemicals for preservation N...

(d) Others (specify) N...

36. (a) How many times did the extension agents visit you on your farm last season? ....

(b) Has the visit improved your production?

(i)... (ii) ....

37. (a) Did you receive any other technical assistance from other sources apart from the extension agent? (i) Yes .... (ii) No...............................

(b) If "yes" to question 37(a) above, please list the technical assistance and the source.

Technical Assistance	Source(s)
(i)	
(ii)	
(iii)	
(iv)	
(v)	

38. What were your sources of finance or capital for rice cultivation in last season?

Sources of Loans	Amount obtained (N)	Interest rates (%)	Duration of loans (months)	Satisfactory: Yes/No
Personal savings				
Family inheritance				
Thrift and credit societies				
Friends/Relatives				
Cooperative society				
Agric. Credit cooperation				
NACB				
Commercial Bank				
Money lender				
Others (specify) ……………				

39. (a) Do you belong to any rice farmers association?

(i) Yes.................................... (ii) No..........................

(b) If yes, give the name of the association..

(c) What benefits do you derive from the association? ....

....

....

40. What were problems you faced in rain-fed upland rice production? (Tick those applicable)

(a) Soil infertility................................ (b) Damage of rice by rodents …….........

(c) Invasion of farm by birds.............. (d) Water-logging…………………….……..

(e) Damage from pest..........................

Thanks for sparing your time.