COMPARATIVE ANALYSIS OF PRODUCTIVITY AND EFFICIENCY IN LOW AND HIGH EXTERNAL INPUTS TECHNOLOGY AGRICULTURE IN IMO STATE

BY

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DEDICATION

This work is dedicated to my parents- Chief Boniface A. Orieagwu and Lolo Mary O. Orieagwu, who sacrificed their comfort to make me comfortable and out of the sweat of their faces and blisters of their palms laid for me a strong academic foundation.

CERTIFICATION

I certify that this work "Comparative Analysis of Productivity and Efficiency in Low and High External Inputs Technology Agriculture in Imo State" was carried out by Anyanwu, Sixtus Onwukwe (20024201118) in partial fulfillment for the award of the degree of Doctor of Philosophy (Ph.D) in Agricultural Economics in the Department of Agricultural Economics of the Federal University of Technology Owerri.

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ABSTRACT

The study was designed to compare productivity and efficiency of Low External Input Technology and High External Input Technology Farms in Imo State. Specifically, it aimed at comparing the socio- economic characteristics of the two groups of farmers as well as their productivities, ascertain the factors influencing aggregate and individual resource productivities, determine production efficiency and returns to scale in the two farm types. The study was conducted in Imo State, Nigeria. Primary data used for the study were collected using structured questionnaire. The sample size comprised 80 Low external input technology and 80 High external input technology farmers who were selected using the multistage and purposive sampling techniques. The sampling frame comprised all the LEIT and HEIT farmers in Imo State. Data were analyzed using both statistical techniques, the Ordinary Least Square (OLS), multiple regression and profit function. The results of data analysis for the two farm types showed that farmland was more productive in the HEIT than LEIT farms while planting materials and organic manure were more productive in LEIT than planting materials and inorganic fertilizer in HEIT farms. Furthermore, man-days of labour and capital inputs are statistically significant in LEIT farms but non significant in the HEIT farm type at the 5% and 1% levels of probability though they possess the expected positive signs. The results of data analysis further showed that farm size, expenditure on planting materials, capital inputs, expenditure on organic manure, number of crops planted in a mixture in the farms, level of education and farming experience are the main determinants of aggregate agricultural productivity in LEIT farms. These variables are statistically significant at 1% and 5% levels. On the other hand farm size, capital input, number of crops planted in a mixture in the farm, distance to the nearest market, level of education, farming experience, man-days of labour, and non farm income are the main determinants of aggregate agricultural productivity in HEIT farms. These variables are statistically significant at 1% and 5% levels. A comparative analysis of aggregate agricultural productivity between LEIT and HEIT farms showed that LEIT farmers achieved higher aggregate agricultural productivity than HEIT farmers. The results of data analysis on production efficiency showed that HEIT farmers were relatively more technically efficient than the LEIT farmers, in the use of resources. However, both farm types are allocatively inefficient in the use of farmland, labour, planting materials, capital inputs and organic manure or inorganic fertilizer. The existence of resource use disequilibria in both farm types implies that there is still the possibility of increasing output at the current level of technology in the study area. The result also showed that the LEIT and HEIT farm types are equally economically efficient in the use of productive resources as there is no significant difference in their levels of economic efficiency. The result further showed that LEIT farmers experienced increasing returns to scale while HEIT farmers experienced decreasing returns to scale.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The agricultural sector was the mainstay of the Nigerian economy before and immediately after independence until the oil boom of the 1970's. In the period before the 1970's agriculture provided the needed food for the population as well as serving as a major foreign exchange earner for the country (CBN, 2003).

Nigerian agricultural development policy over the years has been informed by the belief that the development of agriculture is a *sine qua non* for the over all growth and development of the economy. This understanding constituted the basis of all efforts made in the planning and design of programmes and projects to ensure growth in the sector (CBN, 2003). Agriculture is the largest non oil export earner and largest employer of labour accounting for 88% of the non oil foreign exchange earnings and 70% of the active labour force of the population (FGN, 2001).

However, over the years the growth rate of agricultural production has either stagnated or failed to keep pace with the country's rapid population growth rate of about 3.2 per cent resulting in perennial food shortages, soaring food prices and massive importation of food by governments. While food production increases at the rate of 2.5 per cent, food demand increases at a rate of more than 3.5 per cent (FOS, 1996).

It is very obvious that the sustainable growth rates of the Nigerian economy cannot be achieved in the absence of increased agricultural output in the country. Harsch (2004) noted that higher output will directly reduce hunger and bring down the cost of food imports as well as have wider economic benefits, stimulating rural incomes and provide raw materials for African industries. The main thrust of Nigeria's agricultural development efforts, therefore has been to enhance and sustain the capacity of the sector to play this assigned role, with particular emphasis on the attainment of sustainable level in the production of basic food commodities, especially those in which the country has comparative advantage. It also involve developing the capability to increase the production of agricultural raw materials to meet the growing needs of an expanding industrial sector, as well as the production and processing of exportable cash crops to boost the nation's non oil foreign exchange earning capacity. This process of transformation from a predominantly subsistence agriculture to a highly mechanized farming to enhance agricultural production as well as ensure its sustainability has been undermined by the disincentives induced by the macroeconomic environment (CBN,2003). For instance the realignment of the Naira exchange rate, which resulted in the depreciation of the Naira, has increased the prices of imported agricultural inputs such as fertilizers, agro-chemicals, tractors and vaccines among others. In 1997, subsidies on fertilizers were removed completely but re-introduced in 1999 (CBN, 2003).The potential of these high external input technologies (e.g. inorganic fertilizer, agrochemicals, pesticides tractors etc.) in improving agricultural productivity in Imo state in particular and Nigeria in general is not in doubt. The small-holder farmer in Imo state appears to be in dilemma on the need to increase agricultural productivity in a harsh macroeconomic environment. In the face of the apparent scarcity and expensiveness of the high external input agricultural technologies , it becomes compelling to re-examine the low external input agricultural technologies, (e.g. organic manure, compost, animal manure, etc.) with a view to determining which of the two offers the farmer higher productivities and why.

1.2 Statement of the Problem

Analysis of food production in Nigeria shows that a large part (80- 90 %) is derived from small-scale farmers operating at or near the subsistence level with only modest excess production to supply the rapidly growing urban centres (Ajayi, 2001). Productivity growth appears to be the main determinant of income growth and poverty reduction. Government view increasing and sustaining agricultural productivity as a means of over all growth, poverty reduction and promotion of food security. In particular, it has been shown that agricultural productivity growth is more poverty alleviating than non agricultural productivity led growth (Nomaan, 2004).

On the other hand, Graves et al., (2004) observed that the significant reduction in the total number of the undernourished in the world in the past was as a result of the use of high external input agricultural technologies (HEIT) i.e. high yielding cereal varieties, together with high levels of inputs such as water from irrigation system, fertilizer to provide the nutrients needed by the varieties and pesticides to control any associated weeds, pests and diseases. These technologies according to him generally need a relatively high capital investment and a well functioning economic and physical infrastructure for effective implementation.

In order to increase farm level productivity, some scholars (Pretty, 1995, Snapp et al., 1998) propose labour intensive low external input technology (LEIT) while others argue that food security cannot be achieved without widespread adoption of HEIT. Proponents of LEIT often claim that the reliance on local sources of inputs is more sustainable, but the analysis of De

Jager et – al., (2001) suggests there is little difference between HEIT and LEIT in this respect. However, the disincentives induced by the macroeconomic environment on HEIT utilization such as removal of subsidy on fertilizer and re-alignment of the Naira exchange rate and consequent increase in the prices of imported agricultural inputs (such as fertilizer, agro-chemicals , tractor etc) have narrowed down its use.

Despite the continuing debate on the relative performance of the two approaches, Graves et al., (2004) noted that there are few studies that compare yields and production under the same soil and climatic conditions and over wide areas. Furthermore, both Tripp (2006a) and Graves et al., (2004) argued that there is little in the literature on the issues that need to be faced in scaling up production in LEIT.

Apart from the findings of Graves et al., (2004) and Tripp (2006a), previous studies on relative production efficiencies and agricultural productivities among small-holder farmers in the study area (Onyenweaku et - al 2000; Ohajianya and Onyenweaku, 2001, 2002; Olagoke 1991; Onyenweaku et – al; 1996, Anyanwu, 1993, 2005; Onyenweaku and Nwaru; 2005) appear to have been silent on the comparative analysis, productivity and efficiency in the HEIT and LEIT farm types. The gap in knowledge is what this study intends to fill.

1.3 Objectives of the Study

The broad objective of the study is the comparative analysis of productivity and efficiency in the low and high external input technology farming in Imo state. The specific objectives are to:

(1) estimate and compare the socio-economic characteristics of the two groups of farmers in the state;

(2) determine and compare productivity of resources in the HEIT and LEIT farms in the state;

(3) determine and compare the factors influencing aggregate agricultural productivity in the HEIT and LEIT farms in the state;

(4) determine and compare the factors influencing individual resource productivities in the HEIT and LEIT farms in the state;

(5) determine and compare the production efficiency of HEIT and LEIT farmers in the state, and

(6) estimate and compare the returns to scale among the two groups of farms in the state.

1.4 Hypotheses of the Study

The following null hypotheses were tested:

1. Aggregate agricultural productivity among LEIT and HEIT farms in Imo state are not significantly influenced by farm size, expenditure on planting materials, non farm income, crop mixture, level of education of household head, labour input, capital input, age of household head, household size, farming experience and distance to the nearest market.
2. There is no significant difference between aggregate agricultural productivities of LEIT and HEIT farmers in the state.
3. The HEIT and LEIT farmers are not equally technically, and economically efficient in the use of resource inputs.

1.5 Significance of the Study

Previous studies (Olagoke (1991), Obasi, (1995), Onyenweaku, et al., (2000), Nweke et al., (1992, 1994, 1995, 1999), Nweke (1996), Okorji (1983), Anyanwu (2005, 1993,2003), Ohajianya and Onyenweaku (2001, 2002), have examined different aspects of productivity and efficiency in the study area but none of them addressed the problems of high and low external input technology agriculture. This study intends to bridge the gap in knowledge. The studies also pointed to the low resource productivity and efficiency in Nigerian agriculture but were silent on whether they are obtainable in the high external or low external input agricultural technological divide. This study intends to fill this vacuum.

At the global level, Graves et al., (2004) argued that despite the continuing debate on the relative performance of HEIT and LEIT, that there are few studies that compare yields and production under the same soil and climatic condition. This is a challenge which the study addresses. Above all these, this study will also enrich current literature on the issues that need to be faced in scaling up production in these two farm types.

A comparative analysis of these two farm types in terms of their productivities will enable the farmers to make rational choice in order to increase productivity of farm output in a depressed economy.

In addition, a critical examination of resource use efficiency on both the high external and low external input technology agriculture will indicate for instance; where resource adjustments are needed for the purpose of increasing output per given unit of input.

1.6 Plan of the Study

This thesis is organized as follows:

Chapter one contains background to the study, statement of the problem, objectives of the study, hypotheses of the study, significance of the study and plan of the work.

Chapter two presents literature review.

Chapter three discuses the methodology used in this research work. Here, the study area, processes of sample selection, data collection and analytical tools were discussed.

The analysis of some socio-economic characteristics of the sampled farmers, results of empirical data analysis and discussion of findings are presented in chapter four.

Chapter five summarizes the work, highlights the policy implications of the findings and conclusion reached.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 Sustainable agriculture

The term most commonly used in framing a response to the environmental and equity challenges posed by dependence upon external inputs is 'sustainable agriculture'. Unfortunately, the term seems to create as many problems as it resolves. Although a precise and widely accepted definition of sustainable agriculture eludes us, the substitution of local resources for purchased inputs is certainly a common theme. Sustainable agriculture includes both an approach to evaluating agricultural development and a set of specific techniques and technologies (Tripp, 2006b). The approach features a number of concerns including an emphasis on the externalities of agricultural production particularly environmental costs.

With respect to technological approaches, the range of those espousing support for sustainable agriculture includes (at one extreme) those seeking to eliminate the use of all external (synthetic) inputs from farming and (at the other extreme) those who are simply willing to acknowledge the need for addressing certain environmental excesses in the pursuit of otherwise conventional and "high tech" agricultural development strategies.

Pretty (2002) present's sustainable agriculture as "farming that makes the best use of natures goods and services while not damaging the environment. Sustainable farming does this by integrating natural processes, such as nutrient cycling, nitrogen fixation, soil regeneration and natural pest control within food production processes. It also minimizes the use of non renewable inputs that damage the environment or harm the health of farmers and consumers. It makes better use of farmers knowledge and skills, thereby improving their self reliance, and it makes productive use of peoples capacities to work together in order to solve common management problems. Long term sustainability of LEIT, however, depends on the production of animal manure, and hence the availability of pasture (Graves, et al 2004).

As with many low external input agricultural (LEIA) systems, therefore, there is a reliance on nutrients collected and concentrated from a much wider area. Through careful integration of crops, livestock and trees, the long term sustainability of the system seems possible (Pantanali, 1996). In relation to its applicability to other areas, the system's economic sustainability rests on being able to grow crops all year round, which will not be feasible in areas with a pronounced dry season unless irrigation is available (Graves et al, 2004).

There are a number of approaches to the theme of sustainable agriculture such as, agro-ecology, organic agriculture, low external input technology agriculture (LEIT), permaculture, etc.

2.1.2 Agro-ecology

Those working on agro-ecology (Altieri, 1995, Uphoff, 2002a) are concerned about production systems rather than particular technologies. Agro-ecology recognizes that an agricultural system differs from a natural ecosystem because it includes external controls and sources of energy and lowered diversity; but it approaches the study of field crop cultivation as a system involving ecological processes such as nutrient cycling and predator-prey interactions.

2.1.3 Organic agriculture

Organic agriculture as defined by International Federation of Organic Agriculture Movement (IFOAM) includes all agricultural systems that promote environmentally, socially and economically sound production of food and fibres. Recycling nutrients and strengthening natural processes helps to maintain soil fertility and ensure successful production. By respecting the natural capacity of plants, animals and the landscape, it aims to optimize quality in all aspects of agriculture and the environment. Organic agriculture dramatically reduces external inputs by refraining from the use of synthetic fertilizers and pesticides, genetically modified organisms and pharmaceuticals. Pests and diseases are controlled with naturally occurring means and substances according to both traditional as well as modern scientific knowledge, increasing both agricultural yields and disease resistance (IFOAM, 2004).

An organic farm, properly speaking, is not one that uses certain methods and substances and avoids others; it is a farm whose structure is formed in imitation of the structure of a natural system that has the integrity, the independence and the benign dependence of an organism.

Methods of organic farming vary. However organic approaches share common goals and practices. In addition to the exclusion of synthetic agrichemicals, these include protection of the soil (from soil erosion, nutrient depletion, structural breakdown) promotion of biodiversity (for example growing a variety of crops rather than a single crop or planting hedges around fields) and outdoor grazing for livestock and poultry (USDA, 2007).

2.1.4 Permaculture

This is an interpretation of sustainable agriculture which is more comprehensive than that for organic agriculture. Permaculture envisions farm production in a holistic and integrated fashion, aims for self sufficiency, includes attention to compatible technologies for housing and energy provision, and offers its own strategies for community development (Tripp, 2006b). Rigid adherence to such ideologies according to Vaessen and de Groot (2004) may at times hinder progress in developing relevant technologies for resource –poor farmers.

2.1.5 Low External Input Technology

The examination of low external input agriculture must acknowledge that the issues at stake go well beyond the use of particular production resources. The concerns include the capacities of farmers and their communities and the nature of agricultural development (Tripp, 2006a). It is not difficult to understand why low external input technology (LEIT) agriculture has attracted so much interest and support in discussions about the future of farming in developing countries. Continuing rural poverty, the high cost of purchased inputs and a growing list of environmental problems all support the view that farmers should rely as much as possible upon local resources to enhance their soils and manage their crops (Tripp, 2006b).

LEIT takes as its focus the development of a range of technologies that complement or substitute for external inputs (and hence may be more accessible to farmers), provide significant environmental benefits and usually require local adaptations (Tripp, 2006a). LEIT does not always imply a strict reliance upon farm- level resources, and it is best to remember that the major motivation is to reduce reliance upon non- renewable resources rather than to limit trade in agricultural inputs. Among the most common target for reduction or replacement are manufactured pesticides (including insecticides, fungicides, and herbicides) through various examples of integrated pest management (IPM). Another target for LEIT is the substitution of mineral fertilizer in agricultural production.

The relative costs of inorganic sources of nutrients are a major determinant of the use of LEIT techniques (Graves et al, 2004).

2.1.6 The Concept of Low External Input Technology and High External Input Technology Agriculture

A school of thought is of the view that high external input agriculture (HEIT) approach as used since 1960 can also be used to address the demand for food in the next 50 years by improving the productivity of this group of subsistence farmers, perhaps using new emerging technologies such as genetic modification (Crossons and Aderson 2002). A second school of thought is that such an approach is not sustainable, and more over is damaging to the environment as the inputs of fertilizer and chemicals accumulate in neighbouring ecosystems. Thus technologies using low levels of external inputs readily available either on-farm or from nearby off-farm sources are seen by some experts as more appropriate and sustainable (Pretty, 1995). This approach often referred to as low external input agriculture (LEIT), emphasizes the use of techniques that integrate natural processes such as nutrient cycling, biological nitrogen fixation, soil regeneration and natural enemies of pests into food production process (Pieri, 1995, Snapp et al 1998). Efforts are also made to minimize losses from the system, such as by leaching or removal of crop residues. The use of non renewable inputs such as pesticides and fertilizers that can damage the environment or harm the health of farmers and consumers is also minimized, and more emphasis is placed on the use of such techniques as , for example intercropping, agro forestry, cover-crops, or animal manure. Usually but not always, such technologies are more labour intensive than the HEIT approach (Deugd, et al 1998). In many cases LEIT technologies are not new but are variations of those practiced by farmers for generation, who have sought to make use of resources such as vegetation or animal manure that have always been ready to hand (Graves et al, 2004). Thus the heart of the debate is not about whether either approaches work as clearly both do and have done, under the appropriate conditions and according to their own criteria. Rather, the central question concerns which approach can best address the future demand for food production while protecting the environment as much as possible. More specific questions relate to whether LEIT technologies really have the capability to maintain or increase productivity per unit area above current levels in Imo state. Certainly there is evidence to suggest that the relative rate of increase in crop yields through the use of HEIT is slowing down (Mann, 1997), although Crosson and Anderson (2002) argue that this is more likely due to the practice of quoting annual percentage increases of a constantly increasing baseline rather than absolute annual growth. Proponents of LEIT technologies often claim that the reliance on local sources of inputs is more sustainable but the analysis of De Jager et al (2001) suggests there is little difference between the two approaches in this respect, with both mining similar quantities of soil nutrients to generate farm income. Graves et al (2004) insists that despite the continuing debate on the relative performance of the two approaches, there are few studies that compare yields and production under the same soil and climatic conditions and over wide areas. With LEIT technologies in particular, Graves et al (2004) and Tripp, (2006a) posit that there is little in the literature on the issues that need to be faced in scaling up production from plot level to supplying input and meeting food demand on a larger scale.

2.1.7 Low External Input Technologies and Resource Utilization

Low external input technologies are those technologies designed to address problems of soil fertility and weed control; these include inter-cropping, alley cropping, cover cropping, and green manuring, biomass transfer, compost, animal manure and improved and enriched fallows.

2.1.7.1 Intercropping

Intercropping is the growing of two or more crops on the same piece of land within the same year. Various forms of intercropping have been a central feature of many tropical agricultural systems for centuries. Vandermeer (1989) had noted that intercropping can be divided into three general categories- full, relay and sequential intercropping -depending on the extent of physical association between the crops. Full intercropping involves complete association between crops planted at the same time, while relay cropping involves only partial association, in which a second crop is planted into an already standing crop before it is harvested. Sequential intercropping, where there is no physical association, is the extreme case where two crops are grown on the same land in the same year but not at the same time.

The main advantages of intercropping are in reducing the risk of total crop failure, and in product diversification-food crops are often mixed with cash crops to help ensure both subsistence and disposable income (Vandermeer 1989, Sing and Jodha 1990).

2.1.7. 2 Alley cropping

This is an agro forestry practice developed at International Institute of Tropical Agriculture (IITA) Nigeria in the 1970's in which hedgerows of trees and shrubs are established and annual crops are cultivated in the alleys between the hedgerows. The hedgerows are pruned before planting the crops and periodically while it is growing to prevent shading, with the pruning being applied to the soil as green manure and / or mulch. Between cropping cycles, hedgerows are usually allowed to grow without pruning. It was originally hoped that by incorporating fast growing nitrogen fixing woody perennials with crops, their abilities to cycle nutrients, suppress weeds, and reduce erosion would create soil conditions similar to those in the fallow phase of shifting cultivation. In this way, the cropping and fallow phases could take place simultaneously on the same land, allowing the land to be cropped for an extended period when long fallow periods are not feasible under the particular socio-economic conditions. Researchers saw the technology as the combination of farmers' accumulated traditional wisdom with the efficiency of modern science. (Kang, 1993).

2.1.7. 3 Cover crops and green manure

A cover crop is a crop grown to provide soil cover to prevent erosion by wind and water, regardless of whether it is later incorporated. Green manuring involves the incorporation of a crop while it is still mainly green into the soil for the purpose of soil improvement .Cover crops and green manures are generally annuals, biennial or perennial herbaceous plants grown in a pure or mixed stand during all or part of the year, and as such can be seen as a special case of intercropping. In addition to providing ground cover and, in the case of a legume, producing nitrogen, they may also help suppress weeds and reduce insect pests and diseases. Catch crops are cover crops that have been planted specifically to reduce losses of nutrients by leaching following a main crop.

2.1.7. 4 Compost

Compost is the aerobic, thermophilic decomposition of organic wastes to relatively stable humus. Although it makes use of the same decomposition processes occurring naturally the aim in compost- making is to control the conditions to a level that allows faster decomposition. The biophysical conditions that are required for effective composting are generally those that are required by the micro organisms at various stages of the composting process, i.e. good moisture levels, moderate temperature, mixed quality organic matter and a fairly neutral PH range. Composting is not a new technique for the improvement of soil fertility and structure, and tropical farmers have been aware for centuries of its impact on crop yields, soil structure and fertility, crop growth and vigour (Diop, 1999; Onduru et al., 1999). However in the Zai system used by farmers in Burkina Faso in times of drought, Roose et al., (1999), reported that the system involves digging holes (20 – 25,000 ha^{-1}), typically 30cm wide and 20 cm deep, filling them with compost, and planting seeds of sorghum, millet, and cowpea into them. According to him, the compost is made from farmyard manure, plant residues, garbage, and rock phosphate – a natural product from mines in Burkina Faso.

2.1.7. 5 Animal manure

The use of animal manure is related to its role as part of a larger system. In many subsistence-farming systems, there is a close interdependence between crop production, animal production, and possibly neighbouring forests and/or rangelands. In Nepal, Pilbeam et al., (1999b) reported that animals are grazed in the forest, crop residues and forage collected from the forest are used to feed housed animals, animal manure is applied to cropped areas, crop residues and forest litter are used for animal bedding, and animals are used to provide tillage and transport. But in certain areas of western Africa, some arable farmers make arrangements with itinerant herdsmen to corral livestock on their land (Waldie, 1990; Enyong et al., 1999). Farmers may also move their homesteads from place to place so that crops can be grown on that land to benefit from the manure left over by livestock (Ruthenberg, 1980). The use of animal manure as a source of crop nutrients is often a nutrient harvesting technique in which nutrients are gathered through grazing of a relatively large area and concentrated on a small area where crops are grown. Even where animals are stall fed, the nutrients they consume must be brought to them from else where, either as collected fodder or as purchased concentrate. The beneficial effects of animal manures on crop yields, when applied in sufficient quantities are well documented (Selvarajan et al., 1990; Drechsel et al., 1998 Ali, 1996).In many cases there may be a high opportunity cost of using manure as a fertilizer, and farmers may often value it more for uses other than soil fertility maintenance. Benefits obtained from manure include the provision of materials for plastering and building and fuel for heating and cooking (Murwiraa et al., 1995).

2.1.7. 6 Improved fallows

Shifting cultivators have traditionally alternated periods of crop production with periods of fallow in order to restore soil fertility and suppress weeds. In some cases, the cropping period only lasts 4-5 years while the fallow period may be as long as 30 years (e.g. Matthews et al., 1992a), during which time the land is usually unproductive in terms of generating a livelihood. In recent years researchers have focused on ways to shorten this period, and/ or to make some use of the land while it is fallow. Thus an “accelerated fallow “is where specific fast growing leguminous trees, shrubs, legumes and other plants are used to improve soil fertility faster than would occur otherwise, while an “enriched fallow “is where trees or shrubs of economic value are planted into the Fallow so that the farmer can derive some income from them while the land is regenerating (Garrity and Lai., 2000).

In general it has been found that short term fallows (less than 3years) growing leguminous trees or shrubs and trees can increase crop yields compared to the natural fallow control (Szott et al., 1999).

Other benefits derived from improved fallow include reduced soil erosion (Brodd et al., 2002) in northern Vietnam and suppression of weeds over a number of years where woody perennials and cover crops are used (Gallagher et al., 1999).

A major disadvantage of both the natural and accelerated fallow systems is the length of time it takes for any financial benefits to accumulate (Grist et al., 1999). Kaya et al., (2000) observed that improved fallows in Mali were not attractive to farmers if their sole purpose was soil fertility improvement. The technologies so far discussed are used by people and as such must have some resource implications. Amede et-al., (2001) noted that in Ethiopia adoption of various technologies such as cover cropping and crop residue incorporation related as much to farm size and availability of labour as to the conditions of the soil.

2.1.7. 7 Land Utilization

Land tenure is also an important issue influencing the use of LEIT. It is generally thought that land users who do not own their land have less incentive to invest in technologies that take some time for soil fertility benefits to accrue (Tripp, 2006b). Share cropping is one such example, where a farmer exchanges a proportion of farm output in exchange for the right to crop an area of land (Ellis, 1988). Furthermore, fragmented landholdings may result in a single farmer having to transport inputs to several isolated plots of land in several different locations. This difficulty is particularly great with the use of biomass transfer technique, where several tones of biomass per hectare may be required.

2.1.7. 8 Labour Utilization

The labour required to make use of LEIT technologies may also constrain their adoption. Often household labour may need to be supplemented with that purchased from off the farm. Ali (1999) in a study of farmers in Asia found the cost of labour to be partly responsible for making nutrient supply through organic matter less cost effective than through mineral fertilizers, a situation which is likely to get worse due to rapidly rising wages. Similarly the cutting and carrying of biomass, such as from tithonia is extremely labour intensive particularly if it is to supply the full crop P requirement in a P- deficient soil (Buresh et al., 1997). For many farmers, weeding is one of the most labour – demanding activities undertaken. Gill (1982) noted that hand-hoe weeding in India required between 200 and 400 man days per hectare and that two weeding were needed during the growth and development of many field crops.

2.1.7. 9 LEIT and Gender Issues

Gender issues are also important. Women make up a sizable proportion of tropical farmers, and it is they who most often focus on subsistence crops, generally using lower inputs of organic and inorganic fertilizers than men (Gladwin et al., 1997). In a study on constraints faced by women using organic agriculture, Gladwin et al., (1997) found that lack of capital prevented them from investing in either organic or inorganic fertilizers, lack of land limited their use of low-input organic techniques, and lack of labour limited their ability to undertake the activities that were required to implement such techniques, particularly as most women were also solely responsible for household duties and child care. In particular female headed households can have considerable difficulty in undertaking some of the heavier tasks involved in composting, such as preparing the compost pits (Diop, 1999).

2.1.8 High External Input Agricultural Technology

As the name implies, high external input agricultural technology (HEIT) are agricultural technologies that utilize high external inputs such as inorganic or chemical fertilizers to augment nutrient depletion from the soil, pesticides to control pests, herbicides to control weeds and irrigation facilities for water management in the farms which are often beyond the financial reach of the small – holder farmers (CBN, 2002; 2003; Imahe et-al., 2005; Tripp, 2006a; Obasi, 1995; Ohajianya et-al., 2004; Reardon et al., 1997, Graves et – al., 2004). Adoption of the researcher developed high external input technology in sub-Saharan Africa according to De Jager et al., (1998) has been very disappointing for a variety of reasons. Two factors according to him have played crucial roles; farmers were involved only in the final stages of technology development while the technologies were assessed at the crop or livestock activity level only, which does not match with the complex and multiple goals of a farm household at farm level.

The role of fertilizer in increasing agricultural productivity has become a surprisingly controversial topic. It seems self evident to say that fertilizer increases productivity. Yet there have been many attempts to remove fertilizer from the list of key productivity – enhancing options worthy of government and donor policy support. Among the reasons given for down grading its importance in Africa according to Reardon et al., (1997) are its riskiness under conditions of low or erratic rainfall, its relatively low yields response when compared to results in Asia and Latin America as well as its high distributive costs in a context of low effective demand and poor storage facilities and roads.

The upward trend in fertilizer consumption in the early 1980's in Nigeria continued into the 1990 and peaked in 1993 with total consumption reaching 1590 thousand metric tones. Thereafter fertilizer consumption declined consistently from 1010 thousand tones in 1994 to the lowest level of 357.8 thousand tones in Nigeria in 2001. The sharp increase in fertilizer utilization in the early 1990's was sustained by subsidy which was sometimes as high as 75% of the total cost per bag, but the level of subsidy gradually fell to between 50 and 25% as reflected in the sharp decline in fertilizer use from 80kg/ha to 23kg/ha in 1996 and 2000 respectively, compared with the minimum of 200kg/ha internationally recommended standard (CBN, 2003).The Food and Agricultural Organization (FAO) contends that for Africa to achieve 3% annual growth in agricultural output it is required to adopt a 6- fold increase in fertilizer use over the next 20 years (WDR, 2003). However, multiple regression results on basic grain yields revealed that fertilizer application rate was the main and highly significant determinants of yield (Tripp, 2006b). This implies that if insufficient quantities of fertilizers are applied, the expected increase in yield may not be realized.

In Nigeria some of the major constraints to optimum output growth in 2001 were inadequate supply of fertilizers and other inputs as well as tardiness in supply and distribution of some of these inputs (CBN, 2002). On the other hand given the worsening valuation of the Nigerian currency (the Naira) against the pound and dollar, the prices of imported agricultural inputs like fertilizer herbicides, avicides, machinery and farm drugs make their acquisition almost impossible by the common farmers who constitute the bulk of the producers (Imahe et al., 2005, Tripp, 2006a). This makes the search for an alternative technology that is socially just, environmentally friendly and economically viable a necessity.

An important intervention to reduce the risks of flooding and drought and increase the likelihood of adoption of improved technologies is the improvement of water management. Minten et al., (2000) found that irrigation had a significant and positive effect on production but its magnitude was relatively small. In a review on the impact of public spending on irrigated perimeter productivity over the last twenty years in Madagascar (World Bank, 2005), rehabilitated irrigation infrastructure is shown to increase paddy yields by 1 ton/ha. Jacoby et al., (2006) found similar results in their survey in the Lac Alaotra area when they compared *maille* (modern irrigation) versus non *maille* (traditional irrigation) plots. However this technology is beyond the reach of the smallholder farmers in Nigeria and the mandate for which River Basin Development Authority were launched in 1976- essentially to encourage river basin farming through irrigation facilities were not achieved (Imahe et al., 2005). It is also regrettable, that irrigation schemes have over the years fallen in disarray in Madagascar as water user organizations did not have the capacity to organize themselves to manage the schemes properly (Droy, 1997; World Bank, 2003, 2005). They also reported that while farmers are willing to pay for improved irrigation infrastructure through water user associations, the amounts they are willing to contribute are significantly below the costs- and significantly below international standards.

2.1.9 External Inputs and Agricultural Development

The 1960s was a time of great hope for agriculture in developing countries. It marked the beginning of the Green Revolution, the principal manifestation of which was the spread of short-strawed, fertilizer-responsive varieties of wheat and rice that led to vast increase in food supplies in many Asian countries (Tripp, 2006b). For a while, according to Tripp, it looked as if the strategy of supplying appropriate varieties and complementary fertilizers, pesticides and other inputs could bring an end to rural poverty and chronic food shortages. The formular was based on provision systems, often subsidized, for external inputs, and relied upon technology packages whose practices were similar to those used in industrialized countries.

Within the same period, however, another revolution was also beginning to take shape, marked by the publication of the *Silent Spring* by Rachel Carson (1962). This publication provided an inventory of the environmental and health consequences of an ever- growing dependence upon insecticides in agriculture and elsewhere.

As agricultural development programmes tried to redress this imbalance and to devote resources to technologies appropriate for more challenging environments, the top -down nature of the Green Revolution approach was increasingly called into question (Tripp, 2006b). It was recognized that farmers in complex, diverse and risk prone areas (Chambers, 1997) could not take advantage of standardized packages of practices and that other strategies for technology generation would be required.

By this time, environmental problems caused by dependence upon external agricultural inputs were well documented for both industrialized and developing countries (Conway et al., 1991). Fertilizers were an increasingly important component of agricultural development programmes, and although they offered higher yields, they sometimes caused farmers to abandon traditional techniques of soil fertility maintenance. Access to irrigation grew, bringing with it new possibilities of crop production, but also instances of salinization and threatened water tables (Tripp, 2006b). Agricultural expansion and mechanization were at times, the cause of increased soil erosion and appearance of plough pans. Not only did increased use of inputs raise questions about environmental sustainability, but the costs of the chemicals, irrigation and mechanization were often subsidized, raising further concerns about the capacity to support these strategies in the long term.

The combination of growing environmental awareness, the increasing role of NGOs in donor-led agricultural development and the realization that, in many cases, agricultural progress depended crucially upon local knowledge and local solutions was responsible for a significant shift in attitude regarding agricultural technologies (Tripp, 2006b). Such a shift would not only mitigate further environmental degradation, but would also help to build up local capacities and promote the development of well adapted farming methods.

2.1.10 Concept and meaning of agricultural productivity

2.1.10. 1 Input Productivity

Input productivity is the output derived from the use of a standard unit of an input. This ratio is conditioned by the technology and quantity and quality of all inputs used. Farm or agricultural productivity measures can be defined with one to all crops in the numerator. When there is more than one input, input quantities are aggregated using prices as weights (e.g. with a divisia index). When all crops of the farm are in the numerator and all inputs in the denominator, one has an index of total factor productivity (TFP). When a single input is used (with one or more output) one has partial factor productivity. TFP calculations in many areas are constrained by missing input prices (from missing markets) especially for land and manure and to a lesser extent labour (Kelly et al., 1995).

To compare input productivities across goods or to aggregate over goods, productivities are commonly valued at the output price. For example the marginal product of land, multiplied by the price of the good produced is the "marginal value product of land "or land MVP. In theory if the producer is economically rational and there is no constraint on the use of or access to inputs the MVP of the input should equal the pecuniary factor price (which is termed "allocative efficiency "). If however the farmers' access to the labour market is constrained or the farmers lack complementary inputs, the MVP of labour can be below the wage indicating excess use of labour. Labour may be" bottled up "on the farm. Or if the MVP of seed is above its price (because of constraints in access to seed), that means that farmers could efficiently use more seed. If the constraint were removed, farmers would use more seed and the MVP of seed would decline until it equaled the seed price. Moreover with the same conditions of economic rationality and lack of constraint on input, the MVPs of a given input should be equal across crops on a given farm. If they are not equal, it could be because farmers have input access constraints (e.g. limits to the type or quality of land on which the farmer can grow cassava) or have non optimal behaviour due to presence of risks.

Calculations of marginal productivities require estimation of production functions. The production functions shows output as a function of variable inputs (labour, manure, fertilizer) and quasi fixed and fixed inputs (tools, equipment, land) and conditioning factors such as rainfall and soil quality. Input use and agricultural productivity are two mutually influencing factors determining agricultural output. Increase in total factor productivity of the agricultural production show to what extent agriculture is contributing to the over all economic growth of a specific country (Wilfred, 2004). However, Stark and Bottoms (1980) observed that the concept of productivity denotes the trend of productiveness of the factors of production; labour, land, materials and capital, and that it is useful to identify this trend as a measure, a ratio or a rate of returns, a relationship between output and input over a period of time. According to them productivity is linked with efficiency; which is the aspect of productivity concerned with the utilization of resources to produce a given output rather than simply the rate at which input generates output. It was further identified that efficiency has a number of facets: the rate at which inputs generate output; the utilization of inputs to produce outputs and the potential output which may be obtained from specific input. Thus the degree of resource utilization must influence the productiveness of labour and capital and so the two aspects of productivities and efficiency are closely related. However efficiency also contains the additional notion of the effectiveness of resources utilization measured against potential. Another study by Mark (1980) identified two broad classes of productivity measurement. The first expresses productivity as the relationship of output to one type of input such as labour, capital or energy while the second expresses productivity as the relationship of output to a combination of inputs. The former measure relates output to one input and do not measure the specific contributions of the factor to production; rather they express the joint effect of a variety of inter related influences such as changes in technology, substitution of one factor for another, utilization of capacity, skill levels and the efforts of the work force and managerial and organizational skill on the use of the factors in the generation of output.

Similarly, Bernolak (1980) further opined that the measurement of output is the first major element of productivity analysis since the objective of productivity measurement is to find out how to produce outputs of desired goods and services with the minimum amount of human and physical resources. He further contended that output can be measured in many ways at various points in the economic chain from many angles with various yardsticks and by different methods. Thus for a better understanding of their significance and in order to improve the measures, the various concepts and methods have to be clarified and reconciled particularly if meaningful international productivity comparisons are to be developed. The following three guiding principles of productivity measurement have thus been suggested:

(a) Inputs and outputs should match, should be taken from the same universe and should relate to the same period.

(b) Output and inputs should be measured independently from each other. If the available primary data do not meet these requirements, suitable adjustments and weighting procedure are necessary.

(c) Output measures should take quality variations and changes into considerations.

Increase in agricultural output can come from two sources, the use of additional inputs and increased productivity resulting from improved technology (Fan, 1991). Methods for assessing contributions to productivity growth have included the following;

(i) Index numbers or growth accounting techniques (Antle and Capalbo, 1988; Diewert, 1976),

(ii) Econometric techniques (Capalbo and Vo, 1988) and

(iii) Mathematical programming procedure (Chavas and Cox, 1992).

The drawbacks of these methods are as follows. Growth accounting imposes strong assumptions about the technology, while econometric approaches are data intensive. Both accounting and econometric methods require that the data be aggregated. Mathematical programming methods while relatively less restrictive are not statistical and therefore precludes hypotheses testing and construction of confidence intervals. The growth accounting or index approach involves compiling detailed accounts of inputs and outputs, aggregating them into input and output indexes, and using these indices to calculate a total factor productivity (TFP) index. In using the divisia index numbers and their relations to production theory, several strong assumptions are made about the technology and the industry and clearly these assumptions are not likely to be appropriate in many cases (Caves, et al 1982a, b). Apart from this, another disadvantage of the index number approach is that the calculations are not based on statistical theory, so statistical methods cannot be used to evaluate their reliability. However, Antle and Capalbo (1984) argued that the index number calculations can be used when econometric methods are infeasible.

Econometric approach to productivity measurement is based on econometric estimation of the production technology, and production change and technology change are synonymous (Antle, 1984a). In this approach the production function may be specified in the Cobb- Douglas form with a constant exponential rate of extended Hick-neutral technological change. The equation is specified as follows;

$$Q_t = A_t X^{a1}{}_{1t} \ldots\ldots X^{an}{}_{nt} \quad \ldots\ldots \text{eqn (2.1)}$$

Where

$$At = e^{aot} \quad \ldots\ldots \text{Eqn (2.2)}$$

Thus the measured rate of productivity growth under constant returns to scale is

$$TFP = d\text{Ln } At/dt = a_o \quad \ldots\ldots \text{Eqn (2.3)}$$

The rate of growth similarly can be inferred from econometric estimate of either the primal (production) function or the dual (cost or profit) function. However Antle and Capalbo (1984) are of the view that the trans-log model can also be used to measure change in total factor productivity in a manner similar to the Cobb- Douglas model. According to them a significant advance in the econometric approach was achieved by combining developments in duality theory and flexible functional forms with econometric theory to improve estimation efficiency. Studies employing flexible functional terms were introduced by Berndt and Christensen's (1973b) seminal paper on the trans-log production function. The methodology involves specifying a function representing the technology (a production, cost or profit function) and econometrically estimating it or its derivation (Antle and Capalbo 1984). The econometric approach has a major advantage of allowing the researcher to relax some of the assumptions required for index numbers but only at the cost of necessitating other assumptions (Diewert, 1980b; Nadiri, 1970) Estimation of production function such as the translog with aggregate data requires that the outputs be aggregated into a single index, so input-output separability must be assumed. (Antle, 1984a, b). The translog econometric production function can be estimated without making any assumptions about neutrality of technological change returns to scale, or industry equilibrium (Diewert, 1980 b, Nadiri 1970).

2.1.10. 2 Determinants of Agricultural Productivity.

Output per unit of land or crop yield is commonly used by agricultural scientists to assess the success of new production practices. Land productivity is also used by national policy makers to assess agricultural production for meeting national food security needs. Output per agricultural worker, on the other hand, may be a more important indicator of rural standards of living and welfare (Block, 1995). Recognizing that food may be acquired through exchange as well as production, income becomes an important determinant of access to food and thus of food security. As a result, labour productivity may be particularly important as indication of the ability of agricultural workers to acquire sufficient food, whether or not they produce food themselves. Beets (1990) classified factors affecting agricultural productivity into

:(1) Physical factors which include land area, climate and soil.

(2) Technological factors, which is availability of know-how, and inputs

(3) Human factors, - the way society makes use of factors (1) and (2).

One of the most appropriate and successful ways of raising agricultural productivity may be through improvements in crop husbandry, better weeding, better plant configuration, use of better planting materials, better soil fertility management, and better timing of operations, better systems manipulations ,rational crop selection, optimal use of available labour, use of external inputs such as fertilizers, machines and pesticides, lower soil fertility especially in the tropics also constraints agricultural productivity, while environmental degradation in the form of soil erosion produces considerable declines in productivity.

Apart from physical factors; appropriateness of technology has also been found to affect productivity. At times when the technology is available, logistic and financial constraints or even communication problems may arise. Technologies introduced to farmers must be such that they are appropriate for use under the conditions in which the factors operate. In certain cases inappropriate and / or incomplete technologies have been introduced without due consideration to the consequences. Appropriate technologies must also be disseminated through good agricultural extension services that are better coordinated between different agencies (Beets, 1990). Through commercialization, markets and pricing policies have also been found to affect agricultural productivity. Low prices are disincentive to farmers. Improvement in the economic environment in which farmers operate such as reducing the risk to farmers and by better price policies may serve as incentives to farmers to produce more (Beets, 1990).

Reardon et al (1997) argued that farm size, and land tenure, organic inputs and conservation investment, seed, animal traction, fertilizer non cropping income and well functioning inputs and output markets are the major productivity determinants.

(1) **Farm Size and Land Tenure**

Reardon et al (1997) observed that land rental as compared to ownership discourages use of fertilizer, organic matter and soil conservation. In addition smaller farms which had higher land productivity than larger farms tended to have surplus labour.

(2) **Organic Inputs and Conservation Investments**; Organic inputs and conservation investment practices add organic matter to the soil, conserve soil nutrient (prevent erosion) and help water retention (e.g. bunds and tied ridges, terraces) and increase productivity by increasing soil moisture. Conservation investments are complementary with improved input and organic matter.

(3) **Seed:** Case studies (Crawford, 1993) point to the seed as one of the most important determinants of productivity. Plant breeding programmes have developed improved cultivars that have increased productivity or maintained productivity in the face of worsening environmental conditions. Reardon et al (1997) opined that the productivity enhancing potential of seed is dependent not only on the development of appropriate varieties but also on programs that multiply and market the seed in such a manner that ensures quality, availability and affordability.

(4) Animal Traction: Pingali et al (1989) observed that animal traction has historically been associated with the following potential benefits; (a) increase in area cultivated, (b) increase in land yield through improved seed bed preparation, deeper ploughing, moisture conservation (c) income generation through off farm transportation (d) reduction in drudgery (potentially freeing labour) and (e) facilitation of tied ridging for water retention and soil conservation. Farmers use tractors mainly for ploughing and sometimes for seeding and weeding.

In general, researchers have found that the economics of animal traction are problematic for farmers producing only subsistence food grains (such as millet and sorghum) but becomes more favourable in cash cropping areas. On the other hand Eicher and Baker (1982), noted that" the presence or absence of a cash crop is a central determinant of farm level profitability of animal traction (using evidence from Northern Nigeria, peanuts in Senegal, cotton in southern Mali, and cotton in northern Cameroon).

(5) **Fertilizer:** It seems self evident to say that fertilizer increases productivity. Yet there have been many attempts to remove fertilizer from the list of key productivity enhancing options worthy of government and donor policy support in Africa because of its riskiness under conditions of low or erratic rainfall, its relatively low yield response in Africa when compared with results from Asia and Latin America as well as high distributional costs (Reardon et al 1997).

(6**) Non Cropping Income**: Non cropping income earned by households is important to increasing farm input use and hence cropping productivity, and intensification. Reardon et al (1997), shows that non cropping income is important in Burkina Faso to the purchase of fertilizer where institutional credit is not available. According to them the importance of non cropping income in the reduction of household income instability and risk by diversifying income sources are well known.

2.1.11 The Concept of Efficiency of Resource Use:

The measure of the performance of a production system is normally assessed in terms of the achievement of its objective. The concept of efficiency is concerned with the relative performance of the processes used in transforming given inputs into output. In a market economy, the commonly assumed goal of a production system is economic efficiency.

Sankhayan (1988) pointed out that the types of efficiency relevant to the economists include- economic efficiency, allocative efficiency and price efficiency. Mijindadi and Norman (1982) distinguish between at least two types of efficiency; allocative and technical efficiencies.

Allocative efficiency refers to the choice of an optimum combination of inputs consistent with relative factor prices while Technical efficiency refers to the ability of firms to employ the "best practice" in an industry so that not more than the necessary amount of a given set of inputs is used in producing the "best" level of output. The extent to which allocative and technical efficiencies are attained is generally referred to as production efficiency by French (1977). However, Farrell (1957) argued that the concept of economic efficiency provides a theoretical foundation for the measure of the production methods performance, though its validity has been questioned by a number of authors (Kalijaran and Flinn1983), Ellis, 1988). Farrell defined production efficiency in three related terms. First, he defined technical efficiency as the measure of a firm's success in producing maximum output from a given set of inputs, when a range of alternative technologies are available to the farmer. Second, he defined "price efficiency" or allocative efficiency as the measure of a firm's success in choosing an optimal set of inputs, the technology of production already having been done. Third, he defined "overall efficiency "or" economic efficiency" as the simple product of the technical and price efficiencies. The achievement of either one of the efficiencies may be seen as a necessary but not sufficient condition to ensure economic efficiency. According to Doll and Orazem (1984), the necessary condition of economic efficiency is met in the production process when there is (a) no possibility of producing the same amount of product with fewer inputs and (b) no possibility of producing more of the product with the same amount of inputs. In production function analysis; this condition is met in stage two, which is when the elasticity of production is equal to or greater than zero and equal to one.

As stated above several authors have raised criticisms about the interpretation of efficiency measures. Pasour (1981) argues that performance standards derived from the assumption of profit maximization should not be used to measure the performance of enterprises whose objective function includes elements other than profit. Ellis (1988) contends that observed inefficiency may be due solely to our inability to measure inputs accurately. Another pertinent argument suggests that the notion of efficiency is relevant only within the narrow confines of the perfectly competitive equilibrium and hence is irrelevant to real- world problems (Ellis, 1988). As a final criticism can be added the difficulty of interpreting a static efficiency measure in the dynamic setting of agricultural decision –making. To avoid many of these criticisms leveled upon efficiency concepts, Ellis (1988) advises that the producer‘s performance should be estimated only in terms of technical efficiency. This is because measures of technical efficiency rely less heavily on the assumptions of perfect knowledge, perfectly competitive markets, and the profit maximization objective. There is no absolute standard that can be defined to know with accuracy the highest levels of technical and economic efficiency results achievable at any given time and place (Paris, 1991).The only feasible alternative is to measure technical and economic efficiency relative to a group of farmers such as compound and non compound farms

(Onyenweaku, et – al, 1996, Anyanwu, 2003, 2005, 1993), Cooperative and Non cooperative farmers (Nwaru, 1993). Technical efficiency is therefore, a relative concept in so far as the performance of production unit is usually compared to a standard (Kalirajan et al, 1983).

2.1.12 The Concept of Production Function

This concept is basic to the development of the theory of the firm in micro-economic theory. In the classical non stochastic theory of the firm, a production function is defined as a schedule showing the maximum output that can be produced from a specific set of input, given the existing technology. It is the technical relationship between resource input and product output and determined by local condition such as soil type, climate and techniques used in production (Upton, 1973).

The production function can be stated in the implicit form as;

$$Q = f(X_1, X_2, X_3, \ldots, Xn) \qquad \text{eqn. (2.4)}$$

Where

Q = output

Xi (I = 1, 2 … n) = Variable inputs.

This purely mathematical or engineering concept forms the core of all resource use economics.

The relationship described in equation (1) above is the total physical product (TPP). A number of production parameters can be derived from this production function. They include the average physical product (APP), the marginal physical product (MPP), elasticity of production (Ep) and return to scale among others. Olayide (1982), Sankhayan (1988), Dillon (1961) described these parameters.

APP is the ratio of TPP to the quantity of variable resource input used in the production of that level of output. Algebraically it is derived as

$$APP_i = Q/X_i \qquad \text{...... eqn. (2.5)}$$

The MPP is the addition to TPP as a result of a unit change in the variable resource. It is the slope of the TPP and is given by

$$MPP = \Delta Y/\Delta Xi \quad \text{or } MPP = dY/dXi \qquad \text{eqn. (2.6)}$$

The elasticity of production (Ep) is a concept that measures the degree of responsiveness of output to changes in input. The coefficient of elasticity of production is given by

Ep = percentage change in output / percentage change in input.

$$= \frac{\{(Yi - Y_o)/Y_o\}(100/1)}{\{(Xi - X_o)/X_o\}(100/1)} = \frac{\Delta Y / Y}{\Delta X / X} = (\Delta Y/\Delta X)(X/Y) = MPP/APP \qquad \text{........... eqn. (2.7)}$$

Ep is used to demarcate the stages of production.

If Ep > 1, it is stage 1 of production, if Ep is $1 \leq Ep \leq 0$ it is stage 2 of production and if Ep < 0, it is stage 3.

Returns to scale is purely a technological relationship between inputs and corresponding output. It is the relationship between the scale on which a farm operates and the level of its costs. There are three types of returns to scale, these are constant, decreasing and increasing returns to scale.

The functional forms which were estimated in this study include:

(i) Linear function

This is mathematically expressed as

$$Q = bo + b_1X_1 + b_2X_2 + \ldots\ldots + bnXn + e \quad \ldots\ldots\ldots\ldots \text{eqn. (2.8)}$$

$$= bo + \sum biXi + ei \ldots\ldots\ldots\ldots \text{eqn. (2.9)}$$

Here $MPPxi = dQ/dXi = bi \ldots\ldots\ldots\ldots$ eqn. (2.10)

$$APP = biXi/Xi = bi \ldots\ldots\ldots\ldots \text{eqn. (2.11)}$$

$$Ep(xi) = MPPxi / APPxi = bi / bi = 1 \ldots\ldots\ldots\ldots \text{eqn. (2.12)}$$

This functional form assumes a constant marginal physical product, irrespective of the scale of operation, it assumes an additive relationship between inputs and outputs and does not make allowance for increasing or diminishing returns; hence it has a limited use in agricultural economic research.

(ii) Semi – Log function

This has the functional form

$Q = bo + b_1 \log X_1 + b_2 \log X_2 + \ldots + bn \log Xn + e$ ……...................eqn. (2.13)

$MPP = dQ / dX = bi / Xi$ ………………………………………eqn. (2.14)

$Ep = MPPxi / APPxi = (bi / Xi)\ (Xi / Q) = bi / Q$ ………… eqn. (2.15).

(iii) Power (Double log) function

This has the algebraic form

$Q = aX_1^{b1}\ X_2^{b2}$ ………………………………........ …… eqn. (2.16)

When equation (13) is linearized it becomes:

$Ln\ Q = Lnao + a_1 LnX_1 + a_2 LnX_2 + \ldots + an\ LnXn$ …eqn. (2.17)

Here $MPP = dQ / dXi\ \ bia\ X_1^{b1}\ X_2^{b2} / X_1$ ……………………..eqn. (2.18).

$Ep = (b_1 aX_1^{b1}\ X_2^{b2} / X_1)\ (X_1 / aX_1^{b1}\ X_2^{b2}) = b_1$ ………… …eqn. (2.19)

(iv) Quadratic function

This has the algebraic form

$Q = a + bX + cX^2$ .... .eqn. (2.20)

Or

$Q = ao + b_1X_1 + b_2X_2 – b_3X_1^2 – b_4X_2^2 + b_5 X_1X_2$ ………… eqn. (2.21)

$MPP = dQ / d X_1 = b_1 - 2b_3X_1 + b_5X_2$ ……………… eqn. (2.22)

$Ep = X_1(b_1 - 2b_3X_1 + b_5 X_2)/(a + b_1X_1 + b_2X_2 – b_3 X_1^2 – b_4 X_2^2 + b_5X_1X_2)$

………………………………………………….eqn. (2.23)

(V) Exponential function

This is mathematically expressed as;

$$Q = ae^{(b1x1 + b2x2 + \ldots + bnxn)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{eqn. (2.24)}$$

When linearized in the logarithm function this becomes

$$\text{Ln } Q = b + b_1X_1 + b_2X_2 + \ldots + bnXn + e \quad \ldots\text{eqn. (2.25)}$$

From equation (21) $MPP_1 = dQ / d\,X_1 = b_1\, ae^{b1x1 + b2x2} \ldots\ldots\ldots\text{eqn. (2.26)}$

$$Ep_1 = b_1\, ae^{b1x1 + b2x2} \,.\, X_1 / ae^{b1x1 + b2x2} = b_1x_1 \quad \ldots\ldots\ldots\text{eqn. (2.27)}$$

2.2 Empirical Framework

2.2.1 Socio-Economic Characteristics of LEIT and HEIT Farms

2.2.1.1 Socio-Economic Characteristics of LEIT Farms

Intercropping

In Zimbabwe, Chivasa et al., (2000) reported that farmers intercropped sorghum, with cowpea, pumpkins, cucumbers and watermelon to provide nutritional and livelihood benefits. This implies that the number of crops in a mixture were four. Intercropping is most likely to be practiced on small farms, in areas where land is scarce forcing the simultaneous production of different crops on the same area of land. For instance, Ali (1999), in a survey of data from India, Nepal and the Philippines, found that the attractiveness of intercropping increased as land and labour cost grew. The Machobane farming system in Lesotho (IIRR, 1998) is an example of a system incorporating intercropping. In this system, despite the crop cover, weeding is essential, and represents a major labour input. Overall, labour inputs are high, and perhaps reflecting this, annual productivity is three times higher than the traditional system, allowing a household of five people to be self-sufficient on 0.4ha of land (Pretty, 1999).

Alley Cropping

Graves et al., (2004) reported that Nigerian farmers gave the high labour demand for establishment and management of the hedgerows, and incorporation of the biomass into the soil as the main constraints. Other studies have shown similar results (e.g., Reynolds et al., 1991; David, 1995; Craswell et al., 1998), with many adopters specifically citing the labour required for pruning as being the most difficult aspect of alley cropping. However, Hoang Fagerstrom et al., (2001) note no difference in labour requirements between a monocrop and *Tephrosia* alley crop in Vietnam. An abundance of available land has also been found to be a factor constraining uptake of alley cropping. Whittome (1994), in his study of farmer experience in Nigeria and Benin, found that in most cases, land was still sufficiently abundant for them not to consider soil fertility decline as a problem and therefore not to find alley cropping attractive. In Kenya, Swinkels and

Franzel (1997) found that alley cropping was most attractive in areas where the population density was high, farms were small, and labour was plentiful. Access to capital is another key socio-economic factor. For example, Cenas et al. (1996) have shown that adoption may be higher where farmers have off- farm sources of income, relatively large farms, and were interested in cash cropping. Security of tenure and long term access to land are important issues affecting uptake in some countries. Carter (1995) argued that where farmers have long-term security of tenure over discreet areas of land, alley cropping may be more relevant. Gender issues are also important. Rocheleau and Rocheleau, (1990) posited that adoption is more likely if it is able to meet the needs of both men (e.g., for poles or fodder) and women (e.g., for fibre, fuel-wood and mulch).

Cover Crops and Green Manure

More recently there has been a widespread decline in the number of farmers using *mucuna*- maize system cover crop in Honduras. Neil and Lee (2001) provide interesting insights into why this has occurred. Their surveys showed that first, a minimum farm size of 2-3 ha is required to meet household food requirements during the wet season while some fields are under *mucuna*, and farmers must have security of land tenure to adopt the system. Secondly, the increase in extensive cattle production in the region has decreased the availability of land for rent and off-farm work. Thirdly, improved road access in the region has made other alternatives, such as fruit-trees and off-farm work more attractive than maize growing. Tarawali et al., (1999) posited that poor farmers are likely to make use of natural fallow unless they are provided with credit facilities and/or other incentives or have a large labour pool. Also labour demand and the timeliness of that demand may also be problematic and cover crops will probably have the best chance of being adopted by households with sufficient surplus labour (Graves et al., 2004).

Compost

The major problem associated with the use of compost is the high labour requirements (Onduru et al., 1999). In particular, female-headed households can have considerable difficulty in undertaking some of the heavier tasks involved in composting, such as preparing compost pits (Diop, 1999). Transportation of biomass and compost is also problematic (Adeoye et al., 1996). Furthermore, large quantities of biomass are required; hence Onduru et al., (1999) and Ouedrago et al., (2001), have raised questions as to how the farmers can obtain this. Since composting is labour intensive, it is most appropriately used close to the homestead (Anyanwu, 2003), on specific crops (Briggs et al., 2002; Anyanwu, 2003).

Tripp (2006b.), argued that in most instances the profile (or socio-economic characteristics) of an adopter of a particular type of LEIT will not differ substantially from the profile emerging from an adoption study of an external input such as fertilizer (an example of HEIT).

Animal Manure

As with other Low External Input Technologies, the beneficial impacts of applying animal manure to land are well known to many tropical farmers and are also well documented in the scientific literature (e.g. Delve et al 2001, Pilbean et al 1999b). Murwira et-al (1995) argues that if manure is to be extensively used to enhance soil fertility, it will need to be culturally acceptable to the farmers, which is most likely to occur where livestock are an integral part of the farming system already. These conditions abound in the study area - Imo state. Both the production and use of manure are labour intensive (Enyong et al., 1999). This implies that households without adequate labour, or the means to procure it (e.g., in communal work groups or through purchase), may only be able to use small amounts of manure. Another socio economic characteristic feature capable of affecting manure use is the fragmentation of farmlands. Enyong et al., (1999), argued that the fragmentation of fields occurring in many developing countries may also make it more difficult to transport manure, reducing farmers' willingness to apply it to fields at a distance from the homestead.

Improved Fallow

Accelerated fallows are most relevant in the intermediate stage between extensive and intensive land use (Franzel, 1999). Security of land tenure is also an important consideration, as farmers are unlikely to be willing to invest time and effort in establishing accelerated fallows if they are not the ones to receive the benefits (Long and Nair, 1999; Tarawali et al., 1999). Pradeepmani (1988) has discussed some of the socio economic issues affecting farmers' decisions to plant multipurpose tree species. These include having adequate land, time, labour, knowledge, and inputs, being able to protect trees properly, and success with tree survival. Security of tenure and access to markets are also important (Mahamoudu and Meritan, 1998; Hellin et al 1999). A certain level of access to capital also appears to encourage adoption. Where these factors are not in place, farmers tend to increase the rate at which they discount future benefits, making such techniques socio- economically unviable (Vosti and Witcover, 1996). Hoang Fagerstrom et al., (2001) give values of 386 and 600 labour days ha^{-1} over a four year period for natural fallow and a *Tephrosia* fallow, respectively.

2.2.1.2 Socio- Economic Characteristics of HEIT Farms

Obasi (1995) reported that 95% of the smallholder farmers in Imo State were highly responsive to new farm ideas such as improved and high yielding seeds, fertilizers, agro-chemicals and yam minisetts. He also reported that small farm holdings might suggest that agricultural mechanization in the area could be hampered. However, in a later study, where the smallholder farmers were disaggregated based on agricultural zones, Obasi (2005), showed that 58% of the farmers in Owerri agricultural zone of Imo State, used inorganic fertilizer, 22%, used yam mini-set technique, 23% , used agro chemicals, while 68% used improved cassava varieties. In Orlu agricultural zone, 38% used inorganic fertilizer, 03% and10% respectively used yam minisett and agro-chemicals. Onyenweaku et al., (2005), reported that on the average, each farmer in Imo State used 201.22kg of fertilizer on a mean farm size of 2.78 hectares. This implies that the rate of inorganic fertilizer application by the smallholder farmers in Imo State within this period was 72.38kg per hectare which is significantly different from the internationally recommended minimum of 200kg/ha (CBN, 2003). This further reveals the inadequacy of the rate of inorganic fertilizer application which tended to mask the potentials of HEIT among the smallholder farmers.

Minten et al., (2003) argued that chemical fertilizer use is strongly linked to road or sea access. According to him, 94% of Madagascar's agricultural households do not use chemical fertilizer. The reason for this scenario is that fertilizers are brought during the lean season and secondly fertilizer prices are prohibitively high for most farmers. Randrianariosa and Barrett (2005) showed that retail fertilizer prices in India (0.10$/kg), Vietnam (0.19$/kg) and Pakistan (0.14$/kg) are significantly lower than the prices that are practiced in rural areas in the Highlands of Madagascar (0.50$/kg).

2.2.2 Empirical Literature on Resource Productivity in LEIT and HEIT Farms

2.2.2.1 Resource Productivity in LEIT Farms

Intercropping

A recent attempt to assess the yield gains from the uptake of sustainable agricultural practices and technologies including LEIT examined data from 89 projects and found an average per project increase of 93 percent in food production (Pretty et al, 2003). A 22 year farm trial study by Cornell University published in 2005 concluded that organic farming produces the same corn and soya bean yields as conventional methods, but consumes less energy and contains no pesticide residue. However a prominent 21 year Swiss study found an average of 20% lower organic yields over conventional, along with 50% lower expenditure on fertilizer and energy and 97% less pesticide (Maeder et al., 2002).

In Zimbabwe for instance farmers intercrop sorghum with cowpea, pumpkins, cucumbers and water melon to provide nutritional and livelihood benefits (Chivasa et al., 2000). Yield advantages through intercropping are well documented. Rao et al (2000) found that compared to sole maize intercropped with pigeon pea (*Cajanus cajan*) in Kenya yield 24% more and was 49% more profitable even though the pigeon pea was affected by pests and diseases. Sequential intercropping of rose (*Rosa damascena*) with potatoes, maize and cowpea greatly increased the land equivalent ratio and provided large economic gains (Yassen et al., 2001). Although grain legume intercrops can often help to increase the resource use efficiency and stabilize yields of the main crop under optimal plant growing conditions, this is not always the case. In India, Indonesia and the Philippines, Ali, (1999) found that although intercropping could help to increase the yield of rice, it also increased the variability of yield.

Alley Cropping

Initial results from on-station experiments in Nigeria were promising for example punning from *Leucaenia leucocephala* increased maize grain yields from 1.9 to 3.5t per hectare (Kang et al 1981). Increases in yields of banana were obtained when alley-cropped with *Enterolobium cyclocarpon* and *Dalium guianense* (Oko et al., 2000). However results from semi arid region were less positive. Yields of sorghum, castor and cowpea were found to be lower when alley cropped with *Leucaenia* than when grown alone (Sing et al., 1989). Hedgerows intercropping did not increase maize yields in below average rainfall years, indicating that competition by trees predominated over benefits to soil fertility (Snapp et al., 1998). Similarly Vanlauwe et al., (2001) found reduced crop yields under alley- cropping in the absence of mineral fertilizers. It has been shown that short term fallows of herbaceous crops such as velvet bean(*Mucuna pruriens*) and *stylo* can help increase main crop yields compared with continous cropping and that weed densities can be reduced (Tarawali et al., 1999).

Cover Cropping and Green Manure

The benefit/cost analysis over a period of eight years indicated a ratio of 1.24 when mucuna was included in the system, 0.62 for the system without mucuna, with the ratio as high as 3.56 if mucuna seeds were sold (UNDP, 1999). The system gives benefits in terms of reduced labour (15 – 20% less) and increased yields after the second year – while the traditional system provided four harvests over six years from single plot, the maize-*mucuna* system produces six harvests with yields 50 -100% higher (Tripp, 2006b). In

Honduras, adoption was widespread as farmers appreciated the benefits of the technique, which included higher maize yields (Buckles and Triomphe, 1999). Still in Honduras, the seasonality of maize prices also encouraged the uptake of the technique, as maize planted during the dry season commanded higher than average value. These factors all helped to improve productivity both to land and to labour.

Compost

Composting is not a new technique for the improvement of soil fertility and structure, and tropical farmers have been aware for centuries of its impact on crop yields, soil structure and fertility, crop growth and vigour (Diop, 1999; Onduru et al., 1999). Ouedraogo et al., (2001) observed that yields of sorghum in Burkina Faso could be tripled by the application of 10t per hectare of compost. Another benefit noted is the reduced need for capital inputs (Onduru et al., 1999), although some capital may be necessary for farmers to adopt the technology (Girish et al., 2000; Slingerland et al., 2000). The major problem associated with the use of compost is the high labour requirements (Onduru et al., 1999; Diop, 1999).

Some systems seem capable of producing quite large quantities, for instance Briggs and Twomlow (2002) found that smallholder households in Uganda produced 40 kg of fresh organic waste per day, or about 9.2tDM $year^{-1}$, 25%

of which was used to make compost. Yields of both groundnut and millet, have been approximately tripled through the application of 2t ha^{-1}, of compost (Diop, 1999). Crop yields can be more than 10-fold higher using the Zai system traditionally used by farmers in Burkina Faso than otherwise (from 150 to 1700kg ha^{-1}), and the holes can be reused for 3 years (Roose et al., 1999). A comprehensive descriptive analysis on rice trade in the highlands of Madagascar, conducted by a team of French and Malagasy researchers in 1999 (UPDR, 2000) found that only organic fertilizer had a large significant impact on rice productivity but not chemical fertilizers.

Animal Manure

In smallholder farms in Uganda, Briggs and Twomlow (2002) calculated that an average of 4.6t of manure was produced annually from a household with 2.2 ha of land- this was mainly from goats grazing on communal land during the day, but tethered near the household at night-a figure that could be increased if better manure management was practiced.

2.2.2. 2 Resource Productivity in HEIT Farms

Many factors according to Howard et al., (1999) affect the performance of technology packages. Most basic are the yield potential of the technology and input/ output price ratios. If maize is sold within three months of harvest, according to him, Mozambican HEIT users must produce 950 – 2074g of maize to pay for one hectare of inputs (48-104% of average yield) versus 913-1189kg (17 -22% of average yield) in Ethiopia. Maize varieties are so responsive in Ethiopia, such that farmers can pay for their inputs and start to make money even with relatively mediocre yields. But in Mozambique, HEIT users who get average yields risk losing money; profits for those who get excellent yields may not be significantly higher than profits from well-managed low-input plots (Howard et al., 1999).

A comparative analysis of fertilizer users and non users in Imo State, Nigeria by Ohajianya et al., (2004) showed that the gross revenue for fertilizer users was N9063.65 ha^{-1} compared with N39797.07 ha^{-1} for non users. Total costs of production were N34920.63ha^{-1} for fertilizer users and N17391.93 ha^{-1} for non fertilizer users. The resultant net returns were N55763.02 ha^{-1} for fertilizer users and N22405.14 ha^{-1} for non fertilizer users. These results implied that fertilizer users produced higher quantities of vegetable output at relatively higher unit costs of production than non fertilizer users. Also, per unit net returns were much higher for fertilizer users, suggesting that fertilizer use increased the profit margin. Results of data analysis on the marginal value product (MVP) of resources indicated that land and seeds were more productive among fertilizer users (N1800.76) compared with N1085.01 for non fertilizer users. Labour and other inputs were more productive among fertilizer users (N60.94 and N7.13) than N46.48 and N4.37 for non fertilizer users.

In a review on the impact of public spending on irrigated perimeter productivity over the last twenty years in Madagascar (World Bank, 2005), rehabilitated irrigation infrastructure is shown to increase paddy yields by one ton/ha. Similar results were reported by Jacoby et al., (2006) in their survey in Lac Alaotra area. Furthermore, Bernier et al., (1993) who studied rice productivity in the central region of Madagascar including the Lac Alaotra area and the highland region found that chemical fertilizer affected rice production positively with a marginal physical return of 6.2kg of paddy for one additional kg of fertilizer. Also Randrianariosa (2001) and Randrianariosa et al., (2001) showed a significant marginal return of about 6kg of paddy-rice per kg of fertilizer use.

2.2.3 Empirical Literature on Production Efficiency in LEIT and HEIT Farms

2.2.3. 1 Production Efficiency in LEIT Farms

In Imo State, Ohajianya, (2005), posited that farmers who used mulch (LEIT) experienced significantly less loss of profit than farmers who did not use mulch. Huge increases in rice yields up to 21t ha^{-1} without the use of purchased inputs of fertilizer and pesticide have been claimed (Uphoff, 1999). Also, average yields of 8.8t ha^{-1} in farmers fields have been reported (Stoop et al., 2002). Mbagwu, (1974) and Anyanwu, (2005b), reported that soil fertility in the Compound farms are maintained by the use of household refuse and organic manure while soil fertility in the Non compound farms are maintained by the use of inorganic fertilizer. Furthermore, Onyenweaku et al., (1996), and Anyanwu, et al., (2006), showed that in the compound and non compound farm stereotype, in South-eastern Nigeria, farmers were equally technically efficient in the use of resource inputs. The Compound farms were however more economically efficient than their Non compound farm counterparts (Onyenweaku et al., 1996, Anyanwu, 2005). This implies that farmers who used organic manure in the Compound farms achieved higher levels of economic efficiency than farmers who used inorganic fertilizer, in Imo State, Nigeria.

2.2.3. 2 Production Efficiency in HEIT Farms

Ohajianya et al (2004), who studied the Economics of fertilizer use in vegetable production in Imo State, Nigeria showed that the production function for fertilizer users in vegetable production had a large intercept term, denoting higher level of technical efficiency for fertilizer users in vegetable production. They also showed that both fertilizer users and non users were allocatively inefficient in the use of resource inputs of land, seeds, capital and other inputs. Fertilizer users' under–utilized land, seeds and capital inputs, relatively more than non fertilizer users.

In Ethiopia, Howard,et al., (1999), reported that profit or economic efficiency for farmers using HEIT and selling output in January (soon after harvest) ranged from $314 to $463/ha, 45 – 59% higher than for farmers who used local seed. According to her, profits from HEIT use are very robust: net income is positive even if output prices decline by 25 – 50% from January levels. However, in Mozambique, Howard et al., (1999) posited that the use of improved maize technology is far less profitable for the farmers.

Randrianariosa et al., (2005) also reported that the ratio of marginal value product over factor price (allocative efficiency) is significantly greater than one among inorganic fertilizer users in Madagascar. This implies that, these farmers were allocatively inefficient in the use of production resources.

2.2.4 Empirical Literature on Nature of Returns to Scale in LEIT and HEIT Farms

Anyanwu, (1993), showed that in both the Compound and Non compound farms maintained by organic and inorganic fertilizer respectively, the farmers operated in stage one (increasing returns to scale). On the other hand

Obasi (2005), reported that smallholder farmers who used inorganic fertilizer in both Owerri and Orlu agricultural zones of Imo State, experienced increasing returns to scale. Ohajianya et al., (2004), who investigated economics of fertilizer use in Vegetable production in Nigeria, reported that both users of inorganic fertilizer and non users were characterized by constant returns to scale.

2.2.5 LEIT and Land Requirements

A minimum of three hectares of land is required to produce enough plant biomass to maintain soil organic matter content at 1% or to meet the nutrient requirements of one hectare of cropped land (Matthew et al., 1992a). In such a system according to him nutrients are being harvested from a wider area to enhance productivity within a smaller area as in slash and burn cultivation system in Zambia. In the case of animal manures, where animals are used to gather nutrients from a wider area, the ratio is likely to be more than 3: 1. Palm et al., (1997a) estimated that between 14 and 42 hectares of *miombo* woodland would need to be grazed to provide enough nitrogen in manure for a 2 t ha^{-1} maize crop, while ratios of up to 45 : 1, have been estimated for other extensive systems (Turner, 1995). According to him, if organic materials are to be used solely for soil fertility maintenance in most cases it would seem that they must be obtained from off- farm sources such as forests or wastes from urban areas. Even with intercropping or alley cropping where leguminous species are grown on the same piece of land as the main crop, there are costs in terms of area taken up by the legume crop and competition for resources such as light, water and nutrients (Musa et al., 2001).

2.2.6 LEIT and Labour Requirements

In the Ichilo – Sara area of Bolivia, Pound et al., (1999) found that weeding could require from 35 man days per hectare of labour in the first year of a cropping cycle to 53 man days per hectare in the third year as weeds started to dominate the system. The increase in weed cover was associated with large decrease in rice yield, with yields in the third year only about 30% of those in the first year. This was probably due to the combined effect of weed growth and declining soil fertility. The labour requirement for weeding was reduced when *Calopogonium* was sown as an intercrop, 25 days after the rice planting. On the other hand Moser et al., (2002) observed that opportunity cost is often over looked in evaluating LEIT technologies, i.e. even though the financial cost of inputs may be low, this does not mean that the technology is without other costs.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was carried out in Imo state of Nigeria. Imo State is located in the south eastern part of Nigeria. The State lies between longitude 6° 4' East of the Greenwich Meridian and latitude 4° 4' and 8° 15' North and is located in the tropical rain forest belt of Nigeria. According to the National Population Commission (NPC, 2006), Imo state has a population of 3,934,899 people with an annual growth rate of 3.2 per cent.

The predominant soil in the area is deep well drained sandy loam while the natural vegetation is the tropical rain forest. The state is bordered on the North and North West by Anambra state, on the south and south west by Rivers state and on the East and North East by Abia and Ebonyi states. The state experiences two seasons; the rainy season which lasts from March to October and the dry season which lasts from November to February. The mean annual rainfall ranges between 20,000 and 25,000 mm while the relative humidity is about 98% during the rainy season and from 60% to 80% during the dry season. Temperature is high through out the year, having an annual mean range of 23°c - 32°c (Meteorology Dept., 2002). Imo state is divided into 27 administrative units called Local Government Area. These are grouped into three agricultural zones viz, Owerri, Orlu and Okigwe. The Local Government Areas in Owerri zone include, Ahiazu Mbaise, Aboh Mbaise, Ezinihitte Mbaise, Ikeduru, Mbaitoli, Ngo Okpalla, Owerri West, Owerri North, Owerri Municipal. Okigwe zone consists of the following Local Government Areas – Obowo, Ihitte Uboma, Ehime Mbano, Isiala Mbano, Okigwe, and Onuimo while Orlu zone comprises Ideato, Ideato North, Isu, Njaba, Nkwerre, Nwangelle, Oguta, Orlu, Oru West, Oru East, and Orsu,

Farming is the predominant occupation of the people. Almost all the families farm either as primary or secondary occupation. It was estimated that 84% of the total land area is potentially productive with 48% being devoted to the production of annual crops under the traditional bush fallow systems, while the rest 36% is under the tree crops (ISMANR, 1986). Low external input agricultural technologies especially intercropping, animal manuring, alley cropping are predominant while high external input agricultural technologies such as inorganic fertilizer application, irrigation facilities, use of herbicides are not predominant due to their scarcity and high prices.

Ecological zoning of Nigeria into crop possibility areas favours the growing of tree crops, root and tuber crops, cereals, vegetables and nuts in the state. These crops are grown on small holder plots usually in mixtures of at least two crops. Crops such as yams, cassava, groundnuts, maize, rice and vegetables such as fluted pumpkin, Okra, tomatoes, garden egg are cultivated in the state. Also fruit crops such as banana, plantain and citrus are cultivated.

3.2 Sample Selection

The multi-stage random sampling technique was used in selecting the sample. This technique was used in order to enable the researcher capture a significant portion of the resource characteristics of the farmers at different stages and to ensure a good spread of the data. Two agricultural zones (Owerri and Okigwe) were randomly selected from Owerri, Okigwe and Orlu that make up the state. From these two agricultural zones, two local government areas (LGA) were purposively selected from the list of LGAs in each zone making a total of 4 LGAs. These 4 LGAs are Ohaji- Egbema, Ahiazu-Mbaise, Ihitte-Uboma, and Isiala-Mbano. The basis for the purposive selection of these LGAs is where the usage of organic manure, poultry droppings and inorganic fertilizer are more predominant. From each of these LGAs two communities were randomly selected from the list of communities in the LGAs collected from the LGA headquarters. The communities selected include Umuokanne, Mgbuishii, Obohia, Amuzi, Amainyi-Ukwu, Umuezegwu, Umuelemai and Isiama. The list of farmers that use high external input technology (HEIT) and low external input technology (LEIT) in the communities were compiled with the assistance of the extension agents. This list formed the sampling frame. From this sampling frame, 10 farmers that used the HEIT and another 10 farmers that used the LEIT were randomly selected from each of the 8 communities making a sample size of 160 farmers (made up of 80 HEIT and 80 LEIT) users.

3.3 Data Collection

Data used for the study were collected using structured questionnaire and interview schedule. Practical field measurement of plots was undertaken using global positioning system (GPS). Data were collected on socio-economic characteristics of the farmers such as age, years of farming experience, years spent in school, farm size, input prices, expenditures on fertilizer and organic manure, expenditures on agro- chemicals, seeds, labour input (including contract sum in case of farm operations contracted out) wage rate, income sources, number of crop species (in a mixture) planted per plot per year, household size, capital inputs used, farm output and output prices, value of produce (in Naira) consumed, stored and sold.

3.4.0 Methods of Data Analysis

Descriptive statistical tools like frequency tables, means and percentages were used in the analysis of objective (1), while objectives (2), (3), (4) and (6), were achieved with the aid of multiple regression analysis. Objective (5) was achieved using multiple regression analysis, multiplicative dummy variable and profit function analysis.

3.4.1 Determination and Comparison of Productivity of Resources among High External Input Technology (HEIT) and Low External Input Technology (LEIT) Farms.

The production function model employed in its implicit form is stated as follows;

$Q_L = f(X_1, X_2, X_3, X_4, X_5, e)$……………………………eqn. (3.1)

$Q_H = f(X_1, X_2, X_3, X_4, X_5, e)$……………………………..eqn. (3.2)

Where;

Q_L = Value of total output in LEIT farms (₦)

Q_H = Value of total output in HEIT farms (₦)

X_1 = Farm size (Ha)

X_2 = Man-days of labour (man days)

X_3 = Value of planting materials (₦)

X_4 = Value of capital inputs (₦)

X_5 = Expenditure on either organic or inorganic fertilizer and agro-chemicals for LEIT and HEIT (₦)

e = error term.

Four functional forms were fitted to the data. These are the linear, semi- log, double log and the exponential functions. The function that gave the best fit was selected based on the magnitude of the coefficient of the multiple determination (R^2) and the size and signs of the estimated coefficients and the statistical significance of the parameter estimates.

Productivity of Resources

The marginal value product (MVP) of each resource was computed in order to determine the productivity of resources in the two farm types. The MVP is the marginal physical product (MPP) multiplied by the product price. The MPP of a variable factor input is the partial derivative of the production function with respect to that factor. It may also be defined as the slope of the total product curve. The MPP may be positive, zero, or negative.

For a linear function: $Q = bo + b_1X_1 + b_2X_{2,} + \ldots, + b_nX_n$ ……eqn. (3.3)

$MPP_1 = b_1$

$MPP_2 = b_2$

For semi –log: $Q = bo + b_1\log X_1 + b_2\log X_{2,+} \ldots, + b_n\log X_n$ …eqn. (3.4)

$MPP_1 = b_1/ X_1$, $MPP_2 = b_2/ X_2$

For the double log function: $Log\ Q = bo + b_1 logX_1 + b_2 logX_2$...eqn. (3.5)

$MPP_1 = b_1\ Q / X_1$, $MPP_2 = b_2\ Q / X_2$

For the exponential function: $Log\ Q = bo + b_1X_1 + b_2X_2 + \ldots + b_nX_n$ ……………………………………………………..eqn. (3.6)

$MPP_1 = b_1 a e^{b_1x_1 + b_2x_2} = b_1 Q$ ……………………………….. eqn (3.7)

$MPP_2 = b_1 a e^{b_1x_1 + b_2x_2} = b_2 Q$ ………………………………. Eqn (3.8)

3.4.2 Analysis of the Determinants of Aggregate Agricultural and Individual Resource Productivities among LEIT and HEIT Farms.

To determine and isolate the main determinants of agricultural productivity, it will be necessary first to isolate the determinants of aggregate agricultural productivity and second the determinants of individual resource productivities. Aggregate agricultural productivity in this study is measured by the index of the ratio of the total value of farm output (measured in naira values), to the value of total inputs (measured in naira values) used in farm production. This approach is consistent with Olayide and Heady (1982) and Obasi (2000). In its implicit form, the function estimated in this study is specified as: $Q = f(X_1, X_2, \ldots, X_{12}, e)$……………………eqn. (3.9)

$Q = \sum Yp / \sum Xr$ = Aggregate Agricultural productivity …eqn. (3.10)

$\sum Yp$ = total value of output

$\sum Xr$ = total value of input

$Q_L = (X_1, X_2, \ldots, X_{12}, e) \ldots$ ……………………………eqn. (3.11)

$Q_H = (X_1, X_2, \ldots, X_{12}, e)$…………………………………eqn. (3.12)

Where

Q, Q_L, Q_H = aggregate agricultural productivity (ratio of total value of farm output to total value of farm input), Q_L = for low external input technology and Q_H = high external input technology.

X_1 = farm size (ha)

X_2 = Labour input (man-days)

X_3 = Expenditure on planting materials (₦)

X_4 = Non farm income (₦)

X_5 = Capital input (depreciation and interest charges) (₦)

X_6 = Expenditure on fertilizer (HEIT) or organic manure (LEIT) (₦)

X_7 = number of crops in a mixture (number)

X_8 = Distance to the nearest market (km)

X_9 = Years in schooling of the farmer (years)

X_{10} = Age of the farmer (years)

X_{11} = Household size (persons)

X_{12} = Years of farming experience (years)

e = random error

In order to measure the different dimensions of agricultural productivity (that is to determine and isolate the determinants of the different individual resource productivities), equations (3.13) and (3.14) were estimated. The model estimated is implicitly specified thus:

$Z_{jL} = f(X_1, X_2, \ldots, X_5, e)$……………………………….....eqn (3.13)

$Z_{jH} = f(X_1, X_2, \ldots, X_5, e)$…………………………………eqn (3.14)

Where

Z_{jL} (j = 1, 2, …,n) represents individual resource productivities in LEIT farms.

Z_{jH} (j =, 1, 2,…,n) represent individual resource productivities in HEIT farms.

Z_{1L} = land productivity

Z_{2L} = planting material productivity

.

Z_{1H} = land productivity

Z_{2H} = planting material productivity

.

While $X_{!,}$ $X_{2,}$ $X_{3,}$ …,X_5, e are as previously defined.

a_i (i = 1, 2, 3, …,n) represents the production elasticities of the respective input variables. Ao represents the efficiency parameter.

Following Obasi (2000) the multiple regression of equation (3.13) and (3.14) were estimated.

In order to compare individual resource productivities between LEIT and HEIT farms, we examine the constant intercept terms of the two equations estimated for LEIT and HEIT. The farm type with higher intercept term has higher resource productivity relative to the alternative farm type (Koutsoyiannis, 1979).

3.4.3 Comparative Analysis of Productivities among LEIT and HEIT Farmers

In order to achieve the third objective, a structural stability test was carried out on the two relations specified in (3.11) and (3.12) for LEIT and HEIT.

In the structural stability test the Chow (1960) F – test was used to establish the existence or absence of structural changes in the two functions. In this test the two samples were pooled together ($n_1 + n_2$) to compute a pooled function and the unexplained (residual) variations $\sum e^2_p = (\sum Q^2_p - \sum Q_p\hat{}^2)$ estimated (with $n_L + n_H - k$) degrees of freedom.

Regression analysis also were performed on each of the samples and their respective unexplained variations $\sum e^2 = \sum Q^2 - \sum Q\hat{}^2$ with n – k degrees of freedom computed. The unexplained variations of these two samples were added together

($\sum e^2_L + \sum e^2_H$) with ($n_L + n_H - 2k$) degrees of freedom and then subtracted from the pooled residual variance thus; $\sum e^2 p - (\sum e^2_L + \sum e^2_H)$ with $(n_L+n_H - k) - (n_L+n_H - 2k)$ degrees of freedom.

$$F^* = \frac{\sum e^2 p - (\sum e^2 L + \sum e^2 H) / k}{(\sum e^2 L + \sum e^2 H) / (nL + nH - 2k)} \quad \text{..............eqn. (3.15)}$$

Where p = pooled, k = total number of b's, L = LEIT, H = HEIT, others are as previously defined.

Ho: bo = Bo

We compare the observed F* ratio with the theoretical value at 1% or 5% (level of significance) with $V_1 = K$ and $V_2 = (n_L + n_H - 2K)$ degrees of freedom

Decision rule: we reject Ho, if F* > F0.05 and accept that the HEIT and LEIT farms differ significantly in their productivities.

However structural changes in the parameters of a function can arise due to changes in either bo or b_1..., bn or both (Koutsoyiannis 2001). Thus to establish the identity or otherwise of the two constant intercept terms (denoting equality or otherwise in aggregate productivity a dummy variable separator was introduced in the combined data explicitly specified thus:

$LnQp = Lna_0 + boD + b_1LnX_1 + b_2LnX_2 + b_3LnX_3 + b_4LnX_4 + b_5LnX_5 + b_6LnX_6 + b_7LnX_7 + b_8LnX_8 + b_9LnX_9 + b_{10}LnX_{10} + b_{11}LnX_{11} + b_{12}LnX_{12} + e.$ ……………………………..… eqn. (3.16)

Where Ln = the natural logarithm

Q_p = pooled data

Ao = intercept term

D = Dummy variable which takes the value of unity for HEIT (farmers who used fertilizers or agro- chemicals etc) and zero For LEIT (farmers who used animal manure)

Bo = coefficient of the intercept shift dummy.

$b_1 \ldots b_{12}$ = slope coefficients. Others are as earlier defined in equations (3.9) (3.11) and (3.12).

Hence for HEIT farmers equation (3.16) will now be given by

$LnQ_H = Ln\,Ao + bo + \sum biLnXi + e$…………………………eqn. (3.17)

While for LEIT farmers equation (38) will now be given by

$LnQ_L = LnAo + \sum biLnXi + e$ …………………….eqn.(3.18)

If the intercept is significant and positive it shows a higher level of aggregate agricultural productivity for HEIT, the reverse will be the case if otherwise.

3.5.0 Analysis and Comparison of Production Efficiencies among LEIT and HEIT Farmers

3.5.1 Analysis and Comparison of Technical Efficiency among LEIT and HEIT Farmers

The main objective of the relative technical efficiency is to establish whether any distinct group of farms under consideration is characterized by neutral production, non neutral or factor biased production or by the same production function. Neutral production function imply that the two production function under consideration differ only in the intercept while the slope coefficients are the same in both functions. Factor biased or non – neutral production function differ significantly in one or more of the slope coefficients, whether or not the intercept terms are the same in both production functions. If there are no significant differences in both the intercepts and slope shift coefficients for the two production function faced by the two groups (HEIT and LEIT) of farms, it is concluded that both farms face the same production functions.

In this analysis, multiplicative dummy variable approach was used rather than the traditional method of fitting separate model and testing the equality of coefficients between them. Obasi et al (1995) observed that two approaches could be used in determining technical efficiency among farmers viz, (1) examination of the value of the constant intercept term associated with the two groups of farmers. According to Koutsoyiannis (1979) the more efficient farmers will have larger constant terms than the less efficient farmers. According to Obasi et al., (1995), following this rule may be misleading. Adopting the methodology Obasi et al., (1995), the quantitative multiplicative dummy variable model was estimated.

The model in its implicit form is specified as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5, D, X_1D, X_2D, X_3D, X_4D, X_5D, + e) \ldots\ldots\ldots\ldots\text{eqn. } (3.19)$$

Explicitly, the log linear Cobb- Douglas functional form is:

$$LnY = LnAo + BoD + A_1LnX_1 + B_1DLnX_1 + A_2LnX_2 + B_2DLnX_2 + A_3LnX_3 + B_3DLnX_3 + A_4LnX_4 + B_4DLnX_4 + A_5LnX_5 + B_5DLnX_5 + e \ldots\text{eqn. } (3.20)$$

Semi – Log

$$Y = LnAo + BoD + A_1LnX_1 + B_1DLnX_1 + A_2LnX_2 + B_2DLnX_2 + A_3LnX_3 + B_3DLnX_3 + A_4LnX_4 + B_4DLnX_4 + A_5LnX_5 + B_5DLnX_5 + e \ldots\text{eqn. } (3.21)$$

Exponential Form

$LnY = Ao + BoD + A_1X_1 + B_1DX_1 + A_2X_2 + B_2DX_2 + A_3X_3 + B_3DX_3 + A_4X_4 + B_4DX_4 + A_5X_5 + B_5DX_5 + e$ ……… …………………… eqn. (3.22)

Linear Form

$Y = Ao + BoD + A_1X_1 + B_1DX_1 + A_2X_2 + B_2DX_2 + A_3X_3 + B_3DX_3 + A_4X_4 + B_4DX_4 + A_5X_5 + B_5DX_5 + e$ ………………………………eqn. (3.23)

Where

Ln =natural logarithm

Y = Gross farm output (₦)

X_1 = Farm size (Ha)

X_2 = Labour input (man-days)

X_3 = Value of planting materials (₦)

X_4 = Capital (made up of depreciation and interest on borrowed capital) (₦)

X_5 = Expenditure on fertilizer and agro- chemicals for HEIT or cost of manure for LEIT (₦)

Ao = the intercept or constant term

Bo = coefficient of the intercept shift dummy or neutral technical efficiency parameter

D = Dummy variable, (1 for HEIT farms and zero otherwise)

Bi (i=1, 2… 6) = the factor biased technology parameter or the coefficient of the ith Dummy

Ai (i = 1, 2… 6) = slope coefficient

ei = stochastic error term assumed to fulfill all the assumptions of the classical linear regression model.

The above equations (3.20) to (3.23) were estimated by the method of ordinary least squares (OLS). Since the dummies were defined as zero for LEIT farmers, the intercept and slope coefficients for these farms is given by Ao and Ai (i = 1, 2 …6).

For the HEIT farms, however the intercept and slope coefficients would be recovered from the sums of (Ao + Bo) and Ai + Bi (i=1, 2 …6) respectively, (since the dummies were defined as unity for this group of farms).

If the estimated production function differs only in the intercept (Ao + Bo) and is significantly different from Ao, while the slope coefficients are the same for both HEIT and LEIT farms (that is Ai + Bi) and not significantly different from Ai for all the variables, then neutrality in technical efficiency abounds. However if Bo is statistically significant and positive, then the HEIT production function has a larger intercept denoting a higher level of technical efficiency. On the other hand, if Bo is statistically significant and negative, it implies that the HEIT farms production function has a smaller intercept denoting a lower technical efficiency.

To ascertain whether both groups of farmers are characterized by factor biased production function (or the same production function) the value and statistical significance of the slope coefficients were examined. For instance if Ai + Bi is statistically significant and different from Ai for at least one factor, we conclude that both HEIT and LEIT farmers face factor biased ness. In other words they face different production function.

On the other hand, if there is no significant differences in both the intercepts and slope shift coefficients (that is neither Ao + Bo is significantly different from Ao nor Ai + Bi (i= 1, 2….6) is significantly different from Ai (i=1, 2….6), for the two production functions, it is concluded that both HEIT and LEIT farms face the same production function.

3.5.2 Determination and Comparison of Allocative Efficiency among LEIT and HEIT Farmers

Allocative efficiency denotes the ability of farm firms to equate the marginal value product of a factor to its unit price. Mathematically, a farm is allocatively efficient if

$$MVPxi = Pxi \text{ or } MVPxi / Pxi = 1 \quad \text{……………………eqn. (3.24)}$$

Where

MVPxi (i= 1, 2 …6) = marginal value product of the ith factor

Pxi (i= 1, 2 …6) = the unit price or marginal factor cost (MFC) of the ith factor.

In order to examine the allocative efficiencies of the two groups of farms, the production function estimated in equations (3.1 and 3.2) were used.

A comparison of the allocative efficiency of any two groups of farms according to Onyenweaku (1994) requires that they are characterized by constant returns to scale the same of neutral production function and the same configuration of input and output prices.

As a means of comparing the allocative efficiencies of the two groups of farms, an index of allocative efficiency, W, is derived by

MVPxi /Pxi = Pyfi /Pxi = Wij …………………………eqn. (3.25)

Where

MVPxi (i= 1, 2 …6) = the marginal value product of the ith input

Wij = allocative efficiency index for each farmer group,

Py = unit output price

Fi = dy / dx = marginal physical product of the ith input

i= the particular input, j represents the farm type (HEIT and LEIT) (other terms are as previously defined).

In this study the dependent variable; (the gross farm output) was measured in naira terms. Also the variable factors of production; except land and labour were measured in naira terms (see equation 25). Thus the marginal product (MP) is in monetary terms and the output price (P_y) becomes irrelevant (Bagi, 1981; Onyenweaku et-al 1996, 1991, Anyanwu, 1993, 2003, 2005; Ohajianya et-al 2004; Nwaru, 2003). Accordingly the marginal value products will be directly equal to the allocative efficiency indices for all factors except land, and labour.The price of capital input will be taken as one naira plus the relevant interest charge (Adesimi, 1982; Anyanwu, 1993; 2003, 2005).This is because the marginal value products are already deflated by the unit factor prices, since the values of the factors are the products of the quantity employed and the unit factor prices. Thus for X_3, X_4 and X_5 that are measured in naira terms

Wij = Pyfi = MVPxi …………………………………eqn. (3.26)

Variables remain as previously defined.

Optimal allocative efficiency for a particular group of farm is confirmed with respect to a given input if Wij = 1.

If Wij > 1, the resource is under utilized. Efficiency could therefore be increased by an increased use of that particular input. However if Wij < 1, the resource is over utilized hence a reduced use of that input is desirable to increase efficiency. On the other hand, one of the pair groups of farms is considered more allocatively efficient than its counterpart if the Wi for that group is nearer unity than the W_i for the other group in the pair. The two groups of farms achieves parity or equal allocative efficiency if

$Wi_1 = Wi_2$ ……………………………………………eqn. (3.27)

To show the extent to which a particular factor of production should be increased or withdrawn from current use to achieve the objective of profit maximization, the formular below was used;

$K_{ij} = (1- W_{ij})\ 100$ ……………………………………..eqn. (3.28)

Where K_{ij} is the required percentage change in allocative efficiency and Wij is as defined before.

If equation (3.28) is evaluated, a negative percentage implies that an increased employment of the factor is required. A positive percentage implies that a withdrawal of some of the factors from current use is required. If K_{ij} equals zero, then optimal allocative efficiency has been achieved.

3.5.3 Determination of Economic Efficiency of LEIT and HEIT Farmers

Data for this objective was analyzed using the Unit Output Price (UOP) profit function developed by Lau and Yotopoulos (1971, 1972). The form of this model used is as adapted from Onyenweaku and Fabiyi (1991). The statistical test of relative economic efficiency used here involve the estimation of profit function and employing a dummy variable to differentiate the two farm types in order to test the significance of the value of its coefficient. The UOP model used is specified thus;

$\text{Ln } \Pi = bo + b_1D + b_2LnWr + b_3LnFs + b_4LnKv + e$ …eqn. (3.29)

Where

Ln = natural logarithm

Π = profit per farmer in naira (defined as total value of output less total cost) The total wage bill for each farmer were calculated to include wages paid to hired labour and imputed values of family and exchange labour based on the prevailing wage at the time of interview.

D = Dummy variable distinguishing farm type (1, for HEIT and zero otherwise)

Wr = money wage rate (Naira) per man day of an adult farm worker

Fs = Farm size (Ha)

Kv = Capital input (Naira) per farmer. This consists of fixed capital inputs in terms of depreciation on tools and equipment and working capital such as the costs of seeds, planting materials, fertilizer, agro – chemicals, etc.

e = the disturbance term.

While b_o, b_1, … b_4 are parameter estimates.

If the coefficient of the dummy variable for the HEIT farm is positive and significant it implies a larger intercept term of that farm type than the alternative farm type suggestive of higher level of economic efficiency and higher profit.

For a given level of technology and a given endowment of fixed factors of production, the profit function expresses the maximized profit of a farm as a function of the prices of output and variable input and the quantities of the fixed factors of production. According to Lau and Yotopoulos (1972) the assumptions employed in the formulation of the profit function are;

(a) Firms are profit maximizing

(b) Firms are price takers in both output and variable input markets and

(c) The production function is concave in the variable input.

3.6 Estimation and Comparison of Returns to Scale among LEIT and HEIT Farmers

The elasticity of production is a concept that measures the degree of responsiveness of output to changes in input. It measures the proportionate change in output as a result of a unit change in input. The production function specified in equations (3.1 and 3.2) were used.

Estimates of the elasticity of production of each of the resources were obtained using the following formular;

ERx_{ij} = bi $\acute{X}/\bar{y}$ ……………………………………………eqn. (3.30)

Where ERx_{ij} = Elasticity of production of the given resource, (j, = farm type).

b_{ij} = regression coefficient of the given resource

$\acute{X}$= mean value of input

$\bar{y}_{ij}$ = mean value of output in each farm type.

Returns to Scale

Returns to scale in agricultural production show the relationship that exists in the input – output mix when all input can be varied in the long run. Returns to scale thus signify the effect of a simultaneous one percentage change (increase) in the variable inputs will have on gross farm income. Returns to scale are derived through the summation of the elasticities of production (ERx_{ij}), for the various resources.

For $\sum ERx_{ij}$ = 1 = constant return to scale

$\sum ERx_{ij} > 1$ = increasing returns to scale

$\sum ERx_{ij} < 1$ = decreasing returns to scale.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio – Economic Characteristics of the Farmers

The production function models developed in chapter three can only explain the technical aspects of the production behaviour of the farmers; but these models do not often provide full explanation of the observed variations in farmers' output and income levels. Better explanation may be obtained through the combination of socio – demographic and economic variables. Although the inclusion of socio- demographic variables in a production function model cannot easily be justified on theoretical grounds, factors such as household size, age structure, farming experience and educational attainment of the farmers can influence production behaviour to a great extent. That may explain why Graves' et-al (2004) contends that the sustainability of a technique is a function both of the agronomic performance of the system and the socio-economic context in which it is located including the knowledge and understanding of the farmers. Thus an attempt is made in this section to describe some socio- economic factors in recognition of their role in enhancing the interpretability of the functional analysis later.

4.1.1 Age Distribution of Farmers

Table 4.1 presents the distribution of the sampled farmers by age. It shows that about 78.2 percent of LEIT farmers and 77.2 percent of HEIT farmers are below the age of 57 years. The mean ages are 52.31 and 51.44 for LEIT and HEIT farmers respectively.

The age factor in traditional agriculture is important in at least two aspects; increased productivity and increased rate of adoption of innovations. Traditional agricultural production system still rely on rudimentary implements such as hoes and cutlasses powered by human muscle.

This implies that very old farmers will face severe energy constraint and will thus be less productive than the younger and more energetic farmers.

Older farmers tend to be more conservative and less vulnerable to the wind of change involving the adoption of modern technologies than the younger farmers. The highest percentage of farmers in the LEIT (37.2%) and HEIT (36.3%) fall within the 46 -51 years age bracket and on the whole 55.1 and 56.3 percent of LEIT and HEIT farmers, respectively are within the 46 – 51 age bracket which could be regarded as productive age group.

Table 4.1: Distribution of Farmers according to Age

Age (Years).	LEIT Farmers		HEIT Farmers	
	Frequency	Percentage	Frequency	Percentage
34 – 39	1	1.3	1	1.3
40 – 45	13	16.7	15	18.8
46 – 51	29	37.2	29	36.3
52 – 57	18	23.1	17	21.3
58 – 63	7	9.0	11	13.8
64 and above	10	12.9	7	8.8
Total	80	100	80	100
Mean	52.31 years		51.44 years	

Source: Survey data, 2008.

4.1.2 Farming Experience

The distribution of the sample farmers based on their experience in farming is summarized in Table 4.2. The number of years a farmer had spent in the farming business could give an indication on the practical knowledge which has been acquired (Olomola, 1988).

As shown in Table 4.2, both the LEIT and HEIT farmers are well experienced in farming activities. Among the LEIT farmers 62.5 percent of the farmers have between 15 – 24 years of experience while 57.5 percent of the HEIT farmers have between 15 – 24 years of experience. Improvements over the years on the productive activities of the farmers are expected with an increase in the years of farming experience.

Table 4.2: Distribution of Farmers According to Farming Experience

Year of Farming	LEIT Farmers Frequency	LEIT Farmers Percentage	HEIT Farmers Frequency	HEIT Farmers Percentage
5 – 14	8	10	9	11.3
15 – 24	50	62.5	46	57.5
25 - 34	10	12.5	16	20
35 – 44	10	12.5	7	8.8
45 – 54	2	2.5	2	2.5
Total	80	100	80	100
Mean	22.98 years		22.44 years	

Source: Survey data, 2008.

4.1.3 Farm Size

A summary of the distribution of the LEIT and HEIT farmers according to farm size is presented in Table 4.3.

Low external input technology and high external input technology farmers who cultivated between 0.03 – 0.60 hectares were 73.8 and 66.3 percent respectively. Majority of the farmers in both LEIT and HEIT cultivated less than one hectare during the last planting season. Only about 26.2 percent and

33.7 percent of LEIT and HEIT farmers respectively cultivated farmlands above 0.6 hectares. It should be realized that the farm sizes are not contiguous pieces of land, but the sum of different pieces and portions of land located in various places whose sizes were measured with the aid of global positioning system (GPS).

This result agrees with Obasi (1995), Anyanwu, (1993), Olayide et-al, (1982) and Njoku et-al, (1991) that farm sizes for small scale farmers range between 1 acre to 5 acres (0.4047 -2.024 hectares) in Nigeria. However the mean farm size for HEIT farmers (1.1617 hectares) appears to be greater than that of LEIT farmers (0.6709 hectares). The fact that farms are small sized and scattered is one of the greatest challenges facing agricultural mechanization and HEIT adoption in Nigeria.

Table 4.3: Distribution of Farmers According to Farm Sizes

Farm Size (Ha)	LEIT Farmers		HEIT Farmers	
.	Frequency	Percentage	Frequency	Percentage
0.03 – 0.60	59	73.8	53	66.3
0.61 – 1.17	13	16.3	15	18.8
1.18 – 1.73	6	7.5	7	8.8
1.74 – 2.29	2	2.5	3	3.8
2.30 and above	-	-	2	2.6
Total	80	100	80	100
Mean	0.6709 ha		1.1617 ha	

Source: Survey data, 2008

4.1.4 Household Size

Availability of family labour for work in the farm is a function of household size. Families with larger household appear to have an advantage over those who are less endowed with large household sizes. However, the children or members of these large families may also be unavailable for farm work as some may be students or pupils in various institutions. Thus large household size may not necessarily be an index of availability of family labour for farm work.

Table 4.4: Distribution of Farmers According to House hold Size

House hold Size	LEIT Farmers		HEIT Farmers	
	Frequency	Percentage	Frequency	Percentage
2 – 7	35	43.8	27	34.2
8 – 13	37	46.3	46	58.2
14 – 17	8	10	2	2.5
18 and above	-	-	4	5.1
Total	80	100	80	100
Mean	8.4 persons		8.9 persons	

Source: Survey data, 2008

Majority of both the LEIT (46 %) and HEIT (58.2 %) farmers have between 8 and 13 members in the household. The size of the household depends on the marital status of the respondent and number of wives of the household head.

4.1.5 Level of Education

Table 4.5 presents the distribution of LEIT and HEIT farmers by number of years spent in school. The relevance of the literacy level of farmers to farm productivity and production efficiency has been documented by several authors (Nwaru, 2001, 2004, and Olomola, 1988). The educational attainment of a farmer raises his productivity and increases his ability to understand and evaluate the information on new techniques and processes being disseminated through extension. As shown in Table 5 about 51.2 percent and 64.6 percent of LEIT and HEIT farmers respectively spent between 2 and 6 years in school. The percentage for HEIT farmers (64.6 %) appears slightly higher than that for LEIT (51.2 %). It appears also that majority of the HEIT farmers received primary school education than the LEIT farmers. However the level of educational attainment of LEIT farmers (20%) appears slightly higher than that of their HEIT counterpart (15.2%) in the acquisition of secondary school education (7 – 11years). In general the mean educational attainment of LEIT farmers (9.4 years) appears slightly higher than that of HEIT farmers (8.6 years).

Table 4.5: Distribution of Farmers According to Level of Education

Years in School.	LEIT Farmers		HEIT Farmers	
	Frequency	Percentage	Frequency	Percentage
Less than 2	1	1.2	-	-
2 – 6	41	51.2	51	64.6
7 – 11	20	25	12	15 2
12 – 16	19	23.7	16	20.3
Total	80	100	80	100
Mean	9.4 years		8.6 years	

Source: Survey data, 2008

4.1.6 Labour Use

The distribution of farmers according to type of labour used is shown in Table 4.6. A summary of the distribution of the LEIT and HEIT farmers according to type of labour used show that majority of the farmers in both LEIT (73.8 %) and HEIT (91.3%) farm types combined both family and hired labour in their farming activities. In the LEIT and HEIT farms only 15 and 6.3 percent of the farmers used only family labour while 9 and 2.5 percent of the farmers used only hired labour in the LEIT and HEIT farms respectively. It is probable that the scarcity and high cost of labour must have necessitated the combination of both family and hired labours in both farm types.

Table 4.6. Distribution of Farmers According to type of Labour Used

Type of labour	LEIT Farmers		HEIT Farmers	
	Frequency	Percentage	Frequency	Percentage
(1) Family	12	15.0	5	6.3
(2) Hired	9	11.3	2	2.5
(3) Combination of (1) and (2)	59	73.8	73	91.3
Total	80	100	80	100

Source: Survey data, 2008

4.1.7 Number of Crops in a Mixture

The frequency distribution of farmers by type of crop mixtures practiced is summarized and presented in Table 4.7. The results of the analysis show that only a few farmers 1.25 and 5.0 percent planted six crops and 1 crop respectively in the same piece of land in the same year in LEIT farms. Also 40 and 32.5 percent planted 4 and 3 crops respectively in a mixture among LEIT farmers. The mean number of crop mixtures in the LEIT farms is 3.57. On the other hand only 3.75 and 1.25 percent planted one or two crops in a mixture on the same piece of land in the same year among the HEIT farms. It appears most (56.25 percent) of the farmers planted 4 crops in a mixture.

The mean number of crops planted among the HEIT farms is approximately 4 and appears relatively higher than that of LEIT.

Table 4.7 Distribution of LEIT and HEIT farmers according to crop mixtures practiced.

	LEIT Farmers		HEIT Farmers	
Crop Mixtures	Frequency	Percentage	Frequency	Percentage
Yam/Maize/cassava/vegetable (4)	32	40	45	56.25
Cassava/maize/melon (3)	26	32.5	16	20
Yam/maize/okro/vegetable/cassava (5)	12	15	12	15
Cassava/vegetable//melon/maize/okro/pepper (6)	1	1.25	3	3.75
Cassava//maize/ (2)	5	6.25	1	1.25
Pineapple (1)	4	5.0	3	3.75
Total	80	100	80	100
Mean	3.5 mixtures		3.9 mixtures	

Source: Survey data, 2008

4.2.0 Determination and Comparison of Productivity of Resources among LEIT and HEIT Farmers.

This objective was achieved by the estimation of equations (3.1) to (3.5). The results of the estimated production function for the two farm types are presented in Tables 4.8 and 4.9

4.2.1 Low External Input Technology Farms

In the linear model four of the explanatory variables are statistically significant at 1 percent and 5 percent levels in the LEIT farms. The coefficients of multiple determination ($R^{2)}$ is also relatively high in LEIT farms (0.848). In the exponential function, four of the explanatory variables are statistically significant at 1 percent and 5 percent levels of probability in the LEIT farms. Also, three of the explanatory variables are statistically significant at 1 percent and 5 percent levels in the LEIT farms in the semi log model. In the double log model on the other hand all the explanatory variables are statistically significant at 1 and 5 percent levels and possess the appropriate signs in the LEIT farms. The coefficients of multiple determination in the linear, semi log, double log and exponential functions are 84.8, 49.0, 80.3, 66.8. The double log model where all the explanatory variables are statistically significant appears to be a better fit for the data in LEIT farms. More so the coefficient of multiple determination for LEIT farms in the double log model (0.803) is relatively high. The double log function produced F-values of 60.385 for the LEIT farms which is statistically significant at 1percent level, implying that the double- log function gave a good fit to the data. The result of the double-log function is therefore used for discussion and further analysis in the LEIT farms. The coefficient of multiple determinations of 0.803 shows that 80.3 percent of the variations in the gross income of LEIT farmers are accounted for by the variations in the explanatory variables. The remaining 19.7 percent are accounted for by variables such as topography, soil quality and other unquantifiable variables which are not included in the model.

The explanatory variables- farm size, labour, expenditure on planting materials, capital inputs (depreciation and interest charges) and expenditure on organic manure are statistically significant at 5 percent level and positively related to gross farm output. This shows that an increase in these inputs will lead to an increase in the gross income of LEIT farmers, all things being equal. These positive relationship existing between farm size, labour input, planting materials, capital input and organic manure and gross output of farmers agrees with the findings of Onyenweaku et-al, (2005), and Obasi, et-al (1995) in Imo State of Nigeria and Olomola, (1988) in Ondo State of Nigeria. In addition the coefficient of multiple determination (R^2 = 0.803) shows that about 80.3 percent of the variations in the gross income of LEIT farmers are accounted for by the explanatory variables included in the model. Table 4.10 shows that an increase of farm size by one hectare would increase gross output of LEIT farmers by N97159.13. Similarly an increase of one man day of labour would increase the gross income of this group of farmers by N1876.14. Furthermore an increase of one Naira expenditure on planting materials, and organic manure would increase the gross income of LEIT farmers by as much as N1.96 and N5.47. An increase of one Naira capital input would all things being equal increase the gross output of these farmers by ₦23.40.

Table 4.8 Estimated Production Functions for Low External Input Technology Farms in Imo State .

Explanatory variables	Linear	Semi log	Double log	Exponential function
Farm size(X_1)	166096.1	231847.6	0.169	0.193
	(4.160)***	(1.99) **	(2.26)**	(3.166)***
Labour input(X_2)	219.81	41020.7	0.505	0.000657
	(1.52)	(0.269)	(5.147) ***	(2.97) ***
Expenditure on planting materials (X_3)	1.74	197302.8	0.279	0.00000292
	(4.44)***	(1.67)	(3.671)***	(4.87)***
Capital input (Depreciation & interest)(X_4)	19.74	308762.2	0.412	0.0000363
	(3.56)***	(2.34)**	(4.87)***	(4.29)***
Expenditure on manure (X_5)	11.86	274664.3	0.131	0.00000148
	(11.76)***	(2.95)***	(2.20)**	(0.963)
Constant	-87929.5	-2487681	1.233	4.599
R^2	0.848	0.490	0.803	0.668
F-ratio	82.285	14.237	60.385	29.831

** = Significant at 5% *** = Significant at 1%.
Figures in parenthesis are t – ratios
Source: Survey data, 2008.

4.2.2 High External Input Technology Farms

In the HEIT farms (Table 4.9), two of the explanatory variables are statistically significant at 1 percent and 5 percent in the linear model. In the semi log and exponential functions only one explanatory variable in each case was statistically significant at 1 percent and 5 percent levels. Three explanatory variables are statistically significant at 1 percent and 5 percent levels in the double log model. The double log model appears to be a better fit for the HEIT data. More so, the coefficient of multiple determination of 0.703, shows that about 70.3 percent of the variations in the gross income of the HEIT farmers is accounted for by the variations in the explanatory variables included in the model, while the remaining 29.7 percent are accounted for by some unquantifiable variable such as soil quality and topography, not included in the model. The double log function produced F-values of 34.965 for the HEIT farms which is statistically significant at 1percent level, implying that the double- log function gave a good fit to the data. The result of the double-log function is therefore used for discussion and further analysis in the HEIT farms.

Three of the explanatory variables, namely, farm size, expenditures on planting materials, and fertilizer are statistically significant at 1 and 5 percent levels and positively related to gross farm output as shown in Table 4.9. The coefficient of multiple determination (R^2 = 0.703) shows that 70.3 percent of the variations in the gross income of the HEIT farmers are accounted for by the explanatory variables included in the model. Thus an increase of farm size by one hectare would increase the gross income of HEIT farmers by N130387.3. Similarly, an increase of expenditure on planting materials and fertilizer by one naira would increase the gross income of HEIT farmers by N1.28 and N1.10 respectively. Man days of labour and capital inputs however are statistically non significant at the chosen levels, however they possess the expected positive signs.

The non significance of labour and capital among the HEIT farms could be because these inputs may have been uneconomically utilized.

Table 4.9 Estimated Production Function for High External Input Technology Farms in Imo State.

Explanatory Variables	Linear	Semi log	Double log	Exponential Function
Farm size (X_1)	225507.2	141566.1	0.389	0.377
	(2.85)***	(.844)	(4.13)***	(7.15)***
Man days of labour (X_2)	3.297	-19009.2	0.128	0.000135
	(0.011)	(-0.109)	(1.307)	(0.660)
Expenditure on planting material (X_3)	1.34	241673.7	0.217	0.000000727
	(2.25)**	(1.53)	(2.45)**	(1.84)*
Capital input (Depr. & Interest) (X_4)	-24.61	23608.1	-0.122	-0.0000084
	(-1.708)*	(0.102)	(-0.94)	(-0.872)
Expenditure on fertilizer(X_5)	1.107	364511.8	0.228	-0.00000023
	(1.708)*	(2.76)***	(3.07)***	(-0.528)
Constant term	87043.65	-2324365	3.592	4.857
R^2	0.484	0.363	0.703	0.661
F- ratio	13.870	8.433	34.965	28.870

** = Significant at 5%,

*** = Significant at 1%

Figures in parenthesis are t – ratios

Source: Survey data, 2008

For instance man days of labour may not be statistically significant due to low opportunity cost of family labour. Capital input is non significant and negative implying that this resource may have been uneconomically used such that only a reduction of the current level of use could lead to an increase in the gross income of HEIT farmers.

4.2.3 Comparison of Productivity of Resources among LEIT and HEIT Farms

The marginal value product (MVP), of each resource input shows the expected increases in gross income that is forthcoming from the use of an additional unit of the resource, the levels of other inputs being held constant. The marginal value product is the product of the marginal physical product (MPP) and the product price. However the outputs of the two farm types (except land and labour) were measured in Naira terms. Thus in the model MPP =MVP, for all resources except land and labour. Following Bagi,(1981), Onyenweaku et al., (1991), and Ohajianya et-al., (2004) and the information in table 4.21 the MVP are calculated as: $MVP = bi (Qij / Xij)$

Where bi = output elasticity or regression coefficient,(for Cobb-Douglas function)

Qi = Geometric mean of output,

Xi = Geometric mean of the ith input.

The MVP of each of the resources in the two farm types are presented in Table 4.10.

An increase of farm size by one hectare would increase gross output of LEIT farmers by N97159.13. Also an increase of one man day of labour would increase the LEIT farmers' gross income by N1876.14. Furthermore a one naira increase on expenditure on planting materials, organic manure and capital input would increase the LEIT farmers' gross income by N1.96, N5.47 and N23.40, respectively, ceteris paribus.

Similarly, in the HEIT farms an increase of farm size by one hectare would increase the gross income of the farmers by N130387.3. Also an increase of one naira expenditure on planting materials and fertilizer would increase the gross income of the HEIT farmers by N1.28, and N1.10 respectively. Man days of labour and capital inputs however are statistically non significant at the chosen levels of probability though they possess the expected positive signs. This shows that an increase in these non significant explanatory variables will equally result in an increase in the gross income of the HEIT farmers, but such increases may not be significant ceteris paribus.

Table 4.10 : Marginal Value Product of Resources .

Farm type	Farm size (X_1)	Labour input(X_2)	Expenditure on planting materials(X_3)	Capital input(X_4)	Expenditure on organic manure/fertilizer (X_5)
LEIT	97159.1	1876.14	1.959	23.40	5.468
HEIT	130387.3	368.10	1.275	-8.38	1.097

Source: Survey data, 2008

Implication of Findings

On comparative basis, the results show that farm size may have contributed more to gross farm income in the HEIT farms (N130387.3) than in the LEIT farms (N97159.1). On the other hand expenditure on planting materials and organic manure appears to have contributed more to gross farm output in the LEIT farms than expenditure on planting materials and fertilizer in the HEIT farms. As a result agricultural productivity may be enhanced in the state by making policies that encourage the use of organic manure in agricultural production, while de- emphasizing the use of commercial fertilizer.

The impact of inorganic fertilizer is found in most analysis to be largely positive (Obasi, 1995; Ohajianya et-al, 2004; Randrianariosa, 2001, Bernier and Dorosh, 1993, Randrianariosa et-al 2001, 2005), however this result could be due to the fact that the reduction of subsidy on fertilizer and realignment of the naira exchange rate with the American dollar made the input to be expensive and beyond the reach of the small holder farmers (Obasi et-al, 1995; Imahe, et-al 2004, CBN, 2003). According to CBN (2003) "the level of subsidy on fertilizer in Nigeria, gradually fell to between 50 and 25 percent as reflected in the sharp decline in fertilizer use from 80kg per hectare to 23kg per hectare in 1996 and 2000 respectively compared with the minimum of 200kg per hectare internationally recommended standard". In addition the National Fertilizer Company of Nigeria (NAFCON) as well as other fertilizer blending plants were either shut down or reduced to producing at very low capacity (CBN, 2003). The beneficial effects of animal manures on crop yields, when applied in sufficient quantities are well documented (Selvarajan and Krishnamoorthy, 1990; Ali, 1996; Drechsel and Reck, 1998). The result is in consonance with Ohajianya (2005) that farmers who used mulch experienced less loss of profit than farmers who did not use mulch in cocoyam production in Imo state.

The result agrees with UPDR, (2000), in Madagascar, where the use of animal manure was widely reported to have significant positive effect on rice yield relative to inorganic fertilizer. Randrianariosa et-al (2005) also reported that in Madagascar, fertilizer prices were "prohibitively high for most farmers thereby reducing profitability of fertilizer use"; a situation similar to the Nigerian scenario. Furthermore, Reardon, et-al (1997) posited that fertilizer has a relatively low yield response in Africa when compared with results from Asia and Latin America.

Furthermore, man-days of labour, capital inputs (depreciation and interest charges) were shown to be statistically significant in the LEIT farms but non significant in HEIT farms. The statistical non significance of labour and capital inputs in the HEIT farm type may suggest that these variables may have been uneconomically utilized. Man days of labour is however positively related to gross farm output while capital is inversely related to gross farm output.

4.3. Determinants and Comparison of Aggregate Agricultural Productivity among LEIT and HEIT Farms

The results of the multiple regression models on the determinants of aggregate agricultural productivity in LEIT and HEIT farms are presented in Tables 4.11 and 4.12.

In the linear model, seven and nine of the explanatory variables are statistically significant at 1 percent and 5 percent levels in the LEIT and HEIT farms respectively. Similarly, in the semi-log, double-log and exponential functions five, four and five explanatory variables respectively, are statistically significant at 1 percent and 5 percent levels in the LEIT farms. Also in the semi-log, double-log and exponential functions, eight, five and seven explanatory variables respectively, are statistically signific ant at 1 percent and 5 percent levels in the HEIT farms. The coefficients of multiple determination (R^2) for LEIT farms in the linear, semi-log, double-log and exponential functions are 0.896, 0.770, 0.846 and 0.895 respectively. Also in the HEIT farms, the coefficients of multiple determination (R^2) are 0.772, 0.610, 0.479 and 0.560 for the linear, semi-log, double-log and exponential functions respectively. The linear model produced f- values of 82.285 and 13.870 for the LEIT and HEIT farms which are statistically significant at 1 percent level. The linear model with the coefficient of multiple determination of 0.896 and seven statistically significant explanatory variables gave a good fit to the data in the LEIT farms. . Similarly the linear model in the HEIT farms with a coefficient of multiple determination of 0.772, and nine statistically significant explanatory variables gave a good fit to the data. Thus, the results of the linear model in the LEIT and HEIT farms are therefore used for discussion and further analysis.

4.3.1 Determinants of Aggregate Agricultural Productivity in LEIT Farms in Imo State

In the low external input technology farms it was hypothesized that aggregate agricultural productivity is significantly and positively related to farm size, man days of labour, expenditure on planting materials, capital inputs (depreciation and interest charges), expenditure on organic manure, number of crops planted in a mixture, level of education, age, and farming experience but significantly and negatively related to non farm income and distance to the nearest market.

Table 4.11 shows that farm size, expenditure on planting materials, capital inputs, expenditure on organic manure, and number of crops planted in a mixture in the farms, level of education and farming experience are statistically significant at 1 and 5 percent levels. The coefficient of multiple determination (R^2 = 0.896), shows that 90 percent of the variations in aggregate agricultural productivity of LEIT farmers in Imo state was accounted for by the variations in the explanatory variables included in the model. As expected, variables such as farm size, capital input, expenditure on organic manure, number of crops planted in a mixture in a farm, level of education and farming experience are positively related to aggregate agricultural productivity and statistically significant at 1 and 5 percent levels. This implies that an increase in farm size, capital inputs, expenditure on organic manure, and number of crops planted in a mixture, level of education and faming experience (all things being equal) will lead to an increase in aggregate agricultural productivity in Imo state. This result agrees with Obasi, (2000), in Nigeria, Reardon et-al (1997) in Burkina Faso, Senegal and Zimbabwe. Expenditure on planting materials was found to be statistically significant at 1 percent level but negatively related to aggregate agricultural productivity. The farmers may have used unimproved planting materials. Therefore, a reduction in expenditure on these unimproved planting materials would increase aggregate agricultural productivity among LEIT farmers, all things being equal. Reardon et-al (1997) argued that the productivity – enhancing potential of planting materials is dependent not only on the development of appropriate varieties but also on programs that multiply and market the planting materials in such a manner that ensures quality, availability and affordability. The positive relationship between aggregate agricultural productivity and level of education agrees with Ali and Flinn (1989) and Lockheed et-al (1999) in Pakistan. Other variables such as man days of labour, non farm income, distance to the nearest market, age of the farmer and household size were not statistically significant within 1 percent and 5 percent levels. Man-days of labour is positively related to aggregate agricultural productivity but non significant. The non significance of labour input could be because the resource may have been uneconomically utilized given the low opportunity cost of family labour. Distance to the nearest market as expected is inversely related to aggregate agricultural productivity but non significant. Distance may not be significant probably because most of the inputs in LEIT such as organic manure are not purchased from the conventional markets. The variable age, is inversely related to aggregate agricultural productivity and non significant. This could be so where the farmers are too old. Table 4.1 shows that the mean age of the farmers is 52.31years which shows that the farmers are in their productive age. Probably, a reduction in their mean could make them more productive.

Household size is also inversely related to aggregate agricultural productivity and non significant. This is at variance with a priori expectation. The result could be due to the fact that some members of the family who are either pupils or students in schools may not always be available for farm work. Table 4.4 shows that the mean household size among the LEIT farmers is 8.4.

Table 4.11: Estimated Multiple Regression Results on the Determinants of Aggregate Agricultural Productivity for LEIT Farms in Imo State.

Explanatory Variables	Functional Forms Linear	Semi log	Double log	Exponential function
Farm size(X_1) .	0657	1.48	0.023	-0.037
	(3.64)***	(3.87)***	(0.499)	(-1.01)
Labour input(X_2)	0.00022	-0.28	-0.057	-0.0002
	(0.38)	(-0.58)	(-0.98)	(-1.73)*
Expenditure on planting materials (X_3)	-0.000051	-0.904	-0.07	-0.00000015
	(-3.36)***	(-2.48)**	(-1.59)	(-0.495)
Non farm Income(X_4)	-0.0000002	0.154	-0.01	-0.000000035
	(-0.49)	(0.510)	(-0.57)	(-0.412)
Capital input (X_5)	0.000116	1.064	0.23	0.000000195
	(4.97)***	2.38)**	(4.18)***	(4.08)***
Expenditure on manure (X_6)	0.000026	0.864	0.166	0.00000389
	(4.42)***	(3.42)***	(5.41)***	(3.24)***
Crop Mixture (No)(X_7)	0.67	4.23	0.69	0.123
	(5.27)***	(3.91)***	(5.26)***	(4.76)***
Distance to nearest market (X_8)	-0.029	-0.042	-0.087	-0.022
	(-0.44)	(-0.080)	(-1.36)	(-1.63)
Level of Education(X_9)	0.0546	1.31	0.23	0.00727
	(1.95)**	(1.78)*	(2.54)**	(1.27)
Age (X_{10})	-0.0031	-o.29	0.0217	0.008065
	(-0.28)	(-0.13)	(0.08)	0.035)
Household size(X_{11})	-0.047	-1.01	-0.15	-0.0053
	(-1.44)	(-1.20)	(1.46)	(-0.803)
Farming Experience (X_{12})	2.74	1.89	0.306	0.0059
	(2.27)**	(2.29)**	(3.07)***	(2.4)**
Constant term	-818	-3.673	-1.344	-0.264
	(-1.09)**	(-0.831)	(-2.51)**	(-1.732)*
R^2	0.896	0.770	0.846	0.895
F – ratio	48.12	18.72	30.57	22.406
S.E (e^2)	0.8874	1.3191	0.1596	0.1814

** = Significant at 5% *** = Significant at 1%

Figures in parenthesis are t-ratios

Source: Survey data, 2008

4.3.2 Determinants of Aggregate Agricultural Productivity in HEIT Farms in Imo State

The results in Table 4.12 show that farm size, capital input, number of crops planted in a mixture in the farm, labour input, expenditure on planting materials, non farm income, distance to the nearest market, level of education and farming experience are statistically significant at 1 and 5 percent levels. This implies that these variables play significant roles in determining aggregate agricultural productivity in HEIT farms in Imo state. Farm size, capital input, number of crops planted in a mixture in the farm, distance to the nearest market, level of education and farming experience are positively related to aggregate agricultural productivity. On the other hand, man days of labour, expenditure on planting materials and non farm income are negatively related to aggregate agricultural productivity. These shows that an increase in farm size, capital inputs, number of crops planted in a mixture, level of education, distance to the nearest market, and farming experience will lead to an increase in aggregate agricultural productivity in Imo state, all other factors being held constant. This result is in agreement with Obasi (2005) that farm size,labour, and planting materials are among the significant determinants of aggregate agricultural productivity in Imo state. The positive relationship existing between level of education and aggregate agricultural productivity in this study agrees with Feder et-al

(1985) who reviewed some of the evidences behind the often positive relationship between level of education and farm productivity and found that farmers with higher education tend to be early adopters of new technology. In Ghana, Morris et-al., (1999) observed that the adoption of modern maize varieties and row planting is significantly related to the farmers' level of education. The positive relationship between farming experience and aggregate agricultural productivity agrees with Tripp (2006b) who observed that the capacity to take advantage of an innovation may be related to experience in farming. The positive relationship between distance to the nearest market and aggregate agricultural productivity is at variance with a priori expectation. This result, disagrees with Zaal and Oostendorp (2002) in Eastern Kenya, and Cramb et –al, (2000) in the Philippines who compared the experiences of several soil conservation efforts and found that adoption is highest in an area where proximity to markets gives farmers an incentive to conserve their soil. The negative sign on man days of labour and expenditure on planting materials may suggest that a reduction in the current level of use of these inputs may increase aggregate agricultural productivity in Imo state. The negative sign associated with non farm income may imply that a reduction of this factor may increase aggregate agricultural productivity in Imo state. This may be correct since an increase in the time allocated to non farm activities is expected to be negatively correlated to increased aggregate agricultural productivity. If more time is allotted to non farm activities, it implies that less time would be available for allocation to farming activities which may reduce aggregate agricultural productivity. Boyd and Slaymaker (2000) observed that off-farm employment opportunities were an important explanation for farmers lack of interest in soil and water conservation. Similarly, Neill and Lee (2001) found that farmers with more non – farm income were less likely to maintain the use of cover crops. In the United States of America, Smith (2002) points out that smaller farms derive a high proportion of their household income from non – farm activities, and that this division of attention may make them less likely to take interest in resource – conserving, but management – intensive techniques such as precision farming or integrated pest management. In Madagascar, Moser and Barrett (2003) pointed out that those farmers who tried the Systems for Rice Intensification (SRI) techniques and then abandoned them were more likely to be those with higher dependence upon off – farm income, while in Indonesia, Winarto (2002) observed that rice farmers living near the main road and who had other income sources were much less interested in learning the techniques of Integrated Pest

Table 4.12: Estimated Multiple Regression Results on the Determinants of Aggregate Agricultural Productivity of HEIT Farms in Imo State.

Explanatory Variables	Functional Forms: Linear	Semi log	Double log	Exponential function
Farm size(X_1)	1.10	1.78	0.44	0.27
	(6.39)***	(4.23)***	(4.24)***	(5.34)***
Labour input(X_2)	-0.003.	-1.76	-0.51	0.00084
	(-4.19)***	(-3.83)***	(-4.48)***	(-3.94)***
Expenditure on planting materials(X_3)	-0.0000069	-0.86	-0.16	-0.0000014
	(-5.72)***	(-2.08)**	(-1.56)	(-3.83)***
Non farm Income(X_4)	-0.0000024	-0.92	-0.18	-0.00000064
	(-3.23)***	(-2.64)**	(-2.05)**	(-2.90)***
Capital input (X_5)	0.000139	1.94	0.058	0.0000056
	(5.63)***	(3.39)***	(0.40)	(0.77)
Expenditure on fertilizer (X_6)	0.000000411	0.78	0.10	-0.00000012
	(0.28)	(2.25)**	(1.20)	(-0.28)
Crop Mixture (No)(X_7)	0.47	4.07	0.64	0.0898
	(3.34)***	(2.9)***	(1.87)*	(2.16)**
Distance to nearest market (X_8)	0.19	1.50	0.43	4.89
	(3.38)***	(2.28)**	(2.64)**	(2.91)***
Level of Education(X_9)	0.063	0.70	0.029	0.0136
	(2.19)**	(0.94)	(0.16)	(1.6)
Age (X_{10})	-0.029	-2.96	-0.61	-0.0081
	(-1.31)	(-0.86)	(-0.73)	(-1.23)
Household size(X_{11})	-0.012	-0.21	0.11	1.72
	(-0.33)	(-0.20)	(0.42)	(0.16)
Farming Experience (X_{12})	4.46	1.75	0.48	0.0134
	(2.03)**	(1.32)	(1.48)	(2.08)
Constant term	-1.458	2.772	1.856	-0.424
R^2	0.772	0.610	0.479	0.560
F – ratio	18.858	8.725	5.048	7.007
S.E (e^2)	0.9602	1.2549	0.3067	0.2817

** = Significant at 5%
*** = Significant at 1%
Figures in parenthesis are t - ratios
Source: Survey data, 2008

Management (IPM).

The coefficient of multiple determination (R^2 =0.772) indicates that about 77.2 percent of the variations in the aggregate agricultural productivity of HEIT farmers in Imo state are accounted for by the explanatory variables.

Furthermore expenditure on fertilizer, age and household size are statistically non significant at 1 and 5 percent levels. However expenditure on fertilizer was found to be positively related to aggregate agricultural productivity but statistically non significant.

4.3.3 Comparative Analysis of Aggregate Agricultural Productivity among LEIT and HEIT Farmers.

Structural Stability Test

The results of the estimated multiple regression analysis for the two farm types as well as the pooled data are presented in Table 4.13, Figures in parenthesis are t- ratios.

The unexplained variations are computed as 0.8874, 0.9602, and 1.4894 for LEIT, HEIT and pooled data respectively. Using the Chow (1960) F- test, the F- cal = 1.998 > F0.05,13,134 = 1.75, we thus reject the null hypothesis and accept the alternative that there is a significant difference in the aggregate agricultural productivity of LEIT and HEIT farms in Imo state.

However, structural changes in the parameters of a function can arise due to changes in bo or $b_1, \ldots b_{12}$, according to Koutsoyiannis (2001).Thus to isolate the source of the structural changes a dummy variable separator was used.The data from the two farm types (LEIT and HEIT) were pooled

Table 4.13: Estimated Multiple Regression Results on the Determinants of Aggregate Agricultural Productivity for LEIT, HEIT and Pooled Data in Imo State.

Explanatory Variables	LEIT Farms	HEIT Farms	Pooled Data
Farm size(X_1) .	0657	1.10	1.10
	(3.64)***	(6.39)***	(6.09)***
Labour input(X_2)	0.00022	-0.030	-0.0021
	(0.38)	(-4.19)***	(-3.01)***
Expenditure on planting materials (X_6)	-0.0000051	-0.0000069	-0.0000060
	(-3.36)***	(-5.72)***	(-4.08)***
Non farm Income(X_4)	-0.00000020	-0.0000024	-0.0000013
	(-0.49)	(-3.23)***	(-2.21)**
Capital input (X_5)	1.16	0.000139	1.36
	(4.97)***	(5.63)***	(4.85)***
Expenditure on Manure /fertilizer (X_6)	0.000026	0.000000411	9.52
	(4.42)***	(0.276)	(0.571)
Crop Mixture (X_7)	0.67	0.47	0.117
	(5.27)***	(3.34)***	(1.03)
Distance to nearest market (X_8)	-0.029	0.19	0.0181
	(-0.44)	(3.38)***	(0.274)
Level of Education(X_9)	0.0546	0.0630	0.0592
	(1.95)**	(2.19)**	(2.08)**
Age (X_{10})	-0.0031	-0.029	-0.023
	(-0.28)	(-1.31)	(1.45)
Household size(X_{11})	-0.047	-0.012	-0.032
	(-1.44)	(-0.325)	(-0.89)
Farming Experience (X_{12})	2.74	0.0446	0.0428
	(2.27)**	(2.03)**	(2.72)***
Constant term	-818	-1.458	0.845
	(-1.09)**	(-1.44)	(0.947)
R^2	0.896	0.772	0.591
F – ratio	48.12	18.858	17.68
S.E (e^2)	0.8874	0.9602	1.4894

** = Significant at 5%
*** = Significant at 1%
Figures in parenthesis are t- ratios
Source: Survey data, 2008

together and a dummy variable introduced for the purpose of testing the statistical significance of the coefficient of the dummy variable and to measure the direction of the intercept shift using the sign of the estimated coefficient of the dummy variable. The estimated regression results with pooled data and dummy variable are presented in equation 4.1 below.

$$Qp = 0.593 - 2.103D + 1.041X_1 - 0.002X_2 - 0.0000057X_3 - 0.0000013X_4 +$$
$$(0.807) \quad (-8.45)^{***} \quad (7.00)^{***} \quad (-3.62)^{***} \quad (-4.74)^{***} \quad (-2.76)^{***}$$
$$1.04X_5 + 0.00000322X_6 + 0.601X_7 + 0.0379X_8 + 0.0684X_9 - 0.023X_{10}$$
$$(-4.44)^{***} \quad (2.31)^{**} \quad (5.49)^{***} \quad (0.697) \quad (2.91)^{***} \quad (-1.82)$$
$$- 3.2X_{11} + 0.0322X_{12}$$
$$(-1.08) \quad (2.48)^{**} \qquad \text{eqn. (4.1)}$$

$R^2 = 0.725$

** = significant at 5%, *** = significant at 1%

Figures in parenthesis are t- ratios.

Qp = pooled aggregate agricultural productivity of LEIT and HEIT.

Other variables are as previously explained in equation (3.16), (3.9),(3.11), and (3.12)

The coefficient of the dummy variable is statistically significant at 1 percent level but negatively correlated with aggregate agricultural productivity. This further confirms that there is a significant difference between the aggregate agricultural productivity of LEIT and HEIT farm types. The negative sign of the coefficient of the dummy variable indicates that the HEIT farm type has a lower aggregate agricultural productivity relative to the LEIT farm type. An examination of the constant terms of LEIT (-0.818) and HEIT (-1.458) in Tables 4.11 and 4.12 reveal that the LEIT farms have higher intercept than the HEIT farms. This may suggest that low external input technology farms in Imo state achieved higher aggregate agricultural productivity than high external input technology farms.

The impact of inorganic fertilizer is found in most analysis to be largely positive (Obasi, 1995; Ohajianya et-al, 2004; Randrianariosa, 2001, Bernier and Dorosh, 1993, Randrianariosa et-al, 2001, 2005), however this result could be due to the fact that the reduction of subsidy on fertilizer and realignment of the Naira exchange rate with the American dollar made the input to be expensive and beyond the reach of the small holder farmers (Imahe, et-al 2004). According to CBN (2003) “the level of subsidy on fertilizer in Nigeria, gradually fell to between 50 and 25 percent as reflected in the sharp decline in fertilizer use from 80kg per hectare to 23kg per hectare in 1996 and 2000 respectively compared with the minimum of 200kg per hectare internationally recommended standard”. In addition the National Fertilizer Company of Nigeria (NAFCON) as well as other fertilizer blending plants were either shut down or reduced to producing at very low capacity (CBN, 2003).The beneficial effects of animal manures on crop yields, when applied in sufficient quantities are well documented (Selvarajan and Krishnamoorthy, 1990; Ali, 1996; Drechsel and Reck, 1998).Thus, the result agrees with UPDR, (2000), in Madagascar, where the use of animal manure was widely reported to have significant positive effect on rice yield relative to inorganic fertilizer. Randrianariosa et-al, (2005) also reported that in Madagascar, fertilizer prices were "prohibitively high for most farmers thereby reducing profitability of fertilizer use"; a situation similar to the Nigerian scenario. Furthermore, Reardon, et-al (1997) posited that fertilizer has a relatively low yield response in Africa when compared with results from Asia and Latin America.

4.4.0 Determination and Comparison of Individual Resource Productivity among LEIT and HEIT Farmers

The estimated multiple regression results of the determinants of individual resource productivities for LEIT and HEIT are presented in Tables 4.14 to 4.18.

4.4.1 Determination and Comparison of Land Productivity among LEIT and HEIT Farmers

Table 4.14 shows that man days of labour, and number of crops planted in mixtures are the significant determinants of land productivity among low external input technology farmers in Imo state. These explanatory variables are statistically significant at 1 and 5 percent levels. The coefficient of multiple determination ($R^2 = 0.19$) showing that these variables accounted for 19 percent of the variations in land productivity among LEIT farmers in Imo state. Man days of labour and number of crops planted in a mixture are positively related to land productivity showing that an increase in these explanatory variables would, all other things being equal increase land productivity among LEIT farmers in Imo state. However expenditure on organic manure and planting materials are positively related to land productivity but statistically non significant. Level of education, on the other hand, is not statistically significant but negatively related to land productivity. The negative sign is contrary to a priori expectations. This inverse relationship between land productivity and level of education may be that as the level of education of the farmers increase, they are attracted to investments other than agriculture which reduces the land productivity.

With regard to high external input technology farms, man days of labour, expenditure on planting materials and fertilizer are the significant determinants of land productivity. These variables are statistically significant at 1 percent and 5 percent levels. The coefficient of multiple determination ($R^2 = 0.37$) shows that 37 percent of the variations in land productivity among HEIT farmers are accounted for by the explanatory variables included in the model. However, only expenditure on fertilizer is positively related to land productivity. This shows that an increase in the expenditure on this input will increase land productivity among HEIT farmers in the state. However, labour input and expenditure on planting materials are negatively related to land productivity. This may imply that a reduction in the current level of use of these input is necessary in order to increase land productivity among this group of farmers.

Comparatively, while man days of labour is a significant determinant of land productivity in both LEIT and HEIT, the result further shows that it is positively related to land productivity in the LEIT but negatively related to land productivity in HEIT. Similarly while number of crops planted in a mixture is a significant determinant of land productivity in LEIT farms, the reverse is the case in HEIT farms. Expenditure on planting materials and fertilizer are the significant determinants of land productivity in HEIT farms but not in LEIT farms. Following Koutsoyiannis (1979), we examine their constant terms. The constant term for land productivity for both LEIT and HEIT farms are shown in Table 4.14. The value (215090.9) may imply that the LEIT farms had a higher land productivity relative to HEIT farms with a constant term of -43645.7.

Table 4.14 Estimated Multiple Regression Results on the Determinants of Land Productivity in the LEIT and HEIT Farms in Imo State.

Explanatory Variables	LEIT	HEIT
Man days of labour (X_2)	1593.77	-1193.78
	(2.86)***	(-1.99) **
Expenditure on planting materials (X_3)	0.812	-1.90
	(0.590)	(-1.98) **
Expenditure on Manure/ fertilizer (X_6)	0.967	4.76
	(0.188)	(4.70)***
Crop Mixture(No)(X_7)	275547.7	165761.4
	(2.27)**	(1.46)
Level of Education(X_9)	-33705.7	1661.05
	(-1.36)	(0.073)
Constant term	215090.9	-43645.7
R^2	0.187	0.368
F – ratio	3.402	5.160

** = Significant at 5%
*** = Significant at 1%
Figures in parenthesis are t - ratios
Source: Survey data, 2008

4.4.2 Determination and Comparison of Labour Productivity among LEIT and HEIT Farmers

The results of the estimated multiple regression model on the determinants of labour productivity in the LEIT and HEIT farms are presented in Table 4.15. The results in Table 4.15 shows that capital input, expenditure on manure, expenditure on planting materials, non farm income and number of crops planted in a mixture are the significant determinants of labour productivity in the LEIT farms. These explanatory variables are statistically significant at 1percent and 5 percent levels and positively related to labour. This implies that an increase in the level of use of these variables will result in an increase in labour productivity in the LEIT farms. The coefficient of multiple determination (R^2 =0.636) shows that about 63.6 percent of the variations in labour productivity in the LEIT farms are accounted for by the explanatory variables included in the model. Other explanatory variables such as farm size and level of education are positively correlated with labour productivity but statistically non significant. With regard to HEIT farms, Table 4.15 shows that the significant determinants of labour productivity are capital input, farm size, number of crops planted in a mixture, non farm income, and level of education. All these variables are statistically significant at 1percent and 5 percent levels of probability. This implies that these variables play significant roles in determining labour productivity in the HEIT farms in Imo state. The coefficient of multiple determination (R^2 = 0.608) shows that about 61 percent of the variations in labour productivity among HEIT farmers in Imo state are accounted for by the explanatory variables included in the model.

Comparatively, capital inputs, and number of crops planted in a mixture, are significant determinants of labour productivity in both the LEIT and HEIT farms. They are also positively related to labour productivity.

Table 4.15 Estimated Multiple Regression Results on the Determinants of Labour Productivity in the LEIT and HEIT Farms in Imo State.

Explanatory Variables	LEIT	HEIT
Farm size	725.90	2090.94
	(1.27)	(3.40)***
Capital input (X_5)	0.1931.	0.357
	(2.65)**	(4.36)***
Expenditure on planting materials (X_3)	0.135	-0.0062
	(2.91)***	(-1.51)
Expenditure on Manure /fertilizer (X_6)	0.0548	0.00231
	(2.98)***	(0.445)
Crop Mixture (X_7)	928.57	1358.12
	(2.41)**	(2.75)***
Level of Education(X_9)	77.47	- 248.41
	(0.876)	(-2.54)**
Non farm income (X_4)	-0.0084	-0.023
	(-3.11)***	(-1.421)
Constant term	-2239.59	-1922.24
R^2	0.636	0.608
F – ratio	23.968	13.746

** = Significant at 5%

*** = Significant at 1%

Figures in parenthesis are t- ratios.

Source: Survey data, 2008.

This shows that an increase in these variables would increase labour productivity in both the LEIT and HEIT farms ceteris paribus. Expenditure on organic manure in LEIT farms and fertilizer in HEIT farms are also positively correlated with labour productivity. However while expenditure on manure is significant, expenditure on fertilizer is not significant at 1 percent and 5 percent levels. Also while farm size and levels of education of the farmer are not statistically significant but positively related to labour productivity in the LEIT farms, these variables are statistically significant in the HEIT farms. An examination of their constant terms as shown in Table 4.15 shows that the HEIT (-1922.24) has a higher constant term relative to the LEIT (-2239.59) farm type. This may suggest a higher level of labour productivity in the HEIT farm type relative to the LEIT farms in Imo state.

4.4.3 Determination and Comparison of the Productivity Capital among LEIT and HEIT Farmers

The results in Table 4.16 shows that farm size, expenditure on manure, expenditure on planting materials and level of education are the significant determinants of capital productivity among LEIT farms in Imo state. These variables are statistically significant at 1percent and 5 percent levels and positively related to capital productivity. This shows that an increase in the level of use of these variables (all things being equal) will lead to an increase in the productivity of capital among LEIT farms in Imo state. The negative correlation between level of education and productivity of capital was not expected. This result may be explained by the fact that as farmers level of education increases they tend to direct their capital input investments to more productive sectors of the economy other than agriculture. The coefficient of multiple determination ($R^2 = 0.612$) indicates that 61percent of the variations in the productivity of capital among LEIT farms in Imo state are accounted for by the explanatory variables included in the model.

Table 4.16 shows further that the main determinants of capital productivity among HEIT farms are farm size and number of crops planted in a mixture. These variables are statistically significant at 1 percent and 5 percent levels and positively related to capital productivity thus implying that an increase in the levels used of these explanatory variables will lead to an increase in the productivity of capital among HEIT farms in Imo state. Other explanatory variables such as level of education, expenditure on planting materials and man days of labour are positively related to capital productivity but statistically non significant. The coefficient of multiple determination ($R^2 = 0.528$) suggests that 52.8 percent of the variations in the productivity of capital are accounted for by the explanatory variables included in the model.

Comparatively, farm size was found to be a significant determinant of capital productivity in both the LEIT and HEIT farms. In both cases farm size is positively correlated to capital productivity. Furthermore expenditure on organic manure, planting materials and level of education were also shown to be significant determinants of capital productivity in LEIT farms but non significant determinants of capital productivity in HEIT farms.

Similarly, the number of crops planted in a mixture is a significant determinant of capital productivity in HEIT farms the reverse is the case among LEIT farms.

Table 4.16: Estimated Multiple Regression Results on the Determinants of Capital Productivity in the LEIT and HEIT Farms in Imo State.

Explanatory Variables	LEIT	HEIT
Farm size (X_1)	94.20	61.27
	(2.68)***	(4.77)***
Labour input (X_2)	0.0718	0.0412
	(0.886)	(0.785)
Expenditure on planting materials (X_3)	0.000678	0.000145
	(2.57)**	(1.71)
Expenditure on Manure / fertilizer (X_6)	0.00301	-0.000073
	(4.67)***	(-0.662)
Crop Mixture (X_7)	12.61	24.20
	(0.715)	(2.41)**
Level of Education(X_9)	-7.99	2.20
	(-2.14)**	(1.06)
Constant term	93.337	-48.206
R^2	0.612	0.528
F – ratio	13.973	9.944

** = Significant at 5% , *** = Significant at 1%
Figures in parenthesis are t- ratios.
Source: Survey data, 2008

An examination of the constant terms of the two groups of farms reveals that LEIT farms have a positive constant term (93.337) while HEIT has a negative constant term (-48.206). This may imply that capital was more productively used in the LEIT farms than in the HEIT farms.

4.4.4 Determination and Comparison of the Productivity of Organic and Inorganic Fertilizer among LEIT and HEIT Farmers.

The results in Table 4.17 show that the number of crops planted in a mixture in a given farmland, and farm size played major roles in determining the productivity of organic manure in LEIT farms. These two explanatory variables are statistically significant at 1percent level and positively related to the productivity of organic manure. Other explanatory variables such as man days of labour and capital input are positively related to the productivity of organic manure but statistically non significant. The coefficient of multiple determination (R^2 = 0.43)) shows that 43 percent of the variations in the productivity of organic manure is accounted for by the explanatory variables included in the model.

Similarly, explanatory variables such as farm size and number of crops planted in a mixture in the HEIT farms are statistically significant at 1% and 5% levels and positively correlated with the productivity of fertilizer.

The result may suggest that an increase in farm size and crop density will lead to an increase in the productivity of inorganic fertilizer in HEIT farms. The coefficient of multiple determination (R^2 = 0.519) shows that 52% of the variations in the productivity of inorganic fertilizer in the HEIT farms are accounted for by the explanatory variables.

Table 4.17: Estimated Multiple Regression Results on the Determinants of Organic Manure and Inorganic Fertilizer Productivity in the LEIT and HEIT Farms in Imo State.

Explanatory variables	LEIT	HEIT
Farm size (X_1)	173.93	14.83
	(3.54)***	(5.48)***
Labour input (X_2)	0.199	0.00518
	(1.15)	(0.38)
Expenditure on planting materials (X_3)	-0.0000015	0.0000176
	(-0.003)	(0.84)
Capital input (X_5)	0.00487	-0.00044
	(0.725)	(-1.038)
Crop Mixture (X_7)	100.53	5.95
	(3.00)***	(2.26)**
Constant term	-234.658	-41.372
R^2	0.430	0.519
F – ratio	11.187	9.585

** = Significant at 5%, *** = Significant at 1%
Figures in parenthesis are t-ratios.
Source: Survey data, 2008

Comparatively, farm size and number of crops planted in a mixture in the two farm types were shown to be the significant determinants of productivity of organic manure and inorganic fertilizer in the LEIT and HEIT farms respectively. However an examination of the constant terms of these two farmer groups in Table 4.17 shows that inorganic fertilizer was more productive than organic manure.

4.4.5 Determination and Comparison of the Productivity of Planting Materials among LEIT and HEIT Farmers

Table 4.18 shows that farm size, expenditure on organic manure, household size and level of education are the only significant determinants of the productivity of planting materials in LEIT farms. These factors are statistically significant within 1% to 5% levels. Farm size and household size were shown to be positively correlated with productivity of planting materials, while levels of education and expenditure on organic manure have an inverse relationship with productivity of planting materials. This may suggest that while an increase in farm size and household size would lead to an increase in the productivity of planting materials the reverse is the case for level of education and expenditure on organic manure. The inverse relationship was unexpected. This may imply that the current level of use of organic manure needs to be reduced in order to increase the productivity of planting materials. Generally an increase in the level of education is expected to increase the productivity of planting materials but where such an increase (in number of years spent in school), is not marched with an increase in technical know-how, it becomes probable that productivity of planting materials may be compromised and hence an inverse relationship.

Furthermore, Table 4.18 shows that capital input, expenditure on fertilizer and farm size are the significant determinants of productivity of planting materials among HEIT farms. These variables are statistically significant at 1% and 5% levels. Apart from expenditure on fertilizer that is negatively correlated to the productivity of planting materials, farm size, and capital inputs are positively related. The implication of this is that an increase in capital input and farm size would, ceteris paribus, increase the productivity of planting materials. It is probable that the soil may have been so fertile that any further increase in its fertility status could only lead to a diminishing return; hence a reduction in the current level of use of fertilizer may increase the productivity of planting materials among HEIT farms. In addition the realignment of the naira exchange rate which resulted in the depreciation of the naira has increased the prices of imported agricultural inputs such as fertilizer (CBN, 2003).

It therefore becomes uneconomical to increase the level of use of such inputs (as fertilizer) at the prevailing price.

An examination of the constant terms of these two farmer groups as shown in table 4.18 reveals that HEIT farms have a higher constant term than their

LEIT farms. This may suggest that planting materials have higher levels of productivity among HEIT farms than in LEIT farms.

Table 4.18: Estimated Multiple Regression Results on the Determinants of Productivity of Planting Materials among LEIT and HEIT Farmers.

Explanatory variables	LEIT	HEIT
Farm size	46033.85	3.797
	(3.59)***	(2.16)**
Capital input	1.80	0.000693
	(1.023)	(2.92)***
Manure / Fertilizer	-0.964	-0.000036
	(-2.19)**	(-2.47)**
Household size	5534.29	-0.059
	(2.36)**	(-0.185)
Level of Education	-4045.73	0.548
	(-1.92)**	(1.90)*
Constant term	-16797.5	-0.160
R^2	0.239	0.231
F – ratio	3.831	2.669

** = Significant at 5%
*** = Significant at 1%

Figures in parenthesis are t-ratios.

Source: Survey data, 2008

4.5.0 Determination of Production Efficiency of LEIT and HEIT Farmers

4.5.1 Analysis and Comparison of Technical Efficiency among LEIT and HEIT Farmers

The results of the fitted equations 40 to 44 are presented in Table 4.19.

A careful examination of the results in Table 4.19, shows that in the linear model, farm size, planting materials, capital input, fertilizer and organic manure, capital input and expenditure on fertilizer and organic manure dummies are statistically significant within 1% and 5% levels, labour input, intercept dummy, farm size dummy, labour dummy, expenditure on planting material dummy, are non significant. Among the non significant variables, labour input, intercept dummy and farm size dummy are positively correlated with gross farm output while expenditure on planting materials dummy and labour input dummy are negatively related to gross farm output.

While farm size, value of planting materials, capital input, and expenditure on fertilizer and organic manure are statistically significant and positively related to gross farm output, value of planting material and expenditure on fertilizer and organic manure dummies are statistically significant but negatively related to gross farm output. The coefficient of multiple

Table 4.19: Estimated Results of Multiplicative Dummy Variable Approach for the Determination of Relative Technical Efficiency in LEIT and HEIT Farms

Functions	Linear	Semi log	Double log	Exponential Function
Farm size(X_1)	166096.1	230916.4	0.17	0.193
	(2.68)***	(1.847)*	(2.23)**	(3.44)***
Labour input(X_2)	219.8	38123.5	0.504	0.000655
	(0.98)	(0.233)	(5.08)***	(3.20)***
Value of planting materials (X_3)	1.74	200315.8	0.28	0.0000029
	(2.85)***	(1.58)	(3.65)***	(5.26)***
Capital input(X_4)	19.74	308759	0.412	0.0000362
	(2.29)**	(2.19)**	(4.81)***	(4.63)***
Value of fertilizer/manure (X_5)	11.86	274402.3	0.131	0.00000149
	(7.56)***	(2.76)***	(2.17)**	(1.05)
Intercept dummy D	155475.6	2134017	2.74	0.282
	(1.46)	(1.75)*	(3.71)***	(2.91)***
Farm size Dummy	97300.6	59146	0.235	0.201
	(1.11)	0.302	(1.97)**	(2.52)***
Labour dummy	-141.7	836.7	-0.375)	-0.00047
	(-.o.43)	(0.004)	(-2.76)***	(-1.56)
Planting Material dummy	-0.98	14763.6	-0.075	0.0000024
	(-1.33)	(0.077)	(-0.644)	(-3.60)***
Capital input dummy	-20.32	-641936	-0.542	-0.000037
	(-2.35)**	(-3.52)***	(-4.89)***	(-4.68)***
Fertilizer Manure dummy	-11.04	53775.6	0.0713	0.0000019
	(-6.69)***	(0.348)	(0.76)	(-1.24)
Intercept	-87929.5	-2495252	1.232	4.599
F – ratio	25.49	11.15	44.183	27.48
R^2	0.655	0.453	0.767	0.671

** = significant at 5%,
*** = Significant at 1%
Figures in parenthesis are t-ratios
Source: Survey data, 2008

determination (R^2 = 0.655) shows that 65.5% of the variations in the gross farm output is accounted for by the explanatory variables.

In the semi log model, capital input, expenditure on fertilizer and organic manure and capital input dummy are statistically significant at 1% and 5% levels. While capital input and expenditure on manure and fertilizer are positively related to gross farm output the reverse is the case for capital input dummy. However, farm size, labour input, expenditure on planting materials, intercept dummy, farm size dummy, labour dummy, expenditure on planting materials, expenditure on fertilizer and organic manure dummies are non significant but positively correlated with gross farm output. The coefficient of multiple determination (R^2 = 0.453) shows that 45% of the variations in the gross farm output of the farmers is accounted for by the variations in the explanatory variable included in the model.

In the double log model, on the other hand, farm size, labour input, expenditure on planting materials, capital input, expenditure on fertilizer and organic manure, intercept shift dummy, farm size dummy, labour dummy, and capital input dummy are statistically significant at 1% and 5% levels. While farm size, labour input, expenditure on planting materials, capital input, expenditure on fertilizer and organic manure, intercept shift and farm size dummies are positively correlated with gross farm output, labour and capital input dummies are negatively related to gross farm output. In addition the result showed that while expenditure on fertilizer and organic manure are non significant but positively related to gross farm output expenditure on planting material dummy is non significant but negatively related to gross farm output. The coefficient of multiple determination (R^2 = 0.767) show that 77% of the variations in the gross farm output is accounted for by the variables included in the model.

Furthermore in the exponential functions, farm size, labour input, expenditure on planting materials, capital input, intercept shift dummy, farm size dummy, expenditure on planting materials dummy and capital input dummy are statistically significant within 1% and 5% levels. However while expenditure on planting materials dummy and capital dummy are negatively correlated with gross farm output the rest are positively related with gross farm output. In addition in the exponential function and the double log models, the intercept dummy is statistically significant at 1 percent level, while the slope shift dummies for farm size, labour, and capital input, and farm size, expenditure on planting materials, and capital input are statistically significant at 1 percent level in the double log and exponential function respectively. Thus based on the sign and size of the estimated coefficients, the coefficient of multiple determination, and statistical significance of the coefficients, the double log function was chosen as the lead equation and used for further analysis of the data. The intercept shift dummy is statistically significant at 1 percent level of probability which means that a shift in technology exists between the low external input technology (LEIT) farms and high external input technology (HEIT) farms in Imo state. Moreover, the intercept shift dummy has a positive slope. Therefore, there is a shift in neutral technical efficiency parameter to a higher level for high external input technology farms, implying that this group of farms achieved higher levels of output per unit of each input, and hence a higher technical efficiency than the low external input technology farms. The slope shift, dummy for farm size, labour input and capital are highly statistically significant at 1 and 5 percent levels. This implies that the LEIT and HEIT farms are characterized by factor biased or non neutral production functions. In other words, both groups of farms have different functions. Furthermore, the slope shift for labour and capital are negative, suggesting a lower level of use intensities for this resource by the HEIT farmers. The slope shift dummy for farm size is positive, suggesting a higher level of use intensities for this resource by the HEIT farmers in Imo state. This result agrees with Ohajianya and Onu (2004) who observed that the production function of fertilizer users in vegetable production had a larger intercept term denoting higher level of technical efficiency than that of non users.

4.5.2 Determination and Comparison of Allocative Efficiency among LEIT and HEIT Farmers

The ratio of marginal value product (MVP) to marginal factor costs (MFC) for LEIT and HEIT farms are presented in Table 4.20. Using the Cobb-Douglas production function which was the lead equation for LEIT and HEIT farm types, the allocative efficiency indices for land, labour, are derived as

$Wij = bi(Q_{ij} / X_{ij}) / P_{xi}$

Where Q_{ij} = Geometric mean of output (N) in $_j$th farm

X_{ij} = Geometric mean of ith input in $_j$th farm

Others are as defined in equation (46).

Table 4.20 shows the ratio of marginal value product of resources to their marginal factor costs. Table 4.20 suggests that resources such as farm size, labour, planting materials capital inputs, organic manure are underutilized in LEIT farms. Thus the level of parity between marginal value product of each resource and the marginal factor cost has not been reached in the production system in LEIT farms. The LEIT farms were relatively more allocatively efficient in the use of planting materials than any of land, labour, capital input and organic manure.

Similarly, in the HEIT farms, Table 4.20 shows that resources such as land, planting materials and inorganic fertilizer are under utilized. The HEIT farmers were allocatively more efficient in the use of fertilizer than any of land and planting materials. Table 4.20 suggests further that none of the defined farmer groups achieved absolute allocative efficiency in the use of any farm resources. They are inefficient in the allocation of farm production resources such as farm land, labour input, planting materials, capital input, fertilizer and organic manure.

On the whole, LEIT farmers achieved higher allocative efficiency in the use of land (32.71) than HEIT (37.25). HEIT on the other hand achieved higher allocative efficiency (1.275) and (1.097) in the use of planting materials and inorganic fertilizer than LEIT farmers.

Table 4.20: Ratio of Marginal Value Product (MVP) to Marginal Factor Costs (MFC) for LEIT and HEIT Farms in Imo State.

Farm Type	MVP/MFC					
	Farm size (X_1)	Labour input(X_2)	Expenditure on planting mat5erials(X_3)	Capital input X_4)	Fertilizer (X_5)	Manure (X_5)
LEIT Farms	32.71	2.615	1.959	23.40	-	5.468
HEIT Farms	37.25	0.512	1.275	-8.38	1.097	-

Source: Survey data, 2008

Table 4.21, shows that the LEIT farms need to increase the use of farm land by 3171 percent, 161 percent resources of mandays of labour, 95.9 percent resources of planting materials, 2248 percent resources of capital input and 446.8 percent of organic manure to achieve parity or absolute allocative efficiency.

Also the HEIT farm type needs to increase the use of farm land by 3625 percent and expenditure on planting materials by 27.5 percent and inorganic fertilizer by as much as 9.7 percent in order to achieve maximum allocative efficiency and profit maximization.

Table 4.21: Allocative Efficiency Indices for LEIT and HEIT Farms in Imo State

	LEIT	HEIT
Production Elasticities		
Farm Land	0.169	0.389
Labour	0.505	0.128
Planting materials	0.279	0.217
Capital input	0.412	-0.122
Manure / Fertilizer	0.131	0.228
Geometric mean of inputs and outputs		
Farmland (ha)	0.6709	1.1617
Labour (man days)	103.82	135.4
Expenditure on planting materials	54945.56	66275.50
Capital input (Depreciation & Interest charges	6790.75	5667.8
Expenditure on fertilizer or manure	9240	80961.88
Farm output	385704.5	389385.4
Marginal Value Product		
Farm land	97159.13	130387.3
Labour input	1876.14	368.10
Expenditure on planting materials	1.959	1.275
Capital input	23.40	- 8.38
Expenditure on fertilizer or manure	5.468	1.097
Marginal Factor Cost		
Farm land	2970	3500
Labour	717.5	718.75
Expenditure on planting materials (N)	1	1
Interest Rate	1.19	1.19
50kg bag of fertilizer or manure	430.5	3630
Allocative Efficiency Indices		
Farm land	32.71	37.25
Labour	2.615	0.512
Expenditure on planting materials	1.959	1.275
Capital input	23.40	-8.38
Expenditure on Fertilizer or manure	5.468	1.097
Percentage Changes in Allocative Efficiency		
Farm land	3171	3625
Labour input	161	48.8
Expenditure on planting materials	95.9	27.5
Capital input	2248	938
Expenditure on fertilizer or manure	4468	9.7

Source: Survey data, 2008.

4.5.3 Determination and Comparison of Economic Efficiency among LEIT and HEIT Farmers

In order to achieve this objective the data collected for LEIT and HEIT farms were pooled and the profit function fitted to the data using the ordinary least square regression technique. Table 4.22 shows the results of the estimated function.

The included variables – farm size and capital were found to be statistically significant at 1 percent level. This indicates that these variables play significant roles in the determination of the maximized profit of the farm firm. The coefficient of multiple determination (R^2) is 0.236. This suggests that about 24 percent of the variations in profit are accounted for by the independent variables. The coefficient of the dummy variable was negative and not statistically significant at 5 percent level. This implies that the profit function for the HEIT farms has a lower intercept term than that of the LEIT farms. This is suggestive of a higher level of economic efficiency in the low external input technology farms and a lower level of economic efficiency in the high external input technology farms.

Table 4.22: Estimated Profit Function for LEIT and HEIT Farms in Imo State

.Explanatory Variables	Regression Coefficient	t – Ratios
Dummy variable (D)	-0.155	-0.507
Wage rate (Wr)	-1.591	-1.616
Farm size (Fs)	0.601	3.820***
Capital input (Kv)	0.633	2.960**
Constant term	17.484	2.790***
R^2	0.236	
F – Ratio	8.587***	
N	160	.

** = significant at 5%, *** = Significant at 1%
Figures in parenthesis are t-ratios
Source: Survey data, 2008.

4.6 Estimation and Comparison of Returns to Scale among LEIT and HEIT Farmers.

Returns to scale are derived through the summation of the elasticities of production ($\sum ERX_{ij}$) for the various resources. With the double log function as the lead equation for both the LEIT and HEIT farms the regression coefficients are the direct elasticities of production. The estimated elasticities of production and returns to scale are presented in Table 4.23. The values in Table 4.23 indicate the percentage change that would occur in total yield as a result of a one percent change in the level of use of the given resource, while keeping the other resources constant.

The result in Table 4.23 shows that the output of LEIT farmers would change by 0.169, 0.505, 0.279, 0.412 and 0.131 with a 1 percent change in farm size, man days of labour, expenditure on planting materials, capital input, and expenditure on organic manure respectively.

Similarly a one percent change in farm size, expenditure on planting materials and fertilizer would increase the gross output of HEIT farmers by 0.389, 0.217, and 0.228 respectively. In the HEIT farms, output was more responsive to changes in farm size, and fertilizer application and least responsive to changes in expenditure on planting materials.

With respect to LEIT farms, output was found to be more responsive to organic manure than the other inputs.

On the other hand estimated returns to scale for both LEIT and HEIT farms suggests that none of the two groups of farms is operating at constant returns to scale. The returns to scale estimated for LEIT farmers (1.496) shows that they experienced increasing returns to scale ($\sum ERX_{ij} > 1$). The value estimated for HEIT farmers (0.84) show that they experienced decreasing returns to scale ($\sum ERX_{ij} < 1$)

The overall implication of this result is that the LEIT farmers can improve on their productivity by employing more resources while the HEIT farmers can only improve their productivity by reducing their current level of resource employment at the present state of technology.

Table 4.23: Estimated Elasticities of Production and Returns to Scale for LEIT and HEIT Farms in Imo State.

Farm type	Farm size (X_1)	Labour X_2	Planting materials (X_3)	Capital input (X_4)	Fertilizer (X_5)	Manure (X_5)	Returns to Scale
LEIT	0.169	0.505	0.279	0.412	-	0.131	1.496
HEIT	0.389	0.128	0.217	-0.122	0.228	-	0.84

Source: Survey data, 2008

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS.

5.1 Summary

The broad objective of this study was to compare productivity and efficiency in low and high external input technology farms in Imo state of Nigeria. The specific objectives of the study are to ascertain and compare the socio-economic characteristics of the two groups of farmers in the state; to determine and compare productivity of resources, factors influencing aggregate agricultural productivity, factors influencing individual resource productivities, production efficiency of LEIT and HEIT farmers in the state; and to estimate and compare the returns to scale among the two groups of farms in the state.

The study was carried out in Imo state, Nigeria. Random samples of 80 LEIT and another 80 HEIT farmers were chosen using the multistage random sampling technique. Data were collected using structured questionnaire and practical measurements of plot sizes with the aid of global positioning system.

Data collected were analyzed using frequencies, tables', percentages, means, multiple regression analysis technique, multiplicative dummy variable approach and profit function.

The results of data analysis on the productivity of resources show that the statistically significant determinants of gross income in LEIT farms are farm size, labour, expenditure on planting materials, capital inputs and expenditure on organic manure. Similarly, farm size, expenditures on planting materials, and fertilizer are the statistically significant determinants of gross income in the HEIT farms.

The MVP of each of the resources in the two farm types shows that farmland was more productive in the HEIT than LEIT farms. Planting materials was however more productive in LEIT than HEIT farms. Furthermore, organic manure was more productive in LEIT farms than fertilizer in HEIT farms.

The main determinants of aggregate agricultural productivity in LEIT farms were shown to be farm size, expenditure on planting materials, capital inputs, expenditure on organic manure, number of crops planted in a mixture in the farms, level of education and farming experience. On the other hand farm size, capital input, number of crops planted in a mixture in the farm, distance to the nearest market, level of education, farming experience, mandays of labour, and non farm income are the main determinants of aggregate agricultural productivity in HEIT farms.

The result of a comparative analysis between aggregate agricultural productivity of LEIT and HEIT farms, shows that the LEIT farms in Imo state achieved higher aggregate agricultural productivity than HEIT farms.

Results of data analysis on the determinants of individual resource productivity between LEIT and HEIT showed that man days of labour, and number of crops planted in mixtures are the significant determinants of land productivity among LEIT farms in Imo state. With regard to HEIT farms, man days of labour, expenditure on planting materials and fertilizer are the significant determinants of land productivity. Furthermore capital input, expenditure on manure, expenditure on planting materials, and number of crops planted in a mixture are the significant determinants of labour productivity in the LEIT farms. With regard to HEIT farms, the significant determinants of labour productivity are capital input, farm size, number of crops planted in a mixture, non farm income, and level of education.

Farm size, expenditure on manure and planting materials and level of education are the significant determinants of capital productivity among LEIT farms in Imo state. Similarly the main determinants of capital productivity among HEIT farms are farm size and number of crops planted in a mixture. The productivity of both organic manure in LEIT farms and inorganic fertilizer in HEIT farms are statistically and significantly determined by farm size and number of crops planted in a mixture.

The result of data analysis on the determinants of the productivity of planting materials showed that farm size, expenditure on organic manure, household size and level of education are the statistically significant determinants of the productivity of planting materials in LEIT farms. On the other hand capital input, expenditure on fertilizer and farm size are the statistically significant determinants of productivity of planting materials among HEIT farms.

Results of comparative analysis of technical efficiency between LEIT and HEIT farms showed that HEIT farms achieved higher technical efficiency relative to the low external input technology farms.

Data analysis on the relative allocative efficiency of LEIT and HEIT farms indicated that none of the defined farmer groups achieved absolute allocative efficiency in the use of any farm resource.

The result of comparative analysis of economic efficiency between LEIT and HEIT farms showed that the profit function for the HEIT farms has a lower intercept term than that of the LEIT farms. This is suggestive of a higher level of economic efficiency in the LEIT farms and a lower level of economic efficiency in the HEIT farms.

The returns to scale estimated for LEIT farmers (1.496) shows that they experienced increasing returns to scale ($\sum ERX_{ij} > 1$). The value estimated for HEIT farmers (0.84) show that they experienced decreasing returns to scale ($\sum ERX_{ij} < 1$).

5.2 CONCLUSION

Based on the findings of this study the following conclusions are made.

The statistically significant determinants of gross income in LEIT farms are farm size, labour, expenditure on planting materials, capital inputs and expenditure on organic manure while farm size, expenditures on planting materials, and fertilizer are the statistically significant determinants of gross income in the HEIT farms.

The statistically significant determinants of aggregate agricultural productivity in LEIT farms include farm size, expenditure on planting materials, capital inputs, expenditure on organic manure, number of crops planted in a mixture in the farms, level of education and farming experience.

On the other hand farm size, capital input, number of crops planted in a mixture in the farm, distance to the nearest market, level of education, farming experience, man days of labour, and non farm income are the statistically significant determinants of aggregate agricultural productivity in HEIT farms.The LEIT farmers achieved higher levels of aggregate agricultural productivity than their HEIT counterpart.

The HEIT farmers were relatively more technically efficient than the LEIT farms, in the use of resources. Both the LEIT and HEIT farms are allocatively inefficient but equally economically efficient. in the use of productive resources.

While the LEIT farms were operating in region one, the HEIT farms were operating in region three of the production function.

5.3 Recommendations

In line with the findings of this study, the following policy implications are delineated on the basis of which recommendations are made.

(1) Farm size (though more productive in the HEIT farm type) was a significant variable in both the LEIT and HEIT farm types affecting farmers gross income. There is the need for the government to revisit the land use decree essentially to make land available to genuine farmers. In addition farmers with contiguous farm lands could be encouraged to form cooperative society to enable them pool their land resources together and overcome the demerits of land fragmentation.

(2) Organic manure in the LEIT farms was more productive than inorganic fertilizer application in the HEIT farms. In the face of the apparent scarcity of fertilizer and tardiness in its supply in addition to the result of this finding

it is recommended that appropriate policies should be put in place to encourage the production of organic manure through massive establishments of commercial poultry, backyard poultry and livestock rearing generally. Livestock rearing is an integral part of the small holder farming systems in Imo state thus the encouragement of more rearing of live-stocks for an extensive use in enhancing soil fertility will be culturally acceptable and a welcome development.

(3) Planting materials was also more productive in the LEIT than HEIT farms. It is therefore recommended that credit facilities be made available to the farmers generally to enable them have easy access to high yielding and improved planting materials. In addition the distribution of improved planting materials by research institutes at subsidized prices should be encouraged and strengthened by the government.

(4) A comparative analysis of aggregate agricultural productivity between LEIT and HEIT farms shows that LEIT achieved higher aggregate agricultural productivity than HEIT thus factors that accounted for these significant difference should be “the issues that need to be addressed in scaling up production”. The existing number of crops in a mixture which on the average is about 4 should be encouraged through the assistance of agricultural extension agents. In addition the credit facilities to be made

available to farmers should be based on level of education and years of farming experience. This is because education is labour quality indicator.

(5) Results of data analysis revealed that high external input technology (HEIT) farms are technically more efficient than their LEIT counterpart and that both group of farms face factor biased production function.

Farmers should be encouraged to form cooperative societies to enable them have access to credit facilities offered by the government and commercial banks. This will enable them to hire more farm hands; purchase more improved planting materials and inorganic fertilizer when they are available. In this regard the agro – service centers in the various local government area headquarters could be empowered or strengthened and made more functional and result oriented. This can be achieved by using them as channels through which timely delivery of improved farm inputs, extension services and monitoring of loan disbursement to the target farmers is implemented.

(6) Results also showed that there is no significant difference between the LEIT and HEIT farms in their levels of economic efficiency. However the results of returns to scale show that the LEIT farms are operating at an increasing returns to scale while the HEIT farms are operating at a decreasing returns to scale. This implies that on a general note, the LEIT farms can improve on their productivity by employing more resources while

the HEIT farms can only improve on theirs by reducing their current level of resource employment. Therefore, appropriate policies and programmes geared towards realizing these will tend to enable both groups of farms to exhibit higher levels of entrepreneurial capabilities and efficiency leading to higher farm output.

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APPENDIX 1

Allocative Efficiency in LEIT and HEIT Farms in Imo State

For the various resource inputs included in the model, the opportunity costs used were the market prices that prevailed during the production season. The market price of land services was taken as the cost of renting one hectare of farm land which was about N2970 and N3500 for LEIT and HEIT farms respectively.

Given that the employment of additional labour would imply the purchase of hired labour, the prevailing average wage rate per man day of hired farm labour N717.5 for LEIT and N718.75 for HEIT were taken as the opportunity cost of labour. With the resource characteristics of smallholder farmers and the practice of how they finance additional inputs, it was assumed that currently used services of land and labour are purchased out of current funds and does not involve interest burden.

The opportunity cost on durable capital and expenditure on planting materials was taken as one naira plus the relevant interest charges of 19 percent. The annual interest charge was taken as the lending rates of commercial banks. This approach was used by Adesimi (1982), Anyanwu(2003, 2005), and Onyenweaku et – al (1996). For the over all model, the small holder farmers were assumed to operate under free competition so that the individual farmer had no control over the prices he paid and those that he received. With this body of assumptions the MVP and the opportunity cost of resources were obtained.

For the various resource inputs included in the model, the opportunity costs used were the market prices that prevailed during the production season. The market price of land services was taken as the cost of renting one hectare of farm land which was about N2970 and N9500 for LEIT and HEIT farms respectively.

Given that the employment of additional labour would imply the purchase of hired labour, the prevailing average wage rate per man day of hired farm labour – N718.75 was taken as the opportunity cost of labour. With the resource characteristics of smallholder farmers and the practice of how they finance additional inputs, it was assumed that currently used services of land and labour are purchased out of current funds and does not involve interest burden.

The opportunity cost of one naira expenditure on durable capital and expenditure on other inputs like planting materials was taken as one naira plus the relevant interest charges of 19 percent. The annual interest charge was taken as the lending rates of commercial banks. This approach was used by Adesimi (1982), Anyanwu(2003, 2005), and Onyenweaku et –al (1996). For the over all model, the small holder farmers were assumed to operate under free competition so that the individual farmer had no control over the prices he paid and those that he received. With this body of assumptions the MVP and the opportunity cost of resources were obtained.

FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI
DEPARTMENT OF AGRICULTURAL ECONOMICS.
RESEARCH QUESTIONNAIRE.

INTRODUCTION
This research questionnaire is essentially meant for smallholder farmers, in Imo state. The research is aimed at investigating into productivity and efficiency in the Low and High External input technology agriculture of smallholder farmers in the state with the purpose of making useful recommendations to policy makers for improvement. Your response will be treated confidentially and will not be used for any purpose other than this research.

Instruction.

Please carefully answer the following questions.

SECTION A. GENERAL INFORMATION

1. Agricultural Zone ………………………………………..

2. Name of Local Government Area……………………………………….

3. Name of community…………………………….................................

4. Respondent name……

5. Marital status [Tick] Married ……. Single……… Divorced…………

6. Sex of household head [tick] Male …. Female ………..

SECTION B. SOCIO – ECONOMIC CHARACTERISTICS.

Please help provide information on the following.

1. State your age in years ………………………………………..

2. Number of wives ………[3] Number of children …………………….

4 Number of other dependants ……….

5[a] What is your highest certificate [tick] [i] FSLC [ii] WASC [iii] NCE [iv]OND [v] HND [vi] B.Sc [vii] M.Sc [viii] Ph. D

5[b] State number of years in school ………………..

6 For how many years have you been in the business of farming……………

7 Distance between the plots and the nearest market [Km]…...

8 What do you do for a living [major occupation]? ………………………

9 What other things do you do that earn you income [minor occupation] [i] …………………….. [ii] ………………. [iii] ………………… [iv] ……….

SECTION C. PRODUCTION DATA

Please kindly provide information on the following:

1 Farm size [to be measured with GPS]

Plot No	1	2	3	4	5	6	Total
Plot size							
Crop mixture							
Distance to mkt							
Total value of output							

2. How did you acquire the plots used in the last cropping season [Tick] [i] Inheritance [ii] Rent / lease [iii] Gifts [iv] Purchase [v] Others specify [i] …..

[ii] ……………. [iii] ……………. [iii] ……………………

3. State number of plots [i] by inheritance…. [ii] by rent/ lease …….

[iii] by gifts …..[iv] by purchase ....

4. If some plots were purchased state the total amount used ………

5[a]. Did you rent/lease any plot? [Tick] Yes / No.

5[b] If yes please state the amount used per year …N……...

LABOUR UTILIZATION

6. State the type of labour employed in the plots [tick] [i] Family labour

[ii] Hired labour [iii] Reciprocal labour [iv] A combination of [i] and [ii]

[v] Others specify………………………………………………….

7. Kindly provide answers to the questions below.

Plot one

Operations	Hours/day	Wage/day	Type oflabour			Category			No. of people	Days/ week	No. of weeks
			F	H	R	C	AF	AM			
Clearing											
Ploughing											
Planting											
Weeding											
Harvesting											
Others											
1											

Keys: F = Family. H = Hired. R = Reciprocal. C = Children. AF = Adult Female. AM = Adult Male

Plot two

Operations	Hours/ day	Wage/ day	Type labour			Category			No. of people	Days/ week	No. of weeks
			F	H	R	C	AF	AM			
Clearing											
Ploughing											
Planting											
Weeding											
Harvesting											
Others											
1											

Keys: F = Family. H = Hired. R = Reciprocal. C = Children. AF = Adult Female. AM = Adult Male

Plot Three

Operations	Hours/ day	Wage/ day	Type of labour			Category			No. of people	Days/ week	No. of weeks
			F	H	R	C	AF	AM			
Clearing											
Ploughing											
Planting											
Weeding											
Harvesting											
Others											
1											

Keys: F = Family. H = Hired. R = Reciprocal. C = Children. AF = Adult Female. AM = Adult Male

Plot Four

Operations	Hours/day	Wage/day	Type of labour			Category			No. of people	Days/ week	No. of weeks
			F	H	R	C	AF	AM			
Clearing											
Ploughing											
Planting											
Weeding											
Harvesting											
Others											
1											

Keys: F = Family. H = Hired. R = Reciprocal. C = Children. AF = Adult Female. AM = Adult Male.

8. If refreshments were given to the hired labourer, kindly estimate the amount spent for the refreshment…………………….

PLANTING MATERIALS

9. Please kindly provide answers to the questions below.

Planting material	Quantity used per plot							Unit Price [N]	Total Amount [N]
	1	2	3	4	5	6			
Cassava stems									
Seed Yams									
Maize grains									
Melon									
Cocoyam seeds									
Rice seeds									
Beans seeds									
Vegetables									
1									
2									
3									
Others [specify]									
1									
2									

CAPITAL INPUTS/ EQUIPMENTS.

10.. Please kindly provide answers to the questions below.

Farm Implement	Quantity	Unit price	Total	Year bought
Cutlasses				
Hoes				
Spades				
Wheelbarrows				
Diggers				
Axes				
Spraying pump				
Others[specify]				

NON FARM INCOME

11. Kindly identify your other sources of income apart from arable crop farming [tick].Livestock rearing……. Civil service……. Fishing……..

Rented labour………. Trading……. Hunting ….. Food processing……

Selling fire wood…… Carpentry…… Bricklaying ….. Painting……..

Tailoring…… Remittances……. Gifts…… Food vendor………

Selling of snacks…… Others specify[i] ………………………..

[ii]……………………………………..[iii]……………………………….

12. How much did you earn from each of the above sources of income per month [i] ………… [ii] …………… [iii] ………….[iv] …………. [v] …………..

CREDIT USE

13. Did you borrow money for your farming activities? Yes / No

14. If yes, state [a]the total amount borrowed ………………………..

[b] the source……………………………………

[c] the interest paid per year …N………………...

15. Have you started repaying ? Yes / No [tick]

16. If yes, how much have you repaid till date ? N ……….

17. If no, Why ? ……………………………………………………

…………………………………………………………………….

……………………………………………………………………

EXPENDITURE ON INORGANIC FERTILIZER, AGRO- CHEMICALS, IRRIGATION WATER, ANIMAL MANURE AND COMPOST.

18a**. [For HEIT**] If you used inorganic fertilizer, agro- chemicals, irrigation water answer the questions below

Input	Quantity	Unit Price	Total Amount per plot				
			1	2	3	4	5
Fertilizer							
Agro- chemicals							
Irrigation Water							
Others							

18**b [For LEIT**] If you used animal manure or compost or other LEIT as specified, answer the questions below

Input	Quantity	Unit price.	Total Amount per Plot				
			1	2	3	4	5
Animal manure							
Compost							
Green manure							
Biomass transfer							
Mulches							
Planting pits							
Hedge rows and living barriers							
Terraces							

19. Tick the cropping practices you used in your farming activities last year

[i] Intercropping … [ii] Cover cropping …. [iii] Alley cropping………

[iv]Contour planting [v] Conservation tillage [vi] Crop rotation

[vii] Improved fallow [planting of legumes or economic trees on fallow].....

FARM OUTPUT

20. Please kindly provide information on the farm output for last cropping season.

Crops	Quantity Produced per plot							Quantity sold	Quantity consumed	Unit price	Total farm income
	1	2	3	4	5	6					
Cassava											
Yam											
Cocoyam											
Maize											
Vegetables											
Plantains											
Bananas											
Palm oil											
Palm kernel											
Potatoes											
Beans											
Rice											
Others											
1											
2											
3											

21. Briefly identify the problems facing your farming activities

[i] Fertilizers are expensive [ii] Inadequate credit facilities [iii] Land tenure system [iv] High cost of labour [v] High cost of manure [vi] Problems of pest and diseases [vii] High cost of irrigation facilities Expensiveness of agro – chemicals [ix] Inadequacy of improved farm inputs [x] Lack of extension contact [xi] Others [specify] [i]………………… [ii] ………………. [iii]

22. Give probable solutions to the above problems……………………… ………………………………