OUTPUT DIFFERENTIALS, TOTAL FACTOR PRODUCTIVITY AND USE INTENSITY IN RAIN-FED RICE PRODUCTION SYSTEMS OF NIGERIA

BY

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ABSTRACT

Rice production in Nigeria has not kept pace with increase in demand such that importation is used to bridge the demand-supply gap, resulting in drain on foreign exchange reserves. Nigeria has the potential to produce enough rice for local consumption and export through rain-fed Lowland Production System (LPS) and Upland Production System (UPS), which currently account for 73-80% national rice production. However, input use level and productivity differentials between rain-fed lowland and upland production systems have not been well documented. The output differentials, Total Factor Productivity (TFP) and input use intensities under the rain-fed upland and lowland production systems were therefore investigated.

Ekiti and Niger states were selected from southwestern and North-Central zone for the study. The selection was based on the share of the states in rice production representing the upland and lowland production systems for Ekiti and Niger states respectively. In each state, a random selection of two Agricultural Development Programme (ADP) zones was carried out. Eight Local Government Areas (LGAs) were randomly selected from the selected ADP zones. Thirty villages were randomly selected from the LGAs from which 335 rice farmers were randomly selected based on probability proportionate to the population of rice farmers in each village. Data were collected on socioeconomic characteristics, farm-holding, inputs and output using structured questionnaire. Data were analysed using descriptive statistics, factor use intensity measure, TFP measure and multiple regression analyses at p=0.05.

Mean household size, farming experience and commercialization level were 11.0±5.0 people, 22.0±12.3 years and 81.0%±7.7% respectively for LPS and 7.0±4.0 people, 13.7±8.7 years and 77.3%±16.3% respectively for UPS. The proportion of total farm-holding cultivated to rice under UPS and LPS was 43.9%± 21.5% and 37.0%± 14.8% respectively. Mean farm size was 1.9± 1.7 hectares and 2.7±1.7 hectares respectively for UPS and LPS. Input levels at 86.7% seed rate, 20.3% fertilizer and 52.0% agrochemicals in UPS and 51.7% seed rate, 46.1% fertilizer and 16.7% agrochemicals in LPS were sub-optimal relative to WARDA's recommended levels. Mean yield was 2.0tonnes/ha for LPS and 1.2tonnes/ha for UPS. A significant output differential of 0.8 tonnes/ha existed between UPS and LPS. Farmers in UPS and LPS produced 53.7% and 42.3% of their potential outputs. Potential-actual output differentials for UPS and LPS were 1.0tonne/ha and 2.7tonnes/ha respectively. Levels of TFP were 5.6 and 5.2 in UPS and LPS respectively. Increase in output and lower production costs increased TFP. Also, extension visits and commercialization level significantly enhanced TFP in both production systems. Further, increase in household size (0.56) and farming experience (0.22) significantly enhanced TFP in LPS while TFP was significantly reduced by the increase in farm-homestead distance (-0.14) in UPS.

Both lowland and upland production systems produced below their potentials but with higher yield in lowland production system. Input use intensification in rain-fed upland and lowland production systems would result in increased rice output while total factor productivity can be enhanced through higher commercialization levels and extension visits.

Keywords: Rice production, Factor use intensity, Rain-fed agriculture, Lowland and Upland production systems

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My mum (Mrs J.M. Jaiyebo) and my siblings

My husband and children

Thank you all.

Oluwaremilekun I. Akintayo
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CERTIFICATION

I certify that this work was carried out under my supervision by O.I. Akintayo in the Department of Agricultural Economics, University of Ibadan.

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ABBREVIATIONS AND ACRONYMS

ADP	Agricultural Development Programme
FAO	Food and Agriculture Organization
IFPRI	International Food Policy Research Institute
IRRI	International Rice Research Institute
LGA	Local Government Area
LPS	Lowland Production System
TFP	Total Factor Productivity
UN	United Nations
UNEP	United Nations Environment Programme
UPS	Upland Production System
USDA	United States Department of Agriculture
WARDA	West Africa Rice Association (Now Africa Rice)

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

A major challenge facing world agriculture today is to produce enough food to feed the growing world population which has been estimated to reach eight billion people by the year 2025 from the current estimated six billion people (McCalla, 2001; Wiebe, 2003; UN, 2009).

Before independence in 1960, agriculture was the bedrock of the Nigerian economy and the nation could be described as being self-sufficient in food production. With the discovery of oil in the early 1970s, there followed a neglect of the agricultural sector with a consequent drop in national food production. Though now heavily dependent on the oil industry for budgetary revenues, Nigeria is still predominantly an agricultural nation. This sector of the economy (agriculture) contributed forty-two per cent to the gross domestic product (GDP) in 2010 and continues to be the most important employer of labour (NBS, 2010). The performance of the agricultural sector is thus critical to the overall national economic growth. The Nigerian agricultural sector is composed of four sub-sectors (crops, livestock, fishing and forestry). The crop sub-sector which accounts for between seventy and eighty per cent of total agriculture is further sub-divided into crops produced for exports and those produced for domestic consumption. It is remarkable that some crops which had been known as Nigeria's traditional export crops are no longer so recognized mainly due to a decline in total production as well as increase in domestic demand. Thus, Nigeria's agricultural exports as a percentage of total exports for the periods 1979-81 and 1989-91 were 2.5% and 2.0% respectively while it was 4.2%, 3.7%, 1.7% and 1.5% for the years 1998, 1999, 2000 and 2001 respectively (FAO, 2004). The production of cash crops for export has greatly declined and the share of Nigeria in world trade has fallen substantially over the last twenty years (Adenola and Okobaroh, 1992, FAO, 2004). The expansion of food imports has contributed to balance of payments deficits while food prices have risen, thus leading to inflation and slow economic growth.

Nigeria, according to (ILO, 2003), has the largest agricultural labour force in Africa. This equals 17.5% of the region's total and 2.5% of the world total. However, agriculture in Nigeria has not been able to produce enough food and income to keep pace with the nation's rapid population growth. Efforts since the late 1970s to revitalize agriculture in order to make Nigeria self-sufficient again and increase the export of agricultural products have produced only modest results. The challenge, however, is to increase the rate of growth of agricultural production which ultimately depends on increased productivity at the farm level as an important resource base in the agricultural industry.

1.1.1 Rain-fed agriculture and rice production in Nigeria

It is globally recognized that the potential of rain-fed agriculture is large enough to meet present and future food demand through increased productivity. It has been noted that in the attainment of food security for all, rain-fed agriculture will continue to produce the bulk of the world's food (Rosegrant *et al,* 2002). Generally, rain-fed agriculture has been observed to be characterized by substantial heterogeneity over time and space. Also, the importance of rain-fed agriculture varies from region to region but produces most food for poor communities in developing countries (FAOSTAT, 2004)..

The vast potential of rain-fed agriculture needs to be unlocked through knowledge-based management of natural resources for increasing productivity and income to achieve food security in the developing world (Wani *et al,* 2009).

With regard to Nigeria, it has been estimated that about ninety per cent of the farmed land is rain-fed and subsistence in nature (Agwu and Edun, 2007). Rain-fed upland rice cultivation is an important rice production system in Nigeria where it accounts for thirty per cent of the total land area under rice (Akpokodje *et al*, 2001) and twenty per cent of total rice production (Oikeh *et al,* 2008). Rain-fed lowland rice production systems account for forty-seven per cent of the area cultivated to rice (Daramola, 2005; Fashola *et al,* 2007) and have a high potential for intensification. With improved water control and use of external inputs, the rain-fed lowland rice production may become attractive and rice yields could be increased rapidly in these systems that are inherently much more stable than the upland areas (Eklou *et al*, 2008).

1.1.2 Significance of rice

Rice has been defined by the Food and Agriculture Organization of the United Nations as "rice is a food – but more than just food. It is society, culture, politics, business, the beauty of the landscape, people in their communities. In short, rice is life." Rice (Oryza sativa L) is considered the most important cereal crop in the developing world and the staple food for over half the world's population (Juliano, 1993). Also, rice was in 1999 declared as the world's leading cereal for human consumption (CIRAD, 1999) and, globally ranks second to wheat in area harvested and second to maize in yield per hectare. The declaration of 2004 by the United Nations, as the "International Year of Rice" reflects the importance of rice in global concerns regarding food security, poverty alleviation, preserving cultural heritage and sustainable development. This is the first time an international year has been focused on one crop. The theme of 'Rice – the grain of Life' is a sign of the importance of rice as a primary food and income source especially in many developing countries. Rice has also been recognized as a political food (David, 1991).The global rice industry extends from Argentina to Australia, covering all the continents of the world, growing in diverse ecological zones and employing multitudes of people.

Globally, rice is a very important food crop consumed by over four and a half (4.8) billion people in a hundred and seventy-six countries (Daramola, 2005). Africa has become a big player in international rice markets, taking up thirty-two per cent of global rice imports in 2006 (FAO, 2009). In Sub-Saharan Africa, rice employs more than twenty million farmers and sustains the livelihood of more than a hundred million people (Diagne, 2008). Although rice is grown on about 8.5 million hectares of land (equal to 5.5% of the global rice area) in Sub-Saharan Africa, approximately forty per cent of the region's demand for rice is being met by imports (WARDA, 2007). The West African region accounts for sixty-one per cent of total rice imported in Africa (Diagne, 2008).

Rice has become a commodity of strategic significance across much of Africa. Its growing importance is evident in its position in the strategic food security planning policies of many African countries (Norman and Otoo, 2003). Driven by changing food preferences in the urban and rural areas and compounded by high population growth rates and rapid urbanization (Imolehin and Wada, 2005), rice consumption in sub-Saharan Africa has increased by 5.6% per annum between 1961 and 1992. This more than doubles the rate of population growth, with consumption and production spreading well beyond their traditional centers in West Africa and Madagascar. West Africa has become a significant player in world rice markets precisely because of its increasingly significant share of world rice imports (UNEP, 2005). Rice is now providing more than a third of cereal calorie intake in West Africa in general, and up to eighty-five per cent in traditional rice producing countries like Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia and Côte d'Ivoire (UNEP, 2005).

1.1.3 Rice production in Nigeria

Rice is an increasingly important crop in Nigeria and has been found to thrive under four main ecologies suitable for different rice varieties. These are: a.) rain-fed upland which accounts for twenty-five per cent (25%) of national rice production; b.) shallow swamps and inland valley swamps which account for twenty-five to forty per cent (25 to 40%) of national rice production; c.) irrigated lowland which account for ten to fifteen per cent (10 to 15%) of national rice production; and d.) mangrove or tidal swamp ecology (Ademola and Okobaroh, 1993). It is noted however that rain-fed lowland has been included in shallow swamps and inland valley swamps ecology. Some authors, however, have classified rice ecologies in Nigeria into five – rain-fed lowland, rain-fed upland, irrigated lowland, deep water and mangrove swamp ecologies. These account for forty-seven per cent, thirty per cent, seventeen per cent, five per cent and one per cent of national rice land area respectively (Akpokodje *et al*, 2001; Dalton and Guei, 2003; Daramola, 2005). Farmers in these ecosystems, however, have developed rice cropping practices which vary across and within ecosystems. In spite of past and recent positive development in rice production, the crop is still predominantly grown by small scale farmers. Ojehomon *et al* (2009) for instance show that on the average, the smallholder rice farmer in Nigeria produces 1.9 tons of paddy per hectare The inability of the Nigerian rice economy to satisfy the domestic demand raises a number of pertinent questions. For instance, what factors explain why domestic rice production lag behind the demand for the commodity in Nigeria?; At what intensity levels of factor inputs is rice produced by farmers?; What factors affect the level of productivity?. Central to the explanation is the issue of productivity of the rice farmers. The average yields of upland and lowland rain-fed rice in Nigeria are 2.1ton/ha and 3.9ton/ha respectively. This is quite low when compared with the national average potential of 3.0 tons/ha for upland system and 5.0 tons/ha for lowland system (Imolehin and Wada, 2005; Ojehomon *et al*, 2009). Consequently, local production has not been able to meet up with the domestic demand and importation has thus become necessary to meet domestic rice demand.

It is therefore important and of national interest to examine the factors that greatly contribute to improving rice production systems in Nigeria so as to pave the way for sustainable self sufficiency in the production of the crop.

1.2 Research problem

The demand for rice has been reported to be increasing in parts of Africa including Nigeria, at a faster rate than for any other main food staple, with consumption expanding across all socio-economic classes (JIRCAS, 2002; Okoruwa *et al*, 2006; Fatoba *et al*, 2009). Urbanization is noted to be contributing to the pattern of food demand because as urbanization increases, the demand for convenience foods such as rice also increases. In Nigeria, local production of rice estimated to be three million tons, has not been able to keep pace with demand which is currently about five million tons (NAMIS, 2004; Rahji and Adewumi, 2008). Although land area cultivated to rice has been on the increase since 1967 when it was about two hundred and sixty-two thousand (262,000) hectares and rose to over two million (2,451,000) hectares in 2007, the corresponding yields have not been sufficient to bring about the expected increase in total rice production. For instance, while the area cultivated to rice increased from slightly over a million (1,208,000) hectares in 1990 to over three million hectares (3,704,190) in 2004, output per hectare decreased from about two (2.07) tons in 1990 to less than one (0.96) tons in 2003. Area cultivated to rice increased between 1990 and 1992 after which it dropped in 1993 and then increased from 1994 to 2004. The pattern has, however, not been steady since 2004. With regards to yield, this has no clear-cut pattern. However, it can be said that there has not been any appreciable increase in national yield of rice since 1990.

The value of rice imports for Nigeria has been on a steady increase from sixty million US dollars in 1990 through one hundred and thirty million US dollars in 1996 to two hundred and eighty-eight million US dollars in 2001. This indicates a five-fold {500%} rise in foreign exchange expenditure on rice imports within eleven years. This value however rose to over one billion US dollars ($US 1.7billion) in 2008. The consideration of the possible trade imbalances that such huge expenditure on import could or have generated in the past can be fingered as one of the main reason why rice has been one of the principal foci of foreign trade policy of successive administrations in recent past. In addition, this has also underscored the need for Nigeria to embark on measures targeted at self-sufficiency in rice production which has been an important political-economic goal of the Nigerian government over the years.

Nigeria has the potential to be self-sufficient in rice production and be a net exporter of rice. However, local production of rice is constrained by scarcity and high cost of inputs, heavy reliance on manual labour to perform all farm operations, rudimentary postharvest methods and poor marketing standards (Daramola, 2005). Other identified constraints to increased rice production include poor agricultural credit system, changes in government policies in the areas of concessions and tariffs, weak agro-input system and low infrastructural development like feeder/rural roads (NRDS, 2009). Rice yields have been observed to be consistently low on farmers' fields as a result of constraints which include high costs of inputs such as fertilizers, insecticides, herbicides, tractors, manual labour and transportation of produce (Longtau, 2003).

There have been several efforts by the Nigerian government to remove/reduce the constraints of increased rice production. For instance, between 1986 and 1994 there was an import ban, subsidized provision of inputs and finance for production. In 1995, imports were allowed at a hundred per cent tariff which was reduced to fifty per cent in 1996 and reviewed upwards in 2001 to eighty-five per cent (Akpokodje *et al*, 2001). However, none of these measures halted the long term trend of continuing import dependency Also, the 'presidential initiative on rice production, processing and export' was launched in 2003 with one of its objectives as increasing output through the improvement of the productivity of Nigerian rice farmers towards self sufficiency in rice.. Also put in place in 2007 were fifty per cent tariff and fifty per cent levy on imported rice as well as exemption of agricultural capital goods from value added tax (NRDS, 2009). However, progress made with regards to efforts from government and the private sector is yet to match the increasing demand for rice. The implication of this is that the country would continue to rely on rice import for it to remain on the list of common staples within Nigerian households. This option, however, has serious economic implications, considering the enormity of the hard earned foreign exchange that had been, and is currently being committed to rice import.

Rain-fed upland and rain-fed lowland ecologies constitute 80-85% of the national cultivated rice land and contribute 73-80% of total rice production. While these two rice ecologies (rain-fed upland and rain-fed lowland) have the potential to meet national demand, their average rice outputs (1.8tons/ha) fall short of the expected average output.

Nigeria has a potential land area for rice production of between 4.6 million and 4.9 million hectares. However, only about 1.7 million hectares are cropped to rice (Imolehin and Wada, 2005; NRDS, 2009). With this continuous increase in land area harvested to rice and consequently national output in Nigeria, the rate of increase is yet to match the increasing demand for the commodity.

From the foregoing, the key problem is how to increase domestic production of rice to keep pace with demand in the face of high production capacity and thus reduce its importation into the country without exacerbating food security problems. With Nigeria's aim of being self sufficient in rice production, it then becomes important to know how productive the rice farmers presently are in the use of resources in order to contribute to sustainable growth in production. Quantifying the variability in rice productivity between production systems and identifying the determining factors are important prerequisites to the development of system-specific and location-specific recommendations to enhance productivity increases and national self-sufficiency in rice production.

This study was thus designed to provide answers to the following questions.

- What is the difference between the potential and actual rice output under rain-fed production systems?.
- At what levels of intensities are inputs used in rice production ?

- What factors influence the productivity levels of the rice production systems?

- Are there production and productivity variations between rice production systems?

1.3 Objectives of the study

The main objective of this study is to provide empirical evidence on the productivity levels and factor use in rain-fed rice production systems in Nigeria. The specific objectives are to:

1. Determine the output differentials for the rice production systems in the study area
2. Quantify the factor use intensities in the production systems.
3. Examine the total factor productivity differentials between and the determinants of total factor productivity in the production systems.

1.4 Hypotheses

1. Null hypothesis (Ho): There is no significant difference in the output of the two production systems.
2. Null hypothesis (Ho): There is no significant difference in total factor productivity levels of the two production systems.
3. Null hypothesis (Ho): There are no significant effects of farmers' specific socioeconomic and farm characteristics on total factor productivity levels of the production systems

1.5 Justification

Nigeria ranks highest as both producer and consumer of rice in the West African sub-region with figures slightly above fifty per cent (Longtau, 2003). Although Asia currently produces most of the world's rice, Africa has been noted to have the potential of becoming a major producer with Nigeria having a very high potential of becoming a major producer and exporter of rice in West Africa (FAO, 2003; Imolehin and Wada, 2005).In appreciation of this potential, it is important to boost rice production and consequently enhance its export potential especially to countries in the African sub-region. Such intention could, however, only be realized if proper production expansion strategies are put in place. Such strategies will, however, be better built on proper understanding of the prevailing production environment with special focus on factor/input use and productivity at the farm level. An understanding of the rice sector performance, especially the rain-fed sector, and the factors affecting such performance is necessary. This will help decision/policy makers to formulate policies to enhance self-sufficiency in rice production for the nation. Taking this step is important as it has been noted that between seventy-three and eighty per cent of rice produced in Nigeria is produced under rain-fed system (Imolehin and Wada, 2005).

The importance of the assessment of crop-specific productivity analysis has been appreciated. This will give insight into the potential for resource savings and productivity improvements of the specific crop (Ajetomobi, 2009), which in this case is rice.

Several studies have been carried out with regard to rice production in Nigeria. These include Oladele and Sakagami (2005) who examined the impact of extension services on national rice yield gap. They found out that extension intensity had significant impact on the reduction of rice output differential (yield gap) in Nigeria. Abo *et al* (2003) and Okoruwa *et al* (2006) examined the levels of efficiency of rice farmers in north central Nigeria and explained the factors which determined the efficiency levels. Others include Ogundari (2008), Idiong (2007), Idiong *et al* (2007), Oladeebo and Fajuyigbe (2007) who emphasized on the concept of efficiency. Examples of crop-specific TFP international measurement studies are Cassman and Pingali (1995), and Pardey *et al*. (1992) for rice; and Sidhu and Byerlee (1992) for wheat.

Output differential, which is sometimes referred to as yield gap, is the difference between potential and actual yields over some specified spatial and temporal scales of interest (Roetter *et al*, 1998; Lobell *et al*, 2009). Potential yield refers to the attainable yield when recommended management practices are carried out appropriately. Actual yields are average yields obtained on farmers' fields. Narrowing yield gaps of rice not only increases rice yield and production, but also improves the productivity of land and labour use, reduces production costs and increases sustainability (FAO, 2004). It has been noted (Siddiq, 2000) that potential yield of varieties may vary with the production system. Therefore, precise knowledge on production system specific potential is a pre-requisite for meaningfully determining the untapped yield of the currently popular high yielding varieties. Exploitable yield gap cannot be defined in terms of national yield since the latter is an average of yields of rice planted across agro-ecologies. More appropriately, exploitable yield is in terms of farmers' yields in a particular location and season (Duwayri *et al,* 2000). In order to design management interventions aimed at increasing rain-fed rice production, the magnitude of and variation in yield gaps associated with various constraining factors need to be assessed.

It has been acknowledged that there are regional inequalities and these are a striking and persistent feature of both developed and less developed economies (Rice *et al*, 2006).There is thus a need to give attention to the aspect of productivity. The determinants of regional variations as well as production system differences in factor productivity also need to be explained and analyzed. This is very crucial because productivity estimates are best used as a framework to identify those areas that need the most change, or where changes will yield the greatest increases in profitability (Penno *et al,* 2006). It is, therefore, important to establish a good understanding of the factors which affect and determine farmers' productivity. The aim is to help policy makers to proffer and implement measures that contribute positively to overall agricultural productivity and self-sufficiency in food production via crop-specific, system-specific and region-specific policies.

CHAPTER TWO

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Theoretical framework

2.1.1 The concept of output differentials

Yield gap is a concept frequently used in technical agronomic analysis of production as a measure of performance because it implies a comparison between yields actually obtained and potential yields (Nin-Pratt *et al*, 2011). The agronomic yield potential is defined as the yield obtained on experimental stations with no physical, biological, or economic constraints; using the best known techniques; applying sufficient inputs to stimulate crop growth to the maximum; and eliminating all pre- and postharvest losses (Lobell *et al*, 2009; Nin-Pratt *et al*, 2011). Actual yields are farm-level yields obtained by farmers. Output/yield differentials reflect mainly differences in management practices such as the quantity of fertilizers and herbicides used. The concepts of output differentials, yield differentials and yield gaps are the same.

Three components of yield differentials have been identified. The first component is the gap between theoretical potential yield and the research station yield for which scientists conceive and breed potential crop varieties (FAO, 2004). The second component is described as being not exploitable because it cannot be narrowed. This is mainly as a result of factors (such as environmental conditions) which are generally not transferable between experimental/research station and farmers' fields. The third component is due to the use by farmers of input quantities and cultural practices different from those required for the achievement of agronomic yield potential. In other words, the third component is due to farmers' use of suboptimal doses of inputs and cultural practices.

Output differentials in this study were calculated based on the definition of yield differentials. That is, potential yield minus actual average yield obtained for the crop (Nin-Pratt *et al*, 2011). Potential yield is taken as the expected yield as given by research institutions (such as WARDA) when recommended management practices are fully put in place for given rice varieties.

2.1.2 The concept of productivity

The two major concepts used to characterize a firm's resource use performance are efficiency and productivity. These two concepts are not equivalents, but are often treated as such. For instance, it is usually assumed that if firm A is more productive than firm B, then firm A is also more efficient. This however, is not always true. Although closely related, efficiency and productivity are not the same. Figure 1 is used to illustrate the difference between the two concepts. Line OF is the production frontier which defines the relationship between input and output. It represents the maximum output attainable from each level of input (Coelli *et al,* 2005). Points B and C represent efficient points while point A represents an inefficient point on the production frontier. Thus, firms which operate on the frontier are technically efficient while those which operate beneath it are not technically efficient. For instance, a firm which operates at point A is inefficient because technically, it could increase output to the level associated with point B with the same level of input. In figure 2, a line through the origin is used to measure productivity at any particular data point because the slope (y/x) of this line provides a measure of productivity. If the firm operating at point A moves to the technically efficient point B, the slope of the line would be greater. This indicates that productivity is higher at point B in relation to A. The line from the origin through point C is at a tangent to the production frontier. Point C thus defines the point of maximum possible productivity. Thus, operation at any other point other than C on the production frontier results in lower productivity (Coelli *et al*, 2005).

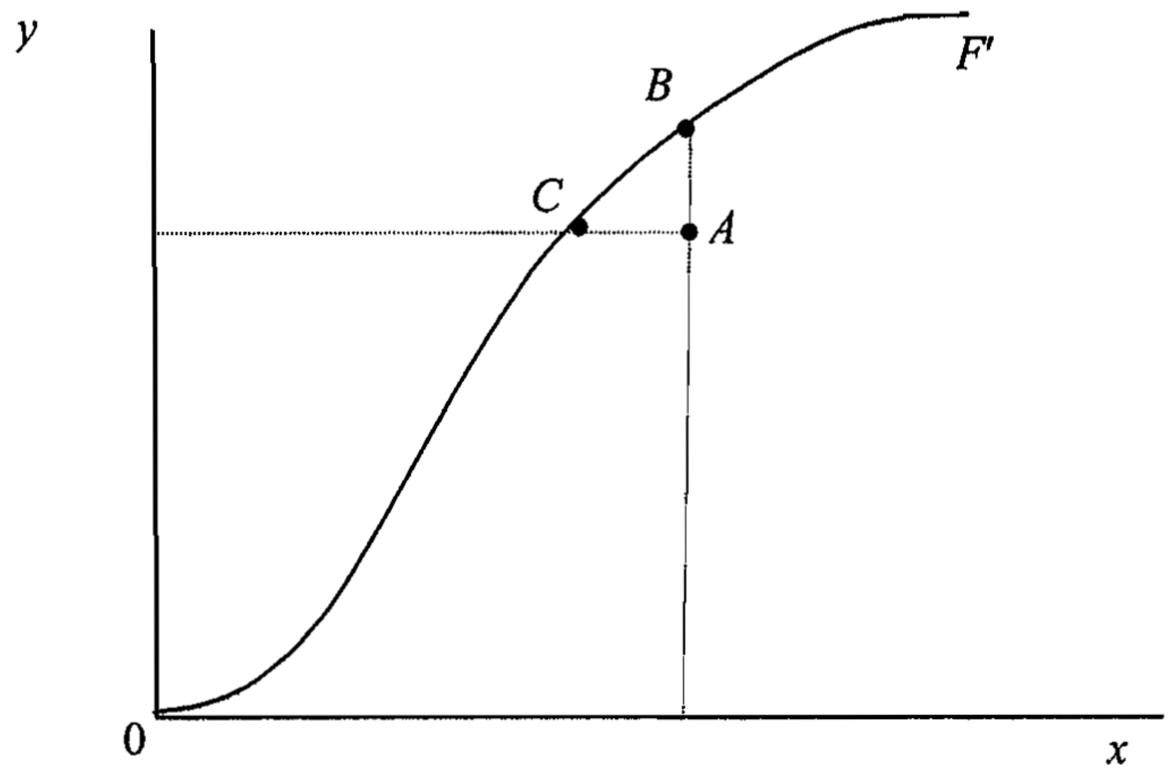

Figure 1. Production Frontier and Efficiency

Source: Coelli *et al*, 2005

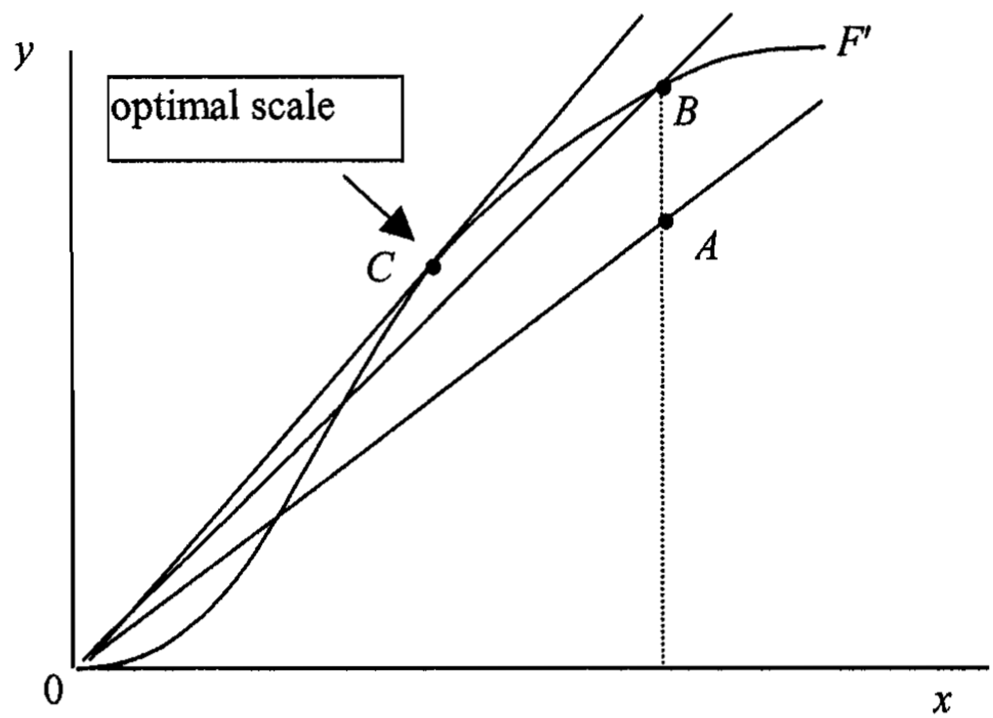

Figure 2. Productivity and Efficiency

Source: Coelli *et al*, 2005

Productivity can be defined as a quantitative relationship between output and input. It is the value of output (goods and services) produced per unit of input (productive resources) used. Thus an increase in productivity means producing more goods and services with the same amount of resources, or producing the same goods and services with fewer resources, or some combination of these two possibilities. It can also be defined as a ratio of some measure of output to some index of input use. In other words, productivity is the arithmetic ratio between the amount of output produced and the amount of any resources used in the production process. This implies that productivity is the output per unit input (Oyeranti, 2006).

Productivity can be viewed as the attainment of the highest level of performance with the lowest possible expenditure of resources. It is an important component of evaluating and monitoring the performance of an enterprise or an economy. Productivity is a relative concept with comparisons either being made across time or between different production units such as two firms in an industry, two industries within or between countries, or between countries. Furthermore, productivity can be measured in a variety of ways, including partial measures, such as the amount of a single output per unit of a single input (average productivity); the ratio of change in output per unit change in input (marginal productivity); the ratio of percentage change in output per percentage change in input (elasticity) or in terms of an index of multiple outputs divided by an index of multiple inputs (total factor productivity). Different measures of productivity may be of interest in addressing different questions (USDA, 2003). Also, the total factor productivity of a firm, industry or group of industries is defined as the real output produced by the firm or industry over a period of time divided by the real input used by the same set of production units over the same time period.

Productivity measures are of great importance as they provide information about how much measured output is being produced in an economy relative to measured inputs. This is an indication of how the economy is performing in terms of its productive efficiency with respect to available resources (Mawson *et al,* 2003). Productivity determines competitiveness and revenues. For example, if two firms (say firm V and firm W) have the same level of output, but firm V uses lesser input than firm W, then firm V is more productive. With lesser usage of input, it is expected that firm V will incur a lower cost of production and thus be able to charge a lower price for its product. As a result of this, it is likely to have a larger share of the market and higher revenues. Firm W will, however, have to improve its productivity in order to compete well with firm V. Improving productivity is essential in attaining global competitiveness with the end goal of achieving sustained economic growth (Cuenca, 2006).

Low productivity is a basic problem of economic progress. In the short run, increased productivity can lead to increased farm income while in the long run, more farms can adopt the more productive practices and inputs, leading to increased output supply.

Typically, measurements of productivity rely upon some function of output (Q) to some function of inputs (X). A partial factor productivity index can be constructed for each input and essentially describes the average productivity (AP) of the input. Traditional partial factor productivity measures do not account for relationships among resources. Labour productivity in particular is often used as a surrogate for overall performance, without regard to other relevant variables. Multi-factor measures are more robust for analyzing actual operational productivity.

Total factor productivity (TFP) is a concept of importance not only in the context of macroeconomic aggregate measures of a country's performance in terms of per capita growth and productivity, but is of equal significance in measuring the determinants of productivity and competitiveness of firms. The total factor productivity (TFP) of a farm can be defined as the real output produced by the farm over a period of time divided by the real input used by the same production unit over the same time period. Output level is a function of a farm's resource endowment and the productivity of factors of production, or total factor productivity

Total factor productivity (TFP) in its simplest definition is the ratio between real product and real factor inputs (Cororaton and Cuenca, 2001). It is the true measure of productivity because it incorporates the contribution of all the factor inputs (Mulwa *et al*, 2006). Total factor productivity is an attempt to measure productivity, taking into account all factors of production. TFP is also a concept linked to the aggregate production function (Felipe, 1997). Total factor productivity can be referred to as a neoclassical concept (Cororaton and Cuenca, 2001) for two reasons. First, it is a notion linked to the aggregate production function which is a neoclassical tool. Second, TFP is an attempt to measure productivity taking into account all factors of production. This puts in place the underlying assumption that labour is not the only production input.

Total factor productivity (TFP) is a concept of importance not only in the context of macroeconomic aggregate measures of a country's performance in terms of per capita growth and productivity, but is of equal significance in measuring the determinants of productivity and competitiveness of firms, industries and the economy at large.

Two major sets of factors have been suggested to determine factor productivity. These are first, the technical properties of the production process and second, the movement of relative factor prices. The technical properties often referred to include the following.

- Efficiency of production. That is, reduction in the unit cost of all factors of production equally by applying better techniques.
- Elasticity of substitution. That is, the extent to which an input can be substituted for another input in the production process.
- Scale of operation of the production process. That is, the economies/ diseconomies which arises as a result of changes in the scale of operation
- Homotheticity of the production function (Nadiri, 1970).

2.1.3 Approaches to productivity measurement

Productivity measurement methods have evolved over time and will continue to evolve as they incorporate improved data and concepts. There are many different measures of productivity levels and growth. The choice between them depends on the purpose of productivity measurement and, in many instances, on the availability of data. Generally, productivity measures can be classified as single-factor productivity measures (relating a measure of output to a single measure of input) or multi-factor productivity measures (relating a measure of output to a bundle of inputs). Another distinction of particular relevance at the industry or firm level is between productivity measures that relate gross output to one or several inputs and those which use a value-added concept to capture movements of output. Productivity is a relative concept and thus the productivity of a firm can be measured relative to that of another firm in the same period of time.

Although partial factor productivity index has a weakness of not accounting for all the inputs used in production, carefully constructed partial measures are legitimate measures of the variations in output attributable to variations in inputs. For instance, partial agricultural labour productivity measures the influence of labour on the value of crop output (Owuor, 2006).

Partial productivity indices are obtained by dividing the output by value of the input.

$$PPL_i = \frac{Q}{X_i} \quad (1)$$

Where PPI_i is the partial productivity index for the i^{th} input

Q is the value of the output measured by the market price and x_i is the value of the i^{th} input in total cost.

The performance of a production unit can be defined in several ways, one of which is the productivity ratio. By defining the productivity of a firm as the ratio of its output to the inputs used, the larger values of this ratio are associated with better performance (Kirikal, 2006).

Producers including farmers think in marginal and average terms as they add and subtract units of factors in a bid to achieve the most profitable course of production action. Simply put, the marginal physical product is the additional or extra product produced by using an additional unit of input. The concept of the marginal productivity of an input in a productive process is a particularly important idea in economic analysis, because under competitive conditions, the equilibrium price of a factor of production will tend towards equality with its marginal productivity. Marginal productivity is the increase in the value of output that can be produced by adding in one more unit of the particular input while holding other inputs constant. Thus, the higher the productivity of a factor of production, the higher the income that may be expected to accrue to its providers. Thus, anything that raises overall levels of productivity within a society may be expected to increase the average overall prosperity of the society as a whole.

Theoretically, Total Factor Productivity (TFP) is the true measure of productivity because it incorporates the contribution of all the factor inputs (Mulwa *et al*, 2006). TFP is an attempt to measure productivity, taking into account all factors of production and it is a concept linked to the aggregate production function (Felipe, 1997).

Several models of production growth have been used to measure the change in output, identify relative contributions of different inputs to output growth and identify output growth not due to increases in inputs. The approaches to measure TFP and growth can be categorized into three major groups. These are

– Growth Accounting/ Index number approach

- Non parametric approach, and
- Econometric/ Parametric approach.

Each of these techniques can be used in the measurement of aggregate agricultural output or total factor productivity (TFP). However, all these techniques differ in data requirements and suitability for addressing different questions. Also, each technique has its own strengths and weaknesses.

The growth accounting/ index number method: Most TFP studies have traditionally used index number method to compute the input and output aggregates The growth accounting methods use the production function as a starting point. However, growth accounting is an estimator of technical change that lacks a stochastic term. Therefore, the growth accounting model is not estimated statistically. As a result, the usual test statistics used in econometric work cannot be applied to growth accounting. For practical purposes, growth accounting method imposes the assumption of profit maximization that allows us to equate the elasticities to the factor shares. Growth accounting makes it easy to calculate the change in total factor productivity growth from year to year, while the econometric estimation provides an average rate for a given period (Diewert, 2006).

Rao and Coelli (2003) measured TFP using the Malmquist index methods in order to examine global agricultural productivity trends. Mulwa *et al* (2006) also employed the Malmquist TFP index in analyzing the productivity of sugarcane production in Kenya. The Malmquist TFP index measures the change between two data points by calculating the ratio of distances at each data point relative to a common technology. It has additional benefits over the Fisher and Torqvist indices in that price data are not required, and that the TFP indices obtained may be decomposed into two components (technical efficiency change component and technical change component). The Malmquist index is defined using distance functions which allow one to describe a multi-input, multi-output production technology without the need to specify a behavioral objective (such as cost minimization or profit maximization). An input distance function characterizes the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector (Mulwa *et al*, 2006).

The growth accounting/ index number approach is based upon the development of indices of input and output which are made under the assumptions of a particular production function.

The non parametric approach: The non parametric approach employs linear programming methods to calculate total factor productivity (TFP). This approach does not impose assumptions about the technology which generates agricultural output and can be used employing time series data or detailed micro-level data (Chavas and Cox, 1992).

The econometric/ parametric approach: Similar to the growth accounting methods, the econometric/parametric approach also use the production function as a starting point The econometric/parametric approach is based on the econometric estimation of the production technology, that is, the production function (primal approach) or a cost function (dual approach). The econometric/parametric approach helps to obtain the different components of TFP. In the econometric estimation, the parameters are, in general, unrestricted, and do not necessarily have to add up to 1. It is hoped, however, that the estimates of α and β will take on interpretable values, that is, coefficients that could be taken to be reasonable elasticities. The efficiency frontier model approach is more appropriate if the study unit is the firm and not the industry. The econometric approach is statistical and thus allows for the testing of hypotheses and the reliability of the estimated model. This enables for the ability to gain information on the full representation of the specified production technology.

Studies employing the production function approach date back several decades. The econometric approach to productivity measurement involves estimating the parameters of a specified production function or cost function (Mawson *et al*, 2003). One advantage of the econometric approach is the ability to gain information on the full representation of the specified production technology. In addition to estimates for productivity, information is also gained on other parameters of the production technology. It is not possible to generate this additional information using the growth accounting or index number approaches. Moreover, because the econometric approach is based on using information on outputs and inputs, there is greater flexibility in specifying the production technology. For example, it is possible to introduce other forms of factor augmenting technological change other than the Hicks-neutral formulation implied by the growth accounting and index number approaches, and to make allowance for adjustment costs and variation in input utilization (Mawson *et al*, 2003).

Production function (econometric) approach permits quantifying the marginal contribution of each category of inputs to aggregate production. For example, one can determine the impact of a one-per cent increase in fertilizer use on overall agricultural output, holding all other inputs constant (FAO, 2009). A production function assumes a parametric functional relationship between output and input and essentially describes the transformation process of inputs into output(s) (Hoff, 2006). The choice of a functional form in an empirical study is of primal importance, since the functional form can significantly affect the results obtained (Griffin *et al*, 1987).

Transcendental Production Function: The transcendental production function presents output as a transcendental, or more specifically, exponential function of the logarithms of inputs. The merits of the transcendental production function include the fact that it places less restrictions on input and output relationships than other functions. It also allows the elasticities of substitution among inputs to vary as input proportions vary, unlike some other production functions including the Cobb-Douglas production function (Dean *et al*, 2006).

Transcendental production function exhibits all three types of factor interdependence. Factor interdependence refers to the case where the marginal productivity is a function of the other factor. Factors are technically complementary in that the marginal productivity of one factor is increased by the other factor. They are technically competitive if the marginal productivity of the one factor is decreased by the other factor and they are technically independent if the marginal productivity of the one factor is not influenced by the other factor.

The function coefficient of the transcendental production function can be calculated. This gives information about the returns to scale and the factor elasticity of factors are also obtainable. The transcendental production function is an attractive flexible function. Ghorbani (2008) used transcendental production function model on farm household data obtained through primary survey in order to determine the effects of agricultural advisory services on input and output of sugar beet in his study area. The author compared two groups of farmers – farmers with and without advisory services and estimated the parameter of the transcendental production function using the ordinary least squares (OLS) method. Maddala (2006) investigated whether measures of multi-factor productivity differ significantly with alternative functional forms for production functions. It was concluded that within the limited class of functions considered (Cobb-Douglas, generalized Leontieff, transcendental and homogeneous quadratic), differences in the functional form produce negligible differences in measures of multi-factor productivity. The intuitive explanation of these results is that the different functional forms differ in their elasticities of substitution (which depends on the second derivatives of the production function) while for productivity measurement, it is the first derivatives we are concerned with. In this wise, other factors such as measurement errors in inputs and outputs as well as aggregation problems are more important than functional form of the production. The logarithm form of a four-input transcendental production function can be written as;

$$\ln Q = a + k \ln K + l \ln L + m \ln M + y \ln Y + \Theta_1 K + \Theta_2 L + \Theta_3 M + \Theta_4 Y \qquad (2)$$

where Q is output L is labour K is capital M is material input

Y is land and a is intercept or the constant term.

2.1.4 Factors that influence agricultural productivity

An understanding of the potential sources of productivity growth is important for formulating appropriate policy tools to increase productivity and a society's standard of living. Several factors have been identified in the social science literature as important determinants and sources of change in agricultural productivity. These include research and development, extension, education, infrastructure and government programs (Aheam et al, 1998). Factors that can influence agricultural productivity levels and growth rates are typically studied using either a production function approach or an index-number approach. In a production-function approach, differences in output or productivity across spatial units (e.g., farms or countries) and/or time are explained by differences in the levels of inputs, both conventional (e.g., land, labour, tractors, livestock, and fertilizer) and non conventional (e.g., land quality, physical infrastructure, research, and government policies). This approach usually uses partial productivity measures, such as land productivity (e.g., crop yields per unit of land) or labor productivity (e.g., output per worker) (USDA, 2003).

Some of the factors which affect productivity have been classified into categories by certain authors. These include Hussein and Perera (2004) who put these factors into five major categories.

1. Land and water related factors (such as farm/water course location, quality of land, sources of water, timing of water application, etc).
2. Climatic factors (rainfall, temperature, sunshine, etc).
3. Agronomic factors such as quality, quantity and timing of input application (seeds, fertilizers, herbicides, labour and so on).
4. Socio-economic factors (such as farmers' health, education, experience in farming, farm size, tenancy terms, land fragmentation and availability of credit).
5. Farm management factors (adoption of modern production technologies, farm planning and management practices).

Also, Mahendra (2000) included land quality and land tenure system as part of the factors which influence productivity in agriculture. Some of these factors have been noted to be interrelated and the effects of some of them may be much greater than that of others. Also, there may be locational variations in the degree of their effects on productivity (Rahman, 2006). Infrastructure is also another factor which has been noted to affect productivity. Studies such as (Gopinath and Roe, 1997) have found a significant positive relationship between infrastructure and agricultural productivity in countries like the US. They reported that the most obvious way investment in infrastructure might affect agricultural productivity is through public transportation. They further stated that an improved highway system can reduce farmers' cost of acquiring production inputs and of transporting outputs to market. Farm level factors such as the distance of the plot from the farmer's residence, roads and markets have also been presumed to have effect on productivity (Pender *et al*, 2002).

2.2 Literature review

2.2.1 Total factor productivity (TFP)

TFP is a neoclassical concept as a result of two major features. First, total factor productivity is an attempt to measure productivity, taking into account all factors of production; thus the underlying assumption that labour is not the only input (classical Ricardian labour theory of value). Second, TFP is also a concept linked to the aggregate production function, a neoclassical tool (Felipe, 1997). Thus, TFP is a neoclassical concept of productivity measure that takes into account all factor inputs that go into the production of a certain product (Cororaton and Cuenca, 2001). TFP is the true measure of productivity because it incorporates the contribution of all the factor inputs (Mulwa *et al*, 2006). Total Factor Productivity is a measure of the physical output produced from the use of a given quantity of inputs by the firm. When there are multiple outputs and multiple inputs, the ratio of the weighted sum of outputs with respect to the weighted sum of inputs is used to calculate the Total Factor Productivity Index. In general, these weights are the cost share for inputs and the revenue shares for the outputs.

Ball *et al* (2001) employed a different approach to productivity analysis. They compared the levels and changes in TFP for the United States and nine European countries (Germany, France, Italy, the Netherlands, Belgium, the United Kingdom, Ireland, Denmark, and Greece) for the period 1973-93. Price and value data were used to construct indices of aggregated agricultural output, intermediate inputs (goods that are used in production during the calendar year, such as feed and seed), capital, labor, and land.

2.2.2 Production costs and total factor productivity

It has been noted that there is an inverse relationship between physical measures of productivity and the cost of production. Furthermore, increasing the physical productivity of an input that is used in a production process reduces the cost of production of a product or service. These relationships however may hold true provided the reduction in the physical quantity of a production input in a production process does not increase the use/employment of other inputs in the same operation or production process.

In estimating the production costs of cotton in Turkey, Yilmaz *et al* (2004) considered various cost components such as seeds, fertilizers, agrochemicals (pesticides, insecticides, herbicides and fungicides), labour, repairs and maintenance, depreciation and land rent and computed the share of each component in total production costs per unit area (hecatare) of farm land. The authors obtained their total production value by multiplying cotton yield (kg/ha) by the price of cotton per kilogram. They went further to determine the total factor productivity by dividing cotton yield (kg/ha) by the total production costs per hectare.

Fakayode *et al* (2008) in their productivity analysis of cassava-based production systems in the guinea savannah zone of Nigeria, estimated the total factor productivity levels of the different production systems and analyzed the effects of various factors on the productivity levels. In computing the total factor productivity levels, the authors found the ratio of output to total variable costs. This of course, is the inverse of average variable costs. Hall (1988) in his own case, employed a method which made no parametric assumptions about the cost function and tested the equality of price and marginal cost directly from data on price, output as well as the quantities and prices of inputs. Conversely, Jensen (2008) in his own case estimated the portion of farm operating costs from various production inputs (with emphasis on fertilizers) in order to determine the returns to investment on the production inputs. This was however done through calculations from data on input and output quantities and their prices.

In the estimation of total factor productivity at the national and sectoral levels for the Philippines, Cororaton and Cuenca (2001) employed the growth accounting method and expressed output as gross domestic product (GDP) in real prices

2.2.3 Productivity in the agricultural sector

Productivity performance in any economy is a very important issue. For instance, the economies of Sub-Saharan Africa are heavily dependent on agriculture, which accounts for two-thirds of the labour force, thirty-five per cent (35%) of gross national product (GNP) and forty per cent of foreign exchange earnings (Fulginiti *et al*, 2003). Thus, the productivity performance in the agricultural sector is critical to improvement in overall economic well-being in any nation.

Cereal crop output and productivity growth rates have been particularly low in Sub-Saharan Africa over the last four decades. The rapid population growth in many parts of the region has outstripped more modest gains in food crop production (Pingali and Heisey, 1999)

The improvement in the production capacity of agriculture in developing countries through productivity increases should be an important policy goal where agriculture represents an important sector in the economy (FAO, 2009). For any strategic agricultural development, productivity is a key issue because it affects both economic and social development. In a broad sense, productivity is a measure of the effectiveness with which resources are used as inputs for the production of goods and services required for the development of the society. In other words, productivity is a very important factor in the attainment of economic growth and development.

Although closely related, the concepts of efficiency and productivity are fundamentally different. Efficiency refers to the minimum resource level that is theoretically required to run the desired operation in a given system while productivity relates to how much resources are actually used (Tangen, 2006). While efficiency is measured as the ratio of output produced with given inputs relative to the maximum feasible output, productivity is the ratio of a measure of total output to a measure of total inputs. Studies such as Adeyeye (1986), Coelli (1995), Ajani (2000), Ogundele and Okoruwa (2006) have given considerable attention to efficiency measures with regard to agriculture in Nigeria.

From the perspective of sustainable agricultural growth and development in Nigeria, the major fundamental constraint has been identified to be the labour-intensive peasant nature of the production system and its low productivity (Manyong *et al*, 2003; Adedipe *et al*, 2004; World Bank, 2007). Productivity increases is a direct means to improving the production capacity of agriculture in developing countries (FAO, 2009).
It is important to note that within the context of growth in food and agriculture, emphasis is placed on productivity (Zepeda, 2001)

Productivity improvement and growth have been important subject matters for intense research worldwide. Development economists and agricultural economists have examined the sources of productivity growth and productivity differences among countries and regions over time periods. Productivity growth in the agricultural sector is considered essential if agricultural sector output is to grow at a sufficiently rapid rate to meet the demands for food and raw materials arising out of steady population growth in any nation (Rao and Coelli, 2003).

It has been noted and appreciated that there exist differences in agricultural productivity among countries. Some of the studies on cross-country differences in agricultural productivity include Hayami and Ruttan (1970), Kawagoe and Hayami (1985), Bureau *et.al* (1985), Fulginiti and Perrin (1993) and Rao and Coelli, (2003). The analysis of Hayami and Ruttan (1970) from the estimation of a cross-country production function of the Cobb-Douglas form for thirty-eight developed and under-developed countries indicated that three broad categories of factors account for about ninety-five per cent of the differences in agricultural labour productivity between a representative group of less developed countries and of developed countries. These three categories of factors are resource endowments; technology (embodied in fixed or working capital); and human capital (broadly conceived to include the education, skill, knowledge and capacity embodied in a country\s population). Alauddin *et al* (2005) constructed the levels of total factor productivity in agriculture for one hundred and eleven countries covering the years 1970 to 2000 employing data in panel and cross-sectional regressions to explain levels and trends in total factor productivity (TFP) in world agriculture. The work of Aiyar and Dalgaard (2001) was more of a methodological issue. The authors developed a 'dual' method to compare levels of total factor productivity (TFP) across nations that rely on factor price data rather than the data on stocks of factors required by standard 'primal' estimates. They showed that for a sample of OECD countries there are significant differences between TFP series calculated using the two different approaches. The authors traced the reason for the divergence to inconsistencies between the data on user-costs of capital and physical stocks of capital.

Coelli and Rao (2003) examined the levels and trends in agricultural output and productivity in ninety-three developed and developing countries that account for a major portion of the world population and agricultural output. Data used were obtained from the Food and Agriculture Organization of the United Nations and the study covered the period 1980-2000. The authors used data envelopment analysis (DEA) to derive Malmquist productivity indexes and examined trends in agricultural productivity over the period.

Quite a number of country-specific studies have been carried out. These include Andzio-Bika and Wei (2005) who analyzed the impact of some production variables on agricultural productivity growth in China between 1989 and 2002. The data used were provincial level agricultural outputs and inputs for estimating the Cobb-Douglas production function of China agriculture from 1989~2002. Carter et al (1999) also utilized data from China to measure productivity growth and went a step further to compare measurements obtained from farm-level data with those obtained from national-level data and found discrepancies between the two sets of productivity measurements.. Owuor (2006) investigated the determinants of agricultural productivity in Kenya from the household level.

Sector-specific as well as sub-sector-specific productivity studies have also not been left out of international research studies. One of such sub-sector-specific productivity studies is that carried out by BEI (2004) in which cross-sectional data were utilized, employing the parametric method to estimate three measures of productivity (land productivity, capital productivity and total factor productivity) for the selected sub-sectors. This was done in order to be able to explain variations in performance across locations for the sub-sectors under review. Another sub-sector study is that by Tauer and Lordkipanidze (1999) who measured the productivity of dairy production in the various states of the United States of America using Census data and non-parametric Malmquist index techniques. Also, Ajetomobi (2009) carried out a productivity improvement analysis for the rice sector across the Economic Community of West African states (ECOWAS). In the study, productivity growth was measured using the extension of two methodological approaches (data envelopment analysis (DEA) and production function using stochastic frontier analysis) to Malmquist index estimation.

Studies on productivity measurements based on data from Nigeria include Oladeebo and Fajuyigbe (2007) who examined the technical efficiency of male and female upland rice farmers in Osun state using stochastic frontier production function analysis. Fakayode *et al* (2008) carried out a productivity analysis of cassava-based production systems in the guinea savannah ecology of the country using total factor productivity to determine the levels of productivity and Ordinary Least Squares (OLS) regression methods to determine the factors influencing productivity.

2.2.4 Output differentials

Often referred to as yield differentials or yield gap, output differential is the difference between potential and actual output (Roetter, *et al*, 1998). In other words, yield gap is the difference between the maximum attainable yield and farm-level yield (FAO, 2004). The concept of yield gap/output differentials/yield differentials is used as a measure of performance frequently in technical agronomic analysis of production (Nin-Pratt *et al,* 2011). The potential farm yield or the maximum attainable yield is the rice yield of on-farm plots with no physical, biological or economic constraints and with the best-known management practices for a given time in a given ecology (FAO, 2004). Potential yield has also been defined as the yield of an adapted crop variety when grown under favourable conditions without growth limitations from nutrients, water, pests or diseases (Lobell *et al*, 2009). Farm-level yield is the average farmers' yield in a given target area at a given time and in a given ecology (Van Tran, 2010). Two exploitable components of output differential have been recognized (Duwayri *et al*, 2000; Singh *et al*, 2001; Bhatia *et al*, 2006; Lobell *et al*, 2009). The first component is the difference between experimental station yields and potential farm yields. This exists mainly because of environmental differences between experiment stations and the actual rice farms. The potential farm yield can be approximated by the yield obtained in on-farm experiments under non-limiting input condition. The second component of yield gap is the difference between the potential farm yield and the actual farm yield. Narrowing yield gaps of rice not only increases rice yield and production, but also improves the productivity of land and labour use. It also reduces production costs and increases sustainability (FAO, 2004).

It has been reported (Singh *et al*, 2001) that before any investment for improving crop production is made, it is essential to have an assessment of the differential (gap) between potential and actual crop output. Scientists have thus taken yield gap as a critical concept which should be given proper attention. An understanding of yield gap (output differential) is important because it can help in projecting future crop yields. Also, knowledge of the factors which contribute to yield gap is useful for efficiently targeting efforts to increase production (Lobell *et al*, 2009).

It has been observed (FAO, 2004) that the causes of rice yield differentials are related to biophysical factors, cultural practices, socioeconomic conditions, institutional and policy thrusts, or levels of technology transfer and linkages. The biophysical factors include climate/weather, soils and water while cultural practices include variety selection, weeds, water, pest and postharvest management. Socioeconomic conditions refer to farmers' socioeconomic status, household income, family size, and so on. Institutional and policy factors involve input supply, credit supply, rice prices, research and extension.

Researchers have examined rice yield gaps in Nigeria from different perspectives. For instance, Oladele and Somorin (2008) carried out a study on rice yield differentials in Ogun state, using technology gap (difference between on-farm-adaptive research yield and small plot adoption technique yield) and extension gap (difference between small plot adoption technique yield and actual farmers' yield) as determinants of yield differentials between farmer groups. Ojehomon *et al* (2006) observed low yield of rice per hectare relative to the potential yield in the lowland ecology. This was found to be a result of partial adoption of improved management practices such as plant density and rate of fertilizer and herbicide application

2.2.5 Rain-fed agriculture

Worldwide, about seventeen per cent of agricultural lands are irrigated; producing forty per cent of total cereal production (Droogers *et al*, 2001).This of course implies that sixty per cent of total cereal production is from rain-fed agriculture. At present, fifty-five per cent of the gross value of food is produced under rain-fed conditions on approximately seventy-two per cent of the world's harvested crop land (Giuliana and Atef, 2009). It is well recognized at the global level, that the potential of rain-fed agriculture is large enough to meet present and future food demand through increased productivity which can be achieved in several ways, In this regard, an important option is to upgrade rain-fed agriculture through better water, soil and land management practices. This can be done through several ways, including

- increasing productivity in rain-fed areas through enhanced management of soil moisture and supplemental irrigation where small water storage is feasible;
- improving soil fertility management including the reversal of land degradation, and
- expanding cropped areas (Giuliana and Atef, 2009).

In the attainment of food security for all, rain-fed agriculture will continue to produce the bulk of the world's food.

The key challenge in rain-fed agriculture is to reduce water related risks posed by high rainfall variability rather than coping with an absolute lack of water because there is generally enough rainfall to double and, even, to quadruple yields but such rainfall is available at fluctuating time periods causing dry spells and much of it is lost. It has been noted that the temporal and spatial variability of climate, especially rainfall, is a major constraint to yield improvements, competitiveness and commercialization of rain-fed crops, tree crops as well as livestock systems in most of the tropics. This is why investment in soil, crop and water management is crucial for upgrading rain-fed agriculture (Giuliana and Atef, 2009).

The food and agriculture organization (FAO) of the United Nations has estimated that ninety-five per cent of agriculture in Africa is rain-dependent, that is, rain-fed agriculture (United Nations, 2007). On a general note, rain-fed agriculture has been noted to be characterized by substantial heterogeneity over time and space. Also, season-to-season variation in the amount of rainfall is a major challenge to crop management (Kerr, 1996). The importance of rain-fed agriculture, however, varies from region to region but produces most food for poor communities in developing countries. In sub-Saharan Africa, more than 95% of the farmed land is rain-fed, while the corresponding figure for Latin America is almost 90%, for South Asia about 60%, for East Asia 65% and for the Near East and North Africa 75% (FAOSTAT, 2009). Most countries in the world depend primarily on rain-fed agriculture for their grain food. The vast potential of rain-fed agriculture needs to be unlocked through knowledge-based management of natural resources for increasing productivity and income to achieve food security in the developing world (Wani *et al*, 2009).

2.2.6 Rice production

Rice production in Africa has been noted to have increased from 3.14 million tons to 14.60 million tons in the past 50 years. During the same period, the area of cultivated land has expanded by 3.3 times, from 2.5 million hectares to 8.2 million hectares, whereas the yield per unit area has achieved an increase of only 30%, from 1.24 t/ha to 1.78 t/ha. On the other hand, during the same period in Asia, rice production has increased from 200 million tons to 570 million tons, yet the area under cultivation has shown only a minor increase, from 107 million hectares to 137 million hectares, whereas the yield per unit area has increased 2.2 times, from 1.86 t/ha to 4.18 t/ha (JICA/AGRA, 2008) The above facts show that increased rice production in Asia has been achieved through an increase in the yield per unit of land. Conversely, the expansion in cultivated land is the primary factor responsible for the increase in the total output in Africa. Sub-Saharan Africa harvested an average of 7.86 million hectares of rice per year during 2001–2005, with 3.29% per annum growth rate. The expansion in total area cultivated explains much of the increase in production, as the average annual growth of aggregate rice yield was negative (1.14%) and average yield stood at 1.51 t/ha

Rice production in Africa has been highly concentrated, with only a few countries which produce more than 0.5 m tons. The top fifteen countries in rice production are, in a descending order: Nigeria, Madagascar, Guinea, Mali, Tanzania, Côte d'Ivoire, Sierra Leone, Democratic Republic of the Congo, Ghana, Senegal, Mozambique, Uganda, Chad, Burkina Faso and Liberia. The total production of these countries accounts for 94% of the African total output JICA/AGRA (2008) It has been reported that among staple food crops, rice represents Africa's best opportunity for reduction of imports. However, the slow growth in domestic rice production has been attributed to the very low yield being achieved by West African rice farmers. The major rice production systems are upland, hydromorphic and rain-fed lowland which together occupy more than 74% of area cultivated (UNEP, 2007).

West Africa remains at the hub of rice production in sub-Saharan Africa but the shortfall in rice production has increased significantly as consumption rises at a rate well above that of production growth. Increasing domestic rice production to satisfy the growing rice consumption and reduce rice import has been a top priority for every West

African government. They have devoted significant resources toward that goal in the past thirty years (Vanichanont 2004)

Although rice is cultivated in virtually all the agro-ecological zones in Nigeria, the area cultivated to rice still appears small. In 2000, out of about 25 million hectares of land cultivated to various food crops, only about 6.37% was cultivated to rice (Akpokodje *et al*, 2001; Fashola *et al*, 2006). With regards to yield and output, there is great disparity between geographical zones as well as between states. On the basis of geographical zone, the central zone of the country was the largest rice producer for the year 2000, accounting for forty-four per cent of total national rice output. On the other hand, the south west zone was the least producer accounting for four per cent of total national output. At the states level, Kaduna state was the largest producer accounting for approximately twenty-two per cent of the country's rice output in 2000. Niger state ranked second with a contribution of sixteen per cent to the total national rice output.

2.2.7 Rice-based production systems

Irrespective of size, each production system is unique and is organized to produce food and to meet other household goals through the management of available resources. The farm household is, therefore, the centre of resource allocation, production and consumption (Edwards and Chater, 1993).

There is an increasing pressure due to rapid population growth, on naturally endowed resources while traditional fallow periods are decreasing at a fast rate. The need therefore for increased food production requires that more intensive production practices be adopted. Such practices need to focus on the improvement of factor productivity. Although the expansion of cultivated area had been the major source of worldwide production gains in the history of agricultural revolution, the emphasis today is on ways of increasing food and fibre from growth in productivity per unit of available resource (Ajibefun and Abdulkadri, 2004).

Nigerian farmers have over the years evolved highly diverse and dynamic practices. Rarely do their fields contain only one crop and rarely are the different crops planted all at the same time – it is either they are mixed or planted in separate parts of the field (Edwards and Chater, 1993). This is evidence that several production systems can exist simultaneously in one area and these can also vary widely in terms of productivity and efficiency in using land, labour and capital (Reijntjes *et al*, 1992). It is believed that the analysis of the production systems within which rice farmers operate can provide powerful insights into strategic priorities for increasing the productivity on rice farms. Every farmer is unique, although those who share similar conditions also often share common problems and priorities .

The four generally recognized factors of production are land, labor, capital, and entrepreneurship. Of course, in a literal sense, anything contributing to the productive process is a factor of production. However, economists seek to classify all inputs into a few broad categories so standard usage refers to the categories themselves as factors. The factor concept is used to construct models illustrating general features of the economic process. These include models purporting to explain growth, productivity, choice of production method, and income distribution. A major conceptual application is in the theory of production functions (Brun, 2006)

Diversity is the norm in African farming systems. Even at the level of the individual farm unit, farmers typically cultivate two or more crops in diverse mixtures that vary across soil type, geographical zone and distance from the household compound. Improvements in productivity and competitiveness in agriculture is a major challenge for food security and cash income as well as for export. It has been observed that African farming is characterized by a pattern of 'low-input, low-output' and 'small-scale, multi-crop' production, mostly by smallholders. While this ensures the minimization of risks necessary for maintaining basic subsistence, it perpetuates low productivity and is susceptible to considerable yield fluctuations from year to year JICA/AGRA (2008)

Rice has been observed to be more of a subsistence crop in West Africa where most of the continent's rice is produced. In West Africa, 75% of the total production of rice in 1999/2003 is from upland, hydromorphic and lowland ecosystems, West African rice ecosystems are conventionally classified as irrigated, rain-fed-lowland, rain-fed-upland, mangrove swamp and deep-water systems. The total area under rice cultivation is currently about 4.4 million hectares (ha). The rain-fed upland and rain-fed lowland ecosystems each accounts for about 1.7million hectares and irrigated rice accounts for another 0.5m ha, making these the high-impact ecologies (Eklou *et al,* 2008).

2.2.8 Rain-fed upland rice production system

Out of about one hundred and forty-four (143.5) hectares of the world's rice growing area, about twenty million hectares are planted to upland rice. Of these, about sixty per cent is in Asia, thirty per cent in Latin America and ten per cent in Africa (Gupta and Otoole, 1986).There is no universal concise definition for upland rice largely due to the fact that upland rice is grown in a heterogeneous array of climatic, edaphic, physiographic, biotic and socioeconomic conditions. Thus, upland rice has been described in various ways in different parts of the world and the true extent of upland rice distribution is not clear. Upland rice can however be described as rice grown in rain-fed, naturally well drained soils without surface water accumulation, normally not bunded and normally without phreatic water supply (Gupta and Otoole, 1986). Except in Brazil where more than five million hectares of upland rice are under mechanized cultivation, upland is generally a subsistence crop cultivated by poor farmers who apply few purchased inputs.

Although estimates of upland rice distribution in Africa vary widely due to the diverse nature of its cultivation, the rain-fed upland rice production system is the most extensive rice ecosystem in Africa and thus has a great influence on the total rice output of the continent. The rain-fed upland rice ecosystem covers fifty-seven per cent (57%) of the total rice area in West Africa and accounts for forty-four per cent (44%) of rice production in the region (Oteng and Sant Anna). Gupta and Otoole (1986) has also reported that most African upland rice is grown in West Africa where about sixty-two (62.5%) per cent of the rice is upland. Also, more than fifty per cent of the rice grown in Ivory Coast, Liberia, Zaire, Sierra Leone, Guinea and Nigeria is upland (IRRI, 2009). It is noted that there are some discrepancies in rice data. For instance, the West Africa Rice Association (WARDA) includes as upland rice areas lands that are occasionally submerged by runoff water and where ground water level is in the root zone during the growing season. These areas are however classified as hyromorphic by the International Institute for Tropical Agriculture (IITA). Weed competition has been observed (Johnson *et al*., 1997) to be the most important yield-reducing factor, followed by drought, blast, soil acidity and general soil infertility. Farmers traditionally manage these stresses through long periods of bush fallow.

Upland rice cultivation is an important rice production system in Nigeria where it accounts for thirty per cent of the total land area under rice (Akpokodje *et al*, 2001; UNEP, 2005). Although found in the northern part of Nigeria, rain-fed upland rice production system is predominant in the southern part. The larger part of rice cultivation in Edo, Delta, Oyo, Osun, Ogun, Ondo and Ekiti states is the rain-fed upland rice which is usually intercropped with other crops such as maize, cassava, yam or vegetables (UNEP, 2005).

2.2.9 Rain-fed lowland rice production system

Rice is grown on some thirty-seven million hectares of rain-fed lowlands worldwide, accounting for about one-fourth of the total rice area (Mackill *et al*, 1996). These lowlands however have been noted to be heterogeneous in any single location and diverse across locations. Rain-fed lowland rice does not have a straightforward and precise scientific definition partly due to the fact that it is central in the continuum of rice cultures. In other words, the hydrology of rain-fed lowland rice overlaps with those of irrigated, upland, deep water and tidal wetland rice. Most of the time, rain-fed lowland rice is defined by the characteristics which differentiate it from irrigated, upland and deep water rice. These characteristics put to definition include the fact that the crop (rain-fed lowland rice) is not irrigated; the soil surface is flooded for at least part of the crop cycle and the maximum sustained flooding depth is less than 50cm (Mackill *et al*, 1996). These definitions are rather not straightforward and precise. Unlike irrigated lowland rice which is characterized by a reliable and controlled external supply of water and a drainage system, rain-fed lowland rice depends solely upon rainfall and runoff (Zeigler and Puckridge, 1995). Rice yields in rain-fed lowlands (flood plains and valley bottoms) depend on the degree of water control and vary from 1 to 3 tons per hectare. These systems have a high potential for intensification. With improved water control, use of external inputs may become attractive and rice yields could be increased rapidly in these systems that are inherently much more stable than the upland areas (Eklou *et al*, 2008). In Nigeria, the most important rice production system has been acknowledged to be the rain-fed lowland (Akpokodje *et al*, 2001)

2.2.10 Demand for rice

Global rice consumption has been outstripping global rice production since 2002. This is causing a gradual drop in globally-held rice inventories and is coupled with rising rice prices in the global market. Rice is a staple food in many countries of Africa and the crop in the past three decades has witnessed a steady increase in demand (Norman and Otoo, 2003). The international model for policy analysis of agricultural commodities and trade (IMPACT) developed by the International Food Policy Research Institute (IFPRI) to project the future demand for certain commodities estimated that per capita demand for cereal crops will increase in Sub-Saharan Africa by about 4.9 percent per year between 1997 and 2020, with the main increase in wheat and rice (Rosegrant *et al*, 2001) It has been noted that the relative growth in demand for rice is faster in SSA than anywhere in the world and this is occurring throughout the sub regions of SSA (FAO, 2009).

Africa has become a big player in international rice markets, accounting for 32% of global imports in 2006, at a record level of 9 million tons that year. Africa's emergence as a big rice importer is explained by the fact that during the last decade rice has become the most rapidly growing food source in sub-Saharan Africa (Eklou *et al*, 2008). According to OSIRIZ, (CIRAD's Observatory of International Rice Statistics), Africa cultivated about 9 million hectares of rice in 2006. Also production, which surpassed 20 million tonnes for the first time, is expected to increase by 7% per year in future. Between 1961 and 1992, rice consumption in Sub-Saharan Africa increased by 5.6% per annum as a result of high population growth rate, rapid urbanization and changing food preferences (UNEP, 2005). Furthermore, the share of rice in cereals consumed in the region between the early 1970s and 1990s increased from fifteen per cent to twenty-six per cent (Akpokodje *et al*, 2001).

In West Africa, where the rice sector is by far the most important in SSA, the situation is particularly critical. Despite the upward trends in international and domestic rice prices, domestic rice consumption is increasing at a rate of 8% per annum, surpassing domestic rice production growth rates of 6% per annum. In Sub-Saharan Africa, West Africa is the leading producer and consumer of rice accounting for 64.2% and 61.9% of total rice production and consumption in Sub-Saharan Africa respectively. The production-consumption gap in this region is being filled by imports, valued at over US$

1.4 billion per year (Eklou *et al,* 2008). Rice consumption in West Africa has been steadily growing at an annual rate of 6% since 1973, with most of this growth being caused by substitution for traditional coarse grains, roots and tubers. Consequently, its share in cereal consumption has reached 26% from 15% in 1973. Rice is now providing more than third of cereal calorie intake in West Africa in general, and up to 85% in traditional rice producing countries like Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia and Côte d'Ivoire (UNEP, 2005). The FAO has projected that annual growth in the West African rice consumption will remain high, at 4.5%, through the year 2000 and beyond. West Africa's rice production has not been able to match growth in demand Rapidly rising imports (8.4% growth per annum since 1997) has been filling the widening gap between regional supply and demand.

Rice is a commodity of strategic importance in Nigeria. The food sub-sector of Nigerian agriculture parades a large array of staple crops, made possible by the diversity of agro-ecological production systems. Of all the staple crops, rice has risen to a position of pre-eminence. Since the mid-1970s, the demand for rice in Nigeria has been increasing at a much faster rate than in other West African countries (Akpokodje *et al*, 2001). Rice consumption has also risen tremendously, at about 10% per annum due to changing consumer preferences (Fashola *et al*, 2006)

The demand for rice in Nigeria has been on the increase as a result of factors such as increasing population growth, increased income levels, rapid urbanization and associated changes in family occupational structures. Rice has been found to fit easily in the urban food lifestyle of both the rich and the poor as its preparation is easy and convenient. Rice is no longer a luxury food in Nigeria but has become a major source of calories even for the urban poor. Data have demonstrated that the availability and price of rice have become a major welfare determinant for the poorest segments of the country's consumers who also are least food secure (Akpokodje *et al*, 2001). The average Nigerian consumes 24.8 kg of rice per year, representing 9% of total caloric intake (IRRI, 2001). However, according to Lancon and Benz (2007), in terms of per capita apparent consumption, rice is one staple in a more diversified diet in Nigeria with 29 kg of rice consumed yearly per capita. Since the mid-1980s, rice consumption in Nigeria has increased at an average annual rate of 11%, of which only 3% can be explained by population growth. The remainder represents a shift in diet towards rice at the expense of the coarse grains (millet and sorghum) and wheat, and other traditional staples such as garri and yams (Nkang *et al,* 2006). Also contributing to increased consumption of rice are increased consumption of food away from home, convenience and ease of cooking and storage. A considerable increase in national rice production to meet up with increasing demand will help to reduce and consequently eliminate importation of the commodity. Local production of rice has not been able to meet the increasing demand for rice. In order to bridge the gap between local supply and demand, Nigeria has had to depend on the importation of rice which has caused a drain on the country's foreign reserve.

2.2.11 Self sufficiency

Self sufficiency is measured by the ratio of production over consumption .The ultimate goal of a nation is to provide sufficient food that will ensure all its citizens a varied and healthy diet. In Thailand, rice is a major grain of special importance which serves as the main food for 64.24 million people. In fact, rice is not just regarded as a staple food, but a culture and way of life. Each year, about 55% of rice production is consumed locally while the remaining 45% are exported to the world market. In addition to being self sufficient, rice export has generated a large amount of income to Thailand. In 2008, Thailand produced over thirty million tons (30.93 million tons) of rice out of which 16.94 million tons were consumed domestically and the remaining 13.26 million tons were exported. With regards to Malaysia, the rice self sufficiency level in 2008 was estimated at seventy-two per cent (72%). However, efforts are being made to increase this level to eighty-five per cent (85%) by the year 2010 through increased production and productivity of existing rice farms as well as the development of new farm areas.

For rice in SSA, self sufficiency declined steadily from 112% in 1961 to 61% in 2006 when the continent depended on the international rice market to satisfy about 39% of its rice consumption needs (WARDA, 2007).Nigeria in the early sixties (1960-1964) was about ninety-nine per cent (98.7%) self sufficient in rice production (Imolehin and Wada, 2005). This self sufficient level was somewhat maintained in the early seventies (1970-1974) when it was 98.8%, but dropped greatly by the early eighties (1980-1984) to

51.4%. This is a clear indication of the country's inability to meet the increasing demand through local production (Oteng and Sant Anna, 1999). Several programmes and institutions have been put in place by past and present national leaders to help attain total rice self sufficiency in Nigeria. Such programmes and agencies/institutions include;

- The Federal Rice Research Station established in 1970 saddled with the responsibility of research into the development of improved grain varieties.
- National Accelerated Food Production Program (NAFPP) which was put in place in 1974 with the main mandate to design, test, and transfer technology packages for the production of rice, maize, sorghum, millet and wheat.
- National Cereals Research Institute (NCRI), launched in 1974 for the purpose of research on high yielding rice varieties.
- World Bank- Assisted development Programmes in 1975;
- Operation Feed the Nation was established in 1976 for self sufficiency in domestic food supply.
- River Basin Development Authorities in 1977;.
- Back to Land Programme in 1988;
- Directorate of Foods, Roads and Rural Infrastructure (DFRRI) in 1988 and
- National Land Development Authority (NALDA) in 1991

In addition to the afore mentioned programmes, the Nigerian government also put in place certain institutions to actualize the goals of improved and increased agricultural production in the nation. Such institutions include;

- The National Seed Service (NSS) which was created in 1972 with the responsibility of production and multiplication of improved seeds of rice, maize cowpea, millet, sorghum, wheat and cassava and
- The establishment of the Nigerian Agricultural and Cooperative Bank (NACB) in 1988 as a specialized credit institution for agriculture and rural development. The major responsibility of the bank was to provide credit to small-scale and large-scale farmers as well as farmer cooperatives and groups on lenient terms.

In 1985, the ban on rice importation came into effect in 1985 in order to stimulate domestic production through increases in the price of rice. The introduction of the

Structural Adjustment Program (SAP) in 1986 contributed to the reinforcement of the ban already placed on rice import.

To encourage the local production of rice in the country, there was a hundred per cent (100%) tariff placed on imported rice in 1995. However, this tariff was reduced to fifty per cent (50%) in 1996 so as to allow the inflow of more rice through imports to meet the increasing demand for the commodity. The fifty per cent tariff lasted till 2000 after which it was increased to eighty-five per cent (85%) in 2001 to encourage domestic production

As a development strategy, self-sufficiency is a necessary precursor to the ultimate goal of self-reliance standards which in turn, is a desirable goal of society (Rahji *et al*, 2008). Economic policies such as self-sufficiency in food production have major implications for the dynamics of the socio-economic and institutional environments within which farmers operate. This has been justified as a means through which farmers can enhance their efficiency and productivity (Rahji and Adewumi, 2008).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 The study area

This study was carried out in Ekiti and Niger states, Nigeria. Located between longitudes 4^0 51 and 5^0 45 east and latitudes 7^0 15 and 8^0 51 north of the equator, Ekiti state was carved out of Ondo state on October 1, 1996. It shares boundaries with Kwara state in the north, Kogi state in the east, Ondo state in the south and Osun state in the west. Ekiti state with a size of about 7,000 square kilometers has a population of 2.7 million (2005 estimate). Agriculture is the main occupation providing income and employment for about eighty per cent of the population and provides over ninety per cent of the state's gross domestic product (GDP). Crops grown in the state include rice, cowpea, maize, yam, cocoa, kola and palm produce. Rice is a major food crop produced, and has become very important in recent years in the state. In southwestern Nigeria, Ekiti state has the largest rice area of between 46,000 and 92,000 hectares while the other states in the south-west do not have more than 46,000 hectares each. The state has a tropical climate with two distinct seasons – rainy season (April-October) and dry season (November- March). Administratively, Ekiti state is made up of sixteen local government areas.

Created in February 1976, Niger state is situated in the North-Central geo-political zone of Nigeria. It is situated between latitudes 8^0 20 and 11^0 30 north and longitude 3^0 80 and 7^0 20 east. It is located in the guinea savannah agro-ecological zone. Niger state is the largest state in Nigeria, representing approximately 9.3% of the total land area of the country. With a land area of 76.363 square kilometers and a population of 4,082,558 (2005 estimate), Niger state shares borders with the republic of Benin in the west, Zamfara state in the north, Kebbi state in the northwest,, Kogi state in the south, Kwara state in the southwest, Kaduna state in the northeast and the federal capital territory (FCT) in the southeast. Agricultural activities form the mainstay of the peoples' economy and engage more than eighty per cent of the population. The state has an annual precipitation of about 1250mm. Rainfall distribution is mono-modal. The length of growing period is between 165 to 270 days for rain-fed crops. The major crops cultivated in Niger state include rice, yams, sorghum, maize, groundnuts, sugarcane, melon and millet. Niger state is one of the three states (Niger, Kaduna and Taraba) in Nigeria which have the largest rice area of between 184,000 and 230,000 hectares. Administratively, the state has twenty-five local government areas.

3.2 Method of data collection and sampling procedure

3.2.1 Data collection

Primary (cross-sectional) data were collected for this study through the use of structured questionnaire which were first pre-tested before being administered to the selected rice farmers. Data were collected on farm and farmers\ characteristics, as well as on details of rice production in the 2008 cropping season. Data obtained include socioeconomic characteristics of the selected rice farmers, distance of farm to market and homestead, level of use of purchased farm inputs, output quantity, proportion of output sold, output price and other data relevant to the objectives of the study. Information from the structured questionnaire was supplemented by the qualitative information received from the farmers using Focus Group Discussion (FGD) approach.

3.2.2 Sampling procedure

Ekiti and Niger states were purposively selected based on the predominance of upland rice production and lowland rice production respectively within the states. Rice farmers in both states, representing upland and lowland rice production systems, formed the sampling frame.

The sampling procedure employed was the multi-stage sampling technique. For Ekiti state, representing upland rice production system, the first stage of sampling was the random selection of eight rice producing local government areas (four from each Agricultural Development Programme (ADP) zone as the state has only two ADP zones). The second stage was the random selection of rice-producing villages from the selected Local Government Areas (LGAs) using the rice-producing village list obtained from the ADP office while the third stage involved the random selection of rice farmers from the selected villages. The multi-stage sampling technique used resulted in a sample of two hundred farmers from sixteen villages. The selected LGAs were Ikole, Oye, Ikere, Ijero, Efon, Ekiti West, Gbonyin and Irepodun/Ifelodun (Figure 3) while the selected villages were Asin, Ayedun, Oke Orin, Ijesha Isu, Oye Ekiti, Ikere, Ipoti Ekiti, Ijero Ekiti, Efon Alaaye, Aramoko, Ajebamdele, Ode Ekiti, Ijan Ekiti, Ilumoba Ekiti, Aisegba Ekiti and Ifelodun.

With regards to Niger state, the first stage of sampling was the random selection of two (zones I and III) out of the three ADP zones. Second sampling stage was the selection of LGAs from the two selected ADP zones while the third stage was the selection of villages. The fourth sampling stage involved the selection of rice farmers from the villages (Appendix 1). Four LGAs were randomly selected from each zone, that is, ADP zone I (Bida zone) and zone III (Kontagora zone). Thus, a total of eight LGAs (Bida, Gbako, Katcha, Larun, Mariga, Wushishi, Lapai and Kontagora) were sampled for the lowland rice production system (Figure 4) with a total of sixteen villages (Ndamaraki, Bida, Sekira, Badeggi, Chanchaga, Gulbin Boka, Mariga, Kanpani Bobi, Wushishi, Kanko, Bankogi, Lapai, Nami, Masuga, Kotangora and Lioji).

The population of rice farmers for each state was obtained from its ADP office.The total sample size for the study was determined following Glenn (2009). Sample size assuming a 5% precision level is:

$$n = \frac{N}{1+N\,(e^{2})} \qquad (3)$$

Where n = sample size for the study

N = population of rice farmers (Ekiti and Niger states)

e = precision level

$$\mathrm{n} = \frac{26{,}700+393{,}444}{1+(26{,}700+393{,}444)(0.05^{2})}$$

$$n = \frac{420{,}144}{1051.36} = 399.62$$

399.62 was rounded up to 400 rice farmers as the sample size for the study. Thus, two hundred rice farmers were sampled from each production system.

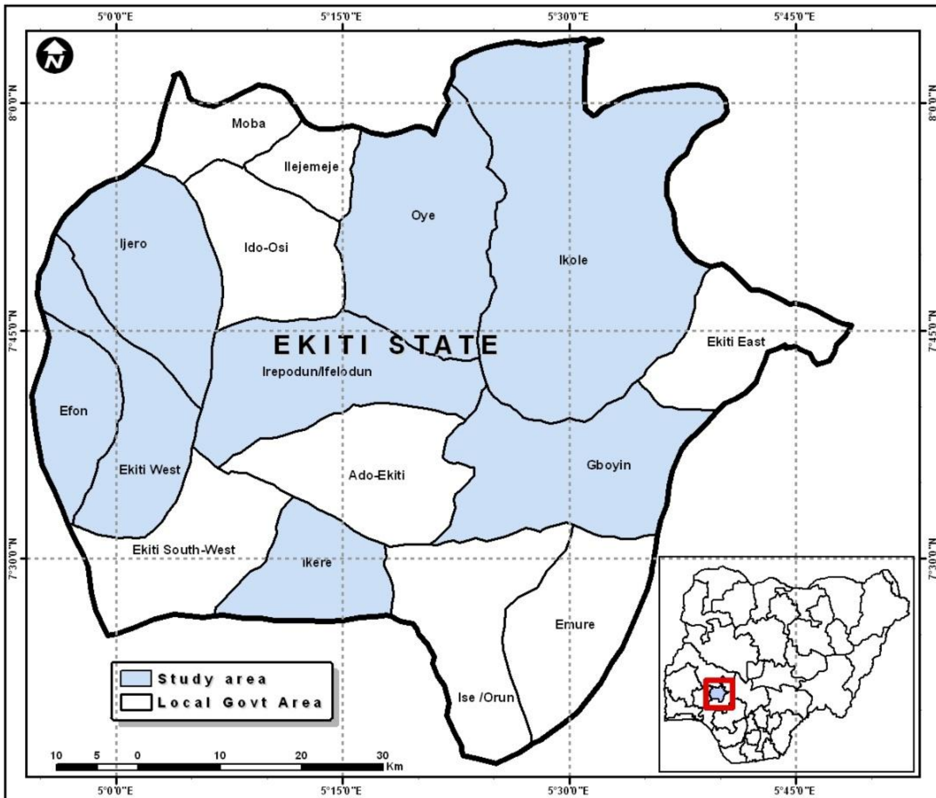

Figure 3. Map showing Local Government Areas selected in study area (Ekiti state)

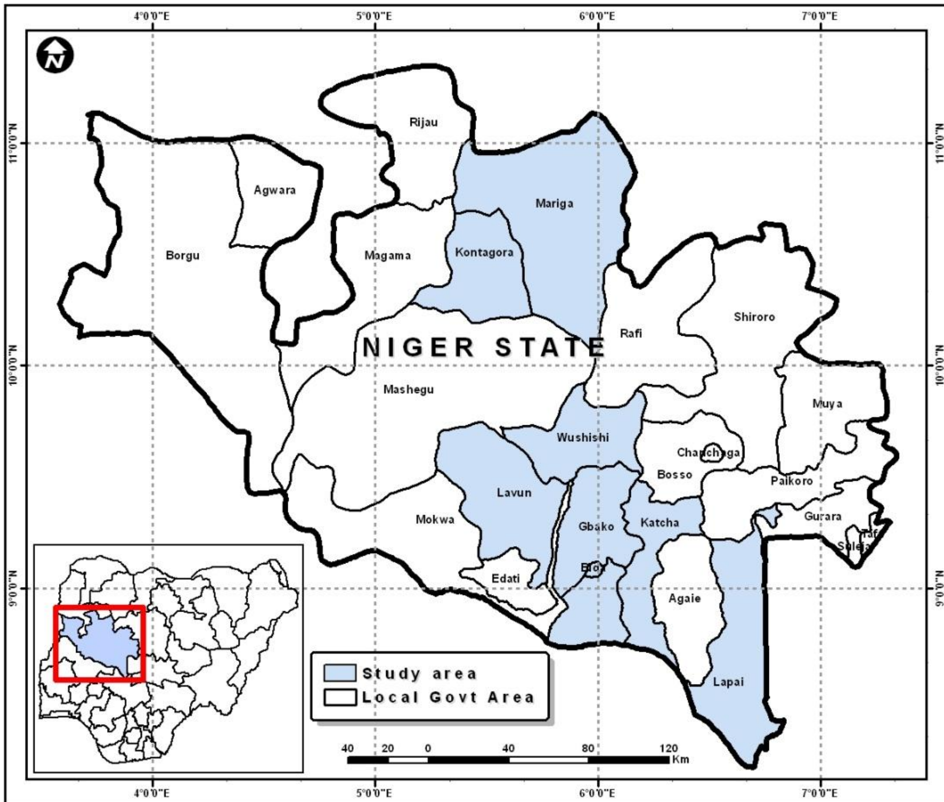

Figure 4. Map showing selected Local Government Areas in study area (Niger state)

3.3 Methods of data analysis

Data were analyzed using descriptive statistics, factor use intensity measures, multiple regression analyses, total factor productivity measure and chow test. The total number of questionnaire fit for analyses was 335 out of the initial 400 administered to the selected rice farmers. These consist of 184 for upland rice farmers and 151 for lowland rice farmers.

3.3.1 Descriptive statistics:

Measures such as percentages, frequencies, means and standard deviations were used in the description of farmers' socioeconomic characteristics and inputs used in the production of rice.

3.3.2 Transcendental production function

A transcendental Production function was estimated for each rice production system .

Consider the production function

$$Q = f\left(X_1, X_2, X_3, \ldots\ldots\ldots\ldots X_n\right) \qquad (4)$$

Where Q (output level) is a vector of inputs whose elements are X_1 ------- X_n

The transcendental form of the production function is

$$Q = \beta_0 X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} e^{(\theta_1 X_1 + \theta_2 X_2 + \theta_3 X_3 + \theta_4 X_4)} \qquad (5)$$

The natural logarithm linearized form of the function is;

$$\text{Ln } Q = \beta_0 + \sum \beta_i \ln X_i + \sum \Theta_i X_i \qquad (6)$$

$$= \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots\ldots\ldots\ldots \beta_n \ln X_n + \theta_1 X_1 + \theta_2 X_2 + \ldots\ldots\ldots \theta_n X_n \quad (3.4)$$

Q = rice output in Kg

X_i = factor inputs in rice production

Where i = 1,2,-----, 5

X_1 = land area under rice cultivation (ha)

X_2 = rice seeds planted (kg/ha)

X_3 = fertilizer (kg/ha)

X_4 = Agrochemical input e.g herbicide (litre/ha)

X_5 = Labour (family and hired labour employed in mandays/ha)

β_0, β_i , Θ_i = parameters to be estimated

b_i = logarithm coefficient of independent variables

Θ = linear coefficient of independent variables.

This function is a hybrid between the Cobb-Douglas and exponential equation (Halter *et al*, 1957). It can exhibit non-constant marginal productivity of increasing, decreasing and negative marginal product, singularly in pairs, or all three simultaneously. It is useful in describing all the three traditional stages of production (Sankhayan, 1988). It also permits variable elasticity of substitution over the range of inputs. Thus, ln Q is a linear function of the levels of the logarithms of the inputs ($\ln X_i$) as well as that of the inputs (X_i). When each of the bias turns out to be zero (that is, not significantly different from zero), the function becomes the Cobb-Douglas function (Halter *et al,* 1957). The following measures of productivity can be obtained from the specified production function.

Marginal productivity $= Q\left(\frac{\Theta_i + \beta_i}{X_i}\right)$ (7)

Average productivity $= Q/x_i$ (8)

Elasticity of production $= \frac{MP}{AP}$

$$= \frac{Q(\Theta_i + \beta_i)/x_i}{Q/x_i} \quad (9)$$

$$= \Theta_i + \beta_i \quad (10)$$

3.3.3 Estimation of total factor productivity (TFP)

Total factor productivity has been conceptualized in relation to production costs. This follows Key and Mcbride (2003), Fakayode *et al* (2008) who expressed total factor productivity as the inverse ratio of the average variable cost (AVC) as well as Yilmaz *et al* (2004) who expressed total factor productivity as a ratio of yield (kg/ha) to cost of production per hectare.

TFP= Q/TVC (11)

From cost theory, AVC = TVC/Q (12)

where AVC is average variable cost.

Thus, TFP =Q/TVC = 1/AVC (13)

Where TVC = $\sum_{i=1}^{n} PiXi$ i= 1,2,____ , n variable inputs

Q in the case of this study represents rice output in monetary (Naira) unit. Q includes all cash and non-cash transactions (Zepeda, 2001). Cash transactions include all rice sold while non-cash transactions include rice consumed, given as gifts, kept for seed and so on.

3.3.4 Total factor productivity model

In order to draw statistical inferences about the sources of productivity differentials, it is necessary to know the patterns of relationship between productivity and individual farm/farmer characteristics. Regression analysis was used to estimate the marginal impact of selected farm/farmer characteristics on productivity for the rice-based production systems.

Regression Analysis Model

$W = a + d_1Z_1 + d_2Z_2 + \text{------------} d_nZ_n$ (14)

Where

W = total factor productivity measure

Z_1 = Farmers age in years

Z_2 = Educational level (years of schooling)

Z_3 = Household size

Z_4 = farmer's rice farming experience (years)

Z_5 = Farm distance from homestead (Km)

Z_6 = Distance of market from farm (km)

Z_7 = Commercialization level (%)

Z_8 = number of extension visits received for the cropping season

d_is = parameters to be estimated

3.3.5 Chow test (Test for output differentials)

A Chow test is a particular test for structural change; an econometric test to determine whether the coefficients/parameters in a regression model are the same in separate subsamples. The standard F test for the equality of two sets of coefficients in linear regression models is called a Chow test. This test was used to test for the equality of production function parameters of the two production systems. This is to determine whether there are significant differences in the production parameters of the two production systems. This test was also used to test for productivity differentials.

$Q = f(X_1, X_2, X_3, \text{-----------} X_n)$ sample size = N_1 (15) for production system 1

$Q = f(X_1, X_2, X_3, \text{-----------} X_n)$ sample size = N_2 (16) for production system 2

The two samples were combined to estimate a third production function given as

$Q = f(X_1, X_2, X_3, \text{-----------} X_n)$ sample size = $N_1 + N_2$ (17)

Thus, equation 3.16 represents the two systems combined.

Following Onyenwaku (1997), Olomola (1998) and Rahji (2009), Chow's F-statistic computed from the estimated equations 15, 16 and 17 is given as:

$$\frac{[\sum e_3^2 - \sum e_1^2 - \sum e_2^2]/K_3 - K_1 - K_2}{[\sum e_1^2 + \sum e_2^2]/K_1 + K_2} = \text{F-statistic} \qquad (18)$$

Where $\sum e_1^2$, $\sum e_2^2$, $\sum e_3^2$ are error sum of squares for equations 15, 16 and 17 respectively

K_1, K_2 and K_3 are degrees of freedom for equations 15, 16 and 17 respectively.

If F calculated is greater than tabulated F, there is significant difference in production parameters between the two groups. However, if F calculated is less that tabulated F, there is no significant difference in production parameters of the two groups. That is, the production parameters are equal and there are no structural differences between the two systems. Therefore, If the *F* statistic exceeds the critical *F*, we reject the null hypothesis that the two regressions are equal.

3.3.6 Test for productivity differentials

In order to test for productivity differentials, a fourth production function was estimated as

$Q = f(X_1, X_2, X_3, \text{-----------} X_n, D)$ sample size = $N_1 + N_2$ (19)

Thus, equation 3.18 represents the systems combined plus a dummy (intercept model).

Where D is a production system dummy to capture the productivity differentials between the two groups.

D = 1, if lowland system

D = 0, if otherwise.

The test for productivity differentials is the test for heterogeneity or homogeneity in the intercepts of equations 17 and 19. Following Onyenwaku (1997(, Olomola (1998) and Rahji (2009), this is calculated as:

$$\frac{[\sum e_3^2 - \sum e_4^2]/K_3 - K_4}{\sum e_4^2/K_4} = F \qquad (20)$$

Where $\sum e_3^2$, $\sum e_4^2$ are error sum of squares for equations 17 and 19 respectively

K_3 and K_4 are degrees of freedom for equations 17 and 19 respectively.

If F calculated is greater than tabulated F, the intercepts are heterogeneous. That is, there are significant productivity differentials between the two systems. However, if F calculated is less than tabulated F, the intercepts are homogeneous and there are no significant productivity differentials between the systems.

3.3.7 Factor use intensity

Zohir (2003) expressed input (factor) use intensity in two alternative ways. These are input per unit of output and input per unit of land. For instance, the author expressed fertilizer use intensity as fertilizer quantity used per 100kg paddy rice and fertilizer quantity used per hectare. Holden and Yohannes (2001) assessed the intensity of use of purchased farm inputs (such as seeds, fertilizers, pesticides and herbicides) in relation to land tenure insecurity. They expressed input use intensity as input used per unit land area. Oyekale (2007), in his study of the effects of agricultural intensification on food production efficiency in southwestern Nigeria, expressed fertilizer use intensity as fertilizer quantity (kg) used per hectare and labour use intensity as labour used per hectare (man-days/ha).

Following the works of Yilmaz *et al* (2004) as well as Kanruzzaman and Takeya (2009), this study conceptualizes factor use intensity as the percentage share of each factor input cost in the total production cost. In addition, this study expresses factor use intensity as quantity of input per unit operated area (Pingali *et al*, 1998; Holden and

Yohannes, 2001; Zohir, 2001), and goes a step further to express it as percentage of the recommended quantity per unit operated area (hectare).

3.3.8 Explanatory Variables for transcendental production function model.

1. Farm Size: For this study, this is the size of land cultivated to rice by the farmer. The unit of measurement is hectare.

2. Labour: Labour inputs are usually measured and expressed in man-hours or man-days, which is simply the product of the number of people employed and the time worked by each individual. For this study, the man-day measurement was employed. Owuor (2006) in his computation of labour productivity computed only the productivity of family labour, leaving out hired labour. For the family labour however, only family members above the age of ten years who lived on the farm throughout the year (twelve months) were considered in his computation. For this study however, all labour inputs (hired and family labour) involved in the production process (land preparation all through to winnowing) were incorporated and converted to man-day equivalent. Conversion factors were used to represent work done by women and children. A conversion factor of two-thirds for women and one-third for children was used.

3. Seeds: These are the planting materials from which rice paddy is obtained. Unit of measurement is kilogram.

4. Fertilizers: These refer to the quantity of chemical fertilizers applied to farmers' rice plots. Unit of measurement is kilogram (Kg).

5. Agrochemicals: These refer to a broad range of pesticides which include fungicides, insecticides and herbicides. They may also include hormones and other chemical growth agents. For this study however, agrochemicals include only insecticides and herbicides as these were the two major chemical products used in rice production by the respondents.

3.3.9 Explanatory Variables for TFP model

1. Age of farmer: This represents the chronological age (expressed in years) of respondents at the time of this study.

2. Household size: This is determined by the number of people living together in a home. The household size includes all those related to the household head by birth, marriage and adoption as well as other dependants living together as a family unit.

3. Distance of market from farm: This is taken to be the distance between farm and place of output sale (Adeogun *et al*, 2008). This is expressed in kilometers (km).

4. Distance of farm from homestead: This is taken to be the distance between the farmer's rice farm and his residence (homestead). This is expressed in kilometers (km).

The distance between the farm and market and that between the farm and the homestead were considered in the regression model because these distances are regarded as very relevant since inputs used in farming and the outputs produced are transported between homestead, farm and market over the course of a production season (Edmonds, 2004).

5. Extension Visits: Although there is no strict universal definition of agricultural extension, the working definition of agricultural extension for this study is as proposed by Davis (2008) who defined agricultural extension as 'the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods and well-being'. Thus the extension visit for this study is taken to be the purposeful interactive visit by an agricultural extension worker to a farmer in order to give advisory services and/or practical demonstrations with regards to the promotion of better rice production.

6.Commercialization level: Commercialization is the percent value of marketed output to total production (Owuor, 2006) Commercialization is expected to enhance agricultural productivity by encouraging shifts in crop mix towards high value crops and the use of productivity enhancing inputs like improved seeds and fertilizer.

Proportion of land cultivated to rice: This refers to the portion of land cultivated to rice by the farmer, taking into consideration the total farmland owned or under the farmer's control.

7.Educational level: This refers to the number of years of formal schooling gone through by the farmers.

8. Rice farming experience: This represents the length of time (in years) the respondents have been involved in the cultivation of rice.

3.3.10 Assumptions for analysis

First, it was assumed that there is equality in the yield of each hectare of a farmer's rice land.

Second, labour was assumed to be equally distributed among all hectares of rice land under a farmer's control.

Third, there is the homogenization of labour in order to present it throughout in adult equivalent (man-days).

Fourth, all farmers in the each production system were assumed to have the same technology.

3.3.11 A priori expectations

This study involved the specification of a transcendental production function and a total factor productivity model. The former model is to identify the determinants of rice output while the latter is to identify the determinants of TFP. The a priori expectations of the influence of the variables included in the models are shown on Table 1.

Table 1. A priori expectations of variables in the transcendental production function and TFP models

Variables	Expected sign	Source
Transcendental Production function		
Farm size	+/-	Carter, 1999
Seeds	+	Olawepo, 2010
Fertilizers	+	Arene and Mkpado, 2002; Olawepo, 2010
Agrochemicals	+	Olawepo, 2010
Labour	+	Binswanger *et al*, 1986
Total Factor Productivity model		
Age of farmers	+/-	Pudasaini, 1983; Tauer, 1984
Household size	+/-	Ogundari, 2008
School years	+	Weir, 1999; Abdulai and Eberlin, 2001
Rice farming experience	+	Kalirajan and Shand, 2009
Farm-market distance Home-farm distance	-	Oppen *et al*, 1997; Haile *et al*, 2004
Extension visits	+	Evenson and Nwabu, 1998; Owens *et al*, 2003
Commercialization level	+	Von Braun *et al*, 1990; Govereh *et al*, 1999; Owuor, 2006

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Descriptive analysis of farmers' socio-economic characteristics

4.1.1 Sex of rice farmers

Although both men and women are involved in rice production, majority of the farmers (approximately eighty-three per cent in the upland system and ninety-two per cent in lowland system) in this study were men (Table 2). The involvement of women in rice cultivation is low although the interviewed farmers reported that women are more actively involved in the post harvest activities such as threshing and winnowing. This is consistent with the finding of Kebbeh *et al* (2003) that women in Niger state participate only little in rice production with their activity mainly restricted to winnowing. UNEP (2005) in a study conducted in Benue, Ekiti and Niger states, found that an average of eighty per cent of the rice farmers were males.

4.1.2 Age of farmers

The average age of rice farmers in this study was approximately forty-seven (46.84) years. This indicates that the majority of the rice farmers in this study are still within the productive age group which has been estimated to be between eighteen and sixty-four years for males and between eighteen and fifty-nine years for females (Simatupang, 1994). In addition, Sabo (2007) defined the productive age group as people between the ages of seventeen and fifty years. Tauer (1984) discovered that middle-aged farmers appear to be the most productive. The age of the farmers in the upland system ranged between 25 and 68 years with a mean of 48.09 years. This is similar to the mean age (48.27 years) of rice farmers in Ondo state (Ogundari, 2006) and 46.27 years as mean age of rice farmers in Osun state (Tijani, 2007). The age range of farmers in the lowland system was between 20 and 70 years with a mean of 45.3 years. In this study, the majority of the rice farmers were below the age of fifty-six and so it is expected that they are productive and will be readily disposed to the adoption of more productive methods and technologies for increased productivity.

Table 2. Distribution of farmers' socio-economic characteristics

Variables	Rain-fed Upland (n=184)		Rain-fed Lowland (n=151)	
	Rice production system			
	frequency	%	frequency	%
Sex				
Male	152	82.61	139	92.05
Female	32	17.39	12	7.95
Age (years)				
<=25	2	1.09	5	3.31
26-40	38	20.65	46	30.46
41-55	117	63.59	79	52.32
56-70	27	14.67	21	13.91
Years of Schooling				
None	35	19.02	90	59.60
1-6	58	31.52	17	11.26
7-11	58	31.52	21	13.91
12+	33	17.94	23	15.23
Household Size				
<=2	6	3.26	6	3.97
3-8	136	73.91	37	24.50
9-14	28	15.22	64	42.39
15-20	8	4.35	38	25.17
21+	6	3.26	6	3.97
Rice Farming Experience (years)				
<= 4	6	3.26	11	7.28
5-10	93	50.54	32	21.19
11-16	36	19.57	14	9.28
17-22	29	15.76	22	14.56
23-28	10	5.43	17	11.26
29-34	6	3.26	23	15.23
35+	4	2.17	32	21.19
Land tenure status				
Landlords (owners)	95	51.63	113	74.83
Tenants	89	48.37	38	25.17
Non-farm income				
Yes	29	15.76	24	15.89
No	155	84.24	127	84.11

Source: Field data, 2008

4.1.3 Educational Qualification

Educational qualification of the farmers is represented by the years of schooling. Primary education is represented by one to six years; secondary education by seven to twelve years; and tertiary education by more than twelve years of schooling. Although the average number of years of schooling for all the sampled rice farmers was six years, there was a significant difference in average years of schooling between farmers in upland and lowland systems (Table 3). Only about forty per cent of the sampled farmers in the lowland system and eighty-one per cent in the upland system had formal education. About half (49.46%) of the farmers in the upland system had more than primary education, that is a minimum of six years cumulative years of formal education while only about twenty-nine per cent (29.14%) in the lowland system had more than the primary education.

Education represents human capital, and it is expected to have a positive effect on productivity (Abdulai and Eberlin, 2001). It is also expected that education would contribute positively to helping a farmer retrieve and analyze information. In addition, the farmer will draw useful conclusions from the information and then act decisively.

4.1.4 Household size

Household size in this study refers to the number of people comprising the household head, the spouse, children and other dependants and relatives living and feeding together as a family unit. This ranged between one and twenty-four people in both production systems with an average of nine people. There was however a significant difference between an average of eight people per household in the upland system and an average of twelve people per household in the lowland system (Table 3). This is an indication of large-sized households in the lowland production system. The household size is expected to have implications for the supply of farm labour, depending however on the family composition and capacity of individual members. It is important to note, however, that large household size does not necessarily translate to a high level of family labour supply for the farm. This is so because a large proportion of the household population may be made up of dependants. Nevertheless, the relatively large household size under the lowland production system is important for sustainable rice production by the farmers because the family is the main source of labour, accounting for over sixty-five per cent (68.62%) of total labour supply for the rice enterprise.

4.1.5 Non-Farm Income

Livelihood diversification in rural areas, particularly in Africa has been noted to occur at various levels, bearing in mind that the causes and processes of such diversification are likely to differ in different places. Rural non farm incomes are important components of the livelihood strategies of small farmers, contributing to the financing of on-farm investments (Hazell, 2003; Dorward *et al*, 2002; Mohammed-Bello, 1999). The links between farm and non farm income activities can be said to be complex. It is however expected that the participation in nonfarm activities would have a positive spillover effect on household farm production (Janvry *et al*, 2005) Non-farm activities can be a very important source of cash income. They can potentially improve farm productivity if used to finance farm input purchase or longer-term investments (Reardon *et al*, 1994). In this study, only a small proportion of the rice farmers under the two production systems (15.76% under upland and 15.89% under the lowland system) earned income from non-farm activities.

4.1.6 Land Tenure Status

The majority (74.83%) of farmers under the lowland system owned their rice farms while only about half (51.63%) of farmers under the upland system were owner operators. Tenure status which has a direct effect on farmland security is expected to have some influence on a farmer's productivity. Hazell (2003) noted that farmers need assured long-term access to land if they are to pursue sustainable farming practices and make long-term investments in improving the productivity of their resources. When farmers feel secure in their right or ability to maintain long-term use over their land, the return on long-term land improvements and conservation measures is high. Therefore the farmers have a greater incentive to undertake investments on the farmlands.

Table 3. Summary of means of famers' and farm characteristics

Variables	Pooled mean UPS + LPS	UPS mean	LPS mean	Mean difference (UPS – LPS)	t-stat
Age	46.84	48.09	45.30	2.79	2.82***
School years	6.16	7.29	4.77	2.53	4.86***
Household size	9.45	7.79	11.48	-3.68	-7.11***
Rice farming experience	17.46	13.73	22.01	-8.28	-7.02***
Home-farm distance	5.40	7.92	2.34	5.58	14.27***
Farm-market distance	11.78	5.06	19.97	-14.91	-14.36***
Commercialization level	78.99	77.28	81.08	-3.80	-2.62***
Extension visits	13.45	14.05	12.73	1.32	1.16

Source: Calculated from field data

4.1.7 Rice Farming Experience

The average years of experience in rice farming was approximately fourteen (13.73) years for the sampled farmers in the upland production system while it was approximately twenty-two (22.01) years for the sampled farmers in the lowland system. Experience in farming is not necessarily equal to experience in rice farming as a farmer may have started his farming business years before he starts to cultivate rice. Also, the age of a farmer may not necessarily be a good proxy for the years of experience in rice farming because some farmers may start rice farming very early in their life while others only take to rice farming after several years of engagement in other farm or non-farm ventures. However, the years of experience in rice farming is expected to have implications for productivity. This is so because it is expected that the longer a person has been on a job, the more he would have learnt through practical experience and the better he will be able to deal with challenges on the job than a new entrant.

4.2 Descriptive analysis of farmers' rice plots

4.2.1 Farm size

Farm size in this study refers to the land area cultivated to rice by the farmers. Average farm size under the lowland production system was about two and a half (2.7 ha) hectares while it was approximately two (1.9 ha) hectares under the upland production system. The majority of the rice farms under both production systems can, therefore, be referred to as small scale since over ninety-eight per cent (98.91%) of farms under upland system and over ninety-five per cent (96.03%) of farms under lowland system were less than six hectares in size.

The proportion of farmers' total landholdings that is cultivated to rice is expressed in percentage. The average land proportion cultivated to rice under the upland production system is about forty-four per cent (43.92%) while it was thirty-seven per cent (37.05%) under the lowland production system. This implies that more than fifty per cent of farmers' landholdings are put to other uses apart from rice production. Other crops cultivated under the upland rice production system include yam, maize, cocoyam and cassava while crops such as sorghum, groundnut and guinea corn were cultivated under the lowland rice production system. This supports the finding of Anderson and Leiserson

(1980) that a large part of the agricultural sector in developing economies comprise semi commercial farms on which multiple crops are produced. This finding has implications for rice production because resources including labour have to be spread over all crops cultivated by the farmers. This also agrees with Longtau (2003) who found rice inter-cropped with maize, yam, cassava, cocoyam and vegetables in upland rice systems as well as rice inter-cropped with cowpea, sorghum and vegetables in lowland rice systems of Nigeria. The proportion of total land that is cultivated to rice varied from one farmer to the other. However, only about nineteen per cent of farmers under the upland system cultivated more than sixty per cent of their land to rice while just about four per cent of the farmers under lowland system cultivated more than sixty per cent of their land to rice. This is a clear pointer to the extent of diversification on rice farms and possible existence of competition between rice and the other crops cultivated by the farmers.

4.2.2 Distance between rice farm and homestead

The average distance between home and rice plot under the upland production system was about eight kilometers (7.9 km) while it was about two kilometers (2.3 km) under the lowland production system. It is interesting to note that none of the rice farms under the lowland system was more than eight kilometers away from farmers' home. However, more than forty per cent (41.29%) of the rice farms under upland production system were more than eight kilometers away from farmers' homestead. Farmers spend time, energy and sometimes cash expenditure in order to move between their farms and homestead. However, the distance and mode of transportation would determine the amount of time, energy and cash expended in the movement between the farm and the homestead.

4.2.3 Distance between farm and market

The distance between farmers' rice plots and the market is an indicator of market access (Holden and Yohannes, 2001). The average distance between rice farms and market for the rice production systems was 11.78 km. However, average distance under upland system was 5.06 km and 19.97 km under lowland system.

4.3 Output differentials in upland and lowland rice production systems

In this section, the factors which affect output level in the rice production systems are examined. In addition, the differences in output between and within the rice production systems are discussed.

4.3.1 Results from the estimation of transcendental production function model

With regard to factors which affect rice output in the rice production systems, four out of five explanatory variables were significant. These are farm size (X_1), seeds (X_2), fertilizers (X_3) and labour (X_5). The coefficient for rice farm size is both positive and significant for the two production systems. This implies that increase in the size of rice farms would bring about increase in rice output. The positive and significant effect of fertilizers on output is an indication of the importance of fertilizers in rice production. Increase in the quantity of fertilizers used by rice farmers would contribute to increase in output. Higher seed rates would give more rice output. This implies that the seed rates currently used by farmers are low and sub-optimal.

However, under the upland rice production system, three explanatory variables, that is, farm size (X_1), fertilizers (X_3) and agrochemicals (X_4) have significant and positive effects on rice output. Seeds and labour have positive but non-significant effects on rice output in the upland production system. Under the lowland rice production system, farm size, seed and labour are positive and significant at 1% level while fertilizer is positive and significant at 10% level. Seeds have positive and significant effects on rice output under the lowland production system (Table 4). This implies that an increase in the quantity of seeds sown per unit land area would significantly increase rice output especially on farms where recommended seed quantities are not sown.

Labour also has positive and significant effects on rice output under the lowland production system. This implies that the more labour there is at the disposal of the lowland rice farmers, the greater will be the output produced.

Mean output per hectare in the upland production system was 1.2 tons of paddy rice as against the expected 1.5-4.5 tons per hectare if recommended practices are followed. Also, when recommended practices are followed under the lowland production system, expected output per hectare would be 2.5-5.0 tons per hectare of paddy rice

(Dalton and Guei, 2003). However, average yield obtained by farmers in this study under the lowland production system was 2.0 tons It is, therefore, obvious that there is a wide gap between potential and actual rice output under both upland and lowland production systems.

Although the use of fertilizer is more pronounced in the lowland production system with an average of 138.45kg per hectare compared with 30.47kg per hectare in the upland production system, fertilizer has positive and significant effect on rice output under both upland and lowland production systems.

4.3.2 Returns to scale

Result on Table 5 shows the summation of the input elasticities which indicate a decreasing returns to scale (0.82) for the upland production system and an increasing returns to scale (1.47) for the lowland production system. This implies that an increase in all inputs at the sample mean by one per cent would increase rice production by 0.82 per cent for upland production system and by 1.47 per cent for lowland production system

Table 4. Parameter estimates of transcendental production function model for each production system

Variable	RURPS Coefficient	t-statistic	RLRPS Coefficient	t-statistic
LnFmsz	0.5965	5.44***	0.3486	5.40***
	(0.1096)		(0.0646)	
lnSd	0.0475	0.45	0.1989	7.56*
	(0.1045)		(0.0263)	
LnFert	0.0193	2.50**	0.0076	0.66
	(0.0077)		(0.0116)	
lnAgcm	0.0044	0.58	-0.0009	-0.11
	(0.0076)		(0.0087)	
lnLab	0.0507	0.43	0.8719	11.22***
	(0.1173)		(0.0777)	
Fmsz	0.1297	3.00***	0.1142	2.62***
	(0.0432)		(0.0435)	
Sd	-0.0021	-1.52	-0.0013	-3.32***
	(0.0013)		(0.0004)	
Fert	0.0005	1.63	-0.0004	-1.72*
	(0.0003)		(0.0002)	
Agcm	0.0134	3.89***	0.0120	0.93
	(0.0034)		(0.0129)	
Lab	0.0001	0.30	-0.0009	-10.96***
	(0.0004)		(0.0001)	
Const	6.5417	10.58	2.9452	9.19
	(0.6180)		(0.3205)	
R^2	0.7304		0.8404	

Source: Field data 2008
RURPS – rain-fed upland rice production system
RLRPS – rain-fed lowland rice production system
*Significant at 10% level of significance
** Significant at 5% level of significance
*** Significant at 1% level of significance   Standard errors in parentheses
Fmsz = farm size   Agcm = agrochemicals
Lab = labour   Fert = fertilizers
Sd = seeds

Table 5 Output elasticity of variable inputs and returns to scale

Variable	elasticity ($\Theta_i + b_i$)	
	Upland system	lowland system
Land	0.6582	0.4503
Fertilizer	0.0203	0.0092
Seed	0.0629	0.1851
Agrochemicals	0.0173	0.0088
Labour	0.0627	0.8115
Returns to scale	0.8214	1.4649

Source: Calculated from Field data, 2008

4.3.3 Result from test of equality of production function parameters (chow test).

The Chow test was performed in order to determine the existence of any differentials in the production function parameters between the production systems.

Chow's test result from equations 15, 16 and 17, using parameters from Table 4 and Table 6, gave an F-calculated value of 18.3407 while tabulated F values were 1.63152 and 1.8307 at 1% and 5% respectively. Since $F_{cal} > F_{tab}$, the null hypothesis is rejected. Thus, there are significant differences in production function parameters between the two rice production systems.

The chow test involving equations 17 and 19 (test of output differentials) produced an F calculated value of 109.4189 with tabulated F values of 1.63152 and 1.8307 at 1% and 5% respectively. This implies that there is heterogeneity of intercepts and thus, there is significant output differential between the two rice production systems.

A t-test, results of which are presented on Table 7, was further carried out in addition to the main chow test to determine the actual magnitude of the output differential between the two production systems. In addition, t-tests were carried out for the improved rice varieties cultivated in each production system to determine the magnitude and direction of difference between actual and potential output of rice within each system. In this way, objective one of the study is achieved.

Table 6. Parameter estimates of transcendental production function model for the combined production systems

	Both systems		Both systems with dummy	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
LnFmsz	0.5964 (0.0935)	6.38***	0.4079 (0.0611)	6.68***
lnSd	0.1251 (0.0288)	4.34***	0.2102 (0.0275)	7.65***
LnFert	0.0512 (0.0049)	10.28***	0.0297 (0.0049)	6.01***
lnAgcm	-0.0094 (0.0065)	-1.44	0.0036 (0.0056)	0.64
lnLab	0.1642 (0.0538)	3.05***	0.2928 (0.0564)	5.19***
Fmsz	0.0583 (0.0257)	2.27**	0.1169 (0.0157)	7.47***
Sd	-0.0002 (0.0003)	-0.77	-0.0009 (0.0002)	-4.54***
Fert	0.0001 (0.0001)	1.22	-0.0002 (0.0001)	-2.24**
Agcm	0.0043 (0.0029)	1.48	0.0074 (0.0028)	2.67***
Lab	-0.0002 (0.01)	-3.3.9***	-0.0003 (0.0001)	-5.67***
Dummy	-----	------	0.6205 (0.0608)	10.21***
Const	5.9735	23.51	4.8351	16.77
R^2	0.7530		0.8155	
F	152.00		227.34	

Source: Field data, 2008
* significant at 10%
**significant at 5%
***significant at 1%
Fmsz = farm size   Lab = labour
Sd = seeds
Fert = fertilizers
Agcm = agrochemicals

Table 7. T-test result for output differential between upland and lowland systems

Upland system	1.208 ton/ha
Lowland system	2.008 ton/ha
Difference	0.800 ton/ha
t-stat	-9.862***

***significant at 1% level of significance

4.3.4 Output differential within upland production system

Farmers under the upland production system cultivated both improved and traditional rice varieties. More than half of the farmers (67.39%) cultivated only improved rice varieties, 21.19% cultivated both improved and traditional/local varieties while 11.42% cultivated only traditional/local rice varieties. Improved rice varieties cultivated by farmers under this rice production system are ITA 150 (FARO 46), FARO 55 and WAB 189. Traditional/local rice varieties cultivated were described as Ofada and Igbemo varieties.

The potential yields for the improved varieties are shown on Table 8. However, the potential yield for the whole upland production system is 1.5-4.5 tons/ha (Dalton and Guei, 2003; WARDA, 2002). The average of the range of potential yield was utilized in analysis for the whole system (all improved and traditional/local rice varieties cultivated).

The differentials between the potential and actual output under the upland production system are illustrated on Table 8. A comparison between improved rice varieties reveals that ITA 150 variety attained forty-four per cent (44.73%) of its output potential while FARO 55 attained fifty-six per cent (56.67%) and WAB 189 attained forty-four per cent (44.29%). Put together, all improved rice varieties cultivated by farmers under the rain-fed upland system did not attain more than forty-nine per cent of the possible/potential output. The average percentage potential output attained was 48.18%. However, upland rice production system as a whole attained 53.69% of its potential output.

These results (Table 8) strongly indicate that there is potential for upland rice production system to attain higher yields.

Table 8. Mean farm output, potential output and output differentials within upland production system

Rice variety	Potential output (ton/ha)	Mean farm Output (ton/ha)	Output Differential (ton/ha)	t-stat	Potential attained (%)
ITA 150	2.75	1.23	1.52	2.66***	44.73
FARO 55	2.1	1.19	0.91	2.66***	56.67
WAB 189	2.1	0.93	1.17	2.66***	44.29
All Imp va	2.47	1.19	1.28		48.18
Whole system	2.25	1.21	1.04	30.42***	53.69

Source: Field data

Imp va = improved varieties

***significant at 1% level

4.3.5 Output differential within lowland production system

All the farmers under lowland production system cultivated improved rice varieties. These are FARO 15, FARO 35, FARO 44 and WITA 4 (FARO 52) varieties. More than fifty per cent (53.64%) of the farmers cultivated WITA 4, 26.49% cultivated FARO 44, 16.56% cultivated FARO 15 and 3.31% cultivated FARO 35.

Actual output obtained from these varieties and their potential output are illustrated on Table 9. WITA 4 variety attained the highest potential output of 61.05%. On the whole, lowland rice production system attained 42.27% of its potential output. This indicates that there are ample opportunities to increase rice output under the lowland system.

Table 9. Mean farm output, potential output and output differentials within lowland production system

Rice variety	Potential Output (ton/ha)	Mean farm Output (ton/ha)	Output differential (ton/ha)	t-stat	Potential attained (%)
FARO 15	4.25	1.39	2.86	2.80***	32.71
FARO 35	4.75	1.72	3.03	4.60***	36.21
FARO 44	5.00	1.79	3.21	2.70***	35.80
WITA 4	3.80	2.32	1.48	2.62***	61.05
All	4.75	2.01	2.74	37.26***	42.27

Source: Field data

4.4 Factor use intensity in rice production

The rate at which the various inputs for rice production are used is important in determining output. The recommended rates/doses of the inputs are released as technology packages with each rice variety by the institution in charge. This section examines the rate/intensity of use of the various inputs/factors utilized in the production of rice.

4.4.1 Land area cultivated

It has been noted that small farms still dominate the agricultural sector of many developing nations (Hazell, 2003).The average size of land devoted to rice cultivation in the upland and lowland production systems were 1.9 hectares and 2.7 hectares respectively (Table 10). Forty per cent of the farmers under the upland production system cultivated not more than one hectare of land for rice. However, fifty-nine per cent and seventy-eight per cent of the farmers under the upland and lowland production systems respectively, cultivated between two and five hectares of land to rice (Table 10). This is a pointer to the scale of operation of these farmers, which can be described as small. Put on the international standard scale where farms less than ten hectares in size are classified as small (Ozowa, 1995), then over ninety-eight per cent (98.91% for upland system and 98.68% for lowland system) of the rice farms can be classified as small farms. Even if the national standard (< 5 ha is small; 5-10 ha is medium and > 10 ha is large) of Upton (1972) was used, over ninety-five per cent of the farms under this study would still be classified as small.

4.4.2 Rice seed planted

The average quantity of seed planted in the upland and lowland production systems were approximately fifty-two and thirty-one kilograms per hectare respectively (Table 10). This quantity of seed is, however, below the recommended rate of 50-65 kg per hectare for the lowland production system. Sixty-six (65.56%) per cent of the rice farmers under the lowland production system planted less than the recommended quantity (50 -65 Kg/ha) of seed. This of course has implications for output. However, more than half (70.11%) of the farmers under the upland production system planted the recommended seed quantity of 50 -100 Kg/ha .

Although all the farmers under the lowland system cultivated improved rice varieties, these varied between farmers. Seventeen (16.56%) per cent of the farmers cultivated FARO 15 variety, three (3.31%) per cent cultivated FARO 35 variety, twenty-six per cent (26.49%) cultivated FARO 44 and fifty-four (53.64%) per cent cultivated WITA 4 variety. This confirms the finding of Ojehomon *et al* (2006) that the adoption rate of improved rice varieties by farmers in Niger state was high. Both traditional/local and improved varieties of rice were cultivated under the upland system.

Farmers planted 51.7% of the recommended seed rate under lowland system and 86.7% in upland system.

4.4.3 Farm Labour

Average labour use for rice production (land preparation to winnowing) was approximately 138 and 99 man days for the upland and lowland production systems respectively. Hired farm labour constituted thirty-seven and thirty-one per cent of total farm labour for upland and lowland production systems respectively. In other words, family labour constituted most of the farm labour employed in rice production. Family labour made up sixty-three per cent and sixty-nine per cent of total farm labour for rice production under upland and lowland systems respectively.

Table 10. Distribution of farmers according to factor use in rice production

Variables	Rice production system			
	rain-fed upland		rain-fed lowland	
	No.	%	No.	%
Size of rice farm (ha)				
≤1	73	39.67	27	17.88
2-5	109	59.24	118	78.15
6-9	0	0.00	4	2.65
10-13	0	0.00	2	1.32
14+	2	1.09	0	0.00
Total	184	100.00	151	100.00
Labour use (mandays/ha)				
≤10.00	2	1.09	0	0.00
10.01-260.00	173	94.02	147	97.35
260.01-510.00	7	3.80	2	1.32
1010.01-1260.00	2	1.09	0	0.00
1260.01+	0	0.00	2	1.32
Total	184	100.00	151	100.00
Seed planted (kg/ha)				
< 50	55	29.89	99	65.56
50-99	123	66.85	42	27.81
100-124	6	3.26	7	4.64
125+	0	0.00	3	1.99
Total	184	100.00	151	100.00
Agrochemical use (litre/ha)				
≤ 2	82	44.57	132	87.42
3-8	60	32.61	19	12.58
9-14	22	11.96	0	0.00
15+	20	10.87	0	0.00
Total	184	100.00	151	100.00
Fertilizer use				
Yes	62	33.70	143	94.70
No	122	66.30	8	5.30
Total	184	100.00	151	100.00

Source: Field Data, 2008

4.4.4 Fertilizer application

With regard to fertilizer use, more than half (66.03%) of the farmers under the upland production system applied no fertilizer to their rice plots. Conversely, majority (94.70%) of the farmers under the lowland production system applied fertilizer to their rice plots. Fertilizer is one of the land augmenting inputs that is likely to enhance land productivity. Increased use of fertilizer leads to higher crop yields (Owuor, 2006). At the prevailing output price levels in the study areas, it is expected that increased crop yield would translate into higher revenues/income per hectare. The fertilizers applied by farmers in this study are the inorganic fertilizers, mainly urea and NPK (nitrogen-phosphorus-potassium) fertilizers.

With regard to the recommended fertilizer application rates, farmers in the two production systems on the average used sub-optimal rates on their rice plots. The average fertilizer quantity applied in the upland production system by only 33.7% of the sampled farmers who used fertilizer was 30.47kg per hectare as against the recommended rate of 150Kg per hectare. On the other hand, the recommended fertilizer application rate for the lowland production system is a total of 300kg per hectare but the average quantity applied by the farmers in this study was 138.45kg per hectare. Although the majority (94.7%) of the farmers under the lowland production system applied fertilizer on their rice farms, the quantity applied was sub-optimal. However, less than fifty per cent of the farmers who applied fertilizer to their rice farms under the upland production system used sub-optimal quantities. Thus, farmers applied 46.15% and 20.30% of the recommended fertilizer rates under lowland and upland production systems respectively.

4.4.5 Agrochemical application

The use of agrochemicals in rice production is important for the control of weeds, pests and diseases. Mean quantity of agrochemicals used per hectare was 5.2 liters and 1.5 liters in the upland and lowland systems respectively. These quantities are equivalent to 52.0% and 16.7% of recommended rates for upland and lowland systems respectively.

4.4.6 Production cost and factor use intensity

Production cost refers to the sum of cost of resources/inputs that are used in the production of a commodity. Input/factor use intensity is represented by the share of each input cost in the total operating cost of production (Adams, 1997; Kamruzzaman and Takeya, 2009). For this study, the input use intensity is expressed in percentage cost of input per unit (hectare) of farm land.

From Table 11, it is can be seen that the input which has the highest intensity of use in the upland rice production system is labour, which takes up thirty-seven per cent (37.28%) of the operating cost; while it is fertilizers (36.46%) in the lowland production system. For this study, the machines and implements refer to tractor hire as well as farm hand tools. Others are wheelbarrows and knapsacks rented/hired for use by the rice farmers. None of the farmers owned a tractor. However, those who used tractors for farm operations did so through tractor hiring services.

4.4.7 Input use intensity as percentage cost under upland rice production system

Labour use intensity: Under this rice production system, farm labour with an intensity use of thirty-seven per cent (37.28%) ranks highest in intensity of use. Farm labour was reported to be non-readily available at crucial farm operation times such as for weeding and bird scaring. The timely execution of these farm tasks greatly affects output. Thus, the available farm labour at the time is employed, though expensive.

Seeds come next after farm labour with an intensity value of 36.54% after which are agrochemicals (herbicides and pesticides) with almost seventeen per cent (16.94%). Farm implements take up a 2.96% portion of the total variable cost.

Fertilizer use intensity: Following the fact that only a few (33.70%) of the upland rice production system farmers applied fertilizers on their rice farms, mostly at sub-optimal rates, the fertilizer use intensity is low, constituting only six per cent (6.28%) of the total variable cost of production.

4.4.8 Input use intensity as percentage cost under lowland rice production system

For the lowland rice production system, fertilizers rank highest in intensity of use and this is followed by farm labour with a value of 26.42%. Agrochemicals had the least intensity of use with a value of almost eight per cent (7.88%).

Machine and implements use intensity: Although most of the operations on the rice farms are not mechanized, land preparation is done with tractor by farmers who get timely access to tractor service. The tractor services were considered expensive and inadequate by the farmers. However, they also indicated willingness to pay when readily available for timely farm operations.

Fertilizer use intensity: Majority (94.70%) of the lowland rice production system farmers applied fertilizers on their rice farms because, according to them, lowland rice would not perform optimally without fertilizers. The cost of fertilizers thus constituted thirty-six per cent (36.46%) of the total variable cost of production.

Agrochemical use intensity: Very few of the rice farmers under the lowland production system applied agrochemicals on their rice farms, and those who applied them did so at sub-optimal levels. Agrochemicals were not regarded as important as other inputs such as fertilizers by the farmers. Thus, most of the farmers did not use agrochemicals on their rice farms.

Labour use intensity: The intensity of labour use for rice production (from land preparation to winnowing) was 26.42%. That is, labour cost accounted for approximately twenty-six per cent of total variable cost of rice production per hectare. Labour was reported to be available when needed for farm operations. In other words, farm labour was not reported to be scarce, although wage could be high.

Seed use intensity: Seeds account for 18.84% of the production costs.

Table 11. Factor use intensity in rice production

Input	rain-fed upland	rain-fed lowland
	Factor use per hectare	
Seeds (kg)	51.91	31.43
Fertilizers (kg)	30.47	138.45
Agrochemicals (litres)	5.20	1.55
Labour (mandays)	138.33	98.54
	Factor use intensity (% cost)	
Seeds	36.54	18.84
Fertilizers	6.28	36.46
Agrochemicals	16.94	7.88
Labour	37.28	26.42
Implements and others	2.96	10.40
Total	100.00	100.00

Source: Field data, 2008

4.5 Factors determining total factor productivity

Total Factor Productivity (TFP) was estimated for each production system using equation 3.12. TFP was estimated to be 5.6 for upland production system and 5.2 for lowland production system. The null hypothesis (Ho) which states that there is no significant difference between TFP levels of upland and lowland rice production systems was tested using the t-test. The t-test statistic was 0.4281 with an associated P value $p > (t) = 0.6689$. Null hypothesis is therefore accepted. Thus, there is no significant difference in TFP levels between the two production systems.

However, in order to examine the factors which determine TFP in both production systems, a regression analysis was carried out. The estimated coefficients of the regression analysis for the sampled farmers in the two rice production systems are presented in Table 12.

4.5.1 Effect of farmers' age on total factor productivity

For the upland rice production system, farmers' age had a positive but non-significant coefficient. Thus, the effect of farmers' age on total factor productivity of the farmers under upland production system can be said to be non significant. This is consistent with the finding of Pudasaini (1983) who found the association between farmers' age and production to be a weak one. On the other hand, the coefficient for farmers' age under the lowland production system had a negative sign and was non-significant. Authors like Tauer (1984) have determined if productivity is linked with farmers' age and have stated that a farmer passes through at least three stages (entry, growth and exit) during his farming career. The entry stage has been associated with low productivity while the growth or mid-career stage is associated with peak productivity and old age with decrease in productivity.

4.5.2 Effect of household size on productivity

Household size is indicated to have positive and significant effect on farmers' productivity in the rice production systems. This is as a result of the high dependence on manual labour for farm operations. Family labour accounts for over sixty-eight per cent (68.62%) of total farm labour for rice production in lowland production system. This implies that the larger the household size, the more labour will be at farmers' disposal. However, household size has no significant effect on productivity in upland production system. Hired farm labour can be scarce and expensive during peak production periods. As a result, farmers depend on family labour, or pay very high wages for the labour hired.

4.5.3 Effect of farmers' educational status on TFP

Weir (1999) observed that formal schooling is necessary for farmers and that it yields economic benefits to them by increasing their productivity. The author also noted that education may enhance farm productivity directly by improving the quality of labour and through its effect upon the propensity to successfully adopt innovations. Also, Asadullah and Rahman (2005) found, through analysis of farm household dataset, that in addition to raising rice productivity and boosting potential output, household education significantly reduces production inefficiencies. However, Evenson and Nwabu (1998) found the effects of schooling on farm yields to be positive but statistically insignificant. In addition, Kalirajam and Shand (2009) found that the level of formal education of farmers was not a significant factor affecting the yield of rice in Asia. Thus, there are arguments that schooling indeed helps farmers to use production information efficiently, as a more educated farmer acquires more information and so is a better producer. Other arguments imply the non-significant effect of formal schooling on farmers' productivity. In essence, formal education is productive for the individual farmer, but the schooling may not necessarily relate significantly to his farming productivity as the case was for farmers in this study. It is expected that a farmer who can neither read nor write, would understand a new production technology the same way an educated farmer would, as long as the technology is communicated properly to him.

Table 12. Regression estimates of variables affecting productivity

Variable	RURPS		RLRPS	
	Coefficients	t-statistic	Coefficients	t-statistic
Age	0.4461	1.50	-0.1966	-0.80
Schyrs	0.0225	0.60	0.0306	0.93
Housze	0.0010	0.02	0.5632	6.10***
Rcexp	0.0753	0.80	0.2226	3.83***
Dstfrm	-0.1457	-2.01**	0.2283	7.00***
Dstmkt	0.2573	5.95***	-0.0137	-0.27
Cmlvl	0.1964	1.80**	0.9387	3.17***
Exvst	0.0061	1.65*	0.1050	4.08***
Constant	0.1408	0.34	-0.8525	-1.27
R^2	0.6467		0.6633	
N	184		151	
F	46.57		55.38	

Source: Field data, 2008

RURPS – rain-fed upland rice production system
RLRPS – rain-fed lowland rice production system
*Significant at 10% level
**Significant at 5% level
***significant at 1% level

4.5.4 Effect of farm-market distance on TFP

Physical infrastructure serves as a means to achieving the broader goals of economic growth and poverty reduction. Rural infrastructure contributes to these goals by providing essential services such as water and sanitation; employment generating commercial activities; transportation of goods and people; and the transmission and communication of knowledge and information.

Physical infrastructure such as roads and market sites are expected to affect productivity through marketing and production. Distance between homestead and farm plot in the upland system had a negative and non significant effect on productivity. Distance of farm to market variable in the upland system had a positive and significant coefficient but had a negative and non-significant coefficient in the lowland system. This implies that the farther the farm is from the market, the higher the productivity level of the upland production system farmer. This is, however, contrary to the finding of Oppen *et al* (1997) who used the road distance from farmers' plot to the nearest market as a proxy for market access. They found out that with improved market access, productivity increased but by amounts that varied across space and society. Haile *et al* (2004) studied the impact of market access on productivity and found an inverse relation between productivity and distance of main market outlet to farmers' plot. These studies, however, support the situation in the lowland system where results indicate increase in productivity with shorter distance between farm plot and market. However, Rios *et al* (2008), in a study on linkages between market participation and productivity, noted that better market access does not necessarily lead to higher productivity.

4.5.6 Effect of commercialization level on TFP

Agricultural commercialization has been noted to be a complementary stimulator of the rural economic growth process. The coefficient for the commercialization level variable was positive and significant in both the lowland and upland production systems. This indicates that the higher the commercialization level, the higher the productivity of the rice farmer will also be. This is consistent with evidence from studies such as von Braun *et al* (1990), Govereh *et al* 1999 and Owuor (2006) who found a positive relationship between agricultural commercialization, agricultural income and productivity. Commercialization level is defined in terms of sales as a fraction of total output (Owuor, 2006) and is also referred to as sales index. Thus, commercialization can be measured along a continuum from zero to unity. This was used as a measure for market participation by Rios *et al* (2008) who found a positive relation between it and productivity of farm households. Zero level commercialization is equivalent to total subsistence-oriented production while a unity level commercialization is a hundred per cent sales of production.

4.5.7 Effect of extension visits on TFP

Access to farm level extension visits is expected to have positive effect on farm productivity. This was the case for the two rice production systems. It can thus be inferred that farm level extension visits have favorable effects on farmers' productivity. This is in line with the findings of Evenson and Nwabu (1998) that a positive and significant relation exists between extension visits and farm yields. They noted that the economic effects of extension are uneven among farmers. In addition, Owens *et al* (2003) indicated that access to farm level extension visits does increase productivity. It is important to note that human capital is also acquired through extension advice, and this contributes to the enhancement of farmers' productivity.

4.5.8 Effect of farming experience on TFP

Experience in rice farming in the two production systems had positive effects on productivity. However, the coefficient was statistically non-significant under upland system but significant under lowland system. This is expected because the farmers are supposed to gain better knowledge from experience through practice of appropriate technologies which in turn contributes to increased productivity.

4.5.9 Effect of homestead-farm distance on TFP

Distance between the farmers' homestead and rice farm has mixed effects on productivity. While the coefficient for this variable was negative and significant for the upland production system, it was positive and significant for the lowland production system. This implies that the further away from home the rice farm is, the lower the productivity level for upland system, but the further away the rice farm is from home, the higher the productivity is in the lowland system.

4.6 Chow test results for test of productivity parameters differentials.

Table 13. Regression estimates of variables affecting productivity for the combined production systems.

Variable	Both systems		Both systems with dummy	
	Coefficients	t-statistic	Coefficients	t-statistic
Age	-0.3561	-1.78*	-0.0896	-0.43
Schyrs	-0.0156	-0.57	0.0166	0.65
Housze	0.2926	4.42***	0.2553	4.04***
Rcexp	0.2515	4.64***	0.2086	3.56***
Dstfrm	0.0043	0.16	0.0743	2.18**
Dstmkt	0.2474	9.69***	0.1848	5.18***
Cmlvl	0.3261	3.45***	0.2731	2.84***
Exvst	0.0416	1.51	0.0459	1.70*
Dummy	_____	____	0.1608	2.85***
Constant	0.8081	2.01	0.5766	1.55
R2	0.6330		0.6451	
N	334		334	
F	72.31		64.23	

Source: Field Data, 2008

*Significant at 10% level
**Significant at 5% level
***significant at 1% level

4.7 Farmers' view and assessment of Constraints and Opportunities for Improving Productivity

Perceptions of important opportunities and constraints of farmers in the upland and lowland rice production systems were evaluated through structured interviews. These aimed at highlighting the important constraints that should be addressed in order to improve the productivity of rice systems in the different agro-ecological zones of the country. In relation to the number of farmers who reported production constraints, access to farm credit had the highest frequency among the upland rice farmers while the availability of farm inputs with particular reference to fertilizers, had the highest frequency among the lowland rice farmers. Other constraints mentioned include biological constraints such as birds and rodents, lack/insufficient access to land, labour and farm machinery.

Access to farm credit: Formal credit for the purchase of inputs was largely unavailable. About forty-four per cent (43.9%) of the upland rice farmers reported lack of access to formal credit as a major limiting factor to improved performance of their farms. The credit that would have been obtained, if available, was reported to have helped in the purchase of expensive inputs such as agrochemicals and labour in the upland production system and fertilizers in the lowland production system.

Access to farm inputs: Access to farm inputs was linked with access to credit because it was reported that lack of access to farm credit also hinders the access to production inputs. In other words, access to farm credit is expected to facilitate the access to production inputs, all things being equal. However, some farmers reported the non-timely availability of farm inputs with particular reference to fertilizers as a major constraint to improved rice production.

Costs of farm inputs: High cost of inputs were identified as primary constraints across all farms in both upland and lowland production systems .Farmers in the two production systems indicated that fertilizers and herbicides were too expensive. Most farmers have, however, responded to this situation by using less than what they consider optimal input application rates. This of course, has implications for yield and output at the farm, regional and national levels.

Pests: Damage by birds and rodents were identified as the main pest problems by farmers in both upland and lowland rice production systems. Although no scientific methods of dealing with these pests were mentioned, local traditional methods were employed to trap some of the rodents and scare away birds from rice plots.

Farm machinery: Three major categories of machinery were mentioned by farmers under the two production systems. These are tractors for land preparation, harvesters and post-harvest machinery. About thirty-four per cent (33.7%) of the lowland rice production system farmers and thirteen per cent of upland rice farmers reported lack of access to machinery such as tractors and harvesters as a major limiting factor to better rice production on their farms. The tractors would be used in land preparation, thus helping to cut back on labour cost and expand cultivated land. The harvesters on the other hand would harvest in a shorter time and also reduce losses while the post-harvest machinery would help more efficiently with activities such as threshing and winnowing. All these, of course, would contribute positively to productivity.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of major findings

Of all the staple crops paraded by the food sub-sector of Nigerian agriculture, rice has risen to a position of pre-eminence and has thus become a commodity of strategic importance. Since the mid-1970s, the demand for rice in Nigeria has been increasing at a fast rate (Akpokodje *et al*, 2001). In addition, rice consumption has risen tremendously, at about 10% per annum due to changing consumer preferences (Fashola *et al*, 2006). Local production of rice is estimated to be three million tons per annum (NAMIS, 2004) leaving a deficit of about two million tons that is met through importation. Thus, importation is a necessity to meet up with the domestic demand.

Although land area cultivated to rice has been on the increase since 1967, the corresponding yields have not been sufficient to bring about the expected increase in total rice production. It is therefore important and of national interest to examine the factors that contribute to the low production of rice in Nigeria so as to pave the way for sustainable self sufficiency.

An understanding of the rice sector performance, especially the rain-fed sector and the factors affecting such performance will also help decision/policy makers to formulate policies to enhance self-sufficiency in rice production for the nation. This is important since over eighty per cent of rice produced in Nigeria is produced under rain-fed system (Akpokodje *et al*, 2001; Ogundari, 2008). The importance of the assessment of crop-specific productivity analysis has been appreciated as this will give insight into the potential for resource savings and productivity improvements of the specific crop (Ajetomobi, 2009). Productivity estimates are best used as a framework to identify those areas that need the most change, or where changes will yield the greatest increases in profitability (Penno *et al*, 2006).

For this study, farmers were selected using the multi-stage sampling technique. Primary data were collected through the use of structured questionnaire which was first pre-tested before being administered to the selected rice farmers. Data were collected on farm and farmers\ characteristics, as well as on details of rice production in the 2008 growing season.

Results from this study indicate that there are more male rice farmers than female rice farmers in the study areas. Farmers' ages were between twenty and seventy. With regard to educational status (represented by cumulative years of formal schooling), more than eighty per cent (80.98%) of the farmers under the upland rice production system had some formal education while forty per cent (40.40%) of the lowland production system farmers had formal education. Farmers under upland rice production system had an average of fourteen (13.73) years experience in rice farming while farmers under lowland rice production system had an average of twenty-two years experience in rice cultivation.

Rice was cultivated on an average of two (1.915) hectares under the upland rice production system. On the other hand, cultivation of rice under lowland rice production system was carried out on farms with average size of 2.749 hectares. Commercialization levels were seventy-seven per cent and eighty-one per cent under the upland and lowland rice production systems respectively.

Rice output obtained by farmers was below the output potentials for the production systems. Average yields were 1.2tons.ha and 2.0tons/ha under upland and lowland rice production systems respectively. There were output differentials within each production system due to the non-attainment of potential yields by rice varieties cultivated. Lowland rice production system attained 42.27% of its potential output while upland system attained 53.69% of its potential output.

With regard to intensity of use, farm labour constituted 37.28% of the production cost under upland rice production system while fertilizers had the highest intensity of use (36.46%) under the lowland production system. Tractor and implements had the least intensity of use (2.96%) under the upland production system while the input with the least intensity of use under the lowland production system was agrochemicals (7.88%). However, 51.7% and 86.7% of recommended seed rates were used by lowland and upland rice farmers respectively. Sub-optimal rates of fertilizers at 46.2% and 20.3% of the recommended quantities were applied by lowland and upland rice farmers respectively.

The factors that were found to significantly affect productivity of rice production are household size, farmers' experience in rice farming, farm-market distance and commercialization level. With regard to each production system, distance between rice farm and market, farm-homestead distance, commercialization level and extension visits had significant effects on total factor productivity under upland rice production system. Under the lowland rice production system, household size, farmers' experience in rice farming, distance between rice farm and homestead, commercialization level and extension visits had significant effects on productivity.

Perceptions of important opportunities and constraints of farmers in the rice production systems were evaluated. This was necessary to highlight the important constraints that should be addressed so as to improve productivity in the rice systems. In relation to the number of farmers who reported production constraints, access to farm credit had the highest frequency among the upland rice farmers. Moreover, the availability of farm inputs, with particular reference to fertilizers, had the highest frequency among the lowland rice farmers. Other constraints mentioned include biological constraints such as birds and rodents, lack/insufficient access to land, labour and farm machinery.

5.2 Conclusion

The existence of output differentials in the rice production systems imply great potential for increasing rice production in the nation. Rice output would increase tremendously if all recommended technology packages for the rice varieties cultivated are utilized appropriately. That is, the utilization of optimum input quantities and appropriate management practices would reduce the differential between potential and actual rice output. This would result in increased rice production.

The factors which affect total factor productivity in rain-fed rice production systems in Nigeria are multifaceted and vary between production systems. However, common to the production systems under this study are farm-homestead distance, extension visits and commercialization level. Other factors affecting productivity are household size and farming experience under lowland production system.

5.3 Recommendations

Although there are vast land areas available for the expansion of rice cultivation, this study rather recommends intensification on cultivated rice farms. In other words, efforts should be directed towards the attainment of the potential output of all rice varieties being cultivated. This can be achieved through the appropriate use of recommended management practices for each rice variety.

Necessary inputs (tractor services, certified seeds, fertilizers and agrochemicals) should be made readily available by appropriate agencies at affordable prices to rice farmers. This is necessary for timely application of these inputs to rice farms for maximum output.

The importance of farm extension visits cannot be over-emphasized in agriculture. There is need to improve and sustain extension services for rice farmers in order to have a strong, effective and reliable research-extension-farmer-inputs linkage system. Education of existing and prospective rice farmers through extension services should be given a high priority as this has significant influence on farmers' productivity.

The provision of good rural feeder roads are necessary to make the movement of farmers between farms and homesteads easier as well as make the movement of farm produce from farm to markets more convenient.

To transform the rice sector in Nigeria, governments must institute policies and instruments that would create easy access to credit, inputs and markets by farmers. Such policies will give farmers incentives to adopt full packages of improved technologies that can raise their productivity and incomes.

5.4 Suggestion for further research

This study has examined output differentials, total factor productivity and factor use intensityp in rain-fed rice production systems. It has shown that production system explicit analysis of rice production can reveal information that is not manifest in aggregated analyses. Aggregated analysis, such as at the national level, cannot adequately shed light on the production situation at farm level because production systems are diverse. There is need to provide insights into possibilities and constraints for increasing rice production at farm and regional levels. Further studies should therefore be carried out in relation to the rice varieties cultivated in each rice ecology. This will allow for proper targeting of specific constraints for increased rice production.

REFERENCES

Abdulai, A and Eberlin, R. 2001. Technical efficiency during economic reform in Nicaragua: Evidence from farm household survey data. *Economic Systems 25.2:113-125.*

Abo, M.E., Ochigbo, A.A., Gana, A.S., Maji, A.T., Ojehomon, V.E.T and Ukwungwu, M.N .2003. The challenges of rice varietal development and production in lowland rice ecology in Nigeria. *Journal of Agriculture and Food Information 5.1:51-66*

Adedipe, N.O, Okuneye, P.A, Ayinde, I.A. 2004. The relevance of local and Indigenous knowledge for Nigerian agriculture. *Paper presented at the International conference on bridging scales and epistemologies: Linking local knowledge with global science in Multi-Scale assessments, Alexandria, Egypt March 16-19, 2004.*

Ademola, O.A. and Okobaroh, B.A..1992. Training needs for rice production in West Africa with reference to Nigeria in human resources development for rice science in West Africa. *Proceedings of a WARDA/NARS Training seminar held at WARDA, Bouake, Cote d'Ivoire, 4th – 6th May, 1992. 17-24.*

Adeogun, O.A; Ajana, A.M; Ayinla, O.A; Yarhere, M.T and Adeogun, M.O .2008. Application of logit model in adoption decision: A study of hybrid Clarias in Lagos State, Nigeria. *American-Eurasian Journal of.Agriculture & Environmental Science 4.4:468-472*

Adeyeye, V.A .1986. Relative economic efficiencies in farm organizations: A comparative study of co-operative and non-co-operative farms in Oyo And Kwara States, Nigeria. *Unpublished Ph.D Thesis, Department of Agricultural Economics, University of Ibadan, Nigeria.*

Agwu, A.E and Edun, O.A. 2007. Influence of farmers' demographic characteristics on Knowledge gap of recommended fadama technologies in Ilaro agricultural zone Of Ogun state. *Agro-science: Journal of agriculture, food, environment and Extension 6.2:52-60.*

Aheam, M; Yee, J; Ball,E and Nehring, R .1998. Agricultural productivity in the United

States. *Agriculture Information bulletin No.740 USDA, Washington, D.C.*

Aiyar, S and Dalgaard, C .2001. Total factor productivity revisited: A dual approach to levels-accounting.

Ajani, O.I.Y .2000. Resource productivity in food crop farming in the Northern Area of Oyo Statem Nigeria. *Unpublished Ph.D Thesis, Department of Agricultural Economics, University of Ibadan, Nigeria. 159pp*

Ajao, O.A .2007. Empirical analysis of agricultural productivity growth in Sub-Saharan Africa: 1961-2003. Retrieved Sept 16, 2009 from www.afdb.org.

Ajetomobi, J.O .2009. Productivity improvement in ECOWAS rice farming: Parametric and non-parametric analysis. *Research report for African economic research Consortium (AERC). 19pp*

Ajibefun, I.A and Abdulkadri, A.O .2004. Impact of size of farm operation on resource use efficiency in small-scale farming: Evidence from Southwestern Nigeria. *Food, Agriculture and Environment 2.1: 359-364.*

Akpokodje, G; Lancon, F and Erenstein, O .2001. Nigeria\s rice economy: State of the Art. *USAID Project report on the Nigerian rice economy in a competitive world: Constraints, opportunities and strategic choices.* West Africa rice development Association (WARDA), Bouake, Cote d'Ivoire.

Alauddin, M; Headey, D and Prasada Rao, D.S .2005. Explaining agricultural productivity levels and growth: An international perspective. *Centre for Efficiency and Productivity Analysis (CEPA) Working Paper Series 02/2005*

Anderson, D and Leiserson, M.W .1980. Rural non farm employment in developing countries. *Economic development and cultural change 28.2: 227-248.*

.Andzio-Bika, H.L.W and Wei, L .2005. Agricultural productivity growth and technology progress in developing country agriculture: Case study in China. *Journal of Zhejiang University Science 6A Suppl. 1:172-176*

Arene, C.J and Mkpado, M .2002. Counter urbanization and agricultural input Productivity in Imo state of Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics 103.2:117-123*

Asadullah, M.N and Rahman, S .2005. Farm productivity and efficiency in rural

Bangladesh: The role of education revisited. *CSAE working paper series WPS/2005-10*

Bangladesh Enterprise Institute (BEI) .2004 .Productivity analysis of select SMEs in Bangladesh..

Becker, M; Johnson, D.E and Segda, Z.J.2009. The role of legume fallows in intensified upland rice-based systems of West Africa .Retrieved Oct 20, 2009 from www.idrc.ca

Binswanger, H., Mundlak, Y., Yang, M and Bowers, A .1986. On the determinants of Cross-country aggregate agricultural supply. *Report no. ARU56.* World Bank.

Brun, M .2006. Factors of production. Retrieved Jan 14, 2007 from www.answers.com

Bureau, C., Färe, R and Grosskopf, S .1985. A Comparison of three Nonparametric measures of productivity growth in European and United States agriculture. *Journal of Agricultural Economics, 46:309-326*

Carter, C. A; Chen, J and Chu, B .1999. Agricultural productivity growth in China:farm level versus national measurement. *California Agricultural Experiment Station, Giannini Foundation for Agricultural Economics Working Paper No. 99-001.*

Carter, M.R .1984. Identification of the inverse relationship between farm size and Productivity: An empirical analysis of peasant agricultural production. *Oxford Economic Papers New Series 36.1:131-145*

Cassman, K.G and Pingali, P.L .1995. Intensification of irrigated rice systems: Learning from the past to meet future challenges. *GeoJournal 35.3:299-305.*

Chavas, J.P and Cox, T .1992. A non parametric analysis of the influence of research on agricultural productivity. *American journal of agricultural economics 74:583-591.*

CIRAD (Centro de cooperation internationale en recherche agronomique pour le Development) 1999. *Images of Research*. CIRAD, Paris, France.

Coelli, T. J .1995. Recent developments in frontier modeling and efficiency measurement. *Australian journal of Agricultural Economics 39.3: 219-245..*

Coelli, T.J and. Prasada Rao, D.S .2003. Total factor productivity growth in agriculture: A Malmquist index analysis of 93 countries, 1980-2000. *Paper prepared for Presentation as a Plenary Paper at the 2003 International Association of*

Agricultural Economics (IAAE) Conference in Durban August 16-22, 2003.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J and Battese, G.E .2005. *An introduction to efficiency and productivity analysis*. 2nd edition. Springer.

Cororaton, C.B and Cuenca, J.S.2001. Estimates of total factor productivity in the Philippines. *Discussion paper series no. 2001-02* Philippines institute for development studies, Makati city.

Cuenca, J.S .2006. Productivity: putting the use of resources at their best. *Economic Issue of the day Vol vi No 7*. Philippine institute for Development studies, Makati city.

Dalton, T.J and Guei, R.G .2003. Productivity gains from rice genetic enhancements in West Africa: Countries and ecologies. *World development 31.2:359-374.*

Daramola, B .2005. Government policies and competitiveness of Nigerian rice economy. *Paper presented at the workshop on rice policy and food security in Sub-Saharan Africa, Cotonou, Republic of Benin. November 7-9, 2005*.

David, C.C .1991. The world rice economy: Challenges ahead. *Rice biotechnology. Biotechnology in agriculture series No.6*.G.S Khush and G.H Toenniessen. Eds. IRRI (International rice research institute), Philippines. 1-18.

Davis, K.E .2008. Extension in Sub-Saharan Africa: Overview and assessment of past and current models, and future prospects. *Journal of International Agricultural and Extension Education 15.3: 15-28.*

Dean, E.R; Harper, M.J and Sherwood, M.S .2006. Productivity measurement with changing-weight indices of outputs and inputs. Retrieved May 7, 2008 from www.oecd.org

Diagne, A .2008. Rice sector development in Africa: Opportunities and challenges. *African Japanese Planery Workshop on Sustainable Rice Production. August 23-26,2008 Rice Research and Training Center, Kafr El-Sheikh*.

Diewert Erwin .2006. The challenge of total factor productivity measurement Retrieved May 7, 2008 from www.econ.iastate.edu

Dorward, A; Kydd, J; Morrison, J and Urey, I .2002. A policy agenda for pro-poor agricultural growth. *Department for international development of the United Kingdom. ESCOR project R7989*. .

Droogers, P; Seckler, D and Makin, I. 2001. Estimating the potential of rain-fed Agriculture. *Working paper 20, international water management institute, Colombo, Sri Lanka.*

Duwayri, M., Van Tran, D and Nguyen, V.N .2000. Reflections on yield gaps in rice Production: How to narrow the gaps in *Bridging the rice yield gap in the Asia-Pacific region.* Papademetriou, M.K., Dent, F.J and Herath, E.M (Eds). Proceeding of the expert consultation on bridging the rice yield gap in Asia And the Pacific, Bangkok, Thailand, October 5-7, 1999. Pg 26-45.

Edmonds, C .2004. Rice production, land use dynamics and infrastructure development in Viet Nam's Mekong river delta. *Asian Development Review 21.2: 57-78.* Asian Development Bank.

Edwards, R and Chater, S .1993. Traditional farming systems and farming systems research. *Dryland Farming in Africa.* J.R.J Rowland Ed. Macmillan Education Ltd and CTA. 95-108.

Eklou, A.S., Guei, R.G and Nguyen, N .2008. Overview: Rice in Africa Retrieved 29/6/2010 from www.africaricecenter.org/publications/nerica.

Emodi, I.A and Madukwe, M.C .2008. A review of policies, acts and initiatives in rice innovation system in Nigeria. *Journal of Agricultural Extension 12.2: 76-83.*

Evenson, R.E and Nwabu, G .1998. The effects of agricultural extension on farm yields in Kenya. *Center Discussion Paper No. 798*. Economic Growth Center Yale University.

Fakayode, S.B; Babatunde, R.O and Ajao, R .2008. Productivity analysis of cassava-based production systems in the guinea savammah: Case study of Kwara state, Nigeria. *American-Eurasian journal of scientific research 3.1:33-39.*

FAO .2003. Untapped Rice Potential in Sub-Saharan Africa. Retrieved Dec 10, 2003 from www.fao.org

FAO .2004. FAOSTAT Retrieved February 6, 2004 from www.fao.org

Fashola, O.O., Imolehin, E.D and Wakatsuki, T .2007. Water management practices for Sustainable rice production in Nigeria. *Nigerian agricultural journal 38. 40-48*

Fatoba, I.O., Omotesho, O.A and Adewumi, M.O. 2009. Economics of wetland rice

Production technology in the Guinea savannah of Nigeria. Journal of development And agricultural economics 1.9:199-203.

Felipe, J .1997. Total factor productivity growth in East Asia: A critical survey. *EDRC Report Series No. 65:1-65* Asian Development Bank,

Fulginiti, L. and Perrin, R .1993. Prices and productivity in agriculture. *Review of Economics and Statistics. 75: 471-482.*

Fulginiti, L.E., Perrin, R.K and Yu, B .2003. Institutions and agricultural productivity In Sub-Saharan Africa. *Proceedings of the 25th International Conference of Agricultural Economists (IAAE) 16-22 August, 2003 Durban, South Africa Pg 507-528.*

Funn, J.C and Denning, G.L .1989. Agroeconomic opportunities in rice-based farming systems research. *Rice Farming Systems: New Directions. Proceedings of an International Symposium, 31 January-3 February 1987. Rice Research and Training Center, Sakha, Egypt. International Rice Research Institute{IRRI},1989. Pg 239-254.*

Ghorbani, M .2008. Evaluation of agricultural advisory services effects on sugar beet in Razavi Khorasan province. *Journal of Applied Sciences 8.20: 3733 – 3737*

Giuliana, T and Atef, H. 2009. Rain-fed agriculture improvement: Water management is The key challenge. Retrieved Dec14, 2009 from www.worldwatercongress2008. org/resource/authors/abs926/article.pdf.

Glenn, D.I .2009. Determining sample size. *IFAS Extension Publication no. PEOD6.* Institute of Food and Agricultural Services, University of Florida, USA.

Gopinath, M and Roe, T .1997. Sources of sectoral growth in an economy wide context: The case of U.S. agriculture. *Journal of Productivity Analysis, 8.3:293-310*

Govereh, J; Jayne, T.S and Nyoro, J 1999. Smallholder commercialization, interlinked markets and food crop productivity: Cross-country evidence in Eastern and Southern Africa. *Paper published by the Department of agricultural economics and the Department of economics, Michigan state university.*

Griffin, R.C., Montgomery, J.M and Rister, M.E .1987. Selecting functional form in production function analysis. *Western journal of Agricultural Economics 12:216-227.*

Gupta, P.C and Otoole, J.C .1986. *Upland rice: A global perspective*. International rice Research institute, Los Banos, Laguna, Philippines. 1-358.

Haile, M; Tesfaye, A; Aregu, L and Mulat, E .2004. Market access versus productivity: The case of Teff. *Paper prepared for presentation at the Ethiopian economic association conference, Addis Ababa, June 3-5, 2004.*

Hall, R.E .1988. The relation between price and marginal cost in U.S industry. *The journal of political economy, 96.5:921-947.*

Halter, A.N., Carter, H.O and Hocking, J.G .1957. A note on the transcendental Production function. *American Journal of Agricultural Economics 39.4:966-974.*

Hayami, Y., and V. W Ruttan .1970. Agricultural productivity differences among countries", *The American economic review, 60.5:895-911*.

Hazell, P.B.R .2003. Is there a future for small farms?. *Proceedings of the 25th International conference of agricultural economists (IAAE), 16-22 August, 2003 Durban, South Africa Pg 103-111*.

Heshmati, A and S.C. Kumbbakar .1997. Estimation of technical efficiency in Swedish crop farms: A pseudo panel data approach. *Journal of agricultural economics 48(1): 22-37.*

Hoff, A .2006. The Translog Approximation of the Constant Elasticity of Substitution Production Function With More Than Two Input Variables. Retrieved 14/6/2006 from www.foi.kvl.dk.

Hussain, I and Perera, L.R .2004. Improving agricultural productivity through integrated Service provision with public-private partnerships. *Working Paper 66 International Water Management Institute.* IWMI, Colombo, Sri Lanka.

Idiong, I.C .2007. Estimation of farm level technical efficiency in small-scale swamp rice Production in Cross River state of Nigeria: A stochastic frontier approach. *World Journal of Agricultural Sciences 3.5:653-658.*

ILO (International Labour Organization) .2003. Agricultural Wage Workers: The Poorest Of the Rural Poor. Retrieved 22/4/2003 from www.ilo.org

Imolehin, E.D and Wada, A.C .2005. Meeting the Rice Production and Consumption

Demands of Nigeria with Improved Technologies. *International Rice Commission Newsletter vol 49.FAO, Rome.*

IRRI (International Rice Research Institute) .2009. Upland Rice Distribution Retrieved17/7/2009from www.knowledgebank.irri.org/uplandRice/globalPerspUplandRice

JICA/AGRA .2008. Coalition for Africa rice development (CARD). Retrieved 14/7/2009 from www.jica.go.jp/topics/achives/jica/2008/pdf/card

Janvry, A; Sadoulet, E and Zhu, N .2005. The role of non-farm income in reducing rural Poverty and inequality in China. Retrieved 26/5/2009 from http://are.berkeley.edu/sadoulet/papers/RNF-

Jensen, T. 2008. Food production and economics of fertilizer use – tracking the returns In a grain crop. *Better crops* 92.3:26-27

Juliano, B.O .1993. Rice in Human Nutrition. FAO *Food and Nutrition Series No. 26.* Food and Agriculture Organization of the United Nations, Rome and the International Rice Research Institute. 162pp.

Kalirajan, K.P and Shand, R.T. 2009. Types of education and agricultural productivity: A quantitative analysis of Tamil Nadu rice farming. Retrieved on Dec 28, 2009 From http://nhjy.hzau.edu.cn/kech/nyijx/zl/xueshulv/en.pdf.

Kamruzzaman, M and Takeya, H. 2009. Determination of capacity building by life stage For the farmers in Bangladesh. *Nature and science 7.1:8-16.*

Kawagoe, T. and Y. Hayami .1985. An intercountry comparison of agricultural production efficiency, *American Journal of Agricultural Economics*, 67, 87-92.

Kebbeh, M; Haefele, S and Fagade, S.O.2003. Challenges and opportunities for Improving irrigated rice productivity in Nigeria. West Africa rice development Association (WARDA), Abidjan, Cote d'Ivoire.

Kerr, J.M. 1996. Sustainable development of rain-fed agriculture in India. *EPTD Discussion paper 20, IFPRI, USA.*

Key, N and Mcbride, W .2003. Production contracts and productivity in the US hog Sector. *American journal of agricultural economics. 85(1):121-133.*

Kirikal, L .2006. Productivity, the Malmquist index and the empirical study of banks in Estonia. Retrieved 24/7/2006 from http://majandus.ttu.ee.

Lancon, F and Benz, H.D .2007. Rice imports in West Africa: Trade regime and food Policy formulation. Poster prepared for the 106th seminar of the European Association of Agricultural Economists, Montpellier, France, October 25-27.

Lobell, D.B., Cassman, K.G and Field, C.B .2009. Crop yield gap: Their importance, Magnitudes and causes. *Annual Review of Environmental Resources 34:179-204*

Longtau, R. S .2003.Multi-Agency Partnerships in West African Agriculture : A Review and Description of Rice Production Systems in Nigeria. Retrieved 17/8/2003 from www.odi.org.uk

Lotsmart, N.F and Mbah, F.A. 2007. The fortunes and misfortunes of women rice Producers in Ndop, Cameroon and the implications for gender roles. *Journal of International women's studies 8.4:133-148.*

Mackill, D.J; Coffman, W.R and Garrity, D.P .1996. *Rain-fed lowland rice improvement*. International rice research institute, Manila, Philippines 242pp.

Maddala, G.S .2006. A note on the form of the production function and productivity. In Measurement and Interpretation of Productivity. National Research Council Pg 309-317. Retrieved 21/1/2007 from www.nap.edu

Mahendra, R .2000. Farm productivity, efficiency and profitability in Fiji's sugar industry .*Fijian studies 1.2:225-241*

Manyong, V.M; A Ikpi; Olayemi, J.K; S.A Yusuf; Omonona, R and Idachaba, F.S (2003) Agriculture in Nigeria: Identifying opportunities for increased commercialization and investment. www.usaid.gov

Mawson, P , Carlaw, K.I , McLellan, N .2003. Productivity Measurement: Alternative Approaches and Estimates. *New Zealand Treasury Working Paper 03/12 pp33*.

McCalla, A. F. 2001. Challenges to world agriculture in the 21st century. *Update: Agricultural and resource economics Vol 4(3). University of California, Davis.*

Menchik, P. L. and Burton A. Weisbrod. .1987. Volunteer Labor Supply. *Journal of Public Economics 32.2: 159-183.*

Mohammed-Bello, Y .1999. Not farms alone: A study of rural livelihoods in the middle belt of Nigeria. DARE Research African Studies Centre, Netherlands. 38-87.

Mulwa, R; Nuppenau, E and Emrouznejad, A. (2006) Productivity Growth in Smallholder Sugarcane Farming in Kenya: A Malmquist TFP Decomposition.

www.tropentag.de.

Munro, B.H (2001) *Statistical Methods for Health Care Research*. Lippincott Williams & Wikins, USA. Fourth Edition.459pg.

Nadiri, M.I. 1970. Some approaches to the theory and measurement of total factor Productivity: A survey. *Journal of economic literature 8.4:1137-1177.*

NAMIS (2004) Nigeria Agri Marketing News Bulletin No.4 www.afmin.net Accessed 3/9/2004.

NBS (National Bureau of Statistics) .2010. www.nigerianstat.gov.ng

Nkamleu, G.B. 2003. Productivity growth, technical progress and efficiency change in African agriculture. *MPRA paper no. 11380:202-223.* Retrieved Dec 4, 2009 from http://mpra.ub.uni-muenchen.de/11380/

Nkang, N. M. , S. O. Abang, O. E. Akpan and E. O. Edet. 2006. Rice production, imports and food security in Nigeria: An application of cointegration and error correction model *Journal of Food, Agriculture & Environment 4.1: 86-90*

Nin-Pratt, A., Johnson, M., Magalhaes, E., You, L., Diao, X and Chambrlin, J .2011. Yield gaps and potential agricultural growth in West and Central Africa. *IFPRI Research monograph.* www.ifpri.org. Accessed 24/8/2011

Norman, J.C and Otoo, E .2003. Rice development strategies for food security in Africa. *Proceedings of the 20th session of the international rice commission, Bangkok, Thailand 23-26 July, 2002.* 306pg.

NRDS (National rice development strategy) 2009 Federal republic of Nigeria. Paper Prepared for the coalition for African rice development (CARD), Tokyo, Japan June 2009. www.jica.go.jp/activities/issues/agricul.pdf271009.pdf Accessed 11/10/2009.

Ogundari, K .2008. Resource productivity, allocative efficiency and determinants of Technical efficiency of rain-fed rice farmers: A guide for food security policy in Nigeria. *Agricultural economics – Czech 54(5):224-233.*

Ogundele, O.O and Okoruwa, V.O .2006. Technical Efficiency Differentials in Rice Production Technologies in Nigeria. *AERC Research Paper 154. African Economic Research Consortium, Nairobi, Kenya.*

Oikeh S.O., Nwilene F.E., Agunbiade T.A., Oladimeji O., Ajayi O., Semon M., Tsunematsu H. and Samejima, H .2008. *Growing upland rice: A production handbook.* Africa rice center, Cotonou, Benin.

Ojehomon, V.E.T, Abo, M.E, Ojehomon, O and M.N Ukwungwu. 2006. Adoption of recommended management practices in the lowland rice ecology of Niger state, Nigeria. Tropicultura 24:2 82-89.

Ojehomon, V.E.T., Adebayo, S.B., Ogundele, O.O., Okoruwa, V.O., Ajayi, O., Diagne, A and Ogunlana, O .2009. Rice data systems in Nigeria: Building a rice data system for Sub-Saharan Africa. NCRI, NBS, NISER and Department of agricultural Economics, University of Ibadan.

Okojie, C.1991. Achieving self-reliance in food production in Nigeria: Maximizing the Contribution of rural women. *Journal of social development in Africa. 6.2:33-52*

Okoruwa, V.O, Ogundele, O.O and B.O. Oyewusi .2006. Efficiency and Productivity of Farmers in Nigeria: A Study of Rice Farmers in North Central Nigeria. *Poster Paper Prepared for Presentation at the International Association of Agricultural Economists' Conference. August 12-18, Gold Coast, Australia.*

Oladeebo, J.O and A.A Fajujigbe .2007. Technical Efficiency of Men and Women Upland Rice Farmers in Osun State, Nigeria. *Journal of human ecology 22(2): 93-100.*

Oladele, O.I and Somorin, A.B .2008. Technology and extension gaps among rice Farmers in Ogun state, Nigeria. *Agricultura Tropica et Subtropica 41.4:160-164*

Olawepo, R.A .2010. Constraints to increased food productivity in rural areas: An Example from Afon district, Ilorin, Nigeria. *Asian Social Science 6.4:106-116.*

Olomola, A.S.1998. Choice and productivity effects of animal traction technology in the Semi-arid zone of northern Nigeria. *Issues in African rural development Monograph series no. 12.* Winrock international, USA.

Onyenwaku, C.E. 1997. Impact of technological change on output, income, employment And factor shares in rice production in southwestern Nigeria. *Issues in African rural development monograph series no. 5.* Winrock international, USA.

Oppen, M.V; Njehin, B.K and Ijaimi,A .1997. The Impact of Market Access on Agricultural Productivity:Lessons from India, Kenya and The Sudan. *Journal Of International Development 9(1):117-131.*

Oteng, J.W and Sant Anna, R (1999) Rice Production in Africa: Current Situation and Issues. *International Rice Commission Newsletter Vol 48, FAO, Rome.*

Owuor, J (2006) Determinants of Agricultural Productivity in Kenya. www.tropemtag.de

Oyekale, A.S .2007. Intensive land use and efficiency of food production in southwestern Nigeria. *Agricultural Journal 2.2:174-179.*

Oyeranti, Gboyega A (2006) Concept and Measurement of Productivity www.cenbank.org

Ozowa, V.N .1995. Information needs of small scale farmers in Africa: The Nigerian Example. *Quarterly bulletin of the international association of agricultural Information specialists. IAALD/CABI Volume 40 no.1*.

Pardey, P.G., Roseboom, J and Craig, B.J .1992. A yardstick for international Comparisons: An application to national agricultural research expenditures. *Economic Development and Cultural Change 40.2:333-349.*

Pender, J; Nkoya, E; Jagger, P and Sserunkuuma, D. 2002. Strategies to increase agricultural productivity and reduce land degradation: Evidence from Uganda *Paper presented at the Cornell University Workshop on "Reconciling rural poverty reduction and resource conservation: Identifying relationships and remedies" Dec 2002.*

Penno, J; Marise, J and Rogers, N .2006. Focusing on improving profitability. www.dexcel.co.nz

Pingali, P.L and Heisey, P.W .1999. Cereal crop productivity in developing countries. *CIMMYT Economics paper 99-03.* International Maize and Wheat Improvement Center, Mexico.

Pingali, P.L., Hossain, M., Pandey, S and Price, L.L .1998. Economics of nutrient management in Asian rice systems: Towards increasing knowledge intensity. *Field Crops Research 56:157-176.*

Pudasaini, S.P.1983. The effects of education in agriculture: Evidence from Nepal. *American journal of agricultural economics 65.3:509-515.*

Rahji, M.A.Y and Adewumi, M.O. 2008. Market supply response and demand for local rice in Nigeria: Implications for self-sufficiency policy. *Journal of central European agriculture 9.3: 567-574.*

Rahji, M.A.Y., Ilemobayo, O.O and Fakayode, S.B. 2008. Rice supply response in Nigeria: An application of the Nerlovian adjustment model. *Agricultural Journal 3.3:229-234.*

Rahji, M.A.Y. 2009. The adoption and productivity impacts of improved management Practices on lowland rice production in Niger state, Nigeria. *Tropical agriculture*

Rahman, S.A .2006. Health technology and agricultural productivity in Nigeria. *Paper Presented at the 20th Annual National FAMAN Conference, held at Federal College of Forestry, Jos, Nigeria, 18-21 September, 2006.*

Rao Prasada, D.S and Coelli, T.J .2003. Catch-up and convergence in global agricultural productivity. www.iaae-agecon.org Accessed 27/4/07

Reardon, T; Crawford, E and Kelly, V .1994. Links between non farm income and farm investment in African households: Adding the capital market perspective. *American journal of agricultural economics 76.5: 1172-1176.*

Reijnkjes, C, Haverkort, B and Waters-Bayer, A .1992. *Farming for the Future: An Introduction to Low-External-Input and Sustainable Agriculture.* Macmillan Press Ltd and ILEIA (Information Centre for low-external-input and sustainable Agriculture), Netherlands. 250pp.

Rice, P; Venables, A.J and Patacchini, E .2006. Spatial determinants of productivity: Analysis for the regiona of Great Britain. *Regional science and urban economics 36:727-752.*

Rios, A.R; Masters, W.A and Shively, G.E .2008. Linkages between market participation and productivity: Results from a multi-country farm household sample. *Paper prepared for presentation at the American Agricultural Economics Association annual meeting, Orlando FL, July 27-29, 2008.*

Rosegrant, M., Cai, X., Cline, S and Nakagawa, N .2002. The role of rainfed agriculture In the future of global food production. *EPTD Discussion paper no. 90* International food Policy Research Institute, Washington, D.C.

Sabo, E .2007. The Prevalence and effects of drunkenness among farmers in Mubi north Local government area, Adamawa state. *Agricultural journal 2.4: 495-498.*

Sankhayan, P.C .1988. *Introduction to the economics of agricultural production*. Prentice-Hall of India Private Ltd, New Delhi.

Simatupang, B .1994. *The Polish economic crisis: Background, causes and aftermath* 255pp. London and New York Routledge.

Singh, P., Vijaya, D., Chinh, N.T., Pongkanjana, A., Prasad, K.S., Srinivas, K and Wani, S.P .2001. Potential productivity and yield gap of selected crops in the rainfed Regions of India, Thailand and Vietnam. *Natural resource management program Report no. 5.* International Crops Research Institute for the Semi-Arid Tropics.

Tangen, S .2006. Understanding the Concept of Productivity. www.aipa.org.

Tauer, L.W. 1984. Productivity of farmers at various ages. *North Central journal of Agric Econs 6(1):81-87.*

Tauer, L. W and Lordkipanidze, N .1999. Productivity of Dairy Production in Individual States. *Paper presented at the 1999 American Agricultural Economics Association meeting, August 8-11, 1999, in Nashville, TN. Working Paper 99-08, Department of Agricultural, Resource, and Managerial Economics, Cornell University, April 1999*

Tijani, A.A.2007. Analysis of the technical efficiency of rice farms in Ijesha land of Osun State, Nigeria. *Agrekon 45.2:126-136.*

UNEP .2005. *Integrated Assessment of the Impact of Trade Liberalization: A Country Study on the Nigerian Rice Sector.* 107pp. United nations environment programme

United Nations. 2007. World food programme: Climate change and the world's hungry. *United Nations joint press kit prepared for climate change conference, Bali Dec 3-14, 2007.*

United Nations (2009) World urbanization prospects: The 2009 revision. UN, department of economic and social affairs, population division.

Upton, M. 1972. Farm management in Nigeria. *Occasional paper. Department of Agricultural Economics, University of Ibadan, Nigeria.*

USDA . 2003. Linking land quality, agricultural productivity, and food security / *AER-823. USDA Economic Research Service. Pp 19-27.*

Vanichanont Pramote .2004. Thai rice: Sustainable life for rice growers. *FAO rice conference 04/CRS.13 7pp. FAO Rice Conference , Rome, Italy, 12-13 February, 2004.*

Van Tran, D .2010. Closing the rice yield gap for food security. *Cahiers options Mediteraneennes vol 58.* http://resources.ciheam.org/om/pdf

von Braun, J; Kennedy, E and Howarth B.1990. Commercialization of smallholder agriculture: Policy requirements for the malnourished poor. *Food Policy 15 (February):82-85.*

Wani, S.P., Sreedevi, T.K., Rockstrom, J and Ramakrishna, Y.S .2009. Rainfed agriculture – Past trends and future prospects in *Rainfed agriculture: Unlocking the potential.* Wani, S.P., Rockstrom, J and Oweis, T. Eds. CAB International, UK. 1-35

Weir Sharada .1999. The effects of education on farmer productivity in rural Ethiopia. *Centre for the study of African economies, University of Oxford, UK working Paper WPS99-7.*

Werner, R .2006. The Production function approach to calculating potential growth and output gaps: Estimates for EU member states and the US. *Paper prepared For the workshop on Perspectives on potential output and productivity growth organized by Banque de France and bank of Canada, April 24-25, 2006.*

West African Rice Development Association (WARDA) 2007. Africa Rice Trends Brief 2007 www.warda.org Accessed 4/9/2008

West African Rice Development Association (WARDA) and Nigerian Institute of Social and Economic Research (NISER) .2001. *Report of the Stakeholders' Workshop. November 8-9, Ibadan, Nigeria.*

Wiebe, K (2003) Linking land quality, agricultural productivity and food security. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 823.

World bank .2007. http://inweb18.worldbank.org

WRI .2006. World Resources Institute. http://earthtrends.wri.org

Yilmaz, I; Akcaoz, H and Ozkan, B.2004. An analysis of energy use and input costs for cotton production in Turkey. *Renewable energy 29:39-51.*

Yohannes, H and Holden, S .2001. Land redistribution, tenure insecurity, and intensity Of production: A study of farm households in southern Ethiopia. CAPRi Working paper no. 21. International food policy research institute (IFPRI), Washington, DC.

Youn, K.H .1992. The translog production function and variable returns to scale: *The Review of Economics and Statistics 74:546-552.*

Zeigler, R.S and Puckridge, D.W .1995. Improving sustainable productivity in rice-based rain-fed lowland systems of south and southeast Asia. *Geojournal 35.3: 307-324.*

Zepeda, L .2001. Agricultural investment, production capacity and productivity. *FAO economic and social development paper*. Food and agriculture organization of the United Nations, Rome.

Zohir, S .2001. Impact of reforms in agricultural input markets on crop sector profitability in Bangladesh. Bangladesh Institute of Development studies.

APPENDIX 1

Sampling procedure for selection of rice farmers

State	ADP zone	LGAs per zone	Selected LGAs	Sample size
Niger	Bida (zone 1)	8	Bida Gbako Katcha Lavun	100
	Kontagora (zone 3)	8	Mariga Wushishi Lapai Kontagora	100
Ekiti	Aramoko (zone 1)	8	Ekiti West Efon Irepodun/Ifelodun Ijero	100
	Ikere (zone 2)	8	Gbonyin Ikole Oye Ikole	100

APPENDIX 2

Questionnaire used for the study

Section A: Background information

1. Name of village ………………….
2. Local Government Area ………………
3. ADP zone ……………..
4. Sex of farmer Male ….. Female ……
5. Age ……
6. Marital status Married ….. Divorced …… Widowed ……. Single …..
7. Household size …….
8. Number of adults in household …….
9. Years of formal schooling …….
10. Primary occupation ……………
11. Experience in rice farming (years) ………..
12. Are you a member of any farmers' association/cooperative ? ………

Section B: General information on farmland

13. Total farmland area owned ……… hectares
14. Total farmland area devoted to rice cultivation ………. hectares
15. List three main crops (in order of preference) you grow on land not cultivated to rice.

	Crop 1	Crop 2	Crop 3
Land area (ha)			

16. Farmland acquisition

Source of Acquisition	Land area	Cost per annum
Family		
Hire		

Lease		
Others (specify)		

17. Provide information on the distance from your rice farm to the listed places

Location	Distance (Km)
Homestead	
Closest tarred road	
ADP office	
Market for farm output	

18. Purpose of rice farming Home consumption only ….. Commercial only …..
Both home consumption and commercial …… Hobby …..
19. Rice production system practiced Rain-fed upland …. Rain-fed lowland …..

Section C: Information and input use on rice farm

20. What is the source of your information on improved/new rice production technologies? …………………………
21. How many visits did you receive from extension workers last cropping season? ………
22. Machines and implements used on farm

Implement	Number owned	Years of use	Purchase price	Number rented	Rental cost
Cutlass					
Hoe					
Sickle					
Wheelbarrow					
Knapsack					
Tractor					
Others (specify)					

23. Rice seed planted

Type	Name	Quantity planted	Price/kg	Source (use code)
Improved variety				
Local Variety				

Code: 1 = farmers' cooperative; 2 = government institution; 3 = another farmer; 4 = private trader; 5 = Others (specify) …………….

24. Did you use fertilizer ? Yes …… No ……

25. If yes, provide more information

Type	Quantity used	Price/kg	Source (use code)
NPK			
Urea			
Others (specify)			

Code: 1 = farmers' cooperative; 2 = government institution; 3 = another farmer; 4 = private trader; 5 = Others (specify) …………….

26. Other agrochemicals used

Type	Quantity used	Price/litre	Source (use code)
Insecticide			
Herbicide			
Others (specify)			

Code: 1 = farmers' cooperative; 2 = government institution; 3 = another farmer; 4 = private trader; 5 = Others (specify) …………….

27. Labour used for rice production during the year

Activity	Month	Family labour (code A)			Non-family labour (code B)			
		Person(s)	No.	Hours	Type	No.	Hours	Cost
Land preparation								
Planting								
1st weeding								
2nd weeding								
3rd weeding								
1st fertilizer application								
2nd fertilizer application								
3rd fertilizer application								
1st herbicide application								
2nd herbicide application								
3rd herbicide application								
Bird control								
Rodent control								
Other pest Control								
Harvesting								
Threshing								
Winnowing								
Others (specify)								

Code A (Family labour): 1 = household head, 2 = wife/wives, 3 = children, 4= others

Code B (Non-family labour): 5= hired, 6= exchange labour, 7= communal, 8= others.

28. Rice harvested

	Quantity
Total rice output	
Rice consumed	
Rice sold	
Rice kept for seed	
Rice used as gift	
Others (specify)	

29. What was your income from rice alone ? ……………….. Naira.

30. What was your total farm income ? ………………… naira.

31. Do you think you produced enough rice, taking into consideration your total input?.

    Yes ……   No ……….

32. If no, what were the constraints (in order of importance)

    ………………………………………………………………………………………

    ………………………………………………………………………………………

33. What are your suggestions for increased rice production ?

    ………………………………………………………………………………………

    ………………………………………………………………………………………