INPUT USE EFFICIENCY FOR MAIZE PRODUCTION IN TANZANIA: A CASE OF SMALLHOLDER FARMER IN IRINGA REGION

BY

JONATHAN HERMAN MPUYA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2010

ABSTRACT

The study on input use efficiency for maize production was carried out in Iringa region specifically in Njombe and Ludewa districts. The study aims at estimating efficiency components of smallholder maize farmers and identifying socio-economic and farm specific factors influencing input use inefficiency. A purposeful sampling technique was employed to select the two districts with relatively higher potential in maize production. In each district two villages were randomly selected to make a total of four villages. Also in each village 25 farmers were randomly selected for interview. Descriptive statistics were employed to study the households' socio-economic characteristics while, a non parametric method of Data Envelopment Analysis (DEA) was used to determine the relative technical, scale and allocative efficiencies of individual decision making unit. Likewise, a logistic regression model was employed to determine the factors influencing inefficiency level of smallholder maize farmers. The results of DEA scores revealed that the mean technical efficiency and scale efficiency were 0.73 and 0.95 respectively. The study further confirmed that, the present inefficiency is largely due to technical rather than scale effect. Therefore, by using the existing technology, the sample households can obtain the same level of output even if the input cost is reduced by 27%. In terms of cost minimization, the result show that the mean allocative efficiency was 0.49 implying that, inefficiency due to inappropriate input mix accounts for 51% loss of households' income. The result of the logistic regression model provided evidence that, technical inefficiency decrease with the frequency of contact with extension agents. However, farmer's actual age, years of schooling, farm size and distance were found to increase technical inefficiency. The empirical findings of this study indicate that, improvement of input use in the study area lies upon improving technical efficiency of the relatively inefficient smallholder farmers.

DECLARATION

I, **Jonathan Herman Mpuya**, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my own original work and has neither been submitted nor being concurrently submitted for degree award in any other Institution.

19/11/2010

Jonathan Herman Mpuya — **Date**

(MSc. Candidate)

The above declaration confirmed

19 Nov 2010

Dr. Joseph P. Hella — **Date**

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENTS

This study would not have been accomplished without the help and encouragement of many people and institutions. So, I wish to express my sincere gratitude to a number of individuals who contributed to successful completion of this work. Special thanks should go to Dr. Joseph P. Hella for his commitments and in supervising the research and dissertation production. This work could not have been possible without his enthusiastic encouragement and constructive advices in the process of shaping up this dissertation.

Appreciation should also go to all academic staff and colleagues in the Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture for their constant encouragement, advice, support and mutual relationship shared during the entire period of the graduate study. To mention a few; Dr. D. Phillip, Mr. Frank Lymo, Mr. Ambilikile Mwenisongole, Mr. Adam Siwingwa, Mr. Ipyana Mwakasaka and Mr. Stanslaus Nyavanga you are advice was so much constructive and appreciated.

The Ludewa District Council is acknowledged for the financial support, which enabled the author to accomplish the study. Sincere thanks are also extended to the former District Executive Director Mr. F. T. Ernest and the District Agriculture and Livestock Development Officer (DALDO) Mr. Nasson Kigobanya for allowing me to attend the study.

Lastly but not least I wish to express my gratitude to all the respondents who took part in this study for their cooperation during the entire period of data collection. There is no doubt that without their cooperation this study would not have been as successful as it has happened to be.

My special thanks and appreciation are due to my wife, sons, parents, and relatives for their moral support during the whole period of study. Above all I thank God for bestowing me with good health and patience during the entire period of this work.

Definitely a study of this kind cannot be successfully completed without the assistance of many individuals. The above-mentioned individuals and institutions constitute only a part of those who helped me in undertaking the study. I therefore extend the same appreciation to all other individuals and institutions that have not been mentioned in this part for their assistance in the course of this study. Stay with the true love and peace of the Almighty GOD.

DEDICATION

This work is dedicated to Almighty God who is the source of all knowledge from which human being we tapc to develop our surrounding for better existence.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ARI	-	Agricultural Research Institutes
BCC	-	Banker-Charnes-Cooper
BCR	-	Benefit Cost Ratio
CCR	-	Charnes-Cooper-Rhodes
CIAT	-	Centre for International Tropical Agriculture
CIMMYT	-	Centro Internacional de Mejoramiento de Maíz y Trigo
CRS	-	Constant Returns to Scale
DALDO	-	District Agriculture and Livestock Development Officer
DAP	-	Di-ammonium Phosphate
DEA	-	Data Envelopment Analysis
DEAP	-	Data Envelopment Analysis Software Programme
DMU	-	Decision Making Unit
DRS	-	Decreasing Return to Scale
FAO	-	Food and Agriculture Organisation
IFDC	-	International Fertilizer Development Centre
IRS	-	Increasing Return to Scale
MAFSC	-	Ministry of Agriculture, Food Security and Co-operatives
NBS	-	National Bureau of Statistics
NFRA	-	National Food Reserve Agency
NSGRP	-	National Strategy for Growth and Reduction of Poverty
OLS	-	Ordinary Least Square
PPF	-	Production Possibility Frontier
R&AWG	-	Research and Analysis Working Group
SAP's	-	Structural Adjustment Programs

SFA	-	Stochastic Frontier Approach
SGR	-	Strategic Grain Reserve
SNAL	-	Sokoine National Agricultural Library
SPSS	-	Statistical Packages for Social Sciences
SSA	-	Sub-Sahara Africa
TZS	-	Tanzania Shillings
URT	-	United Republic of Tanzania
VRS	-	Variable Return to Scale

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Maize is both a traditional staple food and source of income to most smallholder farming households in Iringa region. Although the region is generally reputed for high maize yield, but in recent year, productivity per unit area is incredibly low. For instance in the past five years from 2003/04 to 2007/08 maize yield was on average 2 tons per hectare against the attainable capacity of 6.5 tons (URT, 2007a). A number of studies have shown that the underlying causes of low crop yield maize in particular vary across countries. Sanchez *et al.* (1997) claim that soil fertility depletion on smallholder farms is the fundamental biophysical root cause of declining per capita food productivity in Africa in general and Iringa in particular. Chiwele and Sikanu (2006) indicated that declining in the number of households with access to modern inputs and low prices for agricultural produces contribute significantly to low food productivity in Zambia, which is also equally important in Iringa context. Achieving maize productivity growth in Iringa region and Tanzania as a whole is likely to involve among many other things, substantially increased use of modern inputs.

Tanzania agriculture like that of other Sub-Sahara African (SSA) countries is still characterized by low input use. For instance, the Poverty and Human Development Report of 2007 (R&AWG, 2007 cited by Msuya *et al.*, 2008) showed that; 87% of Tanzanian farmers interviewed by the research and analysis group under Tanzania's National Strategy for Growth and Reduction of Poverty (NSGRP) were not using chemical fertilizers; 77% were not using improved seeds; 72% were not using pesticides, herbicides or insecticides (agrochemicals). Problems of accessing modern inputs during the Post-Structural Adjustment Programs (Post-SAPs) in many of the SSA countries have been reported by

Kelly *et al.* (2003). Not only that adoption levels are generally low, but de-adoption of hybrids and fertilizer has occurred in recent years. High prices of most of essential input especially fertilizer and low profitability have been identified to contribute to low use of modern inputs in Sub-Sahara African countries which in turn has forced some of SSA countries to re-introduce input subsidy (Ricker-Gilbert and Jayne, 2008; Xu *et al.*, 2006).

In Tanzania input subsidy was officially reintroduced in 2003/04 growing season. The purpose of subsidies in less developed nations has been to encourage farmers to use modern inputs and thereby expand total production. However, from the national budgetary point of view this measure has proven to be unsustainable in many of the less developed countries. For example, in Bangladesh (Faruq, 2008) showed that, fertilizer subsidies alone accounted for about 2% of the annual development budget by the mid 1970s which provide an idea of the heavily subsidized input in that time. The budgetary burden on input support have been also experienced in Tanzania where in 2008/09 growing season the government had reduced the package of input subsidy provided to farmers and decided to target only food insecure households. Such a decision is an indication that the government is unable to sustain the input subsidy program, which suggests the need to find a feasible solution that would address efficiency of input use on the side of smallholder farmers.

Considering the importance of maize production in rural farming households in Tanzania and Iringa region in specific, this study conducted efficiency analysis for input use with the aim of finding an optimal level of input usage for profitable maize production in the study area.

1.2 Problem Statement and Justification

Modernization of agriculture normally involves the wider use of an array of inputs such as improved seeds, fertilizers, and pesticides-usually in the form of package. Some studies such as Chianu *et al.* (2008); Heisey and Mwangi (1996) have indicated that, growth rates in input use in SSA countries including Tanzania have never been high, because real price of these inputs especially fertilizer is higher than other developing countries.

The reasons for lower input use in Tanzania are not clearly understood. Empirical studies during the Post-SAPs, (Mwakalobo, 1998; Hawassi, 1997 and Turuka, 1995) have shown that, low relative prices ratio of input and output, input subsidy removal and currency devaluation raised the price of inputs (such as fertilizers, herbicides, pesticides etc), and made them unaffordable to a large proportion of smallholder farmers. However Nguruse (2007) has noted evidence of inconsistency increase of input price especially fertilizer during the period in which input subsidies was re-introduced. Taking an example of one input only, URT (2008) has reported that, the price of commercial Di-Ammonium Phosphate (DAP) fertilizer has risen for more than 300% and more than 150% for other types of fertilizers from 2005 to 2007. This concurs with the findings by Nguruse (2007).
The fact that prices of input play a significant role in determining their level of usage in smallholder agriculture cannot be underestimated. A price of input is one factor, but in actual situation other factors ranging from physical delivery problems and lack of farmers knowledge about potential payoff of the inputs may interfere the responsiveness of input use particularly in smallholder agriculture. Achieving agriculture growth productivity given a set of constraints depends on the farmer's ability to make an efficient choice among alternative paths of technical change. If the crop is of significant value (it must be produced), as prices of input go up (*Ceteris Paribus*), economic literature (e.g. Ellis 1993; Boehlje and Eidman, 1984) suggest three alternative technological paths should be adopted

by a farmer. The first path would involve shifting the inputs from one production unit to the one we are interested in. The second path would involve substituting the existing inputs by new inputs that are close substitutes. If the first and second paths are not possible for some reasons such as resources scarcity, or lack of close substitutes, then the third path can be adopted. This involves improvement in input use efficiency of that crop using the same existing inputs. In the study of input substitutability in smallholder farming Dalton *et al.* (1997) found that, labour, biochemical inputs, and capital can be substituted to each other. But, overall, smallholder farmers in SSA countries operate in a constrained optimization scenario which often leads to low productivity (Gadzirayi *et al.*, 2006).

In view of that, the third technological path is considered relevant in this study. If a farmer decides to adopt the third technological path, he can approach the improvement in input use efficiency either by using the constrained output maximization (maximizing output for a given cost) or constrained cost minimization (minimizing cost subject to a given output). These two approaches constitute what is known as constrained optimization behaviour. In most cases farmers are interested in the total cost of producing an output as well as the unit cost of production at a given level of output (Kadigi, 2009). But the problem of most of smallholder farmers has been that of deciding the least cost combination of inputs that maintain output at the same level. Previous studies in maize farming in Africa (e.g. Msuya *et al.*, 2008; Oluwatayo *et al.*, 2008 and Kibaara, 2005), investigated input use efficiency using Stochastic Frontier Approach (SFA). But, all these studies, suggested no least cost combination of inputs that minimize costs. Contrary to previous studies, this study, quantitatively expounds the assumption of cost minimization using Data Envelopment Analysis (DEA) method and suggest input combinations that minimize cost. This is achieved using smallholder maize farmers in Iringa region as the case study.

1.3 Study Objectives

1.3.1 Main objective

The main objective of this study was to analyse the efficiency of farm input use in maize production under smallholder farming in Iringa region with the aim of suggesting an optimal proportions of input usage for profitable maize production.

1.3.2 Specific objectives

The specific objectives were;

(i) To identify the most important inputs used in maize production.

(ii) To estimate technical efficiency (a measure of the ability of a farm to obtain maximum output from a bundle of inputs given the best available technology).

(iii) To estimate scale efficiency (the ability of a firm-farm to use the inputs in optimal proportions).

(iv) To estimate allocative efficiency (a measure of a farm ability to produce a given level of output at lower cost).

(v) To determine socio-economic and farm specific factors influencing inefficiencies.

1.4 Hypotheses

(i) Smallholder maize farmers in the study area are technically efficient in the allocation of available resources, which means, the observed input bundle (input price not considered) produces the observed output quantity given technologically feasible input-output combinations.

(ii) Given the price vector for inputs smallholder maize farmers are allocatively efficient, which means, they select input and output quantities that minimize cost.

1.5 Organization of the Study

This study is organized into five chapters. After this 1st chapter, the following chapter gives a critical review of literature relevant to the study, while the third chapter gives a detailed description of the methodology employed for this study. Chapter four presents results and discussion while the last chapter provides concluding remarks and recommendations of the study. A list of references cited in the text and appendices are given at the end of this work.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

Production is the process of transforming a certain level of inputs such as capital, labour, seeds, fertilizer, etc into output, subject to the technical rules specified by the production function. Symbolically the production function can be represented as:

$Q = f(X_i)$ .... (1)

Where;

Q= amount of output produced

X_i= amount of inputs used in the production process (where $X_i = X_1, \ldots\ldots, X_n$)

From (1), if the level of X_i are increased or reduced then it is expected that Q will also correspondingly increase or decrease. Hayami and Ruttan (1985) have shown that agricultural output can grow in two ways; an increase in use of resources of land, capital and intermediate inputs or through advance in techniques of production from which greater output is achieved by using constant or declining resource base. The latter is also referred to as productivity which occurs without a correspondingly change in output.

In order to know how the same output can be achieved through declining resource base, a researcher needs first to know the ultimate objective of the production process. Oluwatayo *et al.* (2008) have indicated that, the ultimate objectives of any agricultural production process may be profit maximization, output maximization, cost minimization or utility maximization or a combination of the four. Considerable researches in agriculture assume that farmers pursue to maximize profit as their main goal. However, this is not always the case, because sometimes farmers may want to pursue other goals such as maximum output for reasons that are best known to them. In either case, the farmer or entrepreneur is concerned with efficiency in the use of inputs to achieve his aim i.e. the technological versus economic efficiency. Koutsoyiannis (1979) argue that, the economic efficiency occurs when the cost of producing a given output is low, which implies that in a given time of the production process farmers are faced with a single decision namely; maximizing output for a given cost and minimizing cost subject to a given output. Both these decisions comprise cases of constrained optimization problem and they lead to the same rule for allocation of inputs and choice of technology.

Since the purpose of this research was to determine the efficiency with which smallholder farmers in Iringa region allocate resources in a cost minimizing sense, then, the cost minimization scenario was used. From economics point of view, it is recognized that, firms-farms seek to minimize cost subject to constraint that they produce Q units of output. Assuming the production process uses two inputs (i.e. labour and capital); the firms' cost minimization problem is given by:

$$\begin{aligned} &MinC = f(X_i) = wl + rk \\ &s.t. f(k,l) = Q \\ &l \geq 0 \\ &k \geq 0 \end{aligned} \qquad \text{.......... (2)}$$

Where;

MinC = Minimize cost

w = price of labour (wage rate)

r = price of capital (interest rate)

l= labour inputs

k = capital inputs

Q = output

s.t.f = subject to a function of

Equation (2) can be solved using substitution or Lagrange multiplier methods and both they lead to the same equilibrium condition. If the first order conditions for cost minimization are met, the optimality is the equality between the technical rates of substitution to the ratio of the relative factor prices given by:

$$\frac{f_l}{f_k} = \frac{w}{r} \quad \ldots\ldots (3)$$

Where;

f_l= marginal product of labour inputs

f_k= marginal product of capital

It can be noted from (3) that, the firm-farm minimize its cost by employing the combination of l and k determined by the slope of the factor prices $\left(\frac{w}{r}\right)$. Empirically, the input quantities of labour and capital that minimize cost can be determined using different methods ranging from parametric to non-parametric. The present study used nonparametric method of Data Envelopment Analysis (DEA) to measure the efficiency of cost minimization in smallholders' maize farming in Iringa region. The detailed description of DEA method has been provided in section 3.3.2.

2.2 Farming/Production Systems and Farm Input Use in Tanzania

A system of farming usually refers to a specific combination of crop and /or livestock enterprises in a given agricultural industrial unit. In Tanzania, the officially recognized modes of agricultural production are; subsistence agriculture, small scale farming, and large scale farming, both relating to resource utilization and hence degree of development (Mlambiti, 1994).

Small scale also known as smallholders farming is the dominant production system in Tanzania and generally is characterized by low input use in contrast to large scale production system which is characterized by the high input use of capital, labor, or heavy usage of technologies such as pesticides, and chemical fertilizer relative to land area.

In Iringa region the dominant production system is small scale farming where farmers pursue a balance between main staple and cash crops, livestock, fishing, forestry and off-farm activities. In terms of crops, some parts of the region can grow a number of crops such as; maize, wheat, beans, round potato, tea, pyrethrum and coffee. Of these crops maize has remained the most important crop in smallholder production system. The reason why maize is so dominant is that, it can provide both subsistence and cash income, and those who can get higher productivities from inputs; it can compete with beans, round potatoes, vegetables, and other grains. Smallholder farmers in this region differ from many of other in the country in that they know about and make use of inputs, though at varying degrees. The region maize statistics shows that, the average maize yield stands at 2 tons per hectare as compared to 1 ton per hectare during the 1970s through 1980s (URT, 2007a). However the potential maize yield is estimated at 6.5 tons per hectare. The current observed growth in maize production in the region to the large extent has been accounted for by the widespread of technologically yield enhancing inputs such as fertilizers, hybrid seeds and pesticides rather than from the growth in labor productivity and capital.

2.3 Input-Output Relationships and Farm Decision Making

In economic theory of farm production, a farmer is described as an individual decision maker concerned with question such as how much labor to devote to the cultivation of each crop, whether or not to purchase inputs, which crops to grow in which fields and so on. In such a case a farmer has to make right decision on how to allocate his scarce available resources in different production systems. Ellis (1993) identifies three relationships between farm inputs and outputs which are typically recognised as encompassing the economic decision making. These three relationship are; (1) the varying level of output corresponding to different level of variable inputs. This is also called the factor-product or input-output or simply the production function (i.e. the physical relationship between inputs and output to which all other aspects of the production process are ultimately related), (2) the varying combination of two or more inputs required to produce a specified output. This is called factor-factor relationship. It is also referred to as the method or technique of production and (3) the varying level of output resulting from competing for one fixed resource. This is called product-product relationship, also called production possibility frontier (PPF). The (PPF) represents the maximum product combinations for a given input level.

In economic literature the theory of production is considered as a device that provides theoretical and empirical frameworks to facilitate proper selection among alternatives so that any one or a combination of the farmer's objectives can be attained. However in order for the farmer to make decisions that will enable to attain some specified goals, certain parameters of interest must be known and these are derived through the production function. A production function stipulates the technical relationship between inputs and output involved in production, usually denoted as:

$$TPP = Q = f(X)$$
$$AP = \frac{TPP}{X} = \frac{Q}{X} \qquad \text{.... (4)}$$
$$MP = \frac{\Delta TPP}{\Delta X} = \frac{\partial TPP}{\partial X}$$

Where;

TPP= Total Physical Product

AP= Average Product

MP= Marginal Product

The TPP, AP, MP and other parameters not shown above specifically marginal rate of substitution (MRS), elasticity of production (EP), and returns to scale (RTS) help the farmer in determining or specifying the use of resources and the pattern of output which maximize farm profit (FAO, 2009). These parameters can be derived for various production functions such as exponential, power such as Cobb-Douglas, semilog, Constant Elasticity of Substitution (CES) and applied to both short-run and long-run production. Rasmussen (1989) used partly a Cobb-Douglas and partly a linear additive production model in the investigation of input use for maize in the southern highland of Tanzania and obtained satisfactory results. Msuya *et al.* (2008) applied Cobb-Douglas production function and stochastic frontier function to explain productivity variation among smallholder maize farmers in Tanzania. Thus, the choice of any of these functional forms depends upon the purpose of the study and methodology.

2.4 Input Use versus Productivity

An input is defined as any scarce resource used in the production of goods and services. Mushtaq *et al.* (2007) classified inputs into: conventional such as land, labor, capital, and management; physical such as fertilizer and pesticides; biological such as seeds and irrigation water; and environment such as soil, rainfall and temperature. In agriculture production these inputs can be combined in different proportions in order to produce a certain level of output and this is embodied in the production function.

There is huge evidence suggesting that worldwide increased productivity in agriculture has been accounted for by input use (FAO, 1982). On the other hand, Morris *et al.* (2007)

argue that, the substantial differences in agricultural productivity and yields seen between Asia and Africa can be largely explained by differences in modern input use. Gómez-Limón *et al.* (2004) point out that, output growth can be attained through expansion in farmed area, intensification of production and improvement in input use efficiency. The constraints imposed on agricultural development by an inelastic supply of land have been offset by the development of high yielding crop varieties designed to facilitate the substitution of fertilizer for land (Dalton *et al.*, 1997).

But this reality has not been manifested itself in Tanzania's smallholder agriculture due to imperfect markets of both inputs and outputs (i.e. high prices of inputs relative to low price of output). Therefore the first two options (expansion of farmed area and intensification) can generally be considered redundant in most parts of the country. The last option (improvement in input use efficiency) is of particular importance in this regard because it has relationship with minimizing cost of production which in most cases is the interest of farmers and it can be achieved through input substitution. The idea that two or more variable inputs may be combined in different quantities to produce the same result is called the principle of substitution (Boehlje and Eidman, 1984). It is also sometimes referred to as the law of variable factor proportion.

Empirical studies of factor substitution usually assume that households make optimum use of resources by allocating them efficiently (Linde-Rahr, 2005). This assumption has been mostly used as the approximation of actual behavior of agricultural production systems. Despite this intuitive appeal, most farmers in Iringa region have not reached an efficient allocation of resources (optimal level) as recommended by different national and international agricultural bodies such as Agricultural Research Institutes (ARI) and or Food and Agricultural Organisation (FAO). In the investigation of input use for maize in the southern highland of Tanzania, Rasmussen (1989) found that, the use of biochemical inputs is very profitable, although farmers do not use bigger quantities of inputs. The main reason could be that smallholder farmers are constrained with funds to purchase all the inputs required for profit maximization.

2.5 Maximum Output versus Optimal Economic Output

Ferguson (1971) defined output or product as any good or service whose fabrication or creation requires one or more scarce resource. However, distinction needs to be recognized between maximum output and that level of output which maximizes profit (i.e., the economically optimal output). Ellis (1993) distinguish output into; base output, maximum output and economic optimum output. Base output occurs without any application of variable inputs. Maximum output can be achieved by successive increase in the application of variable inputs, holding all other production inputs constant. This is also sometimes referred to as the technical maximum level of output. The economic optimum level of output is that level of output, which corresponds to maximum profits. Maximum output differs from economic optimum output in that, the point where profit is maximized is not the same as the point where output is maximized. Kadigi (2009) note that, beyond the point of maximum profit, the added inputs cost more than they earn, such that pursuing maximum output may lead to lower net returns or profit.

Economic literature depict that optimal output can be determined mathematically using input or output criteria for profit maximization. In both criteria, farmers are assumed to operate in a competitive market (i.e. farmers are price taker). Using the output criteria as an example, profit may be expressed as:

$$\Pi = TR - TC \quad \text{.......... (5)}$$

Where;

Π = Profit

TR= Total Revenue

TC= Total Cost

Differentiating equation (5) with respect to output (Q) and equating it to zero (i.e. first order condition for profit maximisation) produces the following results:

$$\frac{\delta\Pi}{\delta Q} = \frac{\delta TR}{\delta Q} - \frac{\delta TC}{\delta Q} = 0$$

$$\frac{\delta TR}{\delta Q} = \frac{\delta TC}{\delta Q} \quad \text{.. (6)}$$

$$MR = MC$$

Where;

MR= Marginal Revenue

MC= Marginal Costs

If MC is less than MR, the farmer could always increase profit by increasing the use of variable inputs until the point at which profit are at maximum (Kadigi, 2009). This point occurs in stage two of the classical production function. However most empirical studies in small scale production system (Msuya *et al.,* 2008; Linde-Rahr, 2005; Ray and Badhra, 1993; Rusmussen, 1989) show that smallholder farmers operate at the point below the optimum profit (i.e. in stage one of the classical production function). Koutsoyiannis (1979) indicate that in such a case, a problem of producer become of constrained optimization (i.e. a producer wants to maximize output for a given cost). The producer with limited resources can approach this problem from maximization of output subject to a cost constraint (financial constraint) or minimization of cost for a given level of output. The analyses of these two cases represent what is popularly known as constrained optimization behavior.

2.6 Efficiency Concepts as Applied in Agricultural Production

In economic terms the concept of efficiency can easily be defined as the relationship between inputs and output, whereby the economic efficiency is increased by a gain in unit of output per unit of inputs used in a production process. When applied in agriculture, Haque (2006) has shown that, the term efficiency may be broadly defined to include concepts of technical efficiency and allocative efficiency. From the strict sense of agriculture, an efficient farmer is the one who allocates his land, labour and other resources in an optimal manner so as to maximize his objective (profit, output, utility minimal cost or a combination of the four). However, most of smallholder farmers particularly in SSA often are considered to use their resources sub-optimally. While some farmers may achieve maximum profit per unit of input, some others attain maximum yield per unit of land at a high cost. Faced with the latter situation the challenge would be to improve the resources use efficiency to increase profit.

The possibility of improving resource use efficiency lies in either improving use of existing resources or adoption of improved technology at farm level. Most of the literature related to efficiency measurements grew out of the pioneer work by Farell (1957), where he considered the production of one output with two inputs under the assumption of constant return to scale. According to Farrel (1957), efficiency consists of two components: technical efficiency and allocative efficiency. Technical efficiency otherwise known as overall or pure technical efficiency according to Färe *et al.* (1985) is a major component of productivity which itself is a measure of performance. Measurement of performance implies assessment of industries or individual firm-farm in using real resources to produce goods and services. Technical efficiency indicates whether a farm uses the best available technology. It reflects the ability of a farm to obtain maximum output from a given set of inputs (Coelli *et al.,* 1998). Thus, an efficiency measure should reflect the difference between actual performance and potential performance. Sadoulet and Janvry (1995) have shown that, the concept of technical efficiency entails a comparison between observed and optimal values of output and inputs of a production unit. This comparison takes the form of observed to maximum potential output obtainable from the given input, or the ratio of the minimum potential output to observed input required to produce the given output or some combination of the two. These two give rise to the concepts of technical and allocative efficiency. A productive entity is technically inefficient when, given its use of inputs, it is not producing the maximum output possible (output distance), or given its output, it is using more inputs than necessary. Similarly a production unit is allocatively inefficient when it is not using the combination of inputs that would minimize the cost of producing a given level of output.

2.7 Conceptual Framework

Based on the theoretical and empirical discussions referred above, generally they indicate that, smallholder maize farmers not only in Iringa region but also else where in SSA produce below the potential. This is attributed by difficulties in deciding the right combination of inputs to achieve a prescribed level of output. Often the decisions taken on the use of inputs are taken without an assessment or appreciation of the impact of what will be the resulting output. Given the fact that maize is the main source of income and staple food to majority of smallholder farmers in Iringa region, the greatest challenge revolves around increasing its productivity for improving farmer's livelihoods. A deeper understanding of the different combinations and comparative values of the available resources is required in order to increase the production and efficiency of dominant maize farming system. The present study was intended to determine an efficient combination of resources that would satisfy maize farmer's objectives of improved livelihood and food security in general.

Fig. 1 shows the conceptual framework which depicts the fact that decision making with respect to the efficient use of available resources is complex and influenced by different factors some of which are out of farmer's control. The framework illustrate the idea that, while efforts are required in expanding knowledge of various alternative use of resource and their right mix, similar efforts are also required on the institutional and socio-economic driving forces behind farmers decision making. The focus is to bring together farmers understanding about the available resources and how to trade-offs between these resources, while integrating other issues which facilitate the efficiency of input use and production process in general.

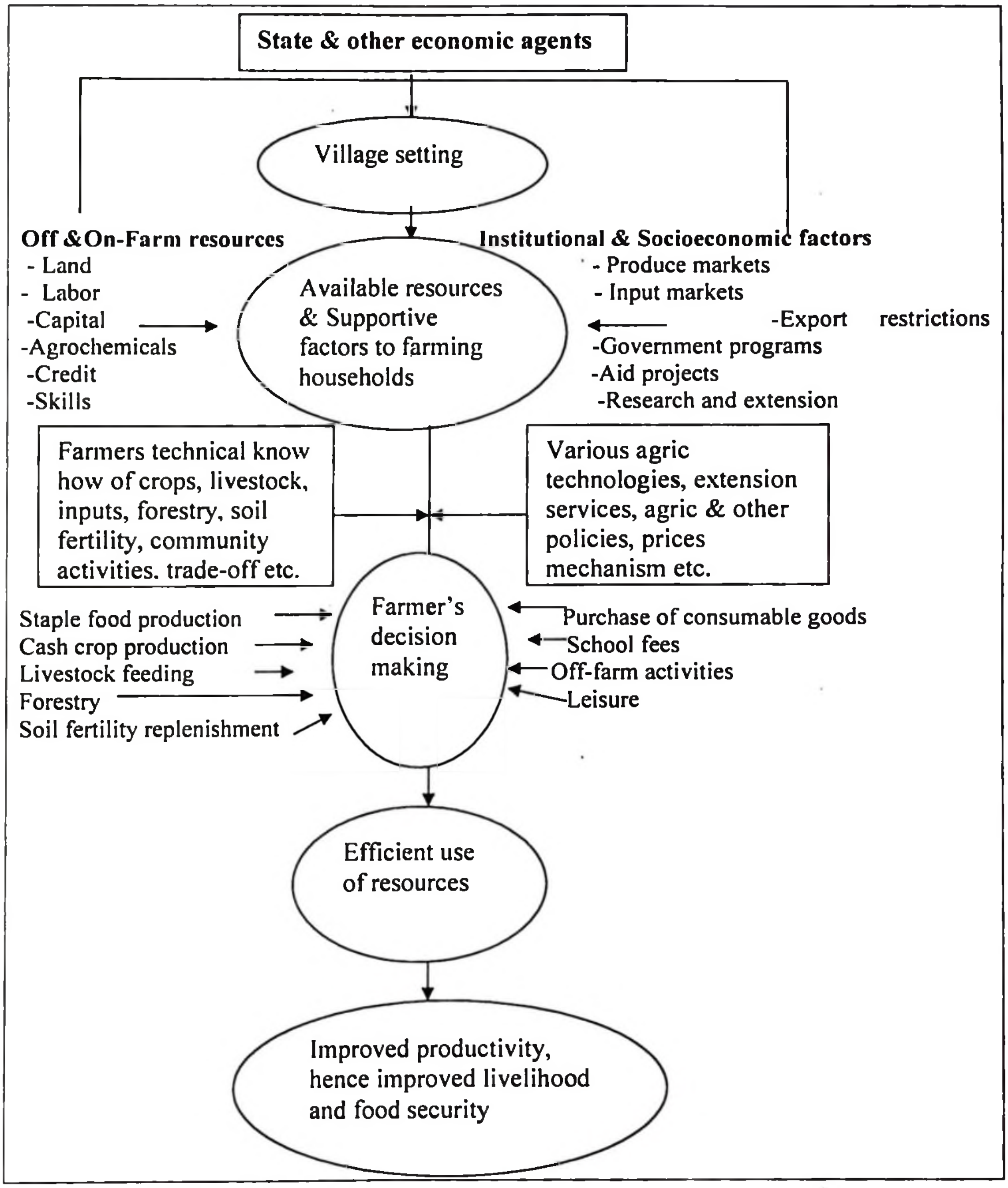

Figure 1: Conceptual framework. (Adopted & modified from source (CIAT, 2000)

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location of Iringa region

The study was conducted in Ludewa and Njombe districts in Iringa region. The region is located between 7°05'-36°32' South and 33°47'-36°32' East. In the north the region borders Dodoma region, Mbeya region to the west, Morogoro region to the east and to the south partly borders Ruvuma region and partly the Lake Nyasa.

Iringa region is formed by seven districts namely; Iringa rural, Iringa urban, Kilolo, Mufindi, Njombe, Makete and Ludewa. The choice of the study area was made based on the fact that the region is among the main producers of maize in the Southern Highland of Tanzania. For instance in 2006/07 season, Iringa, Mbeya and Rukwa regions produced 1 113 882 tons of maize of which 443 828 tons (40%) were produced in Iringa region (URT, 2007a). Also Iringa region is considered to be among the regions that consume large parts of modern inputs particularly fertilizers and thus it would provide a clear picture of the input use efficiency. This study was carried out in Njombe and Ludewa districts. The two districts were selected based on their relative higher potential in maize production compared to the other four districts.

3.1.2 Economic activities of Iringa region

Around 90% of the region's population derives their income primarily from farming which is a bit supplemented by other non-farm activities such as fishing and animal rearing. Maize production represents the main agricultural activity among farming households although some vegetable and fruits are also grown under smallholder. As compared to other crops, maize represents around half of total income of the farming households. Other crops account for almost one-third of total income, while livestock and off-farm income are of minor importance (Rusmussen, 1989).

3.1.3 Description of Njombe district

Njombe district is bordered by Mufindi in the North, Morogoro and Ruvuma region in the East, Ludewa in the South and Makete district and partly Mbeya region in the West. The district has an area of 10 668 sq km out of which 9 728 sq km is suitable for agriculture. On the basis of economic activities Njombe district is divided into 2 zones namely; Highland and Midlands Zones.

According to the 2002 Tanzania national census (URT, 2002), Njombe district had a population of 420 348 people. Administratively the district has seven divisions namely; Njombe town, Igominyi, Makambako, Imalinyi, Wanging'ombe, Lupende and Mdandu. This study was carried out in Igagala and Ulembwe villages which are located in Imalinyi division, Ulembwe ward. Characteristically, Igagala and Ulembwe villages are found in the Highland Zones which has in most cases temperatures below 15°C and receive high amount of rainfall averaging between 1 000 mm to 1 600 mm per year. The rainfall pattern is unimodal (one rain season) starting from November through May.

Most of the people in Igagala and Ulembwe villages are smallholders cultivating small plots which are far from their homestead. Although both food crops such as maize, wheat, round potato, banana, beans, green peas and cash crops such as coffee, tea, pyrethrum grow better in the area, but farmers in these villages mainly have much engaged in the production of maize and round potato as both staple food and cash crop. In fact round potato in recent years has taken the lead because of its market potential compared to maize.

Apart from crops also farmers in Igagala and Ulembwe villages are involved with animal raring specifically beef and diary cattle as well as pigs and sheep.

3.1.4 Description of Ludewa district

Ludewa district is bordered by Njombe in the North, Mbiga district in the East, Lake Nyasa in the South and Makete district in the West. The district has an area of 8 397 sq km out of which 4 650 sq km is suitable for agriculture.. In terms of agricultural potential the district is divided into 3 zones namely; Highland, Midlands and Lowland Zones.

Based on the 2002 population census (URT, 2002), Ludewa district had 128 155 people. Administratively the district has five divisions namely; Mlangali, Lingaga, Mawengi, Mwambao and Masasi. This study was carried out in Mlangali and Lufumbu villages which are located in the Highland zone of Mlangali division in Mlangali ward. In terms of altitude, temperature and rainfall Mlangali and Lufumbu villages have the same characteristics as Igagala and Ulembwe villages. However they differ in terms of distance to the Dar-es-salaam –Songea main road. Mlangali and Lufumbu are far by about 80 km while Igagala and Ulembwe are far by only 20 km which in turn has an implication on transportation of farm inputs and outputs to the market. Probably the distance to the main market has forced Mlangali and Lufumbu village to rely on maize production as the main cash crop rather than round potato because the latter is more perishable which impose risky to transport for a long distance. Otherwise farmers in Mlangali and Lufumbu villages maximize profit through a combination of crops mainly maize, beans, wheat, green peas, groundnut and sunflower which is contrary to farmers in Igagala and Ulembwe villages.

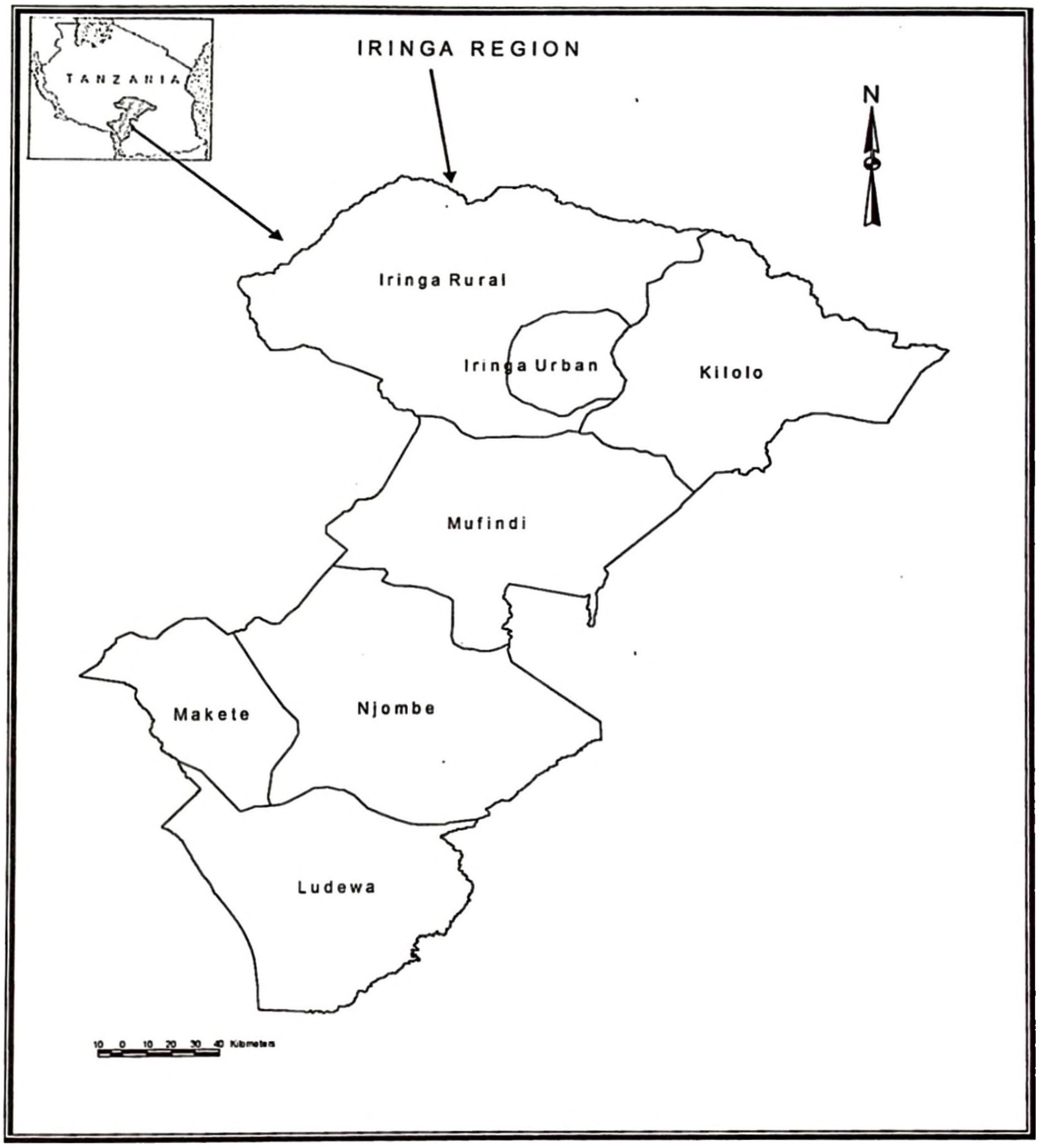

Figure 2: Map of Iringa region showing the study districts

3.2 Research Design

This study adopted a cross-sectional survey method, where data were collected once in the selected areas to get quantitative information. This method is considered useful for descriptive study as well as in providing an overall picture of the relationship among variables as it stands in both with regard to study population and the time of investigation.

3.2.1 Sampling technique and sample size

In Iringa region 5 districts; Njombe, Mufindi, Iringa, Kilolo, and Ludewa are the one with higher potentials in maize production. The study purposefully selected 2 districts one with the highest potential, and one with the relative lower potential. Based on the potentiality criteria the 2 districts selected were Njombe which represented the highest potential and Ludewa represented relatively the lowest potential. The farming population in these two districts constitutes 67 456 households in Njombe and 28 918 households in Ludewa. The sampling frame for this study was individual smallholder households located in these 2 districts. The sampling strategy was such that; in each district, 1 ward and 2 villages per ward were randomly selected to make a total of 4 villages from all districts. Also in each village 25 households were randomly selected, thereby making a sample size of 100 households. Although some literature emphasize that, a sample should at least constitute 5% of the total population, but according to Bailey (1998) such a sample size is justified when facing time, financial resources constraints and for accuracy.

3.2.2 Primary data

The main source of primary data was smallholder maize producing households. The information from this source was captured using structured questionnaire. Some of the information collected included; age, sex, level of education, quantity of maize produced per hectares and quantity and kind of inputs used for maize production. Additionally, information on principal supplier of the inputs and price charged by the supplier, inputs use and availability, the general knowledge about use of modern inputs, number of contacts with extension agents, and market prices for the maize outputs were also captured.

3.2.3 Pre-testing of the questionnaire

Before conducting the main study, pre-testing of the questionnaire was done to 20 farmers who were randomly selected from each village. Each village provided 5 farmers which make a random sample of 20 farmers. The purpose of conducting the pre-test was to acquaint to the study area and to cross-check the precision of the questions in a questionnaire. Before conducting the main study alterations of inconsistent questions were made based on what were observed during the pre-testing.

3.2.4 Secondary data

Secondary data for augmenting the primary data included; input use recommendations, prices of inputs and outputs, input supply systems, infrastructure development (road and markets facilities), population size, and status of extension services. This information were obtained from different public and private institutions specifically; The Ministry of Agriculture, Food Security and Cooperatives (MAFSC), Regional Secretariat Office, DALDO's Offices in the respective districts, Sokoine National Agriculture Library (SNAL), National Bureau of Statistics (NBS), proceedings, official websites, magazines, journals, annual agricultural reports, bulletins, and different input dealers located in the study area.

3.3 Methods of Data Analysis

The methods employed in data analyses were mainly descriptive statistics, Data Envelope Analysis (DEA) and logistic regression (log odds). These methods reflected the study objectives, type and methods for data collection. Further descriptions of the methods used are presented below:

3.3.1 Descriptive statistics

Data collected were compiled, coded and analysed using the Statistical Package for Social Sciences (SPSS) Computer Programme. Descriptive analyses with their related statistics (mean, frequencies, percentages, standard deviation and correlations) were calculated to understand characteristics of the farming households in the study area. Also these statistics were of great use in the determination of the most critical factors influencing inefficiency of input use in maize production in the study area.

3.3.2 Measurement of efficiency

The main quantitative approaches that have been developed for measuring production efficiency range from parametric and non-parametric approaches. Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) are the most commonly used methods (Coelli *et al.*, 1995). Both approaches estimate the efficient frontier and calculate the firm's technical efficiency relative to it. The present study employed DEA to measure efficiency of input use for smallholder maize farmers in Iringa region. The software DEAP version 2.1 developed by Coelli (1996) were used to estimate DEA scores where farms' efficiency scores were calculated under constant return to scale (CRS) and variable return to scale (VRS) assumptions.

3.3.2.1 Justification for using DEA in this study

Data Envelopment Analysis (DEA) is a technique used to estimate the production function on the basis of what is observed. Other techniques exist, namely statistical or parametric ones based on least square regressions or stochastic frontier analysis. Contrary to the latter two techniques which are grounded on a statistical approach, DEA is a mathematical technique, rooted in linear programming. A number of existing studies such as Cooper *et al.* (2004) indicate that, DEA approach has the following main strengths; (i) does not need to explicitly specify a mathematical form of the production technology which means, one can avoid unnecessary restrictions about the functional form that affect the analysis and distort efficiency measures (ii) proven to be useful in uncovering relationship that remain hidden for other methodologies (iii) capable of being used with any input-output measurement (iv) DEA allows the calculation of scale efficiency (v) with a given set of finite sample, the source of inefficiency can be analysed and quantified for every studied unit, and (vi) DEA does not require the distributional assumption of the inefficiency term. These particular strengths have made DEA to be useful in analysing farm efficiency and practical decisions.

The major weakness of DEA is that it is deterministic and it attributes all the deviations from the frontier to inefficiencies, so that a frontier estimated by DEA is likely to be sensitive to measurements error or other issues of the data. On the other hand, the major weakness of parametric methods is that, in the estimation of a production it assumed that all firms use the existing technology efficiently. However, in the real world the observed firms produce homogeneous outputs with differences in factor intensities and in managerial capacity. Hence, inefficiencies are hidden in the estimated production functions (Cooper *et al.*, 2004).

In order to overcome the drawback of the parametric approach and to reveal the true nature of the input-output relations in maize production in Iringa region given the available technology, DEA approach was applied. The aim was to select the farms that utilize efficiently the existing technology, allowing the estimation of a production function that reveals the true input-output relations and identify which factors attributes to inefficiencies. In addition to that, since this study sought to suggest an optimal combination of inputs that can minimize cost at a given output, DEA has been chosen in preference of SFA because the former is capable of partitioning total technical efficiency into pure technical efficiency and scale efficiency. The scale efficiency is used to identify farms which operate under optimal scale, those which operate under super optimal scale and those which operate under sub-optimal scale.

3.3.2.2 Estimation of technical and scale efficiency using DEA

The first DEA model was suggested by Charnes *et al.* (1978) and was based upon the assumption of constant return to scale (CRS), which means, the firm-farm operates at optimal condition. Nonetheless, factors such as financial constraints, imperfect competition among other things can cause firms-farms not to operate at optimal scale. In view of that, Banker *et al.* (1984) suggested the use of variable return to scale (VRS) specification to account for scale efficiency confounded by CRS. The use of VRS permits the calculation of efficiency scores free from scale efficiency effects. Because majority of maize farming households in Iringa region face several constraints such as lack of fund to invest on capital and purchasing of inputs, the technical efficiency scores was estimated using the two approaches and then the same was decomposed into scale and pure technical efficiency. The purpose of decomposition was to determine the source of inefficiency.

In DEA two approaches (input–oriented and output–oriented) are available to estimate the efficient frontier. Input–oriented measures attempt to measure the extent to which input quantities can be proportionally reduced without altering the output quantities produced, whereas output–oriented measures estimate the amount by which output quantities can be proportionally expanded without altering the quantities of inputs used. Since smallholder farmers are assumed to have more control over input than output, in this study input-oriented model was chosen. The following assumptions underpin the model:

- Each of the farms or decision making units (DMU's) uses the same multiple (k=1, 2,....,P) inputs mainly land, labour, capital, nitrogen, phosphorous, seeds, and pesticides to produce several $m^{th}=1,2,\ldots M$ homogeneous output, which is maize.
- The only way that a DMU on the frontier can decrease its use of one of the inputs is to increase its use of the other input which means the inputs are substitutes; if less of one input is used to produce a fixed amount of product, and then more of the other must be used.
- In the data set, each observation of inputs and outputs is strictly positive.

The Constant Return to Scale (CRS) DEA

The CRS input-oriented technical efficiency measure for the maize production in the i^{th} farms in the study area were calculated using the mathematical model developed by Charnes *et al.* (1978) which is popularly known as CCR model (Charnes-Cooper-Rhodes model). This model is given below;

$$\theta_c^i \min_{\lambda,\theta} \theta$$

$$s.t$$

$$y_m^i \le \sum_{z=1}^{N} y_m^z \lambda_z (i = 1,2,\ldots\ldots N; m = 1,\ldots M) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$\sum_{z=1}^{N} x_k^z \lambda_z \le \theta x_k^i (i = 1,2,\ldots\ldots N; k = 1,2,\ldots P)$$

$$\lambda \ge 0$$

Where;

$\theta =$ technical efficiency score of the i^{th} farms (the estimated θ will satisfy the restriction $\theta \le 1$, with a value of one indicating a point on a frontier and hence a technically efficient firm)

$x_k^i =$ the k^{th} input use of i^{th} farms or DMU's

y^{i}_{m} = m^{th} output of the i^{th} farms or DMU's

λ= N-vector of weight, in which elements of weight are denoted by $\lambda_z (z = 1,2,....N)$

The Variable Return to Scale (VRS) DEA

The CCR model can be extended by relaxing the assumption of constant return to scale (CRS) and considering variable returns to scale (VRS). Thus, the CRS linear programming problem was modified to account for VRS by adding the convexity constraint $\lambda_z = 1$. The resulting model is known as Banker-Charnes-Cooper model (BCC) as given below;

$$
\begin{aligned}
&\theta^{i}_{v} = \min_{\lambda,\theta} \theta \\
&s.t \\
&y^{i}_{m} \leq \sum_{z=1}^{N} y^{z}_{m}\lambda_z (i = 1,2,.....N; m = 1,...M) \\
&\sum_{z=1}^{N} x^{z}_{k}\lambda_z \leq \theta x^{i}_{k} (i = 1,2,.....N; k = 1,2,...P) \qquad \text{.. (8)} \\
&\sum_{z=1}^{N} \lambda_z = 1 \\
&\lambda \geq 0
\end{aligned}
$$

Scale Efficiency

Total technical efficiency measure (θ_c) obtained from constant return to scale DEA was decomposed into pure technical efficiency (θ_v) and scale efficiency (SE). The scale efficiency measure can be interpreted as the ratio of average product of a firm-farm operating at a point to the average product of another firm-farm operating at a point of technically optimal scale (Gul *et al.*, 2009). A difference in CRS and VRS TE scores for a particular farm indicates that the farm has scale inefficiency, and that the scale inefficiency can calculated from the difference between the VRS and CRS TE scores (Coelli, 1996).

Note that scale efficiency (SE) was obtained residually from VRS and CRS technical efficiency scores as follow:

$$SE_i = \frac{\theta_c^i}{\theta_v^i} \qquad (9)$$

Where;

SE = Scale efficiency

θ_c^i = Total technical efficiency due to CRS of the i^{th} DMU

θ_v^i =Pure technical efficiency due to VRS of the i^{th} DMU

From equation (9), SE=1 indicates scale efficiency or CRS, and SE<1 indicates scale inefficiency. Scale inefficiency can be due to the presence of either decreasing return to scale or increasing returns to scale, which was determined by solving a Non-Increasing Return to Scale DEA model, which is in turn obtained by substituting the VRS constraints

$\sum_{z=1}^{N} \lambda_z = 1$ with $\sum_{z=1}^{N} \lambda_z \leq 1$

A farm operating under decreasing return to scale means that is operating under super-optimal conditions, while a farm operating under increasing to scale is operating under sub-optimal conditions.

3.3.2.3 Estimation of allocative efficiency

Kim (2001) indicated that, if it is possible to obtain price information for input and output, the farm specific level of cost and allocative efficiency can be derived from the solution related to cost minimization. Since input as well as output prices were obtained in this study, cost efficiency for the selected sample households was estimated. This was based on the premise that constraints on inputs (capital, fertilizer, seed, and pesticides) compelled households to strive to minimise costs on inputs while maintaining output at the same level. In this case, the cost efficient farms were obtained by solving the cost minimization as follow;

$$\min \sum_{j-1}^{m} W_i X_{i0}^{*}$$
$$st$$
$$\sum_{j-1}^{n} X_{ij}\lambda_j \leq X_{i0}$$
$$\sum_{j-1}^{n} X_{rj}\lambda_j \geq y_{r0} \quad \text{.. .... (10)}$$
$$\sum_{j-1}^{n} \lambda_j = 1$$
$$j \geq 0$$

Where;

W_i = a vector of input price for the i^{th} DMUs

X_{i0}*= the cost minimizing vector of inputs quantities for the i^{th} DMUs

X_{ij}= the observed i^{th} input of j^{th} DMUs

y_{r0}= the r^{th} output of the DMUs

λ_j= a non-negative constant assigned to the j^{th} DMUs in forming convex combination of input vector

The total cost efficiency or economic efficiency of the i^{th} DMU would be calculated as:

$$EE = \frac{w_i' x_i^{*}}{w_i' x_i} \quad \text{.. (11)}$$

Equation (11) above represents the ratio of minimum cost over observed cost (Coelli, 1996). Thus, allocative efficiency (AE) is calculated as:

$$AE = \frac{CE}{TE} \quad \text{.. (12)}$$

Where;

CE = Cost Efficiency

TE = Technical Efficiency.

3.4 Estimation of Technical Inefficiency

Recall that, efficiency measures in DEA are estimated based on the frontier, where a technically efficient farm means operates on the frontier and the one operating below or above the frontier is technically inefficient. Several factors can cause a farm to be technically inefficient. These factors may range from socio-economic, institutional, environmental, and or farm specific. From policy context and individual farm decision making in general, it is important to determine what factors influence inefficiency. Javed *et al.* (2010) emphasized two alternate approaches to investigate the relationship between farm inefficiency and specific factors influencing inefficiency. The first method is to determine the influence of those specific factors on efficiency through computing correlation coefficients or to conduct other simple parametric analysis. The second method is to measure inefficiency and then to use regression model in which inefficiency is expressed as a function of those specific variables. The latter approach is also known as 'two step procedure' and is adopted in this study because it is rooted on mathematical grounds and produces parameter estimates which can easily be interpreted to get useful information.

Traditional models that have been used to estimate technical inefficiency are based on linear or Tobit regression. The linear model as used in measuring inefficiency relied upon the Ordinary Least Square (OLS). However it has been criticized due to the assumption it made that the dependent variable (inefficiency scores in this case) is normally distributed with a mean of zero. The critique over this assumption is that, since inefficiency scores are limited between 0 and 1, therefore it is impractical to model probabilities with a linear regression because such a model allows the dependent variable to take values greater than 1 or less than 0. If that is allowed, it violates the normality assumption and produces biased results.

To overcome the problem of non normality of OLS, Greene (1997) conceptualized DEA inefficiency scores as presenting a censored normal distribution and proposed the use of Tobit model instead of OLS. The Tobit model is based on the normally distributed latent variable and the parameter estimation of the model is usually done by maximum likelihood. However Banker and Johnston (1994) content that, DEA scores do not fit the theory of sampling censoring that gives rise to Tobit models. They argue that, when efficiency/inefficiency scores are used in Tobit model, the assumption of normal distribution of the latent variable is inconsistent, instead they propose a non-maximum-likelihood estimator to be used for empirical application.

Based on Banker and Johnston (1994) proposition, this study adopted the logistic (log odds) regression as given in Loikkanen (2002) which assumes that the inefficiencies are log-normally distributed. To achieve the purpose, inefficiency score (I) was first defined as:

Inefficiency score (I) = 1-Efficiency score.. .... (13)

Then, the dependent variable (I) in the logistic regression model was defined as the logarithm of the odds of being inefficient given as:

$$In\left(\frac{I_i}{1-I_i}\right) = X_i\beta_i + \mu_i \quad \text{.......... (14)}$$

Where;

$ln\left(\frac{I_i}{1-I_i}\right)$=Dependent variable (the odds of being inefficient)

X_i = Vector of explanatory variables

β_i = Vector of the parameter to be estimated

μ_i = The random error term that is assumed to be independent and log-normally distributed.

Note that equation (14) can be applied as none of the I_i is zero or 1, rather all farm inefficiency scores are in the (0, 1) interval.

The dependent variable was obtained by subtracting the DEA score from 1 as indicated in (13) to obtain technical inefficiency. In this case, the CRS model was chosen in preference of VRS because for its high accuracy in discriminating efficiency. The technical inefficiency scores were regressed on socio-economic and farm specific variables to identify sources of technical inefficiency. The explanatory variables included in the model were; (1) the actual age of the farmer (years) expressed as younger farmers <50 years and older farmers >50 years; (2) farmer's experience (years) in maize farming expressed as less experience <10 years and experienced >10 years; (3) farmer's years of schooling categorized into less than primary school, primary school and post primary school; (4) farm size categorized as <1 hectare and >1 hectare; (5) distance from the Dar-es-Salaam-Songea main road which provide an idea of remoteness of study villages; (6) quantity of fertilizer (kg) used per hectare in 2008/09 growing season categorized as <150 low and >150 high; and lastly (7) number of contact with extension agent which takes a value of 1 if the farmer contacted extension agents and 0 if otherwise.

3.5 Methodological Problems and their Solutions

It is well known that, the common problem in most of agricultural research is to deal with measurement error. And this might become severe if DEA is being used because of its sensitivity to measurement error. In that case, a researcher needs to be keen in the data collection exercise by avoiding error due to measurement. In this study measurement error was minimized first by pre-testing the questionnaire to a sample of 20 households which enabled to remove all inconsistent questions. Second, the respondents were allowed to use local units (such as bags, acres etc) instead of conventional units and thereafter local units were converted to standard units (such as kilograms, hectare etc) by the researcher after data collection exercise was completed. Thirdly, the village extension officers were fully involved so that they clarify all technical aspects related to maize production in their respective villages.

The involvement of extension officers was of paramount importance because they explained the purpose and usefulness of this study regarding input use especially in addressing the aspect of cost minimization in maize production. Due to that, farmers became free to provide all the necessary information without any hesitation which to a greater extent minimized the number of outliers.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Household Characteristics

The household is the main source of labour, and key decision making unit that determine allocation of resources at farm level. Furthermore, household characteristics bear essential attributes to socio-economic and farming practices adopted by farmers in a particular area (Sibuga *et al.*, 1998). Table 1 provides the analysis of socio-economic characteristics of the heads of the households interviewed during the survey of maize farmers in Iringa region. The key household characteristics analysed in this study include age, gender of household, marital status, education level, size of the household, and experience in maize farming of the household head.

4.1.1 Age composition

Table 1 shows that the mean age of the respondents was 38 years and more than 70% of them were aged between 30-50 years, while those aged less than 30 years constitutes 15% of the total number of respondents. Further more, results reveal that respondents aged between 50 - 60 years accounted for 9%, while older respondents aged above 60 years accounted only 2% of the total sample population. These results reveal the fact that maize farming in the study area is mostly practiced by the age group of between 30 – 50 years hence implies that productivity per unit area would be higher because this age group is energetic. But it also implies that maize production in the study area is one of the main economic activities because the age group of 30-50 years comprise people who decided to engage fully in farming compared to people with less than 30 years. On the other hand, the small proportion of respondents aged above 60 years is an indication that as age increases less farmers are involved in maize production probably due to the associated costs particularly fertilizers and labour of which this age group cannot afford.

4.1.2 Gender of households' head

Studies in African agriculture have shown that at individual farm level, gender of head of household bear a great influence on agricultural production. The commonly discussed hypothesis is that; other things equal, productivity is lower for female-headed households. The lower productivity of female-headed households may be attributed to fewer resources owned compared to male-headed households or they can be discriminated against extension agents, and or lenders (Dalton *et al.,* 1997). In the study area male-headed households were about 71% of the households producing maize (Table 1).

On the other hand, female-headed households in the study area were 29% which is slightly higher than the national average in rural Tanzania which is 17.5% (URT. 2009). The higher proportion of female-headed households could be due to prevalence of HIV/AIDS in which Iringa is among the top three regions in Tanzania.

4.1.3 Marital status

Marital status of the head of household can also influence the resource owned by a household and the access to family labour (Sibuga *et al.,* 1998). In other words, under normal circumstance single people tend to have less family labour as compared to couples. Regarding marital status in the study area, it is shown that 77% of the respondents were married; only 7% of the sample population are single (Table 1). The survey results further indicate that 12% of the sample population were widow and only 2% were separated. When the results analysed based on village, the survey noted that Ulembwe village had less percent of married respondents (60%); while in Igagala, Mlangali, and Lufumbu villages 72%, 92% and 84% of the respondents were married respectively. Based on the fact that agriculture is the main economic activity in rural area, marriage can be looked as one way of having access to family labour; thus farmers find it convenient to have married in order to get sufficient labour for farming activities.

4.1.4 Level of education of household heads

Oluwatayo *et al.* (2008) indicated that, the more educated a farmer is, the more the chance she/he will accept and adopt innovations than uneducated ones. The present study also assessed the levels of education of maize farmers in the study area. Survey results shown in Table 1 reveal that about 90% of the respondents reported to have attained some form of formal education. This is above to the national literacy level which is 78% (URT, 2009). This finding indicates that most of the maize farmers in the study area are educated, thus can adopt and implement new innovations including improvement in input use efficiency.

Furthermore, the table shows that 84% of those who reported to have acquired formal education had attained seven years of schooling which is the minimum level of compulsory education in Tanzania. Only 11% of the respondents reported to have more than seven years of schooling out of which 9% had secondary education and 2% attained tertiary education. This implies that maize farming in the study area is undertaken by persons who have got a maximum of seven years of schooling and generally is the case for many of the smallholder farmers in Tanzania because very few people living in rural areas are selected to join secondary and or tertiary school.

4.1.5 Household size

In this study, a household is defined as a group of persons who usually eat and share some common living arrangements. In the study area the average household size (persons per household) was 5.5 (Table 1). The average household size of 6.7 in Lufumbu village is higher than the national average of 4.9 persons per household while, Ulembwe village had smaller household size than the overall national average. The national average household size of 4.9 (URT, 2003) as per the 2002 population census is lower than the region average household size which was 5.5. The distribution of persons in household by age showed no significant variation across the study villages where 47% of the households composed members aged between 18 to 60 years and 32% composed members aged between 14 to 18 years (Table 1). This assessment was aimed to determine the labour available for different farming activities. Under normal situation household members aged between 18 to 60 years are the one expected to provide family labour for the farming activities. The assessment of household by age in the study area indicate that there is no sufficient family labour to attend all field operating thus hired labour is required to supplement for the existing family labour.

4.1.6 Experience in maize farming

Experience in farming is considered to exert significant impact in crop production and efficiency in general because as experience increases the farmers accumulate more knowledge (Kebede *et al.*, 1993). The result in Table 1 shows that maize farmer in all villages have an average of 15 years where Lufumbu village had a maximum experience of 18 years while, Ulembwe had the minimum of 12 years. Also it was found that, 45% of the respondents their experience in maize farming ranged between 10-20 years, while, 30% had experience less than 10 years.

Table 1: Socio-economic characteristics of household heads

Variable measured	Percentage distribution of respondent by village				Average
	Igagala (n=25)	Ulembwe (n=25)	Mlangali (n=25)	Lufumbu (n=25)	(N=100)
Age group (years)					
• < 30 years	24.0	12.0	12.0	12.0	15.0
• 30-50	54.0	84.0	76.0	84.0	74.0
• 50-60	20.0	4.0	8.0	4.0	9.0
• > 60 years	4.0	0.0	4.0	0.0	2.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
• **Mean**	**38.0**	**37.0**	**39.0**	**39.0**	**38.0**
Gender					
• Male	72.0	68.0	76.0	68.0	71.0
• Female	28.0	32.0	24.0	32.0	29.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Marital status					
• Single	0.0	20.0	4.0	4.0	7.0
• Married	72.0	60.0	92.0	84.0	77.0
• Divorced	4.0	4.0	0.0	0.0	2.0
• widower	20.0	12.0	4.0	12.0	12.0
• temporary separated	4.0	4.0	0.0	0.0	2.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Education level					
• No formal education	16.0	0.0	0.0	0.0	4.0
• Adult education	4.0	0.0	0.0	0.0	1.0
• Primary education	76.0	88.0	80.0	92.0	84.0
• Secondary education	4.0	8.0	16.0	8.0	9.0
• Tertiary education	0.0	4.0	4.0	0.0	2.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Household size by age					
• <14 years	16.0	24.0	8.0	16.0	16.0
• 14-18 years	36.0	40.0	40.0	16.0	32.0
• 18-60 years	48.0	36.0	48.0	52.0	47.0
• >60 years	0.0	0.0	4.0	16.0	5.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
• **Mean**	**5.3**	**4.7**	**5.5**	**6.5**	**5.5**
Experience in maize farming (years)					
• <10 years	60.0	28.0	20.0	12.0	30.0
• 10-20	20.0	52.0	56.0	52.0	45.0
• 20-30	12.0	20.0	20.0	36.0	22.0
• >30 years	8.0	0.0	4.0	0.0	3.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
• **Mean**	**12.0**	**14.0**	**16.0**	**18.0**	**15.0**

4.1.7 Household income

4.1.7.1 Major source of household income

The assumption made in the analysis of household income is that higher incomes means a household will be able to satisfy its basic needs and have a surplus for productive activities such as buying fertilizers. In the study area households sources of income are varied, they include both farm and non-farm sources. Table 2 shows that the average cash earning per household is TZS 1 137 735 which range from TZS 1 465 066 in Ulembwe village to 910 447 in Lufumbu village. Crop earnings are the largest source of income for the households which accounts for 76.3% of the total household income (Table 3). This was followed by other sources (9.5%), livestock earnings (7.2%), and business earnings (6.9%). In this study other source of income are classified as employment, selling out casual labour, making burnt bricks, and selling local brews. More than 80% of the cash earnings were obtained from crops in Igagala na Ulembwe villages, while in Mlangali and Lufumbu villages crops earning accounted for 69.3% and 58.9% respectively. Although crops earnings in Mlangali and Lufumbu villages were less compared to Igagala and Ulembwe village but, overall, this results imply that agriculture makes larger contribution to households income and is the primary economic activity in the study area.

Table 2: Average yearly household cash earnings (TZS) by source

Source of income	Mean and percent income by village				Average (N=99)
	Igagala (n=24)	Ulembwe (n=25)	Mlangali (n=25)	Lufumbu (n=25)	
Crop	972 940	1 215 866	749 888	536 167	868 715
	(88.8)	(83.0)	(69.4)	(58.9)	(76.3)
Livestock	85 360	54 400	101 200	85 880	81 710
	(7.8)	(3.7)	(9.4)	(9.4)	(7.2)
Business	0.0	100 800	107 200	108 000	79 000
	(0.0)	(6.9)	(9.9)	(11.9)	(6.9)
Other*	36 800	94 000	122 040	180 400	108 310
	(3.4)	(6.4)	(11.3)	(19.8)	(9.5)
Total	**1 095 100**	**1 465 066**	**1 080 328**	**910 447**	**1 137 735**

Note: Numbers in brackets are percentages
* Earnings from employment, casual labour, brick making, and local brew

4.1.7.2 Earnings from crop based source of income

Among the crops grown, maize, round potato and wheat were identified to be the most important crops in terms of income generation. The results of the assessment of the contribution of each crop to total household income indicated that maize contributes 37%, while round potato and wheat contribute 21% and 14% respectively (Fig. 3).

Although maize was found to have the largest share in terms of contribution to households' income, but in Igagala and Ulembwe villages, the respondents reported that round potato makes larger more contribution than maize. However the situation was contrary in Mlangali and Lufumbu villages where the respondents reported to rely on maize as the main cash and staple food crop.

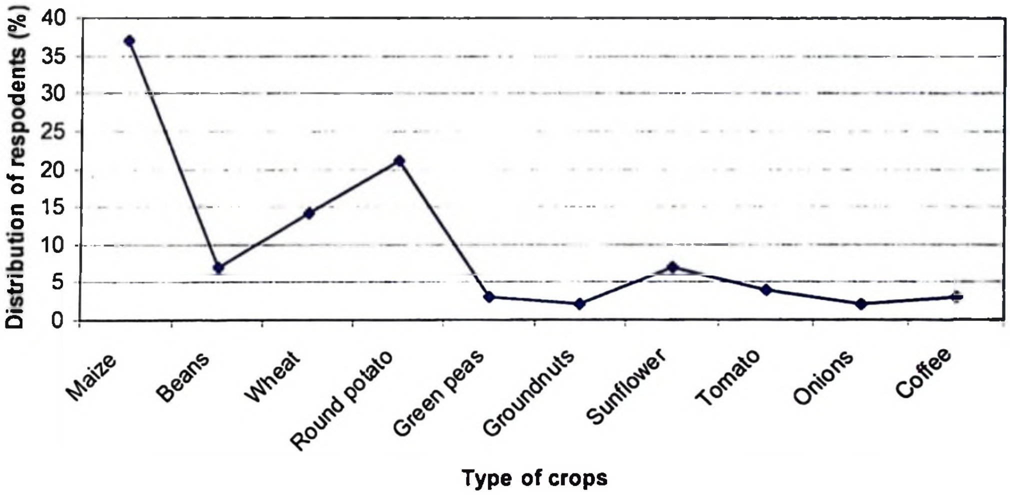

Figure 3: Contribution to total income by type of crops grown

4.2 Crops Production

4.2.1 Main crops grown by the sample households

Since crop production accounts for more than 90% of the households' income, then it was important to know which main crops are normally grown in the study area. When we look at Fig. 4; the cropping patterns shows that maize is the dominant crop of economic importance as it is grown by all farmers (100%) in the study villages. The second crop of economic importance in the study area is round potato but this is specifically for Igagala (96%) and Ulembwe (100%), while in Mlangali and Lufumbu wheat is the second crop after maize. The result also reveals that common bean is mainly grown in Mlangali (64%) and Lufumbu (80%) and very few farmers in Ulembwe (12%) and 8% in Igagala respectively. In the study area also very few farmers grow sunflower. Mlangali and Lufumbu villages are the main producers of sunflower. Overall, the result depict the fact that farmers in Igagala and Ulembwe villages are specialized in maize and round potatoes growing while in Mlangali and Lufumbu villages, farmers seek to maximize profit and minimize risk through a combination of different crop enterprises probably due to market inefficiency.

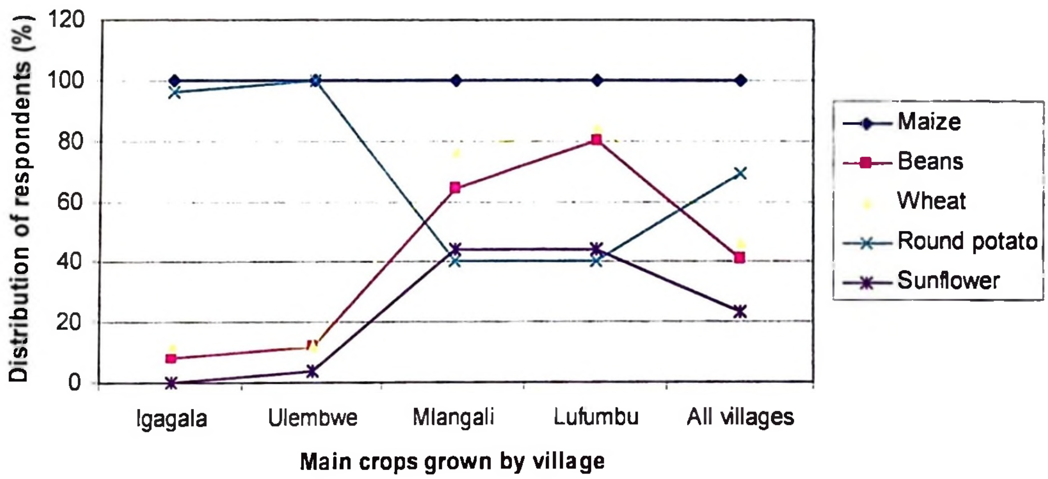

Figure 4: Main crops grown in the target villages

4.2.2 Farm level maize productivity

Table 3 presents average area allocated for maize production and average yield obtained. The area cultivated with maize by each household averaged 0.9 hectares. Among the surveyed villages Mlangali had the biggest average area (1.1 ha) and the smallest was in Igagala village 0.8 hectare. Generally, in Mlangali and Lufumbu villages the area allocated for maize is a bit higher than in Igagala and Ulembwe because in the former villages there are still patches of virgin land. In terms of yield the result in Table 3 reveal that average maize yields achieved by farmers in the target villages in 2008/09 season is 3 313.7 kg/ha which is relatively lower than the potential yield of 6 500 kg/ha in Iringa region. Also the average maize yields in the study area is relatively low compared to the average yields of between 3 500 and 5 600 kg/ha achieved by farmers in Rukwa region (URT, 2007b). However comparison of maize productivity shows that the study villages are far better (3 313.7 kg/ha) compared to the Tanzania mainland average of 1 700 kg/ha. The probable factors which contributed to better yields in 2008/09 growing season could be favourable climate mainly rainfall and the use of modern inputs specifically fertilizers.

Table 3: Farm level maize productivity

District	Village	Area (ha)	Yield (kg)	Productivity (kg/ha)
Njombe	Igagala (n=24)	0.8	2 791.9	3 450.5
	Ulembwe (n=25)	0.9	2 965.4	3 298.1
Ludewa	Mlangali (n=25)	1.1	3 240.0	3 368.7
	Lufumbu (n=25)	1.0	2 786.0	2 985.7
	Average (N=99)	0.9	3 000.2	3 313.7

4.3 Inputs Use and Availability

4.3.1 Land resource

Land in traditional mode of production is the main inputs and farmers in most part of the country believe that any person without access to arable land is poor. In the study area like elsewhere in the country it was noted that all the available land is the property of the government of Tanzania and farmers are allowed to hold it under customary tenure which means there is no private ownership of land. Table 4 presents the total available land and size of land allocated for various agriculture and non agricultural activities in 2008/09 growing season. The results show that on average, household operate 2.3 hectares of land of which 83.9% is customary owned by the household head, 11.1% is rented in and 5.0% is borrowed. In Igagala and Ulembwe villages the land rented in accounted for 21.3% and 19.6% respectively of the total available land while, in Mlangali there was no farmer rented in land and only 3.5% of the land was rented in at Lufumbu village. Although the average land holdings in the study area is relatively higher compared to the national average of 0.2 to 2 hectares per household (Tulahi and Hingi, 2006), it is not sufficient to accommodate various crops grown and other non agricultural activities. This result provides evidence of land shortages particularly in Igagala and Ulembwe villages.

Table 4: Available land and proportion of land used for agriculture and non agriculture activities

Available land	Mean and percentage distribution of sample household by village				Average (N=100)
	Igagala (n=25)	Ulembwe (n=25)	Mlangali (n=25)	Lufumbu (n=25)	
Total available land[a] (ha)					
• Mean owned (ha)	2.3	2.0	2.1	2.8	2.3
• Land owned (%)	72.0	78.0	94.1	91.4	83.9
• Land rented in (%)	21.3	19.6	0.0	3.5	11.1
• Land borrowed (%)	6.7	2.4	5.9	5.1	5.0
• **Total (%)**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Land under main crops[b] (ha)					
• Mean (ha)	1.2	1.5	1.5	1.7	1.5
• Land under maize (%)	75.7	63.1	72.6	64.3	68.7
• Land under other crops (%)	16.2	27.9	17.6	19.5	20.3
• Land under non agricultural activities[c] (%)	8.1	9.0	9.8	16.2	11.0
• **Total (%)**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

[a] Include owned land, land rented in and land borrowed
[b] Total land planted with maize, bean, wheat, round potato , groundnut and sunflower
[c] Fallow land, pasture land and land under trees

Furthermore, the survey results revealed that on average 1.5 hectares of the total available land was allocated for main crops 68.7% of which was allocated for maize production in 2008/09 growing season. Other crops accounted for 20% of the total available land while non agricultural activities (mainly pasture, fallow and land under tree) accounted for only 11% of the total available land. This result supports the argument that maize in the study area is the most essential crop because it provides both staple food and livelihood opportunities.

4.3.2 Labour

Availability and use of labour for a smallholder farmer is very crucial because it determine the success in terms of size of the farms and scope of improvement. Also substitution of labour for mechanical power is a common phenomenon in smallholder agriculture. Table 5 shows the average labour which was used for various maize farming activities in 2008/09 growing season. The results reveal that labour is used intensively. The average labour requirement for all maize farming activities was about 99 persons per annum and much of which was used for weeding. Normally in the study area two weeding are required which suggest that maize is a labour intensive crop. In terms of intensity of use, Lufumbu village had the highest labour use (117 man-days/ha) and Igagala had the lowest (82 man-days/ha). This provides an idea that labour supply in Lufumbu village probably is not a problem compared to Igagala village.

Table 5: Labour use for different maize farming operations

Village	Labour use (man-days/ha)						Total
	Land preparation	Sowing	Weeding (I&II)	Fertilizer application	Pesticides spraying	Harvesting	man-days
Igagala	7.0	5.0	48.3	7.0	2.0	13.0	82.3
Ulembwe	8.0	7.0	54.6	6.0	2.0	17.5	95.1
Mlangali	8.0	6.0	58.0	7.0	3.0	19.0	101.0
Lufumbu	13.0	7.0	61.0	10.0	3.0	23.0	117.0
All villages	9.0	6.3	55.4	7.5	2.5	18.1	98.8

Although this study did not analyse the availability of labour throughout the year but labour shortages were reported in Igagala and Ulembwe villages. Most of the respondents in those two villages acknowledge the fact that labour supply is seasonal and round potato is the main competitor for labour in that area. Furthermore the closeness of these villages to Njombe town is another reason for short supply of labour. This is because due to shortage of land and the fact that some people consider agriculture as a non profitable investment, thus there has been frequent movement of labour from these villages to Njombe and other towns to look for other income generating activities. The situation in Mlangali and Lufumbu is contrary because respondents did not complain about shortage of labour rather their concern was cash with which to purchase labour. Since Mlangali and Lufumbu villages are located in a remote district of Ludewa it could be a reason that frequent movement of labour to other towns is limited.

4.3.3 Other inputs

4.3.3.1 Use of fertilizers, maize seeds and pesticides

Empirical evidence in African agriculture has consistently indicated that the vast majority of smallholder farmers rarely use modern inputs (i.e. fertilizers, seeds and pesticides) particularly farmers located in remote areas (IFDC, 2000; Kherallah, 2000). The finding of this study is however contrary to previous studies because 95 % of the sample households (Table 6) used modern inputs in 2008/09 growing season. The intensity of use varied among the smallholders depending on capital base, price levels of those inputs and information on proper use of inputs. The analysis of type of modern inputs used showed that fertilizer was the mostly used input (95%), while 32% of the respondents used improved maize seeds and 66% used pesticides. The use of fertilizer in the study area is predominantly high, which suggests that maize productivity in the study area is greatly influenced by fertilizer use. The result further shows that fertilizer use is fairly evenly spread over the entire study villages which imply that soil fertility might be a common problem across all villages. Variation was observed on the use of improved maize seeds and pesticides where Igagala and Ulembwe villages had the lowest percentage use of these inputs compared to Mlangali and Lufumbu villages (Table 6). The fact that maize is the main cash crop in Mlangali and Lufumbu villages could be the driving force to slightly higher level use of improved maize seeds compared to Igagala and Ulembwe which depend on round potato as the main cash crop. Also Mlangali and Lufumbu villages have greater use of pesticides probably because the level of insects' infestation is higher than in Igagala and Ulembwe villages. According to the interview with farmers, stock borers were the main insect pest which could inflict losses up to half of the potential maize harvest in these villages.

Although the use of improved maize seeds in the study area is low (32%), but this results is slightly higher than that of the Poverty and Human Development Report which showed that only 23% of farmers in Tanzania used improved seeds in 2007. Also the result of this study is higher than that of Isinika *et al.* (2003) who reported that only 27% of farmers in Tanzania used improved seeds in 2001 which implies that de-adoption of improved maize seeds from 2001 to 2007 has occurred. The reasons for low use of improved maize seeds are diverse. Kaliba *et al.* (2000) showed that, extension service, yield differences between improved and local varieties and geographical characteristics significantly influenced the adoption process of improved maize seeds and inorganic fertilizers in the intermediate and lowland zone of Tanzania. In this study high price of improved maize seeds is also considered to be among the significant factors limiting its use because it makes unaffordable to most of smallholder maize producers.

Table 6: Percent of households using fertilizers, improved maize seeds and pesticides in the study area

Item/village	Igagala	Ulembwe	Mlangali	Lufumbu	Average
Use of inputs					
• Yes	92.0	100.0	92.0	96.0	95.0
• No	8.0	0.0	8.0	4.0	5.0
Type of input used in 2008/09 season					
• Fertilizer	92.0	100.0	92.0	96.0	95.0
• Improved maize seeds	20.0	16.0	44.0	48.0	32.0
• pesticides	48.0	52.0	80.0	88.0	66.0

The analysis of prices of modern inputs in the study area showed that improved maize seeds had the higher average price (TZS 1500/kg) compared with phosphorous and nitrogenous fertilizers which had an average price of TZS 1300/kg and TZS 980/kg respectively (Fig. 5). Due to this, it provides an idea that in the study area farmers rely on either local varieties or seeds from previous crop which in essence give low maize yields. In that case, if maize productivity in the study area were to increase to the potential yield of 6.5 tons per hectare, policy directives need to address the effect of price for increasing the consumption of improved maize seeds.

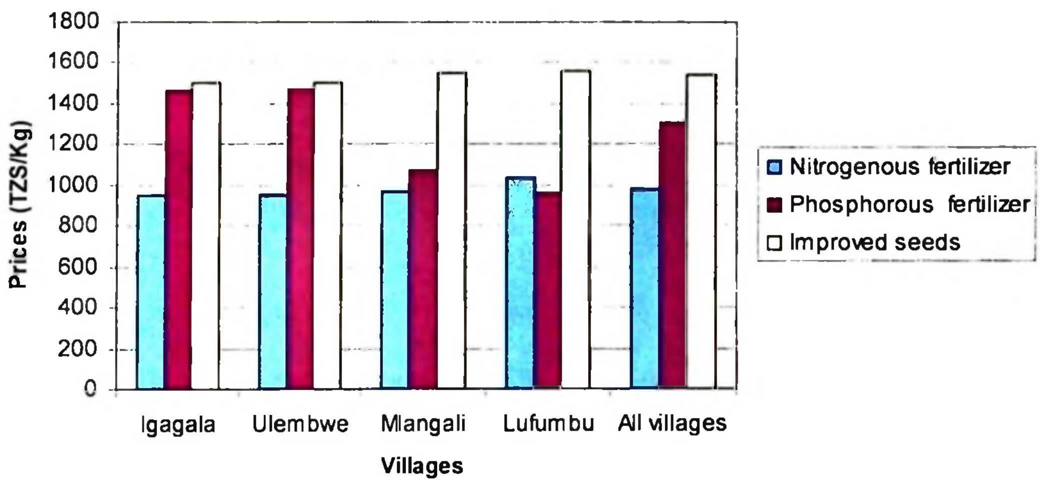

Figure 5: Prices of various modern inputs for 2008/09 growing season

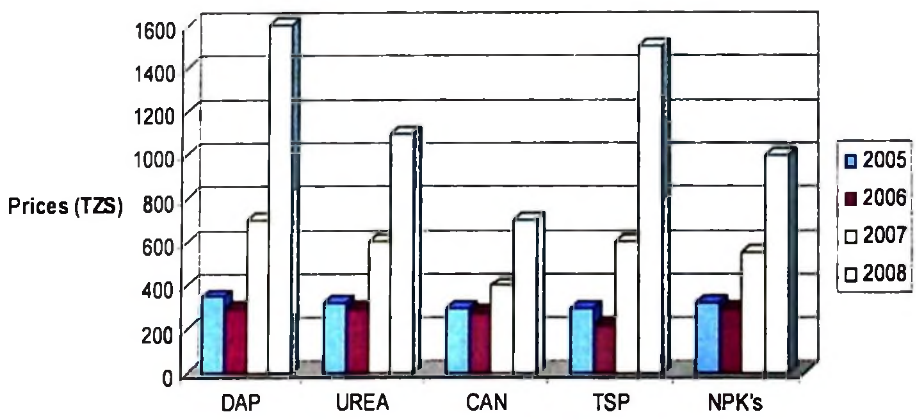

Figure 6: Fertilizer prices (TZS/kg) in Iringa region 2005-2006

On the other hand, the assessment of modern inputs prices by villages indicated that the price of phosphorous fertilizer was significantly higher in Igagala and Ulembwe villages compared to Mlangali and Lufumbu villages; whilst that of nitrogenous fertilizer was almost the same across all villages (Fig. 5). The higher price of phosphorous fertilizer in Igagala and Ulembwe villages is attributable to round potato growing which consumes large proportion of phosphorous fertilizer especially DAP fertilizer distributed in that district than the other type of fertilizers.

4.3.3.2 Availability of fertilizers, improved maize seeds and pesticides

Many analysts of input use in Africa and the rest of the developing world content that the basic problems of availability (i.e., getting the right input at the right place at the right time) are at least important as price response interactions in determining input use (Fontaine, 1991; Blackie, 1995). This study analysed the availability of inputs (unsubsidized inputs) to smallholder farmers where it was observed that the main channel which supplies inputs to smallholder is through stockists (private input dealers). It was noted that some of the stockists supply both unsubsidized and subsidy inputs. However, this study dealt only with unsubsidized inputs and the interview targeted only smallholder farmers who were not part of the subsidy programme in 2008/09 growing season.

In order to understand the availability of inputs in the study area respondents were asked where (within or outside the village) they normally purchase inputs and which month during the year inputs are purchased. The results in Table 7 shows that, 80% of the sample households purchased inputs within the same village and only 20% purchased outside the village of residence. And those farmers purchased inputs outside their village mainly were located in Igagala and Ulembwe villages which in fact are close to Njombe town. In terms of month which inputs were purchased, 62% of the respondents reported to have purchased inputs in December which is the proper month in the study area because the rain season normally begin mid or late November. On the other hand 31% of the respondents reported to have purchased inputs in January and 7% purchased November. This finding generally indicates that availability of inputs in terms of distance from the selling points and time is not a problem which is also justified by Fig. 7 which shows that only 24% of respondents reported unreliable input supply to be one of the factors affecting input use in the study area.

Table 7: Availability of fertilizers, improved maize seeds and pesticides in the target villages

Item	Percent of households by village				Average
	Igagala	Ulembwe	Mlangali	Lufumbu	
Place of purchase of inputs					
• Within the village	68.0	64.0	92.0	96.0	80.0
• Outside the village	32.0	36.0	8.0	4.0	20.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Month of purchasing inputs					
• October	0.0	0.0	0.0	0.0	0.0
• November	10.0	4.0	6.0	8.0	7.0
• December	66.0	56.0	58.0	68.0	62.0
• Other months	24.0	40.0	36.0	24.0	31.0
• **Total**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

4.4 Maize Production Costs in the Study Area

This section presents the results of the estimation of the costs of producing maize in the study area. It can be noted in Table 8 that, the average total production costs attributable to maize is accordingly high (TZS 463 780.4/ha) ranging from TZS 537 167.2/ha in Ulembwe village to TZS 430 993.5/ha in Lufumbu village. Although Mlangali and Lufumbu village are located in remote area, but their average production costs are relatively similar to those in Igagala and Ulembwe villages probably because of good paved road which reduces the transport costs of inputs. The costs shares for each of the main inputs used in maize production are presented below;

4.4.1 Land resource

Majority of households in the study area use own land for crop production the ownership of which is customary. But for the purpose of understanding the value of land resource in monetary terms, the implicit compensation for unpaid own land was estimated using the prevailing land rent. The results in Table 8 depict that on average the opportunity cost of one hectare of land is TZS 36 380 which ranges from TZS 44 800 in Ulembwe village to TZS 29 280 in Lufumbu village. This value is relatively low compared to other parts of the country specifically in the northern zone of Tanzania. Although the opportunity cost of land is low, but it cannot make us to reject the hypothesis of land constraints in the study area in particular Igagala and Ulembwe villages. An interview with some village leaders in Igagala and Ulembwe villages revealed that land shortage has been a common phenomenon because of intensive growing of round potato which according to their opinion currently is the main household income generating crop compared to maize.

4.4.2 Labour inputs

In a labour intensive agriculture, the available labour in the household to a larger extent sets the limits for the land to be cultivated, which is also influenced by the available land. The results in Table 8 shows that the sample households rely on three sources of labour namely; family, exchange and hired labour. Of the three sources, family is the main source, accounting for more than 67% of the labour used for maize farming activities. The average costs of labour per hectare in the study area is TZS 170 770/= which is second to variable inputs. On the other hand, hired labour accounts for more than 20% of the total labour used in maize farming activities and mainly is available in Mlangali and Lufumbu villages. Very few hired labour is available in Igagala and Ulembwe villages. The reason for unavailability of hired labour in Igagala and Ulembwe villages is probably due to closeness of these villages to Njombe town which makes persons aged above 18 years to move to

Njombe town to seek for other income generating activities. Mlangali and Lufumbu villages are somewhat remote as such hired labour is available thus why even the wage rate was a bit lower (TZS 1 500/person/day) compared to Igagala and Ulembwe which was TZS 2 000/person/day. Labour costs in this study were found to be second to variable costs. But generally, this result is consistent to other similar studies that have found the bulk of production costs to be attributable to labour inputs because soaring price of fertilizer during this survey could have contributed to higher costs of variable inputs.

4.4.3 Mechanical inputs

The availability of mechanical inputs in the study area is limited, primarily because few have cattle or tractors. This makes it difficult to increase maize productivity because farming operations remain to be labour intensive. Table 8 shows that on average households used TZS 56 119.4 for ploughing one hectare of land which is too huge for a smallholder farmer constrained with cash income. Of the four villages, Mlangali had the highest cost of hiring tractor/draft power (TZS 73 297.2/ha) while, Igagala had the lowest (TZS 46 063.3/ha). This result suggest review of the tax regime related to import of tractors to allow more tractors to be imported but also to educate farmers the importance of cattle keeping for obtaining draft animals.

4.4.4 Variable inputs

According to the data in Table 8 the average variable costs of variable inputs consisting of fertilizers, improved maize seeds, and pesticides was TZS 200 511.0/ha which is accordingly high than all other inputs used in maize production. Of these inputs, fertilizers have the largest cost share and pesticides have the least cost share. More than 95% of the variable costs were used mainly for fertilizers while improved maize seeds and pesticides accounted for only 3.5% and 1.0% respectively. This indicates that farmers in the study area consider fertilizer to be the most important inputs and that maize production could be possible without improved seeds and pesticides but not fertilizer.

Table 8: Per hectare value of inputs in Tanzanian shilling (TZS)

Variable	Igagala	Ulembwe	Mlangali	Lufumbu	Average
Land [a](TZS/ha)	40 000.0	44 800.0	31 440.0	29 280.0	36 380.0
Total labour[b] (TZS/ha)	164 640.0	190 240.0	152 460.0	175 740.0	170 770.0
Share of family labour (% of total)	86.2	69.7	53. 6	60.4	67.4
Share of exchange labour (% of total)	8.3	20.8	4.6	13. 8	11.9
Share of hired labour (% of total)	5.5	9.5	41.8	25.8	20.7
Tractor/draft power[c] (TZS/ha)	46 063.3	48 457.2	73 297.2	49 881.4	56 119.4
Variable inputs (TZS)	180 634.8	253 670.0	188 086.3	176 092.1	200 511.0
Share of fertilizer (%)	97.7	99.2	93.6	91.6	95.5
Share of seed (%)	1.8	0.3	5.1	6.7	3.5
Share of pesticides (%)	0.5	0.5	1.3	1.7	1.0
Total costs (TZS/ha)	**431 338.1**	**537 167.2**	**445 283.5**	**430 993.5**	**463 780.4**

[a] because majority of households used mainly owned land the implicit compensation for unpaid own land (i.e. rent) was estimated by the prevailing land rent in the study area

[b] labour cost was calculated by converting all labour input (family, hired, and exchange labour) to man-day then multiplied by the prevailing wage rate in the study area.

[c] the cost of tractor/draft power was computed by aggregating cost of hiring tractor or draft power in cultivating the given area in hectare.

4.5 Constraints to Inputs Use

Since the use of inputs particularly yield enhancing inputs in the study area varied among the sample households (section 4.3.3), then it was important to know which factors attribute to these variations. Fig. 7 describes the main limitations perceived by farmers to affect the extent of input use in the study area. The figure shows that 65.6% of the interviewees reported high price of inputs especially fertilizer to be the main obstacles to increased input use. It was noted during the period of survey that, on average the price of phosphorous and nitrogenous fertilizers in the study area was TZS 1300/kg and TZS 980/kg respectively (Fig. 5). This is a bit lower than the prices reported by the agricultural input study conducted in 2008 by the Ministry of Agriculture Food Security and Co-operative (MAFSC) in Iringa region.

The MAFSC input study report found that on average the price of phosphorous fertilizer (DAP in specific) in Iringa region, increased from TZS 350/kg in 2005 to more than TZS 1600/kg in 2008, while that of nitrogenous fertilizer (Urea in specific) increased from TZS 300/kg in 2005 to more than TZS 1000/kg in 2008 (Fig. 6). Despite the small variation, but this finding indicates that fertilizer price in the study area has kept on increasing on the same magnitude as the global fertilizer price soaring. The problem of high price of inputs has a lot to do with high transport costs which in turn could be attributed to high fuel prices rather than poor road condition because the studied villages have well all weather maintained roads. It can further be noted from Fig. 7 that about 60% of the interviewees consider lack of capital (mainly financial capital) to be one of the main drawbacks to investing in inputs. Although this could be true to some of the farmers but the average annual cash earnings (Table 2) from different sources in the study area does not support this argument. In fact the problem could be that, the farmers in the study area like else where in SSA they lack habit of saving for purchasing inputs in the next season. In other words, farmers have a tendency of spending all the cash accrued from agricultural and other enterprises without considering the production costs for the next season. This attitude reflect the problems in farmers' managerial decision-making hence efficiency in input allocation. The cost of these inappropriate decisions can be reduced by strengthening farmers knowledge on issues related to production costs and general farm budget.

On the other hand output prices was also analysed to see if it could be one of the limitations to input use because under normal situation, farmers are expected to invest in inputs based on what is accrued from sell of outputs. This means, if the gains from output is much lower, less will be invested in inputs. In relation to this, the survey results in Fig. 7 shows that about 40% of the respondents mentioned unstable maize price to affects their extent of input use.

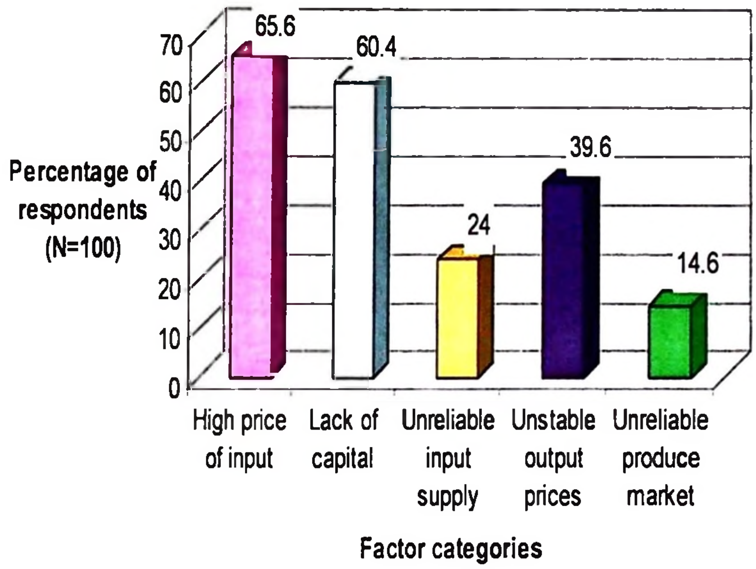

Figure 7: Main limitation to input use for maize production (Percentages are for multiple responses)

Furthermore the implication of unreliable input supply and unreliable produce market on inputs use were also analysed. The results in Fig. 7 show that, 24% of respondents consider unreliable input supply to be a drawback and 14.6% consider unreliable produce market to be a problem. Generally, these two factors were not significant because the study villages are well connected to districts main roads hence movement of both inputs and output from and within the villages is not a problem.

4.6 Maize Output Markets

It is well known that output price bear a direct influence on input use. In other words, if the output price is lower it means a farmer whose goal is profit maximization will incur loss and thus would invest less or not in inputs in the next season. In view of that, this section provides analysis of the farmers' perceptions regarding the availability of markets for their produce and price offered by the principal maize buyers as well as problems associated with maize markets.

4.6.1 Principal maize buyers, time of sale and price offered

The survey conducted in the area (Table 9) reveal that maize is sold in four main markets namely; local traders, middlemen's, village markets, and National Food Reserve Agency (NFRA) formerly known as Strategic Grain Reserve (SGR). Of these markets, local traders and middlemen's bought more than 70% of the maize produce, but local traders were mainly concentrated in Igagala and Ulembwe villages, while middlemen's operated mainly in Mlangali and Lufumbu villages. On the other hand, village markets and NFRA accounted for 13% and 14% respectively and the distribution of which was such that; village markets were only available in Igagala and Ulembwe villages and NRFA was available only in Mlangali and Lufumbu villages.

Table 9: Principle maize buyers, time of sale and price offered

Item/Village	Igagala (n=20)	Ulembwe (n=24)	Mlangali (n=24)	Lufumbu (n=23)	Average (N=91)
Principle buyers					
• Local traders	44.0	72.0	12.0	36.0	41.0
• Middlemen	24.0	8.0	52.0	44.0	32.0
• Village market	32.0	20.0	0.0	0.0	13.0
• NFRA[a]	0.0	0.0	36.0	20.0	14.0
• **Total**	**100**	**100**	**100**	**100**	**100**
Month of sale					
• August	0.0	0.0	24.0	20.0	11.0
• September	8.0	4.0	36.0	40.0	22.0
• October	16.0	52.0	16.0	28.0	28.0
• November	44.0	20.0	12.0	4.0	20.0
• December	12.0	20.0	4.0	0.0	9.0
• Other months	20.0	4.0	8.0	8.0	10.0
• **Total**	**100**	**100**	**100**	**100**	**100**
Average maize price (TZS/Kg)	260.5	260.0	230.0	226.1	243.6

[a] National Food Reserve Agency

The study further assessed the month during which maize is sold so as to understand if farmers sale their produce immediately after harvest or store their produce. The result in Table 9 shows that 70% of the produce is sold between September through November which indicates that maize in the study area is normally sold immediately after harvest which in turn has an implication on price received.

On the other hand, the analysis of price offered in 2008/09 season showed that on average farmers received TZS 243.6/kg which ranged from TZS 260.5/kg at Igagala to 226.1/kg at Lufumbu village (Table 9). Generally the result depict the fact that maize price was lower at Mlangali and Lufumbu village than at Igagala and Ulembwe villages. The lower price at Mlangali and Igagala villages could be attributable to reliance on middlemen's who are the principal maize buyers in these villages. Also the fact that Mlangali and Lufumbu villages are located far away from main markets could be another reason because the maize transaction costs are higher than at Igagala and Ulembwe villages.

4.6.2 Maize price trend in the study area

In order to get an insight of the price trend in the study area respondents were asked to tell whether the maize price is stable or fluctuating. The result in Fig. 8 depicts that 84% of respondents perceived the price is fluctuating while only 16% considered it to be stable. The fluctuation of maize price in the study area is likely to be caused by the inability of smallholder farmers to store their maize produce and thus sell most of the harvest soon after harvesting.

In order to understand why farmers are not used to store their harvest, interviewees were asked the main factors which influence the decision to sell the maize. It was found that 92% of the sample households are forced to sell their harvest due to household cash need rather than price offered (Fig. 8). Since maize in the study area in particular Mlangali and Lufumbu villages is the main source of income, storage after harvesting need to be given due attention. This can possibly be done by adopting the warehouse receipt system where farmers could be able to get cash needed to solve immediate problems which arise during harvesting period. Through this approach, farmers would store their produce hence raise the price and ultimately increase their income.

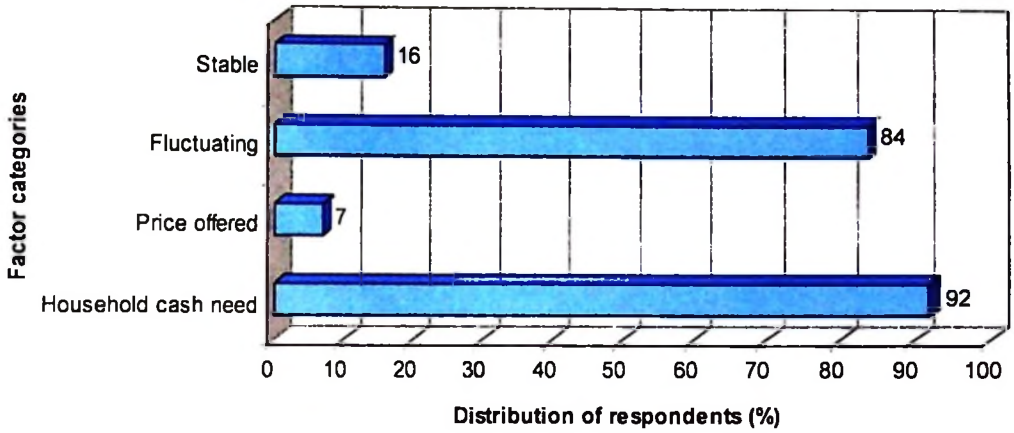

Figure 8: Maize price trend and factors influencing farmer's decision to sell the maize harvest

4.6.3 Problems encountered by farmers in marketing maize produce

Maize farmers in the study area reported that in 2008/09 they sold all the maize harvest which was intended for sell which implies that maize market is not a problem. However, it is important to note that maize markets like that of inputs have undergone reforms so as to allow involvement of private traders to purchase maize directly from individual farmers. This kind of arrangement has not eliminated the maize market inefficiency because among other factors farmers are still complaining about low maize price offered by traders.

Due to that, in this study the sample households were asked to tell currently what are the main problems hindering maize business. In connection to that 70% of the respondents reported that low price of maize offered by buyers is the main drawback, while 34% mentioned lack of transport affects maize marketing (Fig. 9). The transport problem could bring sense in Mlangali and Lufumbu villages because these villages are located far away from the Dar-es-Salaam-Songea main road than Igagala and Ulembwe villages. Also very few people in Mlangali and Lufumbu own trucks to provide transport services to farmers and transporters located in other places like Njombe are normally unwilling to send their truck over there especially during rain season. This contributes greatly to lowering maize price in these villages.

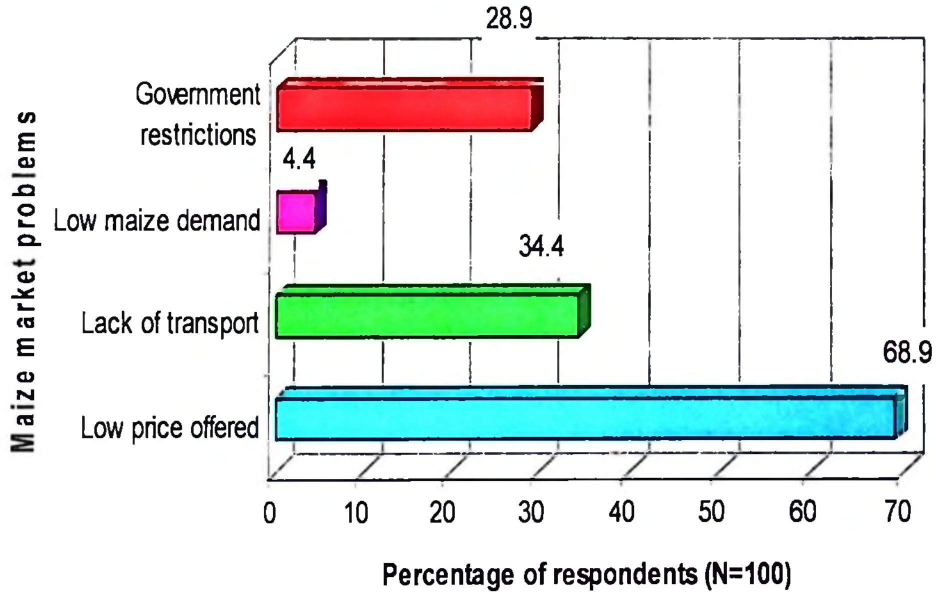

Figure 9: Problems considered by farmers to affect maize marketing (Percentages are for multiple responses)

Government restrictions was also another problem mentioned by 30% of the respondents to be among the drawbacks to maize marketing, while only 4% of the respondents reported low maize demand as the problem. The main restriction mentioned by farmers was the prohibition by the government to export maize to the neighbouring countries especially Malawi and Zambia. Farmers were of the opinion that if they could be allowed to export maize it could raise competition with local traders eventually raising maize price. This suggest the need for the government to review her policy related to maize export for the purpose of improving maize farmers income hence input use efficiency as farmers will find it profitable to invest in inputs.

4.7 Profitability of Maize Production and its Relation to Levels of Fertilizer Use and Maize Outputs

The analysis of maize profitability in this study was undertaken with the assumption that profit is the driving force for a farmer to decide whether to grow a certain crop or not. Also profit pushes a farmer to invest in yield enhancing inputs. Furthermore, for the purpose of knowing whether it pays to invest in maize production it was assumed that farmers sold all what was produced in 2008/09 season.

4.7.1 Profitability of maize farming in the study area

According to FAO (1997) profitability or net economic returns can be calculated as gross returns minus the costs of all variable inputs which include the costs of seed, fertilizers, pesticides and labour. In this study tractor/draft power was also included as a variable cost because majority of the farmers hired this implement in the cultivation of land.

Table 10 shows that the net economic returns from maize production was TZS 328 064.9. Farmers in Igagala village received higher returns (TZS 372 985.6) and Lufumbu village had the smaller returns (TZS 249 211.6). Despite the fact that maize price in Igagala and Ulembwe were almost the same but farmers in Ulembwe received smaller returns mainly due to high production cost. Also farmers in Mlangali received higher returns than Lufumbu village because of higher maize yield obtained in Mlangali in 2008/09 season.

Furthermore, the net return per hectare was TZS 364 516.5, the smallest being TZS 249 211.6 at Lufumbu village and the highest being TZS 466 232 at Igagala village. These ranges are lower than TZS 584 077/ha to TZS 1 454 167 obtained by Aroga *et al.* (2001) in the evaluation of on-farm performance of selected improved maize varieties in the forest zone of central Cameroon. Among others low use of improved maize seeds which result to low use of improved maize seeds which result to low yield and low maize price offered by buyers are the main factors contributing to lower net returns in the study area. Although this result shows that maize farming in the study area is generally profitable, but the benefit cost ratio (BCR) is less than 2 except for Igagala village alone. According to Aroga *et al.* (2001) the acceptable level of BCR before recommending a new technology is 2.5. In this case therefore, it indicate that maize profitability in the study area will keep on declining unless farmers increase the use of yield enhancing inputs particularly improved maize seeds which is in low use compared to the other inputs.

Table 10: Yield, return and profitability of maize production in the target area

Variable/Village	Igagala (n=25)	Ulembwe (n=25)	Mlangali (n=25)	Lufumbu (n=25)	Average (N=100)
Farm size (ha)	0.8	0.9	1.1	1.0	0.9
Maize yield (kg)	2 792.0	2 965.4	3 240.0	2 786.0	3 000.2
Prices (TZS/kg)	260.5	260.0	230.0	226.1	243.6
Gross return (TZS)	725 920.0	771 004.0	745 200.0	629 914.6	730 848.7
Total variable cost (TZS)	352 934.4	490 428.9	387 068.9	380 703.0	402 783.8
Net return (TZS)	372 985.6	280 575.1	358 131.1	249 211.6	328 064.9
Net return/hectare	466 232.0	311 750.1	255 068.3	249 211.6	364 516.5
Benefit Cost Ratio (BCR)	2.1	1.6	1.9	1.6	1.8

4.7.2 Relationship between levels of fertilizer use and maize profitability

Taking into account the fact that fertilizer alone accounted for about 98% of the variable costs (i.e. fertilizer, improved seeds and pesticides), then the relationship between levels of fertilizer use and profit was analysed to see how the two parameters are associated to each other. Clearly it is known that farmers use fertilizer only if it is profitable which implies that all other things equal, the expected sign of the correlation between fertilizer use and profit is positive. In this study the relationship between the levels of fertilizer use and profit was analysed using Kendall's tau-b bivariate correlation.

Contrary to expectation the result presented in Table 11 shows that, there was negative correlation between levels of fertilizer use and profit in the study area. The correlation coefficient between these variable was -0.051 which was not significant. However, the result suggests that if the level of fertilizer use is increased by one unit, the profit level will be reduced by 0.051. In the study of maize yield response to fertilizer use and profitability among small-scale maize producers in Zambia Xu *et al.* (2006) found that, fertilizer use was more likely to be unprofitable in remote areas. This occurred due to higher costs of transport and handling of fertilizer which were found to increase fertilizer price by 13% to 24%. This reason could be equally important in Mlangali and Lufumbu because these villages are located in remote district of Ludewa where transaction costs of both inputs and outputs are higher. In addition to that, the fact that many farmers do not use right quantity of fertilizers could be another reason contributing to negative relationship between these variables. Therefore in order to increase maize profit in the study area the option would be to reduce fertilizer price or raising farm gate prices for maize output, or a combination of both.

4.7.3 Relationship between maize output and profitability

The analysis of the relationship between maize output and profit revealed a positive correlation (Table 11). The Kendall's tau-b correlation was 0.489 which was significant at P<0.01. This implies that, an increase in maize output by one unit would increase profit by 0.489. The positive relationship of 0.372 was also observed between levels of fertilizer use and maize output, which means, opportunities to increase maize profitability lies upon removing the current constraints affecting fertilizer use.

Table 11: Correlation coefficients between profit and selected variables

	Fertilizer use	Profit	Maize output
Fertilizer use	1.000		
Profit	-0.051	1.000	
Maize output	0.372**	0.489**	1.000

**Correlation significant at the 0.01 level

4.8 DEA Efficiency Measurements

This section discusses the results of the assessment of Data Envelopment Analysis (DEA) efficiency scores among the farming households in the study. In the DEA model, one output and six inputs were included. Data on each variable was on the basis of land allocated for maize. Total maize production (kg) was the dependent variable in the DEA model. Variables which formed the constraint set included; (1) land which is the size of plot allocated for maize in hectares; (2) labour which is the total persons per days calculated for each farming activity by converting all labour inputs (family, exchange and hired labour) to man-days equivalent; (3) the data for tractor/draft power is the total hectare of land cultivated by either a tractor or draft power which in this study make sense because the charge of use of tractor or draft power is on hectare basis rather than hours as used in other studies; (4) nitrogen fertilizer which was converted into pure nitrogen kg/ha depending on the type of fertilizer used; (5) phosphorous fertilizer which was also converted into pure phosphorous depending on type used, and (6) spray which were transformed based on the type of pesticides active substance.

4.8.1 Descriptive statistics of the DEA variables

Table 12 presents the basic descriptive statistics of the DEA variables per hectares. Average yield of maize was 3 000.2 kg/ha while maximum yield was 7 380.0 kg/ha which is 17 times greater than the minimum yield. This indicates a very wide range between minimum and maximum yields. The plot size allocated for maize production in the study area on average was 0.9 ha, the maximum being 2.4 ha which is 12 times greater than the minimum. Wide ranges were also observed for minimum and maximum values of labour and tractor/draft power which were 32 and 19 times greater respectively. The average labour use in the study area was 99 man-days/ha. Of all villages, Lufumbu had the greatest use of labour (117 man-days) which indicates that labour availability might not be a problem compared to the other villages.

The average use of other inputs were; nitrogen fertilizer (150 kg/ha), phosphorous fertilizer (75.1 kg/ha) and pesticides (202.7 ml/ha). The use of these inputs also showed greater variations between the minimum and maximum. Nitrogen fertilizers were 17 times greater, phosphorous fertilizers were 15 times greater and pesticides were 12 times greater respectively.

Table 12: Summary statistics of the variables included in the DEA model

Variable	Unit	Village	Min.	Max.	Mean	SD
Maize output	kg	Igagala (n=25)	504.0	6 650.0	2 792.0	1 382.9
		Ulembwe (n=25)	630.0	6 000.0	2 965.4	1 460.5
		Mlangali (n=25)	415.0	5 400.0	3 240.0	1 322.6
		Lufumbu (n=25)	432.0	7 380.0	2 786.0	1 538.3
		Average (N=100)	432.0	7 380.0	3 000.2	1 433.2
Planting area	ha	Igagala (n=25)	0.2	2.0	0.8	0.4
		Ulembwe (n=25)	0.2	1.6	0.9	0.3
		Mlangali (n=25)	0.4	2.0	1.1	0.4
		Lufumbu (n=25)	0.4	2.4	1.0	0.5
		Average (N=100)	0.2	2.4	0.9	0.4
Labour use	man-days/ha	Igagala (n=25)	15.0	213.0	82.3	42.4
		Ulembwe (n=25)	24.0	226.0	95.1	48.6
		Mlangali (n=25)	34.0	193.0	101.0	40.4
		Lufumbu (n=25)	26.0	482.0	117.0	96.9
		Average (N=100)	15.0	482.0	99.0	61.9
Tractor/draft power	(number/ha)	Igagala (n=11)	0.6	6.0	3.1	1.6
		Ulembwe (n=24)	0.8	7.6	2.8	1.8
		Mlangali (n=21)	1.0	6.2	2.8	1.2
		Lufumbu (n=18)	0.4	4.4	1.6	1.1
		Average (N=74)	0.4	7.6	2.6	1.5
Nitrogenous fertilizer	kg/ha	Igagala (n=23)	50.0	200.0	108.7	44.3
		Ulembwe (n=25)	50.0	350.0	160.0	66.1
		Mlangali (n=23)	50.0	450.0	169.9	91.5
		Lufumbu (n=24)	100.0	850.0	160.1	154.5
		Average (N=95)	50.0	850.0	150.0	99.7
Phosphorous fertilizer	kg/ha	Igagala (n=20)	50.0	100.0	57.5	18.3
		Ulembwe (n=19)	40.0	150.0	86.8	28.1
		Mlangali (n=9)	20.0	150.0	96.7	33.2
		Lufumbu (n=13)	10.0	150.0	70.0	36.9
		Average (N=61)	10.0	150.0	75.1	31.4
Pesticides	ml/ha	Igagala (n=12)	100.0	300.0	150.0	79.8
		Ulembwe (n=20)	100.0	300.0	145.0	60.5
		Mlangali (n=20)	100.0	500.0	245.0	127.6
		Lufumbu (n=22)	100.0	1 200.0	245.4	242.5
		Average (N=74)	100.0	1 200.0	202.7	159.6

The greater range between minimum and maximum for most of the inputs used in maize production in the study area is an indication of lack of consistency of input use among the smallholder farmers. This finding suggests that, in the study area probably some of the farmers use excess inputs, others use fewer inputs and also there might be those who use inputs optimally.

4.8.2 Technical efficiency scores

The result of the DEA scores for the two models (i.e. Constant Return to Scale (CRS) and Variable Return to Scale (VRS) assumptions) are presented in Table 13. The result shows that, the average overall technical efficiency in the study area under the assumption of CRS was 0.73 which ranges between 0.23 and 1.00 and only 16 sample households were found to be technically efficient. Likewise, under the assumption of VRS, the average technical efficiency was 0.77 ranging from 0.23 to 1.00 and only 21 sample households were observed to be technically efficient under this assumption.

Table 13: Mean estimates and frequency distribution of the DEA Models.

Efficiency Scores	DEA Measures			
	CRS[a]	VRS[b]	SE[c]	AE[d]
1.00	16	21	23	0
0.90-0.99	13	12	59	0
0.80-0.89	8	13	11	2
0.70-0.79	18	17	6	6
0.60-0.69	21	19	0	10
0.50-0.59	11	9	1	21
<0.50	13	9	0	61
Mean	0.73	0.77	0.95	0.49
Std. Deviation	0.20	0.19	0.08	0.12
Minimum	0.23	0.25	0.56	0.24
Maximum	1.00	1.00	1.00	0.83

[a] CRS: Constant Return to Scale
[b] VRS: Variable Return to Scale
[c] SE: Scale Efficiency
[d] AE: Allocative Efficiency

Based on the assumption of CRS which is considered to be the overall technical efficiency, the mean efficiency score of 0.73 implies that, on average, the sample households are able to obtain 73% of the potential output from a given mix of inputs. It also implies that, by using the same technology, the sample households use on average 27% more inputs than would be necessarily if all of the sample households were operating in the frontier. In other words the same level of output can be obtained even if the sample households reduce the level of input costs by 27%. Since the reduction of inputs at a given level of output is considered to be within the farmers' control, this result provide an idea that in the study area probably the technical inefficiency are due to inappropriate input mix as opposed to scale of operation.

Based on the observed frequency of CRS, the study further analysed the input-output combinations between efficient households and the inefficient ones. This was intended to identifying if there is real significant difference of the input-output levels between those two categories of households. The results in Table 14 show that, efficient households achieved higher level of output (3 122.8 kg/ha) compared to 2 878.1 kg/ha for the inefficient households. In terms of input use, except nitrogenous fertilizer, overall technically efficient households used relatively less of all other inputs than the inefficient ones. The land size for the two categories (efficient and inefficient households) was almost the same. Based on this result, it can be noted that, on average farmers in the study area use excess labour, tractor/draft power, phosphorous fertilizers and pesticides which means the null hypothesis that; smallholder maize farmers in the study area are technically efficient in the allocation of available resources is rejected. Thus, given the feasible technology, the opportunity of attaining the given level of maize output, lies upon the reduction of costs of inputs used in excess while slightly increasing the cost of nitrogenous fertilizer.

Table 14: Average input-output data for technically efficient and technically inefficient households

Variable	Overall technically efficient households (OTE)	Overall technically inefficient households (OTI)
Frequency	16	84
Maize yield (kg/ha)	3 122.8	2 878.1
Maize planting area (ha)	0.9	0.9
Labour use (man-days/ha)	84.0	145.7
Tractor/draft power (number/ha)	2.4	2.6
Nitrogenous fertilizer (kg/ha)	150.6	149.9
Phosphorous fertilizer (kg/ha)	58.3	76.9
Pesticides use (ml/ha)	185.7	204.4

Note: The paired t-test between OTE and OTI showed that, the means are not significantly different

4.8.3 Scale efficiency scores

To be sure whether the inefficiency in the study area is due to technical or scale of operation, the technical efficiency score (CRS) was decomposed into pure technical efficiency (VRS) and scale efficiency (SE). The result in Table 13 shows that, the mean scale efficiency was 0.95, which ranges from 0.56 to 1.00. This result suggests that the sample households are more scale efficient than they are technically efficient. Abay *et al.* (2004) while analysing input use efficiency in tobacco production indicated that, the causes of inefficiencies may either due to; inappropriate input mix or deviation from the optimal scale of production. Since the mean scale efficiency of the sample households is relatively higher (0.95), it means that only 4.5% of the sample households are scale inefficient. This result confirms that the farm's inefficiency in the study area is mainly due to inappropriate input mix as opposed to scale inefficiency.

However, in order to meet the long-run farmers' objective of cost minimization, knowing the mean scale efficiency is not sufficient unless it reveals how the given output can be achieved if all the factors are changed by the same proportion. In the theory of production this constitutes what is traditionally known as long-run analysis of production or 'returns to scale'. In DEA, this is simply achieved by disaggregating the scale efficiency into those households that exhibit constant return to scale (CRS), those that exhibit increasing returns to scale (IRS), and those that exhibit decreasing returns to scale (DRS). By having such information at hand a farmer can make appropriate decision pertaining the potential redistribution of inputs (i.e. increase the input size if IRS and decrease input size if DRS).

The returns to scale analysis presented in Table 15 shows that, only 21% of the sample households were found to operate at constant return to scale, while majority are scale inefficient (either operating at decreasing or increasing returns to scale). Among the inefficient households, 31% of the sample households were found to exhibit decreasing return to scale and all of them used higher levels of the 6 inputs used in the analysis. In other words, these households use much more inputs compared to the gains in output. Taking an example of two inputs; labour and nitrogen fertilizers, the households operating under DRS used more 119 man-days/ha of labour and 123 kg/ha of nitrogen unnecessarily compared to households operating under CRS. This result suggests that, households operating under DRS can reduce costs by reducing input congestion through reallocating some of the over utilized resources to other crop enterprises. On the other hand, 48% of the sample households were found to operate at increasing return to scale which suggests that, these households can reduce costs by increasing scale of operation particularly expanding the use of land, labour inputs and nitrogenous fertilizers which were found to be less used compared to those households operating under optimal scale.

Table 15: Average input output combinations with respect to return to scale

Variable	Return to scale measures		
	DRS	CRS	IRS
Frequency	31	21	48
Maize yield (kg/ha)	3 376.5	3 013.2	2 611.4
Maize planting area (ha)	1.4	0.9	0.8
Labour use (man-days/ha)	206.4	87.7	85.0
Tractor/draft power (number/ha)	2.9	1.3	1.9
Nitrogenous fertilizer (kg/ha)	236.3	113.4	137.0
Phosphorous fertilizer (kg/ha)	59.1	24.8	50.9
Pesticides use (ml/ha)	263.6	91.3	151.5

4.8.4 Allocative efficiency scores

The result in Table 13 shows that, the mean allocative efficiency level was 0.49. This implies that, the inefficiency due to inappropriate input mix accounts for 51% of the loss in the households' income. The Table further depicts that, none of the sample households achieved allocative efficiency of 1.00 indicating that, in the study area though some of the sample households were technically efficient but allocatively were inefficient. Only 39 households achieved an allocative efficiency between 0.50-0.89, while 61 households achieved an allocative efficiency level of less than 0.50. From the point of view of cost minimization, to be economically efficient in maize farming the sample households must be both technically and allocatively efficient. As indicated by Singh *et al.* (2002), the presence of allocative inefficiency reflects lack of cost minimising behaviour among the smallholder farmers in the study area and the need for both adjustments in relative factor input levels. Thus the null hypothesis that; given the price vector for inputs smallholder maize farmers are allocatively efficient is rejected which lead us to accept the alternative hypothesis that smallholder maize farmers in the study area are allocatively inefficient.

4.9 Source of Inefficiency

In consideration of the fact that the DEA models revealed that, the major source of inefficiency is technical, as against scale efficiency (section 4.8.3), the study further examined the factors influencing the level of technical inefficiency. This was achieved by regressing socio-economic and farm specific variables on technical inefficiency scores using logistic regression (log odds) model. In the analysis of data, experience and fertilizer use were excluded in the model implying that they are not significant. However, other explanatory variables (age, education level, distance, farm size and number of contact with extension agents) were included in the model. Furthermore, it should be noted that in the logistic regression model inefficiency scores were treated as the dependent variable. Thus, the independent variable with a negative coefficient means decrease of inefficiency and positive coefficient means an increase of inefficiency.

The results of the logistic regression model is presented in Table 16 which shows that, among of the 5 variables explained by the model only 1 had negative coefficients and 4 had positive coefficients. Age had positive coefficient and significant on technical inefficiency implying that technical inefficiency increase with age. This result suggests that younger farmers who are less than 50 years are more technically efficient than older ones. Similar results were also reported by Kibaara (2005). She argues that the reason for this is probably because age variable picks up the effect of physical strength which means as farmers grow older their physical strength start to decline hence fail to attend farming activities effectively.

The coefficient for years of schooling was positive implying that technical inefficiency increases with increase in years of schooling. However, it is important to note that there has been no consistent results explaining the relationship between years of schooling and technical inefficiency. For example Msuya *et al.* (2008) found that years of schooling have significant impact on decreasing technical inefficiency among smallholder maize farmers in Tanzania. Contrary to that, in the exploration of the potential of producing bio-fuels among small scale farmers in Tanzania, Philip (2007) noted a slight increase of technical inefficiency when the farmer attains post primary education. He argues that the increase in technical inefficiency when a farmer attains post primary education can be attributed to the fact that such farmers are not full time farmers. Most of them might be involved with other off-farm economic activities as their main source of livelihood.

The result of this study concurs with the finding of Philip (2007) and it can be argued that farmers in Mlangali and Lufumbu are technically inefficient than farmers in Igagala and Ulembwe villages. This is justified by the fact that 24% of the sample households in Mlangali and Lufumbu attained post primary education compared to 12% in Igagala and Ulembwe villages (Table 1). Also, apart from farming, about 53% of the sample households in Mlangali and Lufumbu villages were also found to be engaged in off-farm economic activities compared to only 17% in Igagala and Lufumbu villages (Table 2). The conclusion that can be drawn from this result is that, a level of education less or equivalent to primary school is sufficient for smallholder farmer to make appropriate decision pertaining reducing input use inefficiency.

The coefficient of farm size variable was positive on technical inefficiency but not significant. Two categories of farm size were considered in this study that is, farmers with farm size measuring not more than 1 hectare and farmers with farm size measuring above 1 hectare. The positive coefficient indicates that in the study area, as the farm size increase above 1 hectare technical inefficiency increases. Phillip (2007) argue that, the observed tendency of declining efficiency when moving from small farm size to relatively large size could be attributed to change in the land-labour ratio which forces the households to make use of hired labour when farm size increases. This argument is equally applicable in this study because the results in Table 15 shows that, farmers operating under decreasing return to scale had farm size above 1 hectare and used much more labour (206 man-days) compared to 0.9 hectare and about 87 man-days for less inefficient farmers. This result suggests that the best alternative would be to improve input use efficiency rather than expansion of farmed area.

The coefficient for distance variable is positive and significant indicating that remote areas are more inefficient. Taking the distance from Dar-es-Salaam-Songea main road as the reference point; this result suggest that farmers in Mlangali and Lufumbu villages are more inefficient because they are located about 80 km away from the reference point compared to Igagala and Ulembwe villages which are located just 20 km away. Similar findings were also reported by Loikkanen (2002) in the evaluation of economic efficiency of Finnish regions. In fact, the increase in technical inefficiency due to distance is attributed to transport costs which in turn increase price of inputs and thus make them unaffordable to smallholders.

Table 16: Sources of technical inefficiency of maize farmers in the study area

Variable	Coefficients	Z-value	Significance
Constant	1.7293(1.326)	1.304	0.192
Age (years)	0.3507(0.134)	0.649	0.000*
Year of schooling (years)	0.1076(0.167)	0.649	0.521
Farm size (ha)	0.1764(0.308)	0.005	0.996
Distance to reference point (km)	0.1692(0.371)	0.004	0.003*
Contact with extension agents (No.)	-0.0326(1.026)	-0.031	0.975
Entropy	0.356		
Concentration	0.212		
N	61		

*Significant at 1% level
Note: Figures in brackets are standard error

Unlike the other coefficients, number of contact with extension agents was negative which reveals that, farmers having more contact with extension agent are less inefficient than those farmers with no contact with extension agents. This result seems plausible because the assumption being made in many studies is that, number of contact with extension agents bears a crucial role in stimulating effective demand as well as efficient use of inputs.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The primary objective of this study was to analyse the efficiency of farm input use in maize production with the aim of suggesting an optimal proportions of input usage for profitable maize production. Specifically the study sought to identify the most important farm inputs used in maize production and analyse the efficiency of input use as well as factors influencing inefficiency. This is achieved by estimating technical, scale and allocative efficiency of smallholder maize farmers in Iringa region, with particular emphasis on Njombe and Ludewa districts. Furthermore, the study identified socio-economic and farm specific factors influencing inefficiency.

The most important input used in maize production was determined using descriptive statistics, while farm specific efficiencies are computed using 2008/09 maize production cross-sectional data collected from a sample of 100 smallholder maize farmers in the two districts. The study used an input- oriented Data Envelopment Analysis (DEA) to generate the efficiency measures (i.e. technical, scale and allocative efficiency). DEA was chosen in this study because of its ability to disaggregate efficiency into technical and scale measures. On the other hand, econometric logistic model (log odds) was employed in order to explain factors influencing inefficiency. The econometric model was introduced because the DEA models revealed that, not all farmers were technically efficient implying that inefficiency of input use in the study area existed. It was further confirmed that, the inefficiency level of maize farmers in the study area was not due to scale of operation rather it was technical.

5.1.1 Important inputs used in maize production

The study shows that, every farmer in the study area at least used land, labour, tractor/draft power, nitrogenous fertilizer, phosphorous fertilizer and pesticides in producing maize. Surprisingly, improved maize seeds were not found to be among the most important inputs implying that, smallholder maize farmers in the study area rely on local seeds or recycle maize seeds from previous crop. The level of use of the most important inputs varied from farmer to farmer depending on financial capital with which to purchase the inputs. According to the results, the average use of inputs showed significant variation between the minimum and maximum values. The highest observed range was 32 times greater for labour followed by 19 times for tractor/draft power. The values for nitrogen fertilizers, phosphorous fertilizers and pesticides ranged between 12 to 17 times greater.

This result provides information that, in the study area, there is inconsistency of inputs use. In other words, technical aspects related to inputs use as suggested by agricultural scientists are not adhered to by some of the farmers. Therefore, the chances are that, there are farmers who use inputs either above the recommended level or below the recommended levels. But also there are those who use inputs optimally. Lack of consistency on input use has negative impact on the productivity of maize. This can be one reasons contributing to produce below the potential level of 6.5 tons/ha. Therefore in order to increase maize productivity in the study area, the focus should be to set out an area specific inputs use recommendations which is consistency across all farmers and thus it suggests a review of the current recommendations.

5.1.2 Efficiency measures

The results show that, the estimated overall technical efficiency is 73%. Therefore, by using the present technology, the same level of output can be produced even if input cost is reduced by 27%. In other words, smallholders maize farmers in the study area can decrease the use of inputs by 27% without lowering the total obtainable maize output. According to the result the optimal proportions of inputs for the efficient households were; 0.9 ha of land, 84 man-days of labour, 2.4 number/ha of tractor/draft power, 150.6 kg/ha of nitrogen fertilizers, 58.3 kg/ha of phosphorous fertilizers and 185.7 ml/ha of pesticides. These are the inputs at which a household operates on the frontier and only 16 households under the assumption of constant return to scale were found to be using such amounts of inputs.

On the other hand, there were sufficient evidence indicating that, inefficient households in the study area used excess labour, tractor/draft power and yield enhancing inputs specifically phosphorous fertilizer and pesticides. This have had a greater influence on the farmer's technical inefficiency and hence loss of income. The inefficient use of yield enhancing inputs particularly fertilizers and pesticides in the study area can partly be explained by the existence of input subsidy. Although this study targeted only those farmers who were not part of the input subsidy in 2008/09, but it appears some of them have used subsidized fertilizers and pesticides. Presumably this happened because the control mechanism of the input subsidy scheme currently is not that much effective. Also most of the farmers intended for the input subsidy scheme lack financial capital to purchase the inputs as a result the non target farmers took that advantage.

The results also show that, the mean scale efficiency was 0.95 ranging from 0.56 to 1.00 implying that the sample households are more scale efficient than they are technically efficient. However, disaggregation of scale efficiency into returns to scale revealed that, 21% of the sample households were operating under constant return to scale, 31% were operating under decreasing return to scale and 48% were operating under increasing return to scale. This information carries weight in making input readjustment if the household operate under decreasing or increasing return to scale. In fact the result show that those households found to operate under decreasing return to scale though were fewer (31), but they were using excess inputs unnecessarily compared to the gain in output. Thus, these households can maximize profit through minimizing the cost of inputs purchased in excess or relocating them to other crop enterprises where they can be used at their full capacity.

The other efficiency measure which was estimated in this study was the allocative efficiency which indicates the degree to which inputs are being used in a cost minimizing behaviour. According to the result the mean allocative efficiency was 0.49 implying that, the observed inefficiency due to inappropriate input mix accounts to 51% of the loss of the households' income. It also reflects lack of cost minimization behaviour among smallholder maize farmers in the study area. In fact, lack of cost minimization behaviour among smallholder farmers in the study area can be explained by insufficient knowledge and skills on farm budgeting and gross margin calculations. This has been a traditional because most of the smallholders in many parts of the country do not consider agriculture as a business rather they consider it as a way of life. Therefore in order to change this attitude the agricultural interventions and the day-to-day extension activities need to incorporate components of farm budget and gross margin calculations at farm level. This will assist in building farmers' capacity and eventually realizing that agriculture is a business and not a way of living.

5.1.3 Factors influencing inefficiency

The results of the DEA efficiency scores indicated that, there is resource use inefficiency which is mainly caused by inappropriate input mix. The result of the analysis of factors influencing inefficiency showed that age, year of schooling and farm size and distance have had positive impact on inefficiency level in the study area. However, number of contact with extension agents was found to reduce technical inefficiency.

The positive relationship of age on technical inefficiency implies that efforts to improve maize productivity to the potential yield of 6.5 tons/ha should target younger farmers because they are energetic. The strategy should focus on empowering younger farmers with capital to invest in maize production as well as to improve their knowledge and skills in input use through increased contacts with extension agents. Also the positive relationship of years of schooling on technical inefficiency implies the need to introduce agro-processing industries in rural areas such as flour milling machines. This will enable labour force with post primary education to engage in processing of locally produced maize into flours and packaging ready for sale in local and urban markets. The positive relationship of farm size on technical inefficiency, inform us the possibility of improving maize productivity using the existing land area. Therefore the most important thing is to improve the input mix on the same piece of land. On the other hand, the positive relationship of distance from the reference point indicates the need of increasing farm gate maize price through collective bulking and storage. This will enable farmers to avoid selling maize early at harvesting period where maize price is usually low. Otherwise the option of reducing input prices through subsidy schemes is inappropriate because it affects competitiveness of inputs market. Also the current input subsidy scheme adds burdens to the governments' general budget because of the corruption level in the country as well as lack of proper organization which would ensure inputs reach the target population.

5.2 Recommendations

Based on the conclusion drawn from the findings that, there is inefficiency of input use in the study area, therefore the scope to increase maize output lies upon improving the technical efficiency of the relatively inefficient smallholders operating below the frontier. This can be achieved by several ways among others include:

(i) Improving input use efficiency using the existing inputs in Igagala and Ulembwe villages because expansion of farmed area is likely to be impossible due to the noted land constraints. However, given the higher transport costs of inputs in Mlangali and Lufumbu villages, expansion of farmed area would be adopted in short term because land availability would be a limiting factor in a long term.

(ii) Relocating the overused labour into other crop enterprises so as to maximize labour productivity. This is specifically for Mlangali and Lufumbu villages which were found to have excess use of labour.

(iii) Due to the fact that tractors use fuel as their main source of energy, and the fact that the fuel prices has been increasing day-to-day therefore it implies that smallholder maize farmers will never afford the price of hiring tractors for land cultivation. The alternative option would be to encourage the use of draft power and particular emphasis should be directed towards enabling smallholder farmers to own oxen and receive proper training on the use of oxen in land cultivation and other farming activities.

(iv) The use of fertilizers should be accompanied by improved maize seeds which are a key technology upon which fertilizer would display its full potential. This is absolutely important because the study noted significant low use of improved maize seeds particularly in Igagala and Ulembwe villages. This can be achieved through increasing the capital base of maize seeds farms.

(v) Soil management practices should be given priority and practices that cause soil fertility decline such as mono-cropping should be avoided. This will increase the efficacy of fertilizers in turn increase maize productivity.

REFERENCES

Abay, C., Miran, B. and Gunden, C. (2004). An Analysis of Input Use Efficiency in Tabacco Production with Respect to Sustainability: The Case of Turkey. *Journal of Sustainable Agriculture* 24(3): 123-143.

Aroga, R., Ambassa-Kiki, R., The, C., Enyong, L. and Ajala, S. O. (2001). On-Farm Evaluation of Performance of Selected Improved Maize Varieties in the Forest Zone of Central Cameroon. *Seventh Eastern Southern Africa Regional Maize Conference.* February 11th -15th, 2001. 432-437pp.

Bailey, D. K. (1998). *Methods of Social Research.* Macmillan Publishing, Inc. New York. 813pp.

Banker, R. D. and Johnston, H. (1994). Evaluating the Impact of Operating Strategies on Efficiency in the US Airline Industry. In: *Data Envelopment Analysis: Theory, Methodology and Application.* (Edited by Charnes, A., Cooper, W. W., Lewin, A. Y. and Seiford, L. M). Kluwer. pp. 97-128.

Banker, R. D., Charnes, A. and Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science* 30: 1078-1092.

Boehlje, M. and Eidman, V. R. (1984). *Farm Management.* John Wiley and Sons, Inc. New York. 806pp.

Blackie, M. J. (1995). Maize Productivity for the 21st Century: The African challenge. In: *Proceedings of the Fourth Eastern and Southern Africa Region Maize Conference.* (Edited by Jewell, D. C., Waddington, S. R., Ranson, J, K. and Pixley, K. V), 28th March-1st April 1994, Harare, Zimbabwe. 11-23pp.

Center for International Tropical Agriculture (CIAT) (2000). *Integrated Resource Management in Crop-Livestock Farming System of Sub-Sahara Africa.* A Research Proposal from the Soil, Water and Nutrient Management Program of the CGIAR. Submitted to: The Department for International Development (DFID)-UK. CIAT, Apartado Aero 6713, Cali, Columbia. 13pp.

Charnes, A., Cooper, W. W. and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research* 2(6): 429-444.

Chianu, J. N., Akini, A., Sanginga, P., Bationo, A., Chianu, J. and Sanginga, N. (2008). Structural Change in Fertilizer Procurement methods: Assessment of the Impact in Sub-Sahara Africa. *Journal of African Business Management* 2(3): 065-071.

Chiwele, D. K. and Sikanu, R. (2006). *Agricultural Development and Food Security in Sub-Sahara Africa: Building the Case for More Public Support: The Case of Zambia.* FAO, Working Paper 07. 94pp.

Coelli, T. J. (1995). Recent Developments in Frontier Modelling and Efficiency Measurements. *Australian Journal of Agricultural economics* 39(3): 219-245.

Coelli, T. J. (1996). *A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program.* Department of Econometrics, University of New England, CEPA Working Papers 96/08. Armidale NSW.2351. 50pp.

Coelli, T. J., Prasada, R. D. J., O'Donell, C. J. and Battese, G. (1998). *An Introduction to Efficiency and Productivity Analysis.* 2nd Edition. Springer Science+ Business Media, Inc. New York, NY10013, USA. 397pp.

Cooper, W. W., Seiford, L. M. and Zhu, J. (Eds.) (2004). *Handbook on Data Envelopment Analysis.* Kluwer Academic Publishers, Boston. USA. 608pp.

Dalton, T. J., Master, W. A. and Foster, K. A. (1997). Production Costs and Input Substitution in Zimbabwe's Smallholder Agriculture. *Agricultural Economics* 17(3): 201-209.

Ellis, F. (1993). *Peasant Economics: Farm Households and Agrarian Development.* Cambridge University Press, London. 332pp.

Färe, R., Grosskopf, S. and Lovell, C. A. K. (1985). *The Measurement of Efficiency of Production.* Kluwer, Nijhoff Publishers. 216pp.

Farrel, M. J. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistical Society* 20(3): 253-290.

Faruq, H. M. (2008). Economic Efficiency and Constraints of Maize Production in the Nothern Region of Bangladesh. *J. Innov. Dev. Strategy* 2(1): 18-32.

Ferguson, C. E. (1971). *The Neoclassical Theory of Production and Distribution.* Cambridge University Press, London. 383pp.

Food and Agricultural Organization (FAO) (1982). *The State of Food and Agriculture.* Rome, Italy. 203pp.

Food and Agricultural Organization (1997). *Farm Management for Asia: A System Approach.* FAO Farm Systems Management Series No. 13. [www.fao.org/docrep/w7365e/w7365e00.HTM] site visited on 14/09/2010.

Food and Agricultural Organization (2009). *Optimization of Resource Use Levels: Response Analysis.* [http://www.fao.org/docrep/w7365e/w7365e0b.html] site visited on 27/07/2009.

Fontaine, J. M. and Sindzingre, A. (1991). *Microeconomic Linkages: Structural Adjustment and Fertilizer Policy in Sub-Sahara Africa.* Organisation for Economic Cooperation and Development (OECD) Working Paper No. 49. Paris. 68pp.

Gadzirayi, C. T., Mutandwa, E. and Chikuvire, T, J. (2006). Effectiveness of Maize Cob Powder in Controlling Weevils in Stored Maize Grain. In: *African Quarterly.* 8 (4): 2006. [http://www.african.ufl.edu/asq/v8/v8i4al.htm] site visited on 27/07/2009.

Gómez-Limón, J. A., Riesgo. L. and Arriaza, M. (2004). Multi-Criteria Analysis of Input Use in Agriculture. *Journal of Agricultural Economics* 55(3): 541-564.

Greene, W. H. (1997). *Econometric Analysis*. Pearson Education, Inc. Upper Saddle River, New Jersey. 802pp.

Gul, M., Koc, B., Dagistan, E., Akpinar, M. G. and Parlakay, O. (2009). Determination of Technical Efficiency in Cotton Growing Farms in Turkey: A Case Study of Cukorova Region. *African Journal of Agricultural Research* 4(10): 944-949.

Haque, T. (2006). Resource Use Efficiency in Indian Agriculture: Article from: *Indian Journal of Agriculture* 61(1): 65-76.

Hawasii, F. G. H. (1997). The Effect of Fertilizer Subsidy Removal on Fertilizer Use and Production of Maize in Mbinga District. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 151pp.

Hayami, Y. and Ruttan, V. W. (1985). *Agricultural Development: An International Perspective*. Baltimore MD: John Hopkins University Press. 506pp.

Heisey, P. W. and Mwangi, W. (1996). *Fertilizer Use and Maize Production in Sub-Sahara Africa*. CIMMYT Economics Working Paper 96-01. CIMMYT, Mexico. 35pp.

International Fertilizer Development Centre (2000). *A Strategic Framework for African Agricultural Input Supply System Development*. Technical Bulletin IFDC-T-63. Muscle Shoals, Alabama, U.S.A. 38pp.

Isinika, A., Ashimogo G. and Mlangwa, J. (2003). Africa in Transition: Macro Study Tanzania. In: *Lesson from the Asian Green Revolution* (Edited by Djurteldt, G., Holmes, H. and Larsson, R.). CABI Publishing, Wallingford, UK. 288pp.

Javed, M. I., Adil, S. A., Ali, A. and Raza, M. A. (2010). Measurement of Technical Efficiency of Rice-Wheat System in Punjup, Pakistan using DEA Technique. *Journal of Agricultural Resource* 48(2): 227-238.

Kadigi, R. (2009). *Production Economics Lecture Notes*. Depertment of Agricultural Economics and Agribussiness. Sokoine University of Agriculture, Morogoro, Tanzania.

Kaliba, A. R. M., Verkuijl, H. and Mwangi, W. (2000). Factors Affecting Adoption of Improved Maize Seeds and use of Inorganic Fertilizers for Maize Production in the Intermediate and Lowaland Zones of Tanzania. *Journal of Agricultural and Applied Economics* 32(1): 35-47.

Kebede, Y., Coffin, G. and Eisemon, T. (1993). Production Efficiency in Peasant Agriculture: The Case of Mixed Farming System in the Ethiopian Highland. MPRA Paper No. 406. [http://mpra.ub.un:-muenchen.de/406] site visited on 23/06/2010.

Kelly, V., Adesina, A. A. and Gordon, A. (2003). Expanding Access to Agricultural Inputs in Africa: A Review of Recent Development Experience. *Food Policy* 28 (2003): 379-404.

Kherallah, M., Delgaldo, C., Gabre-Madhin, E., Minot, N. and Johnson, M. (2000). *The Road Half Travelled: Agricultural Market Reform in Sub-Sahara Africa.* Food Policy Report. IFPRI, Washington, DC. 25pp.

Kibaara, B. W. (2005). Technical Efficiency in Kenyan's Maize Production: An Application of the Stochastic Frontier Approach. Dissertation for Award of MSc Degree at Colorado State University, USA. 84pp.

Kim, J. M. (2001). Efficiency Analysis of Sustainable and Conventional Farms in the Republic of Korea with Special Reference to the Data Envelopment Analysis (DEA). *Journal of Sustainable Agriculture* 18(4): 9-26.

Koutsoyiannis, A. (1979). *Modern Microecomics.* Macmillan Education, London. 581pp.

Linde-Rahr, M. (2005). Differences in Agricultural Returns: An Empirical Test of Efficiency in Factor Input Allocation using Vietnamese Data. *Agricultural Economics* 32(2005): 35-45.

Loikkanen, H. A. (2002). An Evaluation of Economic Efficiency of Finnish Regions by DEA and Tobit Models. *A Paper Prepared for the 42nd Congress of the European Region Science Association,* August 27th-31st, 2002, Dortmund, German,

Mlambiti, M. E. (1994). *Introduction to Rural Economy for East African Students.* Mzumbe Book Project, Morogoro, Tanzania . 167pp.

Morris, M., Kelly, V. A., Kopicki, R. J. and Byerlee, D. (2007). *Fertilizer use in African Agriculture: Lessons Learned and Good Practices Guidelines.* The World Bank, 1818 H Street, NW Washington, D.C. 144pp.

Msuya, E. E., Hisano, S. and Nairu, T. (2008). Explaining Productivity Variation among Smallholder Maize Farmers in Tanzania. In: *World Congress of Rural Sociology Association.* Goyang, Korea. 31pp.

Mushtaq, S., Hafeez, M. and Khair, S. M. (2007). Determination of Optimal Input usage into the Wheat Production for Kareze Irrigation in the Balochistan, Pakistan. *Asian Journal of Plant Science* 6(5):809-814.

Mwakalobo, A. B. S. (1998). Impact of Structural Adjustment Policies on Smallholder Farming Systems in Mbeya Region: A Case of Mbozi and Rungwe Districts. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 165pp.

Nguruse, G. D. (2007). Supply Chain Analysis for Agricultural Inputs in Tanzania: A Case of Subsidized Fertilizer in the Southern Highland. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 95pp.

Oluwatayo, I. B., Sekumande, A. B. and Adesoji, S. A. (2008). Resource Use Efficiency of Maize Farmers in Rural Nigeria: Evidence from Ekiti State. *World Journal of Agricultural Sciences* 4(1): 91-99.

Philip, H. D. (2007). An Exploration of the Potential of Producing Biofuels and the Prospective Influence of Biofuel Production on Poverty Alleviation among Small-Scale Farmers in Tanzania. . A Published PhD Thesis. Zentrum für Entwicklungs for Schungrheinische Friedrich-Wilhelms-Universität Bonn. 174pp.

Rasmussen, T. (1989). *The Economy of a Green Revolution in the Southern Highland of Tanzania.* Centre for Development Research, Ny Kongensgade 9, DK-1472 Copenhagen K Denmark. CDR Project Papers A. 87(3). 97pp.

Ray, S. C. and Badhra, D. (1993). Nonparametric Test of Cost Minimization Behaviour: A Study of Indian Farms. *American Journal of Agricultural Economics* 75(1993): 990-999.

Research and Analysis Working Group (R&AWG) (2007). *Poverty and Human Development Report.* Mkuki and Nyota Publishers, Dar es Salaam. 116pp.

Ricker-Gilbert, J. and Jayne, T. S. (2008). The Impact of Fertilizer Subsidies on National Fertilizer Use: An Example from Malawi. *Selected Paper Prepared for Presentation at the American Agricultural Economics Association Annual Meeting.* Orlando, FL, July 27- 29, 2008. 23pp.

Sadoulet, E. and De Janvry, A. (1995). *Quantitative Development Policy Analysis.* Baltimore MD: Johns Hopkins, University Press. 397pp.

Sanchez, P. A., Shepherd, K. D., Soule, J. M., Place, F. M., Buresh, R. J., Izac, A. N., Mokwunye, U., Kwesiga, F. R., Ndiritu, C. G. and Woomer, P. L. (1997). Soil Fertility Replenishment in Africa: An Investment in Natural Resource Capital. Replenishing Soil Fertility in Africa. Madison, WI. *Soil Science Society of America* 1 - 46.

Sibuga, K. P., Tarimo, A.J.P. and Senkondo, F. J. (1998). *Preliminary Results on Bambara Groundnut (Vigna substance (L) Verdic) Research.* Proceedings of the Second Faculty of Agriculture Annual Research Conference held at ICE Sokoine University of Agriculture Morogoro, Tanzania, 25 – 27 September, 1996. 1-19pp.

Singh, J., Hone, P. and Kundu, K. K. (2002). Measuring Inefficiency in Crop Production on Degraded Lands. *Indian Journal of Agricultural Economics* 57(1): 65-76.

Tulahi, C. and Hingi, P. M. (2006). Agrarian Reform and Rural Development in Tanzania. *A Country Report Presented at the Conference on Agrarian Reform and Rural Development.* Porto Alegre, Brazil. 6pp. [http://www.icard.org/en/icard_doc_down/national_Tanzania_doc.] site visited on 23/06/2010.

Turuka, F. M. (1995). Price Reform and Fertilizer Use in Smallholder Agriculture. A Published PhD Thesis. Studien Zur Landlinchen Entwcklung; Lit Verlag Munster-Humburg. 288pp.

United Republic of Tanzania (URT) (2002). *Population and Housing Census General Report.* National Bureau of Statistics. Dar-es-salaam, Tanzania. 193pp.

United Republic of Tanzania (2003). *Collection of Official Statistics in Tanzania.* Government Printers Press, Dar-es-salaam, Tanzania. 81pp.

United Republic of Tanzania (2007a). *Iringa Region Socio-economic Profile.* The Planning Commission and Regional Commissioner's Office. Government Printer Press. Dar es Salaam, Tanzania. 179pp.

United Republic of Tanzania (2007b). *Rukwa Region Socio-economic Profile.* The Planning Commission and Regional Commissioner's Office. Government Printer Press. Dar es Salaam, Tanzania. 195pp.

United Republic of Tanzania (2008). *Input Study Report.* Government Printers Press, Dar-es-salaam, Tanzania. 49pp.

United Republic of Tanzania (2009). *Official Statistics in Tanzania.* [www.nbs.go.tz] site visited on 13/06/2010.

Xu, Z., Govereh, J., Black, J. R. and Jayne, T. S. (2006). Maize Yield Response to Fertilizer and Profitability of Fertilizer Use among Small-Scale Maize Producers in Zambia. *Contributed Paper Prepared for Presentation at the International Association of Agricultural Economists Conference.* Gold Cost, Australia, August 12-18, 2006. 14pp.

APPENDIX

Appendix 1: Farmers' Questionnaire

Efficiency Use of inputs for Maize Production: A Case of Smallholders in Iringa Region

A. Household characteristics

1. Full name of household head…..............................Age……………
2. Gender of the household head
   1= Male ( )
   2=Female ( )
3. Household head marital status
   1= Single ( )
   2= Married ( )
   3=Divorced ( )
   4= Widower ( )
   5= Temporary separated ( )
4. Household head level of education
   1=No formal education ( )
   2= Adult education ( )
   3= Primary education ( )
   4= Secondary education ( )
   5= Other ( )

5. Household composition

Age category (Years)	Sex (Gender)	
	Males	Females
0-9		
10-14		
15-65		
Above 65		

6. Household head experience in maize farming (years)…………………..

B. Crop Production Information

7. Farm size in 2008/09 season
a) Land owned: ………………..acres
b) Land rented out: ……………..acres
c) Land rented in: ………………acres
d) Land borrowed: ……………..acres
e) Total available land: …………..acres
8. Area of:
a) Cultivated land in 2008/09 season………………acres
b) Fallow land………………..acres
c) Pasture land………………..acres

d) Land under trees.............acres

9. Which crops do you normally grow?

   1=Maize (   )
   2=Beans (   )
   3=Wheat (   )
   4=Sweet potato (   )
   5=Round potato (   )
   6=Cassava (   )
   7=Groundnut (   )
   8=Sunflower (   )
   9=Coffee (   )
   10=Others (specify) (   )..

10. In 2008/09 cropping season did you grew maize

   1= Yes (   )
   2=No (   )

11. If you grew maize, what was the total area allocated to maize production................acres.

12. Do you set any yield target to be attained given the available inputs in your maize production?

   1=Yes (   )
   2=No (   )

13. If the answer is yes, then what was the maize yield target and actual yield obtained from the set of inputs used in 2008/09 season?

Projection	**Bags**	**Tins/bag**	**Average weight/tin (Kg)**	**Total weight (Kg)**
Target yield				
Actual yield				
Difference				

14 If the answer is no, why not?

   1= Lack of knowledge on setting targets (   )
   2= Targets are not so necessary (   )
   3= No idea (   )
   4= Other (specify (   )

15. Given the set of input used in 2008/09 season, do you think that your maize yield target was attained?

   1=Yes (   )
   2= No (   )

16. If the answer is no, what were the reasons contributed for not achieving the target?

   1= Unreliable weather (   )
   2= Pests and disease attack (   )
   3= Low soil fertility (   )

4= Low input use ( )
5= Shortage of hired labor ( )
6= Not sure ( )
7= Other (specify) ( )..

C. Labour and Other Input Use Information

C₁. Labor Use

17. What is your main source of labour used in maize production?
1=Family labour ( )
2=Exchange labour ( )
3=Hired labour ( )
4=Both ( )

18. For the total maize acres cultivated in 2008/09 season, how much family labour and exchange labour did you use for the following activities?

Activity	**Family labour**			**Exchange labour**			**Total (Man-days)**
	Persons	**Days**	**Man-days**	**Persons**	**Days**	**Man-days**	
Land clearance							
Basal fertilization							
Planting							
Weeding 1							
Top dressing 1							
Weeding 2							
Top dressing 2							
Pesticides spraying							
Harvesting							
Transportation							
Others							
Total							

19. If hired labour was used in 2008/09 season, for the total maize acres cultivated, indicate the cost incurred for the following activities.

Activity	**Hired labour used**			**Unit cost**	**Total cost**
	Persons	**Days**	**Total Man-days**		
Land clearance					
Basal fertilization					
Planting					
Weeding 1					

Top dressing 1					
Weeding 2					
Top dressing 2					
Pesticides spraying					
Harvesting					
Transportation					
Others					
Total					

C_2. Other Input Use

20. What other expenses (apart from labour) did you incur in producing maize in 2008/09 season? (Cost for tractor/plough hire, harvest transport, sprayers hires etc.)

Operation	**Requirement**			**Unit cost**	**Total cost**
	Quantity	**Acres/trip/days**	**Total**		
Tractor hire					
Plough hire					
Sprayer hire					
Transporting					
Other					
Total					

21. Did you purchase fertilizers or any other agrochemicals in 2008/09 growing season?
    1 = Yes ( )
    2 = No ( )
22. If the answer is yes, then where did you buy those inputs?
    1 = Input suppliers within the village/ward ( )
    2 = Input suppliers in Njombe town ( )
    3= Input suppliers in Ludewa town ( )
    4 = Farmers' associations ( )
    5 = Other (specify) ( )..
23. If the answer is no, then what were the reasons for not buying those inputs?
    1 = Not available ( )
    2 = High prices ( )
    3 = Not necessary ( )
    4 = Other (specify) ( )..
24. If you purchased inputs, which ones were specifically for maize production in 2008/09 growing season?
    1= Urea fertilizer ( )
    2= SA fertilizer ( )
    3= CAN fertilizer ( )
    4= DAP fertilizer ( )
    5= Minjingu fertilizer ( )
    3=Seeds ( )
    4=Pesticides ( )

5=Other (specify) ( )..

25. Indicate the quantities and the respective prices for the **non-subsidy** inputs you purchased for maize production in 2008/09 season.

Inputs	**Quantity**	**Unit price**	**Total cost**
Urea (50 Kg bag)			
SA (50 Kg bag)			
CAN (50 Kg bag)			
DAP (50 Kg bag)			
Minjingu (50 Kg bag)			
Farm Yard Manure (Kg)			
Seeds(5kg bag)			
Seeds(2kg bag)			
Pesticides (Mls)			
Other			
Total			

26. Does your decision to use inputs guided by any technical advice?
 1=Yes ( )
 2= No ( )
27. If yes, then, from which source your decision to use the given amount of inputs is based?
 1= Extension service ( )
 2= Research station ( )
 3= Indigenous knowledge ( )
 4= Input suppliers ( )
 5= NGO's ( )
 6= Others (Specify) ( )..
28. If no, why not?
 1= No technical advice provided ( )
 2= I trust my own experience ( )
 3= Not sure ( )
 4= Other (specify) ( )..
29. If your decision to use inputs is based from any of the sources mentioned above, is there any recommended rate from that source?
 1= Yes ( )
 2= No ( )

30. If the answer is yes, then what is the recommended rate of input use for maize production in 1 acre piece of land?

Input	**Quantity**
Urea (50 Kg bag)	
SA (50 Kg bag)	
CAN (50 Kg bag)	
DAP (50 Kg bag)	
Minjingu (50 Kg bag)	
Farm Yard Manure (Kg)	
Seeds(5kg bag)	

Seeds(2kg bag)	
Pesticides (Mls)	
Other (Specify)	

31. Which factors do you think affect greatly your extent of input use in maize production?
   1= High input prices ( )
   2= Lack of capital to purchase inputs ( )
   3= Unreliable input supply ( )
   4= Unstable output prices ( )
   5= Unreliable produce market ( )
   6= Other (specify) ( )..

D. Household Income

D_1. Income from Farming Activities

32. Out of the various crops produced, which ones did you sell? Provide amounts and average prices for the 2008/09 season.

No	Crop sold	Quantity sold					
		Qty	Unit	Price/unit	Income (Shilling)	Month sold	Where/to whom sold
1	Maize						
2	Common bean						
3	Wheat						
4	Sweet potato						
5	Round potato						
6	Cassava						
7	Groundnut						
8	Sunflower						
9	Yam						
10	Sesame						
11	Onion						
12	Tomato						
13	Leafy vegetable						
14	Avocado						
15	Banana						
16	Pears						
17	Mango						
18	Peas						
19	Egg plant						
20	Barley						
21	Coffee						
22	Pyrethrum						
23	Tea						
24	Other (specify)						
Total							

D₂. Income from Off-Farm Activities

33. Apart from crop farming activities, what other activities bring income into your household? And how much did you get from those activities in season 2008/2009?

Source of Income	Average Monthly Income	Total average Annual Income
Formal employment		
Carpentry		
Masonry		
Milling machine		
Shop		
Butchery		
Selling livestock (eg. chicken, pigs, cow etc)		
Selling livestock products (eg. Milk, skins etc)		
Selling Charcoal/firewood		
Brick making		
Brewing and selling local brew		
Lumbering		
Selling labour		
Other (specify)		
Total		

E. Marketing Information

34. Did you harvest maize this year (2009)?
 1=Yes ( )
 2= Not yet ( )
35. If yes did you sell some of the harvest?
 1=Yes ( )
 2= Not yet ( )
36. If yes, where did you sell your maize produce?
 1= Local traders ( )
 2= Middlemen outside from the village ( )
 3= National Food Reserve Agency (NFRA) ( )
 4= Other (specify) ( )..
37. If not yet, what do you wait for?
 1= Price increase ( )
 2= I produced for family consumption only ( )
 3= Other (specify) ( )..
38. What factors do you consider when you decide to sell your maize produce
 1= Price offered ( )
 2= Household cash needs ( )
 3=Other (specify) ( )..

39. What is the price trend of maize produce for the last three years?
 1= Stable ( )
 2= Fluctuating ( )

40. If stable, what is your future plan related to this?
    1= Allocated more land for maize ( )
    2= Increase input consumption ( )
    3= Other (specify)………………………………………………………..
41. If fluctuating, what is your planned intervention?
    1= Store until price increases ( )
    3= Reduce input consumption ( )
    2= Produce for family consumption only ( )
    2=Allocate less land for maize ( )
    4= Other (specify) ( )………………………………………………………
42. Does your location make it easier for customers get your maize produce?
    1= Yes ( )
    2= No ( )
43. If yes, why?
    1= Presence of well maintained feeder roads ( )
    2= Near to the main road and market place ( )
    3= Other (specify) ( )………………………………………………………
44. If no, why?
    1= Feeder roads are poorly maintained ( )
    2= Far from the main road and market place ( )
    3= Other (specify) ( )…………………………………………….

45. Indicate any other problems that you think affect marketing of your maize produce.
    1= Low price offered ( )
    2= Lack of transport ( )
    3= Low maize demand ( )
    4= Government restrictions ( )
    5= Other (specify) ( )………………………………………………………

F. Extension Service Information

46. Do you know anything about extension services? '
    1 = Yes ( )
    2 = No ( )

47. If yes, what is the role of extension agent(s) in your area?
    1= Advising farmers on improvement of crops and livestock ( )
    1=Conducting training to farmers eg. FFS ( )
    2=Conducting field inspections ( )
    3= Establishing demonstration plots ( )
    4= Other (specify)…………………………………………………….

48. If the answer is no, why not?
    1= No extension agent in our area ( )
    2= Extension agent is far from our village ( )
    3= No proper advice is given ( )

49. Do you bother to seek the services offered by extension agent in your area?
    1 = Yes ( )
    2 = No ( )

50. If yes, what kind of improvement have you made out of his/her advice in relation to maize production?

1 = Adopted input use recommendations ( )
2 = Increased output ( )
3= Allocated more land and labour for maize ( )
4= Other (specify) ( )

51. If no, why not?

1= I have enough experience in maize farming ( )
2= I need advise in Livestock only ( )
3= S(he) is not competent enough ( )
4= Not sure ( )
5= Other (specify) ( )..

52. Do you have anything else to tell us about improving extension services in your area and country in general?..

THANK YOU VERY MUCH FOR YOUR COOPERATION!