ECONOMIC EFFICIENCY OF RICE PRODUCTION IN SMALLHOLDER IRRIGATION SCHEMES:

A CASE OF NKHATE IRRIGATION SCHEME IN SOUTHERN MALAWI

MASTER OF SCIENCE (AGRICULTURAL AND APPLIED ECONOMICS) THESIS

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UNIVERSITY OF MALAWI
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ECONOMIC EFFICIENCY OF RICE PRODUCTION IN SMALLHOLDER IRRIGATION SCHEMES: A CASE OF NKHATE IRRIGATION SCHEME IN SOUTHERN MALAWI

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DECLARATION

I, Ruth Magreta, declare that work in this thesis is as a result of my own work and initiative and has never been presented elsewhere for any degree. All sources of information have been acknowledged.

Signature________________________________ Date ________________________________

DECLARATION BY SUPERVISORS

We hereby declare that this thesis is from the student's own work and effort and it has been acknowledged where she has used other sources of information. This thesis has been submitted with our approval.

MAJOR SUPERVISOR: ____________________________________

PROFESSOR A.K. EDRISS

DATE: ____________________________________

SUPERVISOR: ____________________________________

DR L. MAPEMBA

DATE: ____________________________________

DEDICATION

Dedicated with much love to my late father Linus Magreta, a man who inspired me, may his soul rest in eternal peace.

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LIST OF ACRONYMS

AE	Allocative Efficiency
ADD	Agricultural Development Division
CE	Cost Efficiency
CIAT	International Center for Tropical Agriculture
EE	Economic Efficiency
EPA	Extension Planning Area
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GOM	Government of Malawi
Ha	Hectare
IRLAD	Irrigation Rural Livelihoods Agricultural Development Project
Kgs	Kilograms
MDG	Millennium Development Goals
MK	Malawi Kwacha
MLE	Maximum Likelihood Estimations
MLL	Maximum Log-Likelihood
SSA	Sub-Saharan Africa
SFPM	Stochastic Frontier Production Model
TE	Technical Efficiency
TSCF	Translog Stochastic Cost Frontier
TSPF	Translog Stochastic Production Frontier

ABSTRACT

This study used a parametric frontier approach to analyze technical, allocative and economic efficiency of smallholder rice farmers. It further explored the factors that influence the efficiency levels of the rice farmers. The study used a trans-log stochastic production function to analyze the technical efficiency. It used the trans-log cost frontier to analyze the economic efficiency. Results from these efficiencies led to the derivation of the allocative efficiency levels. It further used the inefficiency model to analyze the factors underlying efficiency differentials among the sampled farming households. Results revealed an average technical, allocative and economic efficiency levels of 65%, 59% and 53% respectively. This suggests that farmers have a rice yield potential of 35% to be exploited. The average economic efficiency level entails that farmers can raise their profitability or rice production by 47% by adjusting input use. Soil fertility status, access to credit, household size and farmers experience were the factors that influence the efficiency levels of smallholder rice farmers. It is thus recommended that for improved efficiency levels there is need for better policies and strategies that address input and output markets. Furthermore, farmer groups or associations can play a great role in ensuring that farmers get relevant technical advice, credit access as well as learn and share knowledge from each other.

CHAPTER ONE

INTRODUCTION

1.1 Background Information of Malawi

Malawi is a landlocked country, lying in Southern Africa between latitudes 9°22′S and 17°03′S and longitudes 33°40′E and 35°55′E. It still remains one of the poorest countries in the world. Its Human Development Index (HDI) of 0.464 ranked the country 163rd out of 174 countries in the year 2000. The human population of Malawi is estimated at almost 12 million with 52.4 percent population classified as the poor (Malawi Government, 2005). The rapid increase in population has resulted in great pressure on land. Fallow periods for restoring soil fertility have been reduced greatly in the smallholder farming systems, and cultivation is expanding to marginal and less fertile areas. This is leading to severe deforestation, soil erosion, and a general degradation of the natural resource base. This problem is most serious in southern Malawi as compared to central and northern Malawi (FAO, 2008).

1.2 Agriculture in Malawi

Malawi's economy continue to be agro-based with the agriculture sector accounting for 35-40% of Gross Domestic Product (GDP), employs about 84.5 percent of the labor force, contributes to over 90 percent of export earnings and accounting for 82.5 percent of foreign exchange earnings (Malawi Government, 2008). Tobacco is the major export earner and contributes to about 65 percent of the country's export earnings, followed by Tea at 8 percent and Sugar at 6 percent. Maize is a major food crop seconded by rice, which contributes to about 0.2 percent export earnings (Malawi Government, 2003).

Agriculture in Malawi is composed of two main sub-sections: smallholders and estates. Smallholder farmers comprise an estimated 2 million farm families. They cultivate about 6.5 million hectares where 80 percents of Malawi's food and 20 percent export are produced. The estate sub sector contributes only about 20 percent of total national agriculture production and it provides over 80 percent of the agricultural exports (Malawi Government, 2002). Agricultural production has been increasing over the past four years this is evidenced by national production levels of different food and cash crops (Table 1). This has been however due to the input subsidy program and to some extent increase in cropping area (Malawi Government, 2008).

Table 1: Historical Comparison of Smallholder Crop Production and Hectarage

Crop	2004/05		2005/06		2006/07		2007/08	
	Production (MT)	**Area(ha)**	**Production (MT)**	**Area(ha)**	**Production (MT)**	**Area(ha)**	**Production (MT)**	**Area(ha)**
Maize	1,225,234	1,513,929	2,611,486	1,762,839	3,226,418	1,215,356	2,634,701	1,596,955
Paddy rice	41,270	48,993	91,450	52,031	113,166	58,091	114,885	63,124
g/nuts	141,078	248,276	203,071	244,567	261,810	258,111	243,215	266,115
Tobacco	93,598	141,527	121,600	136,527	306,351	118,551	160,238	161,626
Cotton	50,363	88,535	58,569	62,233	63,290	60,673	76,761	69,826
Sorghum	18,175	68,419	54,309	70,644	63,698	74,131	61,999	74,596
Millet	15,970	41,192	27,037	41,491	32,251	44,878	31,869	43,988
Pulses	209,492	537,863	344,586	549,561	407,531	524,412	387,347	-
Cassava	2,197,640	153,687	2,832,141	163,598	3,238,943	172,539	3,491,183	183,014
Sweet potatoes	1,081,463	128,982	1,781,595	132,461	2,264,969	147,985	2,320,696	159,227

Source: Ministry of Agriculture and Food Security (2008)

1.3 Malawi's Agriculture Sector Policy

Malawi's agriculture policy is to promote and facilitate agricultural productivity in order to ensure food security, increased incomes and creation of employment through sustainable management and utilization of natural resources, adaptive research and effective extension service delivery system, promotion of value addition, agribusiness and irrigation development (Malawi Government, 2006). This agricultural policy is developed in line with the Malawi Growth and Development Strategy (MGDS), Malawi Economic Growth Strategy (MES), Malawi Vision 2020 and the Millennium Development Goals (MDGs).

The Malawi government put in place strategies that aim at increasing agricultural productivity. The key strategies include; encouraging the expansion and intensification of staple food production by smallholder farmers and promoting soil and water conservation and farming techniques. This is to be achieved through increased access to land, credit and farm inputs by smallholder farmers, improvement in agricultural technology, prevention of land degradation and deforestation, improving agricultural diversification, improvement of extension and farming and development of irrigation systems (Malawi Government, 2006).

1.4 Rice Production in Malawi

Rice is the second main cereal food crop from maize which accounts for 60 percent of the cultivated land. Other food crops grown in Malawi include sorghum, millet, pulses, root crops, vegetables, and fruits. Rice is also an industrial crop grown by the smallholder farmers. Other crops include, cotton, groundnuts, coffee, macadamia nuts and tobacco

(FAO, 2008). For some time yield levels of rice have been revolving around the same levels. In most flood plains the yield levels have been ranging from 1.0- 1.5 ton/ha^{-1}. However, under good management the potential yield levels range from 4 - 5 ton/ha^{-1}(GOM, 1993/94). Majority of smallholder farmers in Malawi have low to medium efficiency levels (Chirwa, 2003; Edriss et al., 2004; Tchale, 2006). The wide gap in yields indicates possibilities of improving rice productivity.

Currently the Malawi government is failing to meet its cereal food requirements. This has been attributed to the failure of food production to keep pace with the growing population; droughts and inability of farmers to use available water for production; declining soil fertility combined with small land holding size of smallholder farmers and farmers perception that maize is the only food crop and hence failure to diversify (FAO, 2008).

Crop yields have been satisfactory from 2005 up to date. This is a result of the input subsidy program and the favorable weather conditions experienced by most parts of the country despite some flash floods and localized dry spells experienced is some parts of the country (Malawi Government, 2008). Rice recorded tremendous increase in yields over the past four years (Table 2).

Table 2: Historical Comparison of Smallholder Rice Production and Hectarage

Year	Production (MT)	Hectarage(ha)
2004/05	41,270	48,993
2005/06	91,450	52,031
2006/07	1,131,66	58,091
2007/08	1,148,85	63,124

Source: Ministry of Agriculture and Food Security (2008)

1.5 Irrigation Farming in Malawi

One of the key strategies the Malawi Government put in place to increase agricultural productivity is the development of irrigation schemes (Malawi Government, 2006). However, increasing agricultural production will still be a problem if the existing levels of production are not improved (FAO, 2008). From the pre-colonial period, irrigation farming was characterized by use of seasonal flood plains and stream-bank cultivation commonly known as 'Dimbas' (Mandala, 1990).

There was growing interest in irrigation farming since 1960's. This led to the establishment of smallholder irrigation schemes. Between 1968 and 1979, 16 schemes were established by the government with a total irrigable area of 3,600 hectares. The aim was to increase rice production and, to serve as training grounds for farmers in irrigation among other objectives (FAO, 2008). However, for the past 15 years irrigation has had a low priority in agricultural production in Malawi. Some of the constraints have been the reliance on rain fed agriculture, the emphasis on funding extension service provision rather than on maintenance of existing irrigation schemes, reluctance of donors to fund irrigation development, price setting for crops not viable for irrigation, the lack of irrigation technology training facilities within the country, and finally the lack of farmer ownership of land on government irrigation schemes (FAO, 2008).

Irrigated agriculture is being promoted not only as a way of fostering rural development, but also as a means of reducing rural poverty, malnutrition, and disease as well as stemming the growing social economic inequalities between rural and urban areas (Nkhoma and Mulwafu, 2004). Hence, there is need to improve productivity of rice as one of the major income generating irrigated crop in the country. This is in line with what FAO suggested in 2004 that improving the productivity of rice systems would contribute to hunger eradication, poverty alleviation, national food security and economic development.

1.6 Economic Efficiency

Economic efficiency (EE) as stated by Kent and Vu (2009) is one of the major factors explaining differences in firm survival and growth and changes in industry structure. Thus, factors explaining and determining differences in economic efficiency and changes in efficiency between firms are of major interest to owners, managers, and other stakeholders as they strive to improve earnings and improve the chances of firm survival. Efficiency of a production unit can be described as how effectively the production unit uses available resources for the purpose of profit maximization given; the best production technology available, the level of fixed factors, price of product and factor prices.

Maximum efficiency is obtained when the most efficient production function is used and when the marginal value product of each factor on this production function is equal to its price. Technical efficiency (TE) measures the firm’s ability to use the best available practices and technology in the most effective way. Allocative efficiency (AE) on the other hand is dependent on prices and measures the firm's ability to make optimal decisions on product mix and resource allocation. Combining measures of technical and allocative efficiency yield a measure of economic efficiency (Kent and Vu, 2009; Tchale, 2006).

Changes in production have been linked to technologies used in the production. Technological change and efficiency improvements are important sources of growth in any economy. Technological changes are defined as a shift in the frontier production function. TE arises when actual or observed output from a given input mix is less than the maximum possible. EE arises when the input mix is not consistent with cost minimization. AE occurs when farmers do not equalize marginal returns with true factor market prices. Efficiency plays a very crucial role in agricultural production, studies done in the past emphasized on the role that efficiency plays in production (Tchale and Sauer, 2007). However, recent studies have shown that developing countries still experience low levels of efficiency in agricultural production which is a major contributor to unsustainable agricultural production (Rahman, 2003; Tchale, 2006).

This study will therefore analyze technical, economic and allocative efficiencies among smallholder rice farmers. It will further identify farm specific and socio-economic factors that explain the variation in efficiency of individual smallholder rice farmers. Main focus will be on rice because it is the second important food crop in Malawi after maize, and a major income generating crop of smallholder farmers in irrigation schemes. The relationship between the efficiencies and farm specific practices has not been thoroughly explored especially on rain-fed and irrigated rice production in Malawi. Improving understanding of this will contribute to literature and formation of sound policies that will be directed at increasing rice production among smallholder farmers. The study will further improve the understanding of inter-farm differences and opportunities to improve farm efficiency in utilizing their land, labor, and capital resources to achieve their objectives.

1.7 Research Statement and Motivation

Agricultural performance in Malawi has improved substantially over the past five years. This is mainly due to the input subsidy program that has increased use of fertilizer and improved seed, increase in land area under cropping and the favorable rains received in most parts of the country. Recent reports, however, indicate that agronomic efficiency in smallholder crop production remains very low (Tchale, 2009; Edriss, 2004; GOM, 2006 and Chirwa 2003). Further analysis is required to understand factors affecting and interventions necessary to increase efficiency of crop production in smallholder agriculture.

Research done has revealed that yields for rice in the government-owned irrigation schemes are as low as 1.0 to 1.5 ton/hectare (Malawi Government, 2006). This shows that production levels achieved by farmers are far below the potential production of 4-5 ton/hectare. Land available in these irrigation schemes is limited. It is not possible for farmers to increase their land under production. This means increased production should be gained from maximizing output per unit land under cultivation.

Most existing studies in economic efficiency of smallholder farmers in Malawi did not focus on rice. There is lack of empirical research on EE and AE of smallholder rice farmers in smallholder irrigation schemes. Furthermore, Results from research show wide disparities between yields farmers are currently obtaining and yields from on-farm trials and experimental trials (Malawi Government, 2006).

It is from these schemes that farmers are earning their living both in terms of cash and food. This, therefore, shows how important it is to raise the efficiency in rice production to meet and sustain the above stated major roles. Furthermore, increased efficiency will not only ensure food security and improved income among smallholder rice farmers, but preserve production capacity of the irrigation schemes. This will be possible because the study will reveal the current inter-farm differences and opportunities to improve farm efficiency in utilizing their resources. The study therefore, estimates the current production efficiency levels (technical, allocative and economic) of rice farmers in Nkhate irrigation scheme. The study will contribute to literature on how the three affect production of rain fed rice in irrigation schemes. It will also contribute to sound policy formulation that will in the end assist farmers to increase their production and efficiency levels.

1.8 Objectives

The main objective of this study is to assess economic efficiency of rice production in southern Malawi.

The specific objectives are:

1. To evaluate farmer specific technical, allocative and economic efficiencies for rice producers in Nkhate irrigation scheme
2. To identify social economic characteristics that influence technical, allocative and economic efficiencies of rice producers in Nkhate irrigation Scheme

1.9 Hypotheses

1.9.1 Rice producers in Nkhate irrigation scheme are economically inefficient

1.9.2 There are no factors (age, household size, schooling years, access to credit, soil fertility status, years of growing rice, access to extension services, distance to input and output markets) that determine the economic efficiency of rice farmers in Nkhate irrigation scheme

1.10 Summary and Thesis Organization

This chapter presented the geographical, economic and agricultural background to Malawi, the national agricultural development strategy and agricultural policy. It further presented challenges the agricultural sector is facing and how the government is responding to them. Rice production was introduced as one major cereal crop that provides both cash and income to farming families in Malawi. The chapter also provided the rationale for the study by highlighting research gaps in rice production and later introduced objectives and hypothesis of the study.

Chapter two presents literature review. The reviewed studies are in areas of rice production and it further reviews studies that applied Translog Stochastic Frontier which is the main focus in the study. Chapter three narrates the methodology. The chapter starts with description of the study area, sampling and data collection. Later the translog stochastic frontier models (both production and cost) are discussed.

Chapter four presents the socio economic characteristics of the survey households. Chapter five presents models results of the study, estimated technical, economic and allocative efficiencies. Chapter six concludes the study and presents policy recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter reviews literature for smallholder rice production in Sub-Saharan Africa particularly Malawi, it further reveals production efficiency (technical, allocative and economic) and factors that affect efficient production. Literature on the stochastic frontiers (production and cost) is also reviewed.

2.1 Rice Production in Sub-Saharan Africa

From a low base, rice consumption and production have increased tremendously in SSA over the past decades and this trend is expected to continue. However, as argued by Hossain, (2006), local rice production cannot meet the increasing demand for rice in many African countries. Although total milled rice production increased from 2.2 million Mt in 1961 to 9.1 million Mt in 2004. Rice imports into SSA also increased from 0.5 million Mt of milled rice in 1961 to 6.0 million Mt in 2003 and SSA currently accounts for 25 % of global rice imports at a cost of more than US $1.5 billion per year (IRRI, 2006). This has therefore made many African governments to accord high priority to developing their local rice sector as an important component of national food security, economic growth and poverty alleviation (Balasubramanian et al., 2007).

Currently less than 5 % of the potentially suitable wetlands in SSA are planted with rice because of various constraints. Rice production in the region cannot compete with other crops because it is the only crop that can be grown in low-lying wetlands, including inland valleys in rainy season.

2.2 Rice Production Constraints

As noted by Balasubramanian et al., (2007), rice production constraints in SSA include biophysical, management, human resource, and social economic/policy constraints. These vary with rice ecosystems. Most of the constraints are similar to those experienced in Asia such as; poor land preparation, leveling and irrigation management; inadequate drainage leading to the development of salinity and alkalinity; poor management of production inputs; yield instability due to weeds, insects and diseases; and deteriorating irrigation infrastructure especially in public irrigation schemes (Defoer et al., 2002).

Evenson and Golin (2003) also pointed out that there is lack or researchers in SSA as compared to Asia as the ratio of researchers to extension workers is much lower in the region. This is a problem because the continent lacks profitable technologies of which their dissemination cannot be a problem. Hence, a basic constraint is to improve rice production efficiency in the region. In addition to biophysical and human resource constraints, rice production in SSA is averted by socioeconomic and policy constraints: Unfavorable input and output pricing policies at the national level. Low output prices vis-a` -vis high and rising input prices reduce profit and the competitiveness of smallholder farms in local, regional, and global markets. Limited access to credit, inputs (seed, fertilizers, pesticides, implements, and so on), markets, and market information and poor rural infrastructure and transportation.

2.3 Stochastic Frontier Models

Microeconomic theory states that the objective of firms is to produce the maximum output utilizing given inputs, to minimize costs at given outputs, or to efficiently allocate input and output in order to maximize profits. A frontier defines the maximum feasible output in an environment characterized by a given set of random factors. The stochastic components describe random shocks affecting the production process. These shocks are not directly attributable to the producer or the underlying technology. These shocks may come from weather changes, economic adversities or plain luck. Each producer faces a different shock, but it is assumed that the shocks are random and they are described by a common distribution (Kent and Vu, 2009).

A number of techniques can be employed to measure production efficiency grouped into non-parametric and parametric frontiers (Tchale, 2006; Chirwa, 2003). Non-parametric frontiers do impose a functional form on the production frontiers and do not make assumptions about the error term. The most popular non-parametric frontier is the Data Envelopment Analysis (DEA). It has an advantage that it can analyze technical frontiers for multiple outputs and inputs, characteristics of most smallholder farming systems However, it fails to account for random factors that are beyond the control of the farmer hence it overstates inefficiency levels (Tchale, 2006).

On the other hand, parametric frontier uses econometric approaches to make assumptions about the error terms in the data. It impose a functional form on the production function and makes assumptions about the error term (Battese and Coelli, 1995).The most common functional forms include the Cobb-Douglas, constant elasticity of substitution and the trans-log production functions (Tchale 2006; Chirwa, 2003). The non-parametric frontier assumes that all deviations from the frontier are a result of inefficiency and the parametric frontier assumes that part of the deviation is due to firm's specific inefficiency and the other part is due to random events such as measurement errors (Tchale 2006, Chirwa, 2003).

A production function defines the technological relationship between the level of inputs and the resulting level of outputs. A general stochastic production frontier model can be given by;

$$\ln q_j = f(\ln x) + v_j - u_j \text{ .... (1)}$$

Where q_j is the output produced by firm *j*, *x* is a vector of factor inputs, v_j is the stochastic (white noise) error term and u_j is a one sided error representing the technical inefficiency of firm *j*. Both v_j and u_j are assumed to be independently and identically distributed (iid) with variance σ_v^2 and σ_u^2 respectively (Battese and Coelli,1995).

On the other hand, stochastic cost frontier functions have been increasingly used to measure efficiency of individual producers. A general stochastic cost frontier model can be given by;

$$\ln c_i = \ln c(p_i, q_i, \beta) + v_i + u_i \text{ .... (2)}$$

Where c_i is the observed cost, p_i is a vector of input prices, q_i is a vector of output of technology parameters to be estimated, v_i is a stochastic error term and u_i is a non-negative stochastic error capturing the effects of inefficiency (Battese and Coelli,1995).

In the estimation of production efficiency by using a stochastic frontier approach two methods are used. The first one is the two-step method and the other is one-step methods.

Results from different authors have shown that the two-step approach in estimating production function and efficiency results in having estimates that are seriously biased (Chu-Chia Lin and Yu-Chiang Ma, 2006).

2.4 Application of Stochastic Frontier Models

The rationale for choosing a particular functional form depends on the research questions and the underlying production/cost process to be modeled. Choice of a functional form is also based on the need to ensure theoretical consistency and factual conformity within a given domain of application as well as flexibility and computational easiness (Tchale, 2006). There are a range of functional forms for the production/cost frontier function, with the most frequently used being a trans-log function (Battese and Coelli,1995). This is relatively a flexible functional form, as it does not impose assumptions about constant elasticities of production nor elasticities of substitution between inputs. It allows data to indicate the actual curvature of the function, rather than imposing a priori assumptions.

Chu-Chia Lin and Yu-Chiung Ma (2006) in their study on estimation of production efficiency of Taiwanese firms in main land China, compared use of one-step and two-step estimation of stochastic frontier. Results revealed that average estimated efficiency under one-step method is much higher than that under two-step method. The estimation results were in agreement with what Wang and Schmidt (2002) found that one-step estimation method for the stochastic frontier approach is more accurate than the two-step estimation method.

2.4.1 Existing Empirical Studies on Technical Efficiency

Measuring of technical efficiency was started in 1951 and 1959 by Debreu. However, there has been growing of literature in sub-Saharan Africa recently of production efficiencies. Results from these studies indicated that there is greater scope to improve efficiency in smallholder agriculture. Most of the studies indicate that factors that influence efficiency include; farmer's education, farmers access to extension services, farmers access to credit, farmers access to efficient output and input markets, farmers access to improved technologies have a positive impact on technical efficiency. However, the relationship between farm size and efficiency has not been straight forward (Tchale and Sauer, 2007).

Using a boot strapped trans-log stochastic frontier, Tchale and Sauer (2007) measured the level and determinants of technical efficiency of smallholder maize farmers in Malawi. Results showed that higher levels of technical efficiency are obtained when farmers use integrated soil fertility options compared to use of inorganic fertilizer only. The study further revealed that access to agricultural input and output markets, credit provision and extension services influence smallholders technical efficiency strongly.

Edriss and Simtowe (2003) considered the technical efficiency of groundnut farmers in Malawi and compared it with the number one cash crop tobacco whose production has been declining due to the anti-smoking lobby internationally. Using a deterministic Cobb-Douglas function, their empirical results show that about 75% of groundnut smallholder farmers had an average technical efficiency index of 0.496. This was an indication that technical inefficiencies exists in the groundnut farms.

Chirwa (2003) estimated TE among smallholder maize farmers in Malawi and identified sources of inefficiency using plot-level-data. His results showed that smallholder maize farmers in Malawi are inefficient. Average efficiency scores were 46.23% and 79% of the plots had efficiency scores below 70%. The results further revealed that inefficiency declined on plots planted with hybrid seeds and plots controlled by farmers who are members of farmers club or associations.

Shanmugam (2003) used the stochastic frontier production model to estimate farm specific TE of rice, groundnuts and cotton farms in Tamil Nadu in India. Results showed that average TE values of raising selected crops varied from 68-82% depicting a scope for raising output without additional resources. Land, irrigation, labour and fertilizer were found to be significant determinants of output of almost all the crops grown.

Mythill and Shanmugam (2000) estimated TE of rice growers of Tamil Nadu in India. Results showed that TE varies widely form 46.5% to 96.7% across that sampled farms as time varied. Results further showed a mean TE of 82% which indicated potential in increasing output without use of additional resources. The gap between realized and potential yield highlighted the need for improving farm level extension services.

2.4.2 Existing Empirical Studies on Economic Efficiency

Alene et al. (2005) estimated the cost/economic efficiency of hybrid maize production in western Ethiopia and identified sources of inefficiency. Results showed an average cost inefficiency of 39% from a dual model, indicating that farmers could raise the profitability of maize production by 39% by fully adjusting input use. The inefficiencies were due to use of more, rather than less, fertilizer, and this divergence between economic and biological optimum arising from unfavorable input and output prices facing farmers.

Sarker et al. (1999) used a statistical measures and stochastic frontier production model to determine economic efficiency of commercial poultry farms. Results showed an estimated economic efficiency of 0.62 indicating that there exists potential to increase profits from available resources through improved efficiency.

Tchale (2009) employed the parametric frontier approach to derive the economic efficiency index of maize and Burley tobacco farmers in Malawi. Results obtained showed an economic efficiency level of 38 percent. This was attributed to poor policies that promote private market development.

2.4.3 Existing Empirical Studies on Allocative Efficiency

Goni et al. (2007) examined the resource use efficiency in rice production in the Lake Chad area of Borno State, Nigeria. Findings revealed that the farmers were inefficient in the use of all the resources. However, inputs such as seed, land and fertilizer were under-utilized. The results showed that there is need for making inputs such as fertilizer and improved seeds affordable and accessible to the farmers so as to improve efficiency.

Ogundari (2008) analyzed the resource- productivity, technical efficiency and allocative efficiency of rain fed farmers in Nigeria. Results for allocative efficiency based on $MVP_x = P_x$ showed that none of the respondents optimally allocated the inputs. A greater number of respondents were found to under utilize variables like land, seeds, fertilizer and herbicides ($MVP_x < P_x$) and greater number of farmers over utilized labor ($MVP_x >$

P_x). However in both cases it was revealed that the use of more labor decreased the rice production faster than any selected variables. The mean TE index was found to be 0.75, this means that 0.25 of rice yield is foregone due to inefficiency.

Tchale (2009) analyzed the efficiency of smallholder agriculture in Malawi. In this study, the main crops of interest were maize and Burley tobacco. Results from allocative efficiency revealed that farmers had an average allocative efficiency index of 0.46. Results further indicated that there is need for sound agricultural policies that can lead to improved efficiency levels.

CHAPTER THREE

3.0 METHODOLOGY

This chapter presents the methodology of the study; it includes a description of the research design, study area, data collection methods, sampling procedure and sample size, data collection process and the analytical framework. The analytical framework is presented per objective to give an indication of how each objective of the study was achieved.

3.1 Field Methodology, Data and Sample

3.1.1 Study Area

The study was conducted at Nkhate irrigation scheme (134^{o} 56′ E and latitude 16 ^{o} 9′ S) located in Chikhwawa district, Traditional Authority (TA) Makhwiira in southern Malawi. The site is 50 km from Chikhwawa district along the S152 road from Thabwa road block to Bangula. It has distinct winter (May–September) and summer seasons (October–April) and the annual rainfall is less than 800 mm distributed between November and May. The topography is fairly flat, with slopes around 0 – 2%. The scheme covers a gross area of 243 ha. About 183 ha are irrigable and are grown to rice during the dry season by approximately 915 farm families. An area covering 50 ha is not irrigable and is usually used to grow maize by 250 farm families. The land holding size per family is 0.2 ha. During wet season, crops grown under irrigation include maize, rice, sweet potatoes, beans, cowpeas and vegetables.

3.1.2 Sampling Technique

Purposive sampling was used to select the irrigation scheme under Chikhwawa Agricultural Development Division (ADD). This was because a lot of rice is being grown for food and income generation; furthermore it is where the International Center for Tropical Agriculture (CIAT) in collaboration with the Irrigation Rural Livelihoods Agricultural Development Project (IRLAD) is carrying out different experiments on fertilizer use and management to ensure increased rice production. This technique was also chosen to enhance active farmer participation in the research. The study population consisted of rice farmers farming in Nkhate irrigation scheme. From the irrigation scheme, simple random sampling technique was used to draw a sample of 246 farmers.

3.1.3 Data Collection

The study used both primary and secondary sources of data. Primary data were sourced through interviews with the rice producers using a structured questionnaire. The questionnaires captured data on farmer’s rice production levels, costs incurred in rice production and production related socio economic factors. The household interviews captured data on rice yields, availability of labor, amount of inputs and type of inputs used in rice production, extension contacts, production costs and access to loans. Further more, information on age, sex, marital status, and education level of household head was also captured. Secondary data was sourced from publications from various stakeholders like CIAT, IRLAD, Ministry of Agriculture, policy documents and past research findings on technical, allocative and economic efficiencies of agricultural products.

3.1.4 Training of Enumerators and Questionnaire Pretesting

Data were collected by the researcher with the help of two enumerators. The enumerators were trained for a day in order to master the research and the data collection tools. This was so to minimize human errors. Questionnaires were pretested for one day to ensure that wording and coding matched field situation. The tested questionnaires were used for corrections and production of final questionnaires which were used to collect household data.

3.2 Model Description

3.2.2 Conceptual Framework

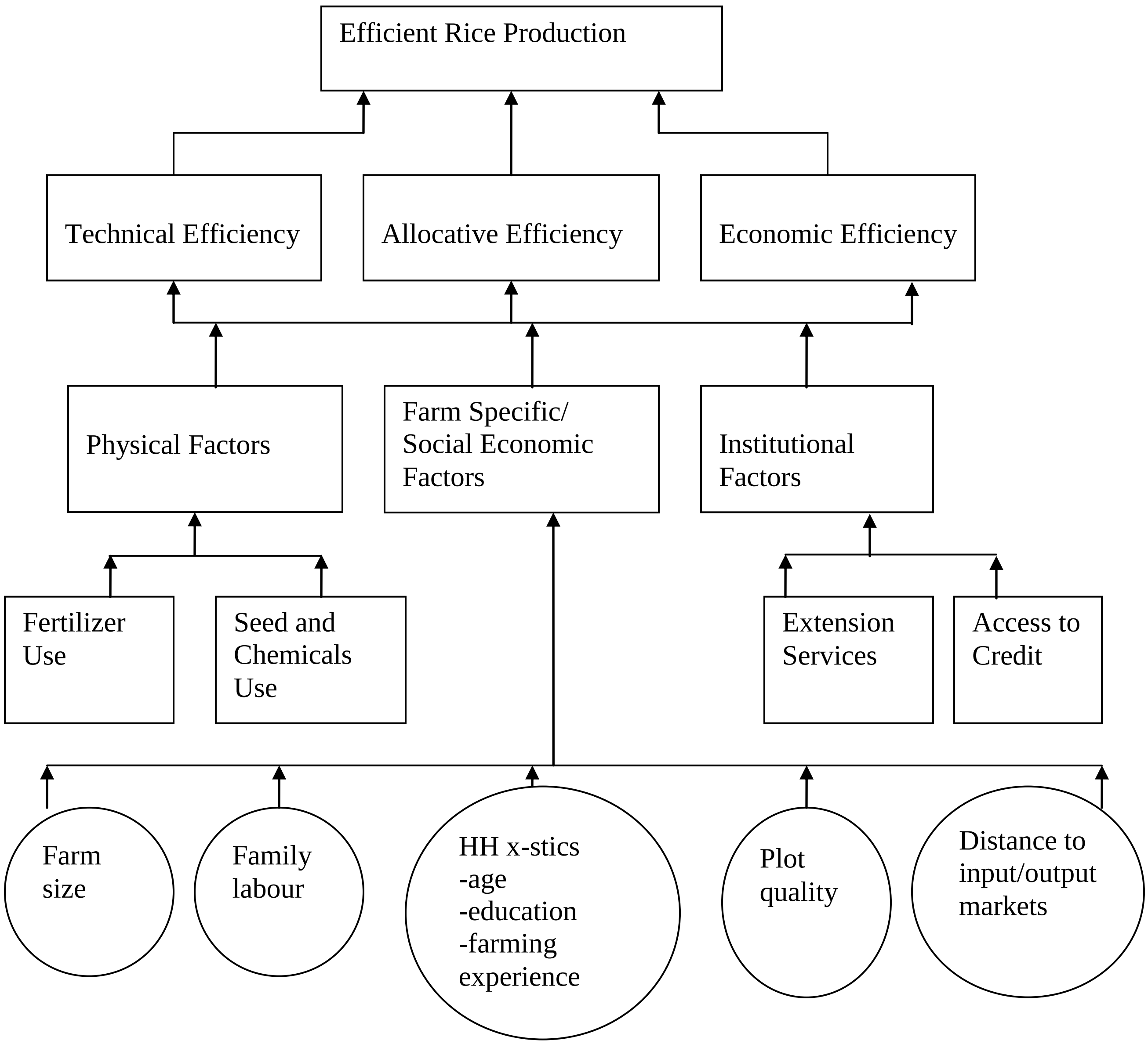

Figure 1: Conceptual Framework

3.2.3 Approach and Empirical Analysis

The study employed the stochastic frontier parametric approach specified by Battese and Coelli (1995) to evaluate TE, AE and EE of rice production.

3.2.4 Theoretical Model of Technical Efficiency

Farm specific technical efficiencies are derived using a stochastic production frontier (Battese-Coelle, 1995). An implicit assumption of production functions is that all firms are producing in a technically efficient manner, and the representative (average) firm therefore defines the frontier. Variations from the frontier are thus assumed to be random, and are likely to be associated with un-measured production factors. In contrast, estimation of the production frontier assumes that the boundary of the production function is defined by "best practice" firms. It therefore indicates the maximum potential output for a given set of inputs along a ray from the origin point. Some white noise is accommodated, since the estimation procedures are stochastic, but an additional one-sided error represents any other reason firms would be away from the boundary. Observations within the frontier are deemed "inefficient", so from an estimated production frontier it is possible to measure the relative efficiency of certain groups or a set of practices from the relationship between observed production and some ideal or potential production (Greene, 2000). A suitable production function can therefore be presented as,

$$Y_i = f(x_i, \beta)\exp(v_i)TE_i \ldots\ldots (3)$$

Where, Y_i is the quantity of agricultural output of the i^{th} farmer (i = 1, 2, 3… N), x_i is a vector of quantity of input applied to crop *i*. β is a vector of parameters, and $f(x_i, \beta)$ is a suitable production function, v_i is a random error associated with random events such as measurement errors in production and it is assumed to be independently and identically distributed as $N(0,\sigma^2)$ random variable and TE_i is technical efficiency of the i^{th} farmer . The possible production Y_i is bounded by the stochastic quantity $f(x_i,\beta)\exp(v_i)$. From this, technical efficiency can be defined as the ratio of the observed rice output to the maximum feasible rice output in an environment characterized by defined random shocks. Mathematically, it can be expressed as;

$$TE_i = \frac{Y_i}{f(x_i,\beta)\exp(v_i)} \quad \text{.. (4)}$$

Estimation of the stochastic production frontier requires a particular functional form of the production function to be imposed. A range of functional forms for the production function frontier are available, with the most frequently used being a trans-log function. This is a relatively flexible functional form, as it does not impose assumptions about constant elasticities of production nor elasticities of substitution between inputs. It thus allows the data to indicate the actual curvature of the function, rather than imposing a priori assumptions. In general terms, it can be expressed as;

$$\ln(Y_i) = \beta_0 + \sum_{i=1}^{n}\beta_a \ln(x_{ai}) + \frac{1}{2}\sum_{a=1}^{n}\sum_{b=1}^{n}\beta_{ab}\ln(x_{ai})\ln(x_{bi}) + \varepsilon_i \quad \text{.......................... (5)}$$

Where i is producer 1, 2, 3 … n, *a* and *b* are physical inputs 1, 2, 3 ….n, $\varepsilon_i = v_i - u_i$; ε is the error term and it is asymmetric, v_i denotes the traditional error component, u_i is the non-negative inefficiency component and is assumed to be asymmetrical, v_i is assumed to be identically and independently distributed with zero mean and constant variance and is independent of the inefficiency component.

3.2.5 Theoretical Model of Economic (Cost) Efficiency

Estimation of cost efficiency differs from estimation of technical efficiency in several aspects, such as data requirements, number of outputs, and quasi-fixity of some inputs and decomposition of efficiency itself. Unlike the output-oriented approaches to the estimation of technical efficiency, the estimation of cost efficiency requires us to apply an input-oriented approach on the cost frontier. A general stochastic cost frontier model can be given by;

$$\ln c_i = \ln c(p_i, q_i, \beta) + v_i + u_i \quad \text{.....} \quad (6)$$

Where c_i is the observed cost, p_i is a vector of input prices, q_i is a vector of output of technology parameters to be estimated, v_i is a stochastic error term and u_i is a non-negative stochastic error capturing the effects of inefficiency. $c(p_i, q_i)$, is the deterministic kernel of stochastic cost frontier $c(p_i, q_i).Exp(u_i)$. The measure of cost efficiency is then,

$$CE_i = \frac{c(p_i, q_i, \beta) Exp\{u_i\}}{c_i} \quad \text{.....} \quad (7)$$

Where CE_i reflects the ratio of the minimum possible cost, given inefficiency u_i, to actual total cost. If $c_i = c(p_i, q_i, \beta).Exp(u_i)$ the $CE_i = 1$ and we say that firm *i*, is fully efficient. Otherwise, actual cost for firm *i* exceeds the minimum costs so that $0 \le CE_i < 1$.

The trans-log cost frontier was originally provided by Christensen, Jorgenson, and Lau (1971). The trans-log cost function takes a second-order Taylor series expansion about mean of the data and can approximate any well-behaved cost frontier. Therefore, contrary to a Cobb-Douglas cost function, flexible trans-log cost function can accommodate multiple outputs without violating the requisite curvature properties in output space. It can be expressed as,

$$\ln C_i = \ln \alpha_0 + \sum_{i=1}^{n} \alpha, \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \varphi_{ij} \ln p_i \ln p_f$$
$$+ \alpha_y \ln y + \frac{1}{2} \varphi_{yy} (\ln y)^2 + \sum_{i=1}^{n} \varphi_{iy} \ln y \ln p_i + v_i + e_i \quad \ldots\ldots (8)$$

From the above, the cost is a function of prices and output hence conforms to theory. The function is non-homothetic because it depends on the level of output. From this general function, restrictions can be imposed and for this function to conform to theory it needs to be homogeneous of degree one in prices for a given y (this is so because doubling the prices costs should also double). The theoretical properties of adding up, homogeneity in prices and symmetry of cross effects of the cost function imply the following parametric restrictions

Adding up $\sum_{i=1}^{n} \alpha_i = 1$ .... (9)

Homogeneity $\sum_{i=1}^{n} \varphi_{ij} = \sum_{j=1}^{n} \varphi_{ji} = \sum_{i=1}^{n} \varphi_{iy} = 0$ .... (10)

Symmetry $\varphi_{ij} = \varphi_{ji}$ .... (11)

3.2.6 Underlying Theory of Allocative Efficiency

Allocative efficiency reflects the ability of a farmer to allocate resources in their optimal levels based on their proportional prices. For a farm to be allocatively efficient, it should be able to equate the marginal value product (MVP) of each resources employed to its unit cost (P). MVP is achieved when the slope of production function (marginal product

(MP)) is equal to the slope of the iso- profit line, which is the ratio of the price of the factor inputs to the price of output (Px/Py). The MVP is used as a yard stick for judging the marginal factor cost. Apparently, MVP is the expected return from additional extra unit of input concerned as other inputs are held constant and when this is compared with the input price it will determine whether to increase the level of resource use or not. When the MVP is greater than the input price implies under-utilization of resources (Tinjani, 2006).

3.2.7 Empirical Model of Technical Efficiency

Analysis of technical, allocative and economic efficiency and identification of the underlying factors were accomplished in one stage using the stochastic frontier and inefficiency model (Battese and Coelli, 1995). Data on paddy rice farmers were considered for the empirical model discussed above. The farm specific technical efficiencies of rice producers were derived from the following trans-log stochastic frontier production function:

$$\ln(Y_i) = \beta_0 + \sum_{a=1}^{4} \beta_a \ln(x_{ai}) + \frac{1}{2}\sum_{a=1}^{4}\sum_{b=1}^{4} \beta_{ab} \ln(x_{ai})\ln(x_{bi}) + v_i - e_i \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Where Y_i denotes total rice output in kg and i = 1, 2, 3 … 246 observations

$X_a, a = b = 1,2,3,4$ are four physical input variables included, namely,

X_1 = total area planted to rice in hectares (ha)

X_2 = total family labor and hired labor used (man-days)

X_3 = total quantity of seed used (kg)

X_4 = total quantity of fertilizer used (kg)

e_i = farm specific/ social economic characteristics related to production efficiency

v_i = random variables associated with disturbances in production

Equation 12 can be expressed as;

$$LnOutput_i = \beta_0 + \beta_1 Lnland_i + \beta_2 Lnlabor_i + \beta_3 Lnseed_i + \beta_4 Lnfertiliser_i + \beta_5 * \frac{1}{2} * Lnlansqrd_i + \beta_6 * \frac{1}{2} * Lnlaborsqrd_i + \beta_7 * \frac{1}{2} * Lnseedsqrd_i + \beta_8 * \frac{1}{2} * Lnfertilisersqrd_i + \beta_9 * \frac{1}{2} Lnland_i * Lnlabor_i + \beta_{10} * \frac{1}{2} * Lnland_i * Lnseed_i + \beta_{11} * \frac{1}{2} * Lnland_i * Lnfertiliser_i + \beta_{12} * \frac{1}{2} * Lnlabor_i * Lnseed_i + \beta_{13} * \frac{1}{2} * Lnlabor_i * Lnfertiliser_i + \beta_{14} * \frac{1}{2} * Lnseed_i * Lnfertiliser_i \quad \ldots\ldots (13)$$

In the translog function, the elasticities of mean output with respect to each of the inputs were defined by;

$$\frac{\partial \ln E(Y)}{\partial \ln X_a} = \beta_a + \beta_{aa} \overline{\ln X_a} + \sum \beta_{ab} \overline{\ln X_{ab}} - \theta_i \left(\frac{\partial \mu_i}{\partial X_{ai}} \right), a = 1,2,3,4. \ldots\ldots (14)$$

Where θ_i, represents the density and distribution functions of the standard normal random variable, the last term in equation 14 drops out for all variables and at the mean values of the inputs, elasticities were computed by the following equations;

$$\varepsilon_{Land} = \beta_1 + \beta_5 Lnland_i + \frac{\beta_9}{2} Lnlabor_i + \frac{\beta_{10}}{2} Lnseed_i + \frac{\beta_{11}}{2} Lnfertiliser_i \ldots\ldots (15)$$

$$\varepsilon_{Labor} = \beta_2 + \beta_6 Lnlabor_i + \frac{\beta_9}{2} Lnland_i + \frac{\beta_{12}}{2} Lnseed_i + \frac{\beta_{13}}{2} Lnfertiliser_i \ldots\ldots (16)$$

$$\varepsilon_{seed} = \beta_3 + \beta_7 Lnseed_i + \frac{\beta_{10}}{2} Lnland_i + \frac{\beta_{12}}{2} Lnlabor_i + \frac{\beta_{14}}{2} Lnfertiliser_i \ldots\ldots (17)$$

$$\varepsilon_{fertiliser} = \beta_4 + \beta_8 Lnfertiliser_i + \frac{\beta_{11}}{2} Lnland_i + \frac{\beta_{13}}{2} Lnlabor_i + \frac{\beta_{14}}{2} Lnseed_i \ldots\ldots (18)$$

3.2.8 Empirical Model of Economic Efficiency

From a Cobb-Douglas stochastic cost frontier function the trans-log cost frontier takes the following form;

$$\ln C_a = \ln \alpha_0 + \sum_{i=1}^{4} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{4} \sum_{j=1}^{4} \varphi_{ij} \ln p_i \ln p_j + \alpha_y \ln y + \frac{1}{2} \varphi_{yy} (\ln y)^2 + \sum_{i=1}^{4} \varphi_{iy} \ln y \ln p_i + v_i + e_i \quad \ldots\ldots (19)$$

Where C_i denotes cost of producing output of rice in Mk

p_i i=j=1, 2, 3, and 4 are four input variables considered in the analysis namely

p_1 = total seasonal rent of a hectare of land (MK)

p_2 = total labor cost (MK)

p_3 = total price of fertilizer per kg (MK)

p_4 = total price of seeds (MK)

e_i = farm specific/ social economic characteristics related to production efficiency

v_i = random variables associated with disturbances in production

Adding up $\alpha p_1 + \alpha p_2 + \alpha p_3 + \alpha p_4 = 1$ ………………………………………………… (20)

Homogeneity
$$\begin{aligned} \varphi p_1 p_1 + \varphi p_1 p_2 + \varphi p_1 p_3 + \varphi p_1 p_4 &= 0 \\ \varphi p_1 p_2 + \varphi p_2 p_2 + \varphi p_2 p_3 + \varphi p_2 p_4 &= 0 \\ \varphi p_1 p_3 + \varphi p_2 p_3 + \varphi p_3 p_3 + \varphi p_3 p_4 &= 0 \\ \varphi p_1 p_4 + \varphi p_2 p_4 + \varphi p_3 p_4 + \varphi p_4 p_4 &= 0 \end{aligned} \quad \ldots\ldots (21)$$

Symmetry $\varphi_{ij} = \varphi_{ji}$ …………………………………………………………………… (22)

3.2.9 Empirical Computation of Allocative Efficiency

Estimation of AE can be achieved through use of efficiency results from TE and EE where EE is derived from the CE function. According to Farrell (1957) and Bravo-Ureta and Pinheiro (1997), EE is the product of TE and AE. From this therefore it is possible to compute AE using equations (4) and (7) as:

$$\frac{CE_i}{TE_i} = \frac{\left(\frac{c(p_i, q_i, \beta) Exp\{u_i\}}{c_i}\right)}{\left(\frac{Y_i}{f(x_i, \beta)\exp(v_i)}\right)} \quad \text{...} (23)$$

Many authors have used the above formula to estimate AE and some of the empirical results are summarized in Table 3;

Table 3: Estimates of Efficiency from Empirical Studies in Developing Countries

Study/Author	**Country**	**Crop(s)**	**Mean efficiency levels**		
			TE	AE	EE
Bravo-Ureta and Pinheiro (1997)	Dominican Rep.	All crops among smallholders	70	44	31
Chirwa (2003)	Malawi	Maize	65	-	-
Bravo-Ureta and Evenson (1994)	Paraguay	Cotton	58	78	40
		Cassava	59	88	52
Fulginiti and Perrin (1998)	Ethiopia	All crops	56	-	-
Townsend et al. (1998)	Lesotho	All crops	24-36	-	-
Edriss (2003)	Malawi	Groundnuts	46	-	-
Edriss et. al (2004)	Malawi	Maize	55	-	-
Tchale (2009)	Malawi	Maize and Tobacco	53	46	38

(Source: Tchale, 2009)

DEFINITION OF VARIABLES

Dependent variable

Rice yield was regarded as the main output for the production function, whilst its cost of production was regarded as the dependent variable for the cost function. Technical, allocative and cost efficiencies of rice farms were determined by comparing the actual observed rice output against the frontier maximum output.

Explanatory variables

In the study farm size, labour, fertilizer and inputs like seed and chemicals were the explanatory variables to be estimated.

Farm size

Landholding size is the scheme varies between farmers and it is a very important decision variable in estimating production efficiency. Most smallholder farmers report their land holding size in acres. In this study, land holding size is presented in hectares using conversion rate of 1 hectare = 2.47 acres.

Labor

Being a very central variable in production labor spent in rice production was captured. This was measured in man-days using conversion rates used in estimating contribution of family labor of household members by availability of family member, gender and age category. Availability of household members was categorized into permanent resident, permanent resident in local employment, permanent resident in full-time education, polygamist spending time in other households and resident hired labour.

Table 4: Conversion Rates for Household Labour Availability

Availability of member	Gender	Conversion rates by age category (years)		
		<15	15-59	≥60
		Man equivalents		
Permanent resident	Male	0.2	1.0	0.6
	Female	0.2	0.8	0.4
Permanent resident in local employment	Male	-	0.2	-
	Female	-	0.2	-
Permanent resident in full-time education	Male	0.1	0.5	NA
	Female	0.1	0.4	NA
Polygamists spending part of time in other households	Male	-	0.5	0.5
	Female	-	-	-
Resident hired labour	Male	0.5	1.0	0.7
	Female	0.5	1.0	0.7

Source: Ministry of Agriculture Headquarters, 1985. Note: NA is not applicable

The labor input variable is therefore constructed by adding up family and hired labor used in rice production activities.

Fertilizer

Use of fertilizer is very important in crop production like rice. This was captured by asking the farmers the amount and price they paid for purchasing fertilizer for their rice.

Seed

This is the amount of rice seed per plot, in kilograms. Seed is a universal input in all crop-based farming systems and it affects crop productivity in two ways. A very high seed density may result in low yields due to high competition for nutrients, whereas a very low seed density may also lead to low yields due to under-utilization of land (Edriss, 2003).

Input Costs

Costs of seed

Costs are expected to influence producer's choice this implies how the higher the costs the higher the chances that the producer might not buy the input.

Cost of labor

Cost of land preparation, weeding, fertilizer application etc was captured. The cost was captured by considering cost of family labor and hired labor separately.

Cost of Land

Shadow values of land in terms of fixed costs was captured, this was captured as the seasonal rentals paid for any 0.1 hectare cultivated. This is essential because value of land tends to appreciate with time.

3.3 Objective 2: Estimation of Social Economic Characteristics that Influence Efficiency

In one-step procedure, the inefficiency e_i is related to the exogenous factors of rice production by;

$$e_i = \sigma_0 + \sum_{n=1}^{m} \sigma_n Z_{ni} \qquad (24)$$

Where Z_i is a vector of farm-specific explanatory variables which are determinants of inefficiency. These include, land husbandry practices like weeding, climatic conditions like rain fall etc. In addition, it is also a vector of individual characteristics such as education level, household size and age.

The Battese and Coelli (1995) model was applied to estimate the efficiency scores and to identify socio-economic factors influencing efficiency levels of rice producers. From the trans-log stochastic frontiers discussed above, the economic inefficiency is associated with non-negative random variables associated with inefficiency. These are obtained by truncation (at zero) of the normal distribution with mean, e_i and variance σ_w^2 such that:

$$e_i = \sigma_0 + \sum_{n=1}^{m} \sigma_n Z_{ni} \qquad (25)$$

Where σ is a vector of the parameters of the inefficiency model to be estimated and

$$e_i = \sigma_0 + \sigma_1 Z_1 + \sigma_2 Z_2 + \sigma_3 Z_3 + \sigma_4 Z_4 + \sigma_5 Z_5 + \sigma_6 Z_6 + \sigma_7 Z_7 + \sigma_8 Z_8 + w_i$$

$Z_n, m = 1,2,.....8,$ are the farm-specific socio-economic and institutional factors hypothesized to influence efficiency of resource use in rice production. These are defined as,

Z_1 = age of household head (years)

Z_2 = farming experience (years)

Z_3 = education of household head (number of schooling years)

Z_4 = distance to the nearest output and input market from home of farmer (km)

Z_5 = access to extension service measured as number of visits paid to the farmer

Z_6 = plot quality as perceived by farmer (1=high fertility, 0 = otherwise)

Z_7 = access to credit (1 = if household head has access to credit, 0 = otherwise)

Z_8 = Household size (numbers)

w_i = error term assumed to be independent and identically distributed

Producer's Socio Economic Characteristics

Age of Household Head (Years)

Age reflects the ability of the respondent as a manager of the farm in making production decisions. It also shows the efficiency of someone in carrying out farm activities.

Farming Experience (years)

It is believed that experience is the best teacher and by the same token, farmers who have been growing rice for many years are assumed to have better production skills than those with little or no experience.

Education level of Household Head (Years)

It is important in decision making as well as in any development process. People with some education easily understand instructions and are able to apply them. It was measured in number of schooling years for easiness of data analysis and also avoiding generalization of results.

Distance to input markets (km)

Distance to input markets contribute to production in a way that if farmers stay near an input market there is high probability that they will access inputs on time. Timely availability of inputs is very crucial in production hence the importance of considering this variable in the analysis.

Access to Extension Service (number contacted in a month)

Extension advice contributes to increased production in a way that it guides farmers in making production decisions. The study evaluated presence or absence of extension workers who could advise farmers on good crop management techniques.

Soil fertility level

Much as proper crop management is important fertility levels of farmer's field also contribute to crop production. This was ranked in the order of high, medium and low fertility levels.

Access to Credit (*whether a farmer has access to credit or not in a particular farming year)*

Here the study attempted to evaluate farmer's access to credit. This variable provided important information on factors affecting production in the area.

3.4 Limitations of the Study

Limitation to the study is that frontier functions assume that all inputs have been taken into account. However, in this study as well as in other studies, it is possible to raise questions about whether all inputs have been actually been accounted for. Since farms that are apparently inefficient may just use less of certain measured inputs.

CHAPTER FOUR

4.0 SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE HOUSEHOLDS

Introduction

This chapter provides results of the socio-economic characteristics of the sampled households of farmers in Nkhate irrigation scheme in Chikhwawa ADD. Statistical tests such as the t-test and the Chi-square test were used to test the significant difference between the socioeconomic characteristics of sampled households by variety of rice grown category. The household characteristics discussed are household size, age of household head, land size, household labour availability, rice yields, education, gender of household head, access to credit, contacts with extension workers and distance to input and output markets.

4.1 Socio-Economic Characteristics

4.1.1 Household Size

The overall average household size of farmers growing rice was 5.5 persons. The average household size of farmers growing Superfire was 5.6 persons whilst that of farmers growing Mtupatupa was 5.5 persons. However, t-test showed that the means of household sizes of Superfire and Mtupatupa were not significantly ($P>0.05$) different (Table 5). The almost similar household sizes in all varieties justifies that growing of rice is the main farming activity in the area which is done by almost each household in the area. Household size has a significant bearing on the availability of household labor for farm activities.

Table 5: Mean Household Size by Rice Variety Category

Rice Variety	Sample size	Mean	Standard error	Standard deviation
Superfire	160	5.6	0.1521	1.9243
Mtupatupa	86	5.5	0.2384	2.2107
Combined	246	5.5	0.1291	2.0254

Pr (|T|>|t|) = 0.6523

4.1.2 Age of Household Head

The overall average age of farmers growing rice in Nkhate irrigation scheme was 46.5 years. The average age of farmers who grew Superfire rice variety was 46.7 years while those who grew Mtupatupa rice varieties was 46.1 years. The average ages of rice farmers shows the average age of farmers who are actively involved in farming rice. Age can also have a negative influence on the levels of inefficiency in that the older the farmer gets, the less willing they are to adopt new skills and technologies in rice production. T-test results showed that were no significant ($P > 0.05$) differences in average age of farmers by rice variety category (Table 6).

Table 6: Mean Age of Farmers by Rice Variety Category

Rice Variety	Sample size	Mean (year)	Standard error	Standard deviation
Superfire	160	46.7	1.2088	15.2900
Mtupatupa	86	46.1	1.7094	15.8526
Combined	246	46.5	0.9856	15.4591

Pr (|T|>|t|) = 0.7796

4.1.3 Inorganic Fertilizer

Results showed that the farmers applied an overall of organic fertiliser. The average organic fertiliser of those who grew the two varieties Superfire and Mtupatupa were mean of 58.1 kgs and 50.6 kgs respectively. Superfire received a lot of fertilizer because it is an improved breed of which failure to apply fertilizer can result in farmers realizing lower yield levels. The amount of fertilizer applied to the different varieties was not significantly (P > 0.05) different between the two (Table7).

Table 7: Mean Amount of Inorganic Fertiliser by Rice Variety Category

Rice Variety	Sample size	Mean (kg)	Standard error	Standard deviation
Superfire	160	58.1	3.9885	36.9885
Mtupatupa	86	50.6	3.7763	47.7671
Combined	246	55.5	2.8284	49.8943

Pr (|T|>|t|) = 0.2116

4.1.4 Rice Seed

Rice seed is important in determining economic efficiency. The results of the study showed that farmers who grew Superfire rice variety planted mean of 21.72kgs of rice seed and those who grew Mtupatupa rice variety planted mean of 20.92kgs. T-test results showed that there was no significant difference (P > 0.05) between the amounts of seed planted for both varieties (Table 8).

Table 8: Mean Amount of Rice Seed Planted by Rice Variety Category

Rice Variety	Sample size	Mean (kg)	Standard error	Standard deviation
Superfire	160	21.72	1.1288	14.2782
Mtupatupa	86	20.92	1.7927	16.6248
Combined	246	21.44	0.9634	15.1109

Pr (|T|>|t|) = 0.6939

4.1.5 Land Size

Land size greatly affects farm decisions and affects both economic and production efficiency of a farm. The overall farm size for the sampled households was 0.95 hectares. The average land sizes for farmers who grew Superfire were 1 ha whilst the average land size of farmers who grew Mtupatupa was 0.9 ha. The average portion of land allocated to Superfire was 0.21 ha whilst that allocated to Mtupatupa was 0.18 ha. T- test showed that there was no significant difference ($P > 0.05$) between the land sizes planted for both varieties (Table 9).

Table 9: Mean Amount of Land Allocated to Rice by Variety Category

Rice Variety	Sample size	Mean (ha)	Standard error	Standard deviation
Superfire	160	0.21	0.0141	0.1779
Mtupatupa	86	0.18	0.0174	0.1612
Combined	246	0.20	0.0110	0.1725

Pr (|T|>|t|) = 0.1850

4.1.6 Rice Yield

Results showed that farmers who grew Superfire produced the highest average rice yield (1089.19 kg/ha) than those who grew Mtupatupa (846.34 kg/ha). There was a significant difference at 10 % level of significance between the average yield of Superfire and Mtupatupa rice varieties. This may be attributed to the variety performance of the two rice varieties (Table10).

Table 10: Average Yield Levels for Superfire and Mtupatupa Rice Varieties

Rice Variety	Sample size	Mean (kg)	Standard error	Standard deviation
Superfire	160	1089.19	79.3076	1003.1710
Mtupatupa	86	846.34	93.3258	865.4681
Combined	246	1004.29	61.3677	962.5151

Pr (|T|>|t|) = 0.0590

4.1.7 Distance to Input and Output Markets

Distance to input and out put markets has a bearing on efficiency of a farm. From the results, farmers who grew Superfire had an average distance of 2.11 km to an input and output market whilst those who grew Mtupatupa had an average distance of 1.43 km. This may be attributed to target of consumers who buy the different varieties. T-tests results showed that there was a significant ($P < 0.05$) difference between the two varieties (Table 11).

Table 11: Average Distance to Nearest Input/output Market by Rice Variety Category

Rice Variety	Sample size	Mean Distance (km)	Standard error	Standard deviation
Superfire	160	2.1	0.2121	2.6828
Mtupatupa	86	1.4	0.1168	1.0827
Combined	246	1.9	0.1451	2.2764

Pr (|T|>|t|) = 0.0261

4.1.9 Soil Fertility Status

Soil fertility status of a farm contributes to the efficiency of production of the farm. EE can be influenced fertility status of farmers land. With minimal physical inputs, production is high due to the high nutrient level of the soil. Thus, farmers with more fertile plots are likely to be more efficient in production than those whose plots are not fertile. Results showed that 43.13 % and 29.07 % of farmers who grew Superfire and Mtupatupa perceived the soil fertility status of their farms to be high respectively. T-tests results showed that there was a significant ($P < 0.05$) difference in farmer's perception of soil fertility of their farms between the two categories.

Table 12: Soil Fertility Status of Rice Farms by Variety Category

Soil fertility status	Superfire (%)	Mtupatupa (%)	Total (%)	P-value
High	43.13	29.07	38.21	0.03
Medium	40.00	39.53	39.84	0.94
Low	16.88	31.40	21.95	0.00
Total	100.00	100.00	100.00	

4.1.10 Gender of Household Head

Gender of household head has an Impact on decision making at a farm. Majority of the respondents (76.83%) were male headed households, whilst the rest (23.17%) were female headed households. Out of these households, 75.63% of farmers who grew Superfire were male headed households. On the other hand, 24.38% of farmers who grew Superfire were female headed households. Farmers who grew Mtupatupa had a higher proportion of male headed households (79.07%) and this was higher than the overall average percentage of male headed households in the area. However, Chi-square test showed that there were was significant difference ($P < 0.05$) among the farmer's gender category in terms of variety grown.

Table 13: Proportion of Household Type by Variety of Rice

Rice Variety	Male-headed (%)	Female-headed (%)
Superfire	121 (75.63)	68 (24.38)
Mtupatupa	39 (79.07)	18 (20.93)
Total	189 (76.83)	57 (23.17)

4.1.11 Marital Status of Household Head

There were a lot of married respondents (74.39%) from the sampled households (Table 14). About 76.74% of the respondents who grew Mtupatupa were married compared to 73.13% of the respondents who grew Superfire. Chi-square test showed that there was no significance difference ($P > 0.05$) between marital statuses of household heads.

Table 14: Proportion of Marital Status of Household Head by Rice Variety

Marital Status	Superfire (%)	Mtupatupa (%)	Total (%)	P-value
Single	13.75	11.63	13.01	0.64
Married	73.13	76.74	74.39	0.54
Widowed	11.25	6.98	9.76	0.28
Divorced	0.63	3.49	1.63	0.09
Separated	1.25	1.16	1.22	0.95
Total	100.00	100.00	100.00	

4.1.12 Education Level of Household Head

Literacy levels have a bearing on decision making at a farm and on efficiency. In the study 68.70 % of the respondents could read and write while 31.30% could not read and write the vernacular language 'Chichewa' (Table 15). Within the two varieties grown, 71.88% and 62.79% who grew Superfire and Mtupatupa respectively could read and write. Chi square test showed that literacy level of the two categories was not significantly ($P > 0.05$) different. The results showed that the overall average schooling years of rice farmers was 7.5 years. The average schooling years of farmers who grew Superfire was 7.21years whilst that of farmers who grew Mtupatupa was 8.22 years.

Table 15: Literacy Level of Rice Farmer by Variety Category

Literacy	Superfire (%)	Mtupatupa (%)	Total (%)	P-value
Able to read and write	71.88	62.79	68.70	0.14
Unable to read and write	28.13	37.21	31.30	0.14
Total	100.00	100.00	100.00	

The results of the study further showed that 47.17 % of the household heads in the area reached primary level of education whilst 17.89% reached secondary level and 31.71% had no education (Table 16). There can therefore be a high probability that these rice farmers do not effectively manage the available resources due to low education levels. As argued by Kwesiga et al., (2003) education plays a great role in farmer's decision making.

Table 16: Education Level of Rice Framers by Variety Category

Education Level	Superfire (%)	Mtupatupa (%)	Total (%)	P-value
Primary	50.63	40.70	47.17	0.14
Secondary	16.88	38.64	17.89	0.57
Tertiary	0.63	1.16	0.81	0.65
Adult learning	1.88	2.33	2.03	0.81
Home craft	0.00	1.16	0.41	0.17
No education	30.00	34.88	31.71	0.43
Total	100.00	100.00	100.00	

4.1.13 Access to Extension Services

Extension has a great impact on rice production efficiency. Results from the study showed that 82.52 % of the respondents had access to extension services on rice production in the scheme. However Chi-square tests showed that there was no significant ($P > 0.05$) difference in accessing extension service among the farmers how grew different varieties. Extension services accessed by both categories were mainly on Sawing, weeding and harvesting of rice.

Table 17: Extension Access of Rice Farmers by Variety Category

Extension access	Superfire (%)	Mtupatupa (%)	Total (%)	P-value
Access	81.25	84.88	82.52	0.47
No access	18.75	15.12	17.48	0.47
Total	100.00	100.00	100.00	

4.1.14 Period of Farming

Period of farming is important in agriculture for it increases farming experience to the farmers and minimizes inefficiencies. The results of the study showed that farmers who grew Superfire had a longer period of farming (17.53 years) than those that grew Mtupatupa (14.73 years). The results showed that there were no significant differences (P > 0.05) between periods of farming of the two categories of rice farmers.

Table 18: Average Number of Years for Growing Rice by Variety Category

Rice Variety	Sample size	Mean (years)	Standard error	Standard deviation
Superfire	160	16.0	0.8045	10.1761
Mtupatupa	86	14.7	1.1180	10.3679
Combined	246	15.6	0.6530	10.2412

Pr (|T|>|t|) = 0.3440

4.1.15 Club Membership

Club membership is critical for effective implementation of any farming decision. In rice farming farmers share experiences on sewing, weeding, harvesting and marketing of rice. Farmers who grew Superfire had a relatively higher proportion of club membership (36.88%) than those who grew Mtupatupa (32.56%).

Table 19: Club Membership of Rice Farmers by Variety Category

Membership	Superfire (%)	Mtupatupa (%)	Total (%)	P-value
Club membership	36.88	32.56	35.37	0.50
No club membership	63.13	67.44	64.63	0.50
Total	100.00	100.00	100.00	

4.1.16 Cost of Production

On-site benefits only without considering the cost-effectiveness of technologies do not justify effectiveness of a production unit. High cost of production affects greatly the economic efficiency of an enterprise. Results from the study indicated that farmers who grew Superfire variety had the highest total variable cost (TVC) per hectare whilst those who grew Mtupatupa had the lowest (Table 20). This may be because Superfire rice has a good aroma, hence fetches higher selling price than Mtupatupa rice. The difference was significant (P < 0.10) between the averages TVC per hectare of the two groups of farmers.

Table 20: Cost of Production of Farmers who grew Superfire and Mtupatupa Rice Varieties

Cost	Superfire	Mtupatupa
Average TVC per ha (MK)	23,507.94[a]	20,301.95[b]
Range of household TVC per ha (MK)	8,700-87,520	3,294-115,600

Pr (|T|>|t|) = 0.0913

Note: *a* and *b* are significantly different at 10 percent

4.1.13 Household Labor Availability

Rice is labor demanding and as such labor availability is very crucial in rice farming. The overall average labor hours of rice farmers were 613.82. The average household labor availability of farmers who grew Superfire and Mtupatupa rice varieties were labor hours 621.75 and 599.07 labor hours respectively. The difference between the two was not significant (P > 0.05). This was due to demands of similar activities by both varieties.

Table 21: Average Available Labor Hours per Variety Category

Rice Variety	Sample size	Mean	Standard error
Superfire	160	621.75	45.8069
Mtupatupa	86	599.07	48.6906
Combined	246	613.8	34.2594

Pr (|T|>|t|) = 0.7530

4.2 Concluding Remarks

The main purpose of this chapter is to analyze the socio economic factors of rice farmers. The results showed that farmers who grew Superfire had a higher average yield than those who grew Mtupatupa. Furthermore, farmers who grew Superfire applied more fertilizer than those that grew Mtupatupa.

The average land size for farmers who grew Superfire was relatively higher than that of Farmers who grew Mtupatupa. Furthermore, Superfire farmers had a higher average distance to an input and output market compared to those who grew Mtupatupa. It was also shown that farmers who grew Superfire had fields with higher soil fertility levels than those who grew Mtupatupa.

CHAPTER FIVE

5.0 MODELS RESULTS AND DISCUSSIONS

Introduction

The previous chapter presented descriptive analysis of household socio-economic characteristics of smallholder rice farmers. This chapter presents an analysis of TE, AE and EE of the rice farmers. In order to determine the efficiency levels and the determinants of inefficiencies, the translog stochastic frontier with the half- normal distributional assumption were used. The translog was used due to its flexibility and simplicity in comparison to the Cobb-Douglas production function which is restrictive in its nature. There is no distinction in the varieties of rice grown in the irrigation scheme. This chapter further presents factors responsible for the respective levels of TE, AE and EE it concludes by presenting a summary of results.

5.1 Stochastic Frontier Models Results

One-stage stochastic production frontiers approach was used to estimate the determinants and distribution of farmer efficiency in this analysis. This involves regressing output on the input variables, as well as the socio-economic variables that determine inefficiency in rice production (Battese and Coelli, 1995). In order to correct for possible heteroscedasticity robust standard errors (presented in parenthesis) were estimated in both the stochastic production frontier and the stochastic cost frontier. The maximum-likelihood estimates (MLE) of the parameters of both functions were obtained using the program STATA. Furthermore, the elasticities of mean output were estimated at the means of the input variables.

5.2 Technical Efficiency of Rice Production

The log-likelihood of -198.0406 indicates the overall significance of the estimated TSPF of rice production which is also significantly correlated to the physical production inputs of land and fertiliser (Table 22). Although some of the production inputs are significant and have the expected signs, results of the first order translog production function coefficients are not conclusive as they do not provide much information on the responsiveness of the output to the various inputs. Based on this argument, output elasticities of each of the physical input used at their mean values were computed. The output elasticities of all the inputs are positive as shown in Table 23. These estimates are 0.59, 0.04, 0.02 and 0.14 for land, labor, seed and fertiliser respectively. The results demonstrate the high response of rice to land and fertiliser.

Table 22: MLE of the Parameters of the TSPF Function for Rice Producers in Nkhate Irrigation Scheme, Southern Malawi

	Parameter	Estimated coefficient	Robust Std. Error
Intercept	β_0	1.1544	0.5983
Lnland	β_1	0.5382***	0.1022
Lnlabor	β_2	0.0042	0.0510
Lnseed	β_3	0.1371	0.1004
Lnfertiliser	β_4	0.1194*	0.0679
$1/2$ Lnlansqrd	β_5	-0.4474**	0.1564
$1/2$ Lnlaborsqrd	β_6	-0.1370	0.1050
$1/2$ Lnseedsqrd	β_7	0.5474*	0.2969
$1/2$ Lnfertilisersqrd	β_8	-0.1256	0.0854
Lnland*Lnlabor	β_9	-0.0680	0.1440
Lnland*Lnseed	β_{10}	0.3276*	0.1649
Lnland*Lnfertliser	β_{11}	0.0885	0.1517
Lnlabor*Lnseed	β_{12}	-0.0373	0.1434
Lnlabor*Lnfertiliser	β_{13}	0.0548	0.0662
Lnseed*Lnfertiliser	β_{14}	0.0167	0.1203
Variance parameters			
Lamda	λ	1.5378**	0.2277
Sigma squared	$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.5418**	0.1166
Sigma-u	σ_u	0.6171**	0.1399
Sigma-v	σ_v	0.4013**	0.0912
Gamma	$\gamma = \lambda^2/(1+\lambda^2)$	0.7028**	
		Chibar2(24) = 310.74***	Prob>=chibar2=0.000
Log-likelihood		-198.0406	
Number of observations	n	245	

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

Table 23 indicates the computed elasticities at the mean values of the inputs. A percentage increase in land allocated to rice leads to a 59 percent increase in the output. Further more, a percentage increase in labor used results in a 4 percent increase in output. Similarly a percentage increase in fertiliser applied leads to a 14 percent increase in the output. Finally a percentage increase in quantity of seed used leads to a 2 percent increase in rice output.

Table 23: Input Elasticities of the TSPF

Input	Elasticity
Land	0.59
Labor	0.04
Seed	0.02
Fertiliser	0.14

Considering the first hypothesis of this study, the presence of technical inefficiency effects in the model, and all deviations from the production frontier are due to statistical noise if $\lambda = 0$ (Coelli et.al, 2005). Therefore, the presence of technical inefficiency effects in rice production is tested by the significance of the variance parameters. From Table 22, the estimated value for λ is large and significantly different from zero ($\lambda = 1.5378$). Therefore, the null hypothesis of no technical inefficiency in rice production is rejected at 5 percent significance level. The variance parameter σ^2 is significantly different from zero ($\sigma^2 = 0.5418$). The inefficiency effects are therefore random and stochastic. The ratio of plot-specific technical efficiency effects to the total output variance, expressed as γ takes on a value of 0.7028. About 70 percent of the variation in rice output is due to differences in technical efficiency among the farmers.

The level of technical efficiency was computed for each farm. Mean technical efficiency for rice farms is 65 percent with a minimum of 13 percent and a maximum of 93 percent and a standard deviation of 14 percent. About 92 percent of the farmers have technical efficiency levels of less than 80 percent. This indicates that in the short run, there is large scope for efficiency gains. Rice farmer's levels of technical efficiency can be increased by up to 40 percent on average using the best practice technology. Therefore 40 percent of smallholder rice yield is lost due to inefficiency. This implies that identifying and addressing the major factors that constrain efficiency in smallholder rice production might double productivity while applying the current technology.

Table 24: Summary of Technical Efficiency of Smallholder Rice Farmers

Variable name	**Number of Observations n**	**Mean Technical efficiency (%)**	**Standard deviation**	**minimum**	**Maximum**
Predicted technical efficiency	245	65.49	0.14	0.13	0.93

5.3 Economic Efficiency of Rice Farmers

The log-likelihood estimate of -220.6924 shows the overall significance of the estimated translog stochastic cost frontier function of the rice farmers. The model has a Wald test statistic of 689.06 with a p-value of 0.0000. The significance of gamma ($\gamma = 0.8608$) shows that the frontier is stochastic. This further indicates that 86 percent variation in rice output among the farmers due to presence of inefficiencies. The results further showed that yield levels and labor cost were significantly affecting the economic efficiency of rice production.

The summary statistics of the estimated cost efficiency indices for rice are presented in Table 25. The estimated mean cost efficiency is 53 percent indicating that farmers could raise the profitability of rice production by an average 47 percent through optimum use of inputs, especially labor.

Table 25: MLE of the Parameters of the TSCF Function for Rice Producers in Nkhate Irrigation Scheme, Southern Malawi

	Parameter	Estimated coefficient	Robust Std. Error
Intercept	α_0	14.1156	0.3204
Lnyield	α_1	0.2561***	0.7589
Lnlandcost	α_2	-0.1228	0.1160
Lnlaborcost	α_3	1.0614***	0.8334
Lnseedcost	α_4	0.1093	0.1040
Lnfertilisercost	α_5	-0.0480	0.0682
$1/2$ Lnlancostsqrd	α_6	0.1636	0.2758
$1/2$ Lnlaborcostsqrd	α_7	0.2157	0.2726
$1/2$ Lnseedcostsqrd	α_8	0.3310***	0.9944
$1/2$ Lnfertilisercostsqrd	α_9	-0.1124	0.1268
$1/2$ Lnyieldsqrd	α_{10}	0.1687***	0.0524
Lnlandcost*Lnlaborcost	α_{11}	-0.2424	0.2328
Lnlandcost*Lnseedcost	α_{12}	0.0072	0.1110
Lnlandcost*Lnfertlisercost	α_{13}	0.0715	0.1949
Lnlaborcost*Lnseedcost	α_{14}	-0.1762	0.1471
Lnlaborcost*Lnfertilisercost	α_{15}	0.2029	0.1241
Lnseedcost*Lnfertilisercost	α_{16}	0.1877	0.1195
Lnyield* Lnlandcost	α_{17}	-0.1496	0.1532
Lnyield* Lnlaborcost	α_{18}	-0.1643	0.1514
Lnyield* Lnseedcost	α_{19}	0.0214	0.0950
Lnyield* Lnfertlisercost	α_{20}	0.0015	0.0960
Variance parameters			
Lamda	λ	2.4871**	0.1704
Sigma squared	$\sigma^2 = \sigma_u^2 + \sigma$	0.8307	0.1424
Sigma-u	σ_u	-0.3354	0.2518
Sigma-v	σ_v	-2.1576**	0.4199
Gamma	$\gamma = \lambda^2 / (1 + \lambda^2$	0.8608**	
Log-likelihood=-220.6924	Chibar2(15) = 603.34***		Prob>=chibar2=0.000

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

5.4 Allocative Efficiency of Rice Farmers

Results from Table 26 indicate large variations in performance across farms. Allocative efficiency of rice farmers ranges from 13 to 91 percent. This implies that if the average farmer in the sample was to achieve the allocative efficiency level of his or her most efficient counterpart in Southern Malawi, he or she should increase the Allocative efficiency by 35 percent[1]. Allocative inefficiency is worse than technical inefficiency hence low level of economic efficiency is due to higher costs of inefficiency.

Table 26: Average Percentage of Technical, Allocative and Economic Efficiency of Malawian Smallholder Rice Farmers

Efficiencies	Mean efficiency (%)	Min (%)	Max (%)	Standard deviation
TE	65.49	13.31	93.23	13.59
AE	59.41	12.86	91.23	16.36
EE	53.32	12.41	89.23	19.13

Figure 1 shows the distribution of efficiency estimates and is apparent that the scope of efficiency gains is fairly large. Economic efficiency in smallholder rice farming system could be increased by up to 50 percent using the current production technology. This therefore implies that smallholder productivity could double if key factors that are currently constraining overall efficiency are addressed adequately.

[1] The percentage increase in Allocative efficiency is obtained by using the following formula: (1-59.41/91.23)) *100 where the figures are the mean and maximum levels of Allocative efficiency as shown in Table 26.

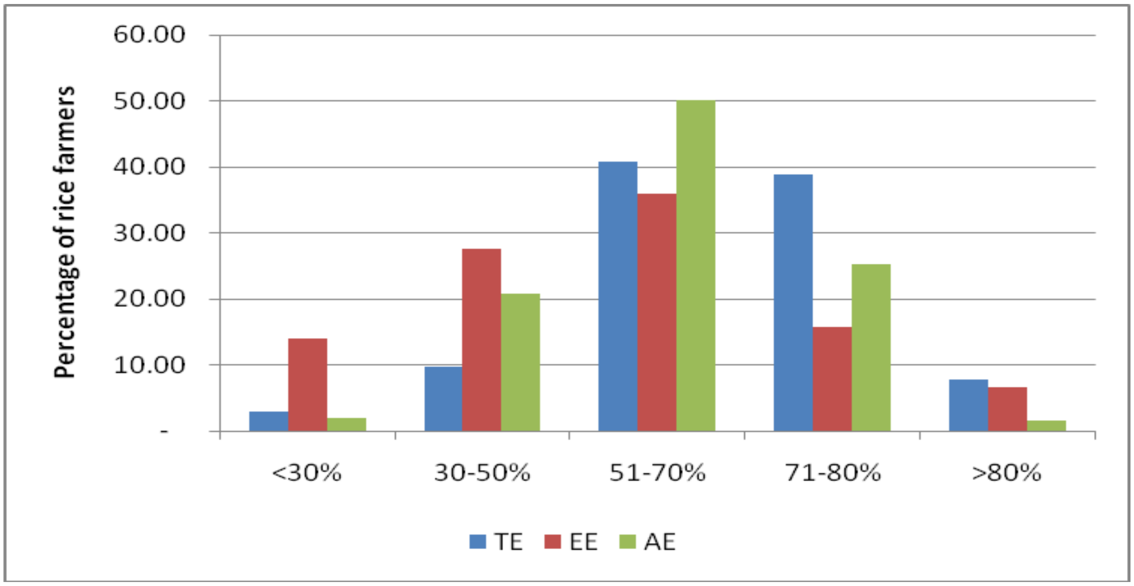

Figure 2: Average Proportion Efficiency in Smallholder Rice Production in Nkhate Irrigation Scheme, Southern Malawi

5.4 Factors that Determine the Levels of Smallholder Rice Production Efficiency

This section intends to identify some of the factors that influence production efficiency of rice farmers in southern Malawi. The results for this will be used as a basis for informing agricultural policy on what needs to be done to improve smallholder productivity. Summary results in Table 27 show the determinants of technical and economic inefficiency. The coefficient for high soil fertility is significant and negative, suggesting that it negatively influence efficiency. The negative influence of high soil fertility levels on inefficiency indicates that those farmers who cultivated on high fertile soils are less inefficient in rice production under improved technology.

Furthermore, there are negative and significant impacts of years of growing rice on both technical and economic efficiency of rice production in Southern Malawi. More experienced farmers are in a better position of understanding and integrating agricultural instructions and apply technical skill imparted on them. Increased farming experience may result in efficient input use through effective extension and research information. In addition to the above, household size and access to credit have positive and significant impact on economic efficiency on rice production. Hence they have an inefficiency increasing effect.

Although the rest of the variables turned out to be insignificant, they have a priori expected signs. The negative sign on the coefficient of age of farmer indicates that younger farmers are more efficient than the older farmers. This could be explained by older farmer's unwillingness to adopt modern technologies. In addition, the older the farmer gets, the more their physical strength declines. An implication of this is that although older farmers are more skillful and experienced the effects of learning by doing dimishes over time (Liu and Zhuang, 2000).

Table 27: MLE of the Inefficiency Model

		Stochastic production frontier		Stochastic cost frontier	
	Parameter	**Estimated coefficient**	**Robust std errors**	**Estimated coefficient**	**Robust std errors**
Age	δ_1	-0.0003	(0.0022)	-0.0023	(0.0026)
Household size	δ_2	0.0006	(0.0182)	0.0650***	(0.0195)
School years	δ_3	0.0017	(0.0075)	0.0042	(0.0072)
Access to credit	δ_4	-0.3354	(0.2748)	0.3021**	(0.1480)
Medium soil fertility	δ_5	-0.0513	(0.0.0811)	-0.1426	(0.0924)
High soil fertility level	δ_6	-0.1399*	(0.0775)	-0.0891	(0.0983)
Years of growing rice	δ_7	-0.0086**	(0.0041)	-0.0146***	(0.0042)
Access to extension advise	δ_8	-0.0505	(0.0818)	-0.0231	(0.1130)
Distance to input/output markets	δ_9	-0.0068	(0.0165)	0.0152	(0.0126)
Log-likelihood		-198.0406		-220.6924	
Number of observations	n	245		245	
		Chibar2(24) = 310.74*** Prob>=chibar2=0.000	Chibar2(15) = 603.34*** Prob>=chibar2=0.000		

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

5.5 Summary of Results

This research used translog stochastic production and cost frontiers and inefficiency model to derive technical and economic efficiencies from which Allocative efficiency was deduced. The results of the models have led to the rejection of the study hypotheses. The results further revealed an average technical inefficiency of 35 percent; Economic inefficiency of 47 percent and Allocative inefficiency of 41 percent. Allocative inefficiency is worse than technical in efficiency hence low level of economic efficiency is due to higher costs of inefficiency. The inefficiency model has showed that there are factors influencing production efficiency and these include; high soil fertility levels, years of growing rice, household size and access to credit.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

This study used trans-log stochastic cost and production frontier and derived technical, allocative and economic efficiencies. It also used the inefficiency model to identify the determinants of the efficiencies from a sample of smallholder rice farmers from Nkhate Irrigation Scheme in Southern Malawi. The results revealed an average of TE index of 65.49 %, an average AE efficiency index of 59.41% and EE efficiency index of 53.32%. These results indicate that farmers are operating with substantial inefficiency and hence have a considerable yield potential of 34.51% to be exploited. Furthermore, the average EE efficiency index indicates that farmers could raise the profitability of rice production by 46.68% all these by fully adjusting input use.

The results further revealed that provision of input credit, farmers experience in growing rice and soil fertility status are some of the significant factors that influence efficiency. In order to improve smallholder rice farming there is critical need of improving the way farmers are organized so that they can have access to credit, input and output markets as well as technological advice. All this in turn requires better infrastructure and the development of efficient input and output markets. Improvement of smallholder efficiency hence relies on the improvement of smallholder policy and institutional environments.

Policies and strategies that promote rural education, credit access, better soil fertility management and better infrastructure and markets will greatly assist smallholder rice farmers realize the unexploited production gains from rice and accompanying profitability. It is thus recommended that these farmers be mobilized in groups so as to benefit from institution innovations. These include; the commodity warranty schemes, contract farming from which they can learn and share farming experiences, new farming technologies, can access inputs and acquire extension support all in one package. This applies to smallholder rice farmers in other irrigation schemes who might be in the same situation as those from Nkhate irrigation scheme.

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APPENDIX 1

Economic Efficiency of Rice Production in Smallholder Irrigation Schemes: a case of Nkhate Irrigation Scheme in Southern Malawi

University of Malawi

Bunda College

Enumerator: Follow instructions before asking questions **Do not give your own views but record information from the interviewee** **Circle appropriate code and fill in the blank spaces where necessary** **Refer to 2008/2009 cropping season** **At the end of the interview, ask the respondent if there are any questions and thank them for their time**

February 2010

Introduction

We are from Bunda College working in partnership with the International Centre for Tropical Agriculture (CIAT) and the Ministry of Agriculture. We are conducting a survey on rice production, costs related to the production and how production resources are allocated. You were chosen to participate in the exercise. Your information will be kept with confidentiality and you will not be singled out in the results. You will be briefed on the results of the study

Name of Data Collector______________________________ Date of interview **Name of Household head____________________________ HH code** **Name of EPA____ Section** **T.A____ Village** **Checked by____ Date**

A. BACKGROUND INFORMATION

1. Household composition

Person No. (HH should be number 1)	Age in Years	Marital status of HH*(use codes below)	Gender 1.male 2.female	Relationship to HH***	Availability****

Codes for HH Marital Status
1. Single
2. Married
3. Widowed
4. Divorced
5. Separated
6. Other (specify) ____________________

Codes for availability
1. Permanent resident
2. Permanent resident in local employment
3. Permanent resident in full employment
4. Resident hired labour
5. Other (specify) ______________

Codes for Relation ship to household head
1. Spouse
2. Child
3. Parent
4. Grand child
5. Other(specify) ______________

2. Do you read and write Chichewa?
   1. Yes
   2. No
3. If yes how far did you go with your education? (Circle where appropriate)

Codes for qualification or academic level (circle depending on where education was obtained)

A. Formal Education

Code:
1. None
2. Primary school (years of schooling) ___________
3. Secondary school (years of schooling) _________
4. High school and above (years of schooling) _____
5. Other (specify) _______________________

B. Informal Education

Code:
1. None
2. Adult Literacy
3. Home craft
4. Farmer training
5. Other (specify)___________________

PART B: HOUSEHOLD INCOME

4. What are your main sources of income?

   Code
   1. Sales of crops
   2. sales of livestock
   3. labour sales
   4. remittances
   5. other (specify)

5. What was your income the previous year?

	Source	Amount (MK)
1	Sales of crops	
2	Sales of livestock	
3	Labour sales	
4	Remittances	
5	Other (specify)	

6. How much of this income did you allocate to agricultural activities?
MK__________________

Part C: LAND HOLDING SIZE AND RICE PRODUCTION

7. How many fields do you have?
Codes

1. One
2. Two
3. Three
4. Four
5. Five
6. More than five (specify)____________________

8. Are some of these gardens owned by you?
Code: 1 = yes 2 = no
9. If no how many are not owned by you?
Codes 1 = One 2 = Two   3= More than two
10. How did you get the garden (s) you do not own?
Codes

1. Rent
2. Borrowed for free
3. Other (specify)__________________________

11. How did you acquire the garden(s) you own?
Codes

1. Allocated by the scheme manager
2. Bought
3. Family inheritance
4. Through marriage
5. Other (specify)_____________________________

12. Out of the gardens you own how many are in the Nkhate irrigation scheme?
Codes

1. One
2. Tow
3. Three
4. Four
5. Five
6. More than five (specify)

13. Do you grow rice in all of your fields?
Codes: 1 = yes 2 = no

14. If no why not?
Codes

1. labour demanding
2. some fields are not irrigable
3. land not fertile
4. other (specify)_____________________________

15. If yes, in how many gardens?

Codes

1. one
2. Two
3. Three
4. Four
5. All gardens

16. What crops do you plant?

Codes

1. Rice
2. Maize
3. Cotton
4. Tobacco
5. Groundnuts
6. Other (specify)______________________________________

17. Of the above crops, what crops do you plant in the Nkhate irrigation scheme?

Codes

1. Rice
2. Maize
3. Cotton
4. Tobacco
5. Groundnuts
6. Other (specify)____

18. On how much land do you have these crops?

	Crop	Land size (ha) out of Nkhate irrigation scheme	Land size (ha) inside Nkhate irrigation scheme
1	Rice		
2	Maize		
3	Cotton		
4	Tobacco		
5	Groundnuts		
6	Other (specify)		

19. Rice field allocation to different varieties in the Nkhate irrigation scheme

Garden number	Garden size	Rice variety grown*	Amount of seasonal rent of land/ha (NK)
1			
2			
3			
4			
5			
6			

Codes for variety

1. Superfire
2. mtupatupa

20. For how long have you been growing rice? ______________________ Years.
21. What made you made start growing rice? ***(Circle where appropriate)***
Code

1. availability of land in the scheme
2. diversity from maize
3. source of income after sells
4. limited land for maize outside Nkhate irrigation scheme
5. continuing what parents were doing
6. source of food
7. influence from government extension workers
8. other (specify)

22. Who introduced the idea of growing rice to you?
Code

1. government extension staff
2. fellow farmers
3. the Chinese who developed the scheme
4. other (specify)___________________________

23. What challenges do you encounter during the growing of rice ***(circle all given responses)***

1. high labour demands
2. lack of seed
3. lack of chemicals
4. lack of technical knowledge
5. lack of time
6. limited extension support
7. other (specify)____________________________

24. Do you have access to any form of credit?
Code: 1= yes 2 = no
25. If yes, indicate the source of credit_________________________________
26. What is the fertility of your soils?
Code: 1. high
2. Medium
3. Low

D. FARM COSTS AND BENEFITS OF RICE FARMING

27 Benefits from rice gardens (2008-2009)

Crop type	Description of benefits	Amount Harvested (kg)	Price per unit (mk)	Total revenue (MK)
Rice variety	1 SUPERFIRE			
	2 MTUPATUPE			

28. Farm inputs used in 2008-2009 growing season (indicate in comment column whether subsidized or not) superfire

Activity	Cost of Item	Unit of Measurement	Amount used	Unit Cost (MK)	Total Cost (MK)	Source of Input
Land preparation	Hired labour	Man-days				
	Family labour	Man-days				
Sawing rice						
	Seed	kg				
	labour	Man-days				
Fertiliser application						
Basal dressing	fertiliser	Kg				
	Hired labour	Man days				
Top-dressing	fertiliser	Kg				
	Hired labour	Man days				
weeding	Hired labour	Man-days				
	Family labour	Man-days				
harvesting	Hired labour	Man-days				
	Family labour	Man-days				
chemicals	pesticides	litres				

	labour	Man-days				
marketing	Hired labor	Man-days				
	Family labour	Man-days				
Transporting input/output	Hired labor	Man-days				
	Family labor	Man-days				
Other (specify)						

Code 1 = subsidised 2 = no

29. Farm inputs used in 2008-2009 growing season (indicate in comment column whether subsidized or not) **Mtupatupa**

Activity	Cost of Item	Unit of Measurement	Amount used	Unit Cost (MK)	Total Cost (MK)	Source of Input
Land preparation	Hired labour	Man-days				
	Family labour	Man-days				
Sawing rice						
	Seed	kg				
	labour	Man-days				
Fertiliser application						
Basal dressing	fertiliser	Kg				
	Hired labour	Man days				
Top-dressing	fertiliser	Kg				
	Hired labour	Man days				
weeding	Hired labour	Man-days				
	Family labour	Man-days				

harvesting	Hired labour	Man-days				
	Family labour	Man-days				
chemicals	pesticides	litres				
	labour	Man-days				
marketing	Hired labor	Man-days				
	Family labour	Man-days				
Transporting input/output	Hired labor	Man-days				
	Family labor	Man-days				
Other (specify)						

Code 1 = subsidised 2 = no

30. Did you experience problems in accessing these inputs?

Code: 1 = yes 2 = no

31. If yes what was the most difficult input to access?

Code

1. rice seed
2. inorganic fertiliser
3. chemicals
4. labour

31. What was the main reason behind inaccessibility?

Code

1. scarcity
2. lack of money
3. distance to where they were found
4. other (specify

32. How did that affect your input use?

Code

1. did not affect
2. reduced input use
3. delayed input use

33. If delayed, by how many days? *(Specify input and number of days accordingly)*

1. _________________ by _________________days
2. _________________ by __________________days

3.________________ by _________________days

34. If it reduced use, by how much (kgs or litres)

1. _______________
2. ________________
3. ________________

E. EXTENSION SERVICES

35. Do you have access to extension services?

Code 1= yes 2 = no

36. If yes, on which main area

Codes

1. land preparation
2. planting and spacing
3. disease and pest control
4. harvesting
5. marketing
6. other (specify)________________________________

37. What is the main source of extension services?

Code

1. Government extension staff
2. Fellow farmers
3. NGOs
4. CIAT
5. Other (specify)

38. How many times per month are you visited by extension service provider(s)?

Code

1. More than four times
2. Four times
3. Three times
4. Twice
5. Once
6. Not al all
7. Other (specify)

39. Do you participate in field days?

Code 1 = yes 2 = no

40. Do you have an experimental plot in the scheme?

Code 1 = yes 2 = no

41. Do you belong to any club or association?

Code 1 = yes 2 = no

42. If no, what is the main reason?

Code

1. Absence of club association
2. No incentive/ benefit

3. Lack of organisation in the club
4. Inexistence of clubs
5. Poor supervision by extension worker (s)
6. Other (specify)______________________________

43. If yes what is the main reason for joining the club/ association?
Code
1. Government staff directive command
2. To learn and share experiences with fellow farmers
3. To easily obtain inputs
4. To sell produce as a group
5. Others (specify)_________________________________

44. Do you keep farm record?
Code 1 = yes 2 = no
45. If yes what is the main reason of keeping such records?
Code
1. To keep track of farm activities
2. Instructed to do so by extension worker
3. For future reference
4. Other (specify)_________________________

46. How frequent do you record your agricultural activities?
Code
1. Weekly
2. Monthly
3. Quarterly
4. Every six months
5. Annually
6. Other (specify)________________________________

47. Did you receive any free or buy subsidized fertiliser?
Code 1 = yes 2 = no
48. If yes, how much? ______________________ Kg
49. Distance to nearest input/output market from homestead _____________