# FARM SIZE AND PRODUCTIVE EFFICIENCY: LESSONS FROM MBINGA COFFEE FARMERS

BY

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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.

SNAL
DATE 7/4/2014
OFFICIAL COLLECTION

2013

## ABSTRACT

Productive efficiency measurement is very important both in developed and developing countries' agriculture and its roles are widely recognized by farmers, researchers and policy makers. This study attempts not only to investigate the farm size and productivity relationship debate, which has not gone through a complete circle in Tanzania, but also to find out whether inefficient resource use by farmers is a problem. Both technical and allocative efficiency were used to analyse productive efficiency. In this study, a direct measure of production efficiency of Mbinga coffee farmers using a stochastic profit frontier and inefficiency effects model was employed. The findings show that there are high levels of inefficiencies in Mbinga coffee production. The mean level of profit efficiency is 52.4% which implied that an estimated 47.6% of the profit is lost due to a combination of both technical and allocative inefficiency in coffee production. Farmers are losing about TAS 787 696 per mean index of coffee trees due to this inefficiency. Moreover, it was also revealed that, it would be more profitable if farmers increased their farm sizes from 501 to 1500 coffee trees. This would help to alleviate poverty through increased farm profit. The efficiency differences were explained largely by the household size, farmer's experience, age of coffee trees, the education level, extension services, level of capital, and time used by a farmer to move from one coffee farm to another. It is concluded that very small and small size farms are associated with more profit-loss compared to medium size farms. It is recommended that farmers should increase their farm sizes at least to medium farm sizes of more than 1 262 coffee trees in order to increase coffee farm efficiency. Potential stakeholders should put in place initiatives which will create conducive environment for improving efficiency and profitability in coffee production business.

## DECLARATION

I, **LUTENGANO MWINUKA**, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is the result of my own original work and has neither been submitted nor being concurrently submitted for a higher degree award in any other university.

26/07/2013

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## ACKNOWLEDGMENTS

I am grateful to various people and institutions, who and which contributed in one way or another towards the successful completion of this study. I am in particular indebted to my supervisors Dr. Damas Philip and Prof. Andrew E. Temu of the Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture (SUA) for their tireless guidance and constructive criticisms during the whole period of my study. My appreciation is also extended to Sokoine University of Agriculture, Department of Agricultural Economics and Agribusiness, in which the degree program was undertaken. I am also very grateful to my employer the University of Dodoma (UDOM) for enabling me to pursue this program.

Moreover, my sincere gratitude is due to the staff and all workers of the Economic and Social Research Foundation (ESRF), Mbinga coffee farmers, and TechnoServe Mbinga Branch, for their assistance during the time of data collection and Internship. I would specifically like to acknowledge Mr. Festo Maro (COSTECH Senior Researcher), Mr. John Mwakisimba, and Mr. Wendo Sudayi (TechnoServe Business Advisors at Agronomy Department) for their tireless efforts during the data collection process and report preparation. I would also like to thank Mr. Privat Djana B. Mignouna (a PhD student at SUA then) for his assistance during data analysis and particularly on the use of the FRONTIER version 4.1 software. However, I remain solely responsible for any errors and emissions found in this report.

## DEDICATION

This work is dedicated to my beloved parents: Mr. and Mrs. Edward Mwinuka for their care and great support during my education to this far. It is also dedicated to the best friend of mine Catherine G. Kijumbe and family of Uncle Valentino. May the Almighty God bless them Amen.

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## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| ACT | Agricultural Council of Tanzania |
| ADB | African Development Bank |
| BoT | Bank of Tanzania |
| CA | Covariance Analysis |
| C-D | Cobb-Douglas |
| COLS | Corrected Ordinary Least Squares |
| COSTECH | Commission for Science and Technology |
| DALDO | District Agriculture and Livestock Development Officer |
| DD | Profit Frontier of Farms |
| DEA | Data Envelopment Analysis |
| ESRF | Economic and Social Research Foundation |
| FAO | Food and Agriculture Organisation of the United Nations |
| FBG | Farmers Business Groups |
| GM | Gross Margin |
| IACO | Inter-African Coffee Organisation |
| ICO | International Coffee Organisation |
| ICRA | International Centre for Development Oriented Research in Agriculture |
| Ha | Hectare |
| kg | Kilogram |
| L-Y | Lau-Yotopolous |
| MLE | Maximum Likelihood Estimation |

| | |
|---|---|
| MOA | Ministry of Agriculture |
| MVP | Marginal Value Product |
| NGO | Non-Governmental Organisation |
| OLS | Ordinary Least of Square |
| SAP | Structural Adjustment Program |
| SG | Sasakawa Global 2000 |
| SSA | Sub-Saharan Africa |
| SUA | Sokoine University of Agriculture |
| TACRI | Tanzania Coffee Research Institute |
| TAS | Tanzanian Shillings |
| TCB | Tanzania Coffee Board |
| TE/PE | Technical Efficiency/Profit Efficiency |
| TR | Total Revenue |
| TVC | Total Variable Costs |
| UCDA | Uganda Coffee Development Authority |
| UDOM | University of Dodoma |
| URT | United Republic of Tanzania |
| USD | United State Dollars |

# CHAPTER ONE

# INTRODUCTION

## 1.1 General Overview

Currently, agriculture is again a major item on the economic development agenda for Sub-Saharan Africa (SSA), although there remains considerable doubts in the international development community as to whether it can successfully generate sufficient growth in Africa (Maxwell and Slater, 2003; Collier, 2005; Ellis 2005). The lack of absolute evidence regarding the existence of economies of scale and required productive efficiency in agriculture in developing countries has made decisions on where to focus agriculture development difficult (Maxwell, 2004).

After World War II, the consensus was that small farms exhibited the highest productivity while physical output and labour investment decreased with increasing farm size. This assumption corresponded with some empirical findings (Kuhnen, 2010). According to Shenggen and Connie (2005) small farms were regarded as being efficient in the 1960s because they could fully use their resources. In this regard, the farm size and productivity occupied a prominent position in the agriculture economics literature in the late 1960s. Conversely, there was a call for larger farms in the 1970s and 1980s. However, in the 1990s "the small is beautiful" view was once again revived (Kausar, 2008).

Increasing agricultural productivity and employment in SSA countries has received widespread attention in the literature on economic development and poverty alleviation. Agricultural growth on the other hand, is linked to farm profits. Over the past years, considerable research has examined efficiency in agriculture in the region (Mock, 1973; Hopcraft, 1974; Lipton, 1988).

In many parts of SSA, agriculture remains at the core of rural livelihoods and has a major influence on livelihood outcomes. Land is one of the most crucial inputs in the agricultural production process for a majority of rural households. Thus, factors that reduce the rural households' access to land significantly affect agricultural productivity, thereby compromising the households' livelihood. Available evidence shows that shortage of arable land is one of the main challenges facing many farm households in SSA (Reardon *et al.*, 1996).

Moreover, the problem of scarcity of arable land in many parts of the continent has been exacerbated by countries' high population growth rates and the accompanying increase in demand for food (Binswanger and Pingali, 1988). In addition, because of the lack of alternative investments and employment opportunities in the non–farm sector, land has become a major source of investment as well as employment for the burgeoning rural population, with a resultant decline in the average land holding size.
On the other hand, households that have easier access to input and financial markets and produce high quality commodities might increase their efficiency by using the best production practices, thus exploiting their comparative advantage (Cardenas *et al.*,

2004). In addition, their reliance on subsistence cropping may diversify towards commercially-oriented crops driven by the market demand.

## 1.2 Coffee Production and Tanzanian Agriculture

As a biggest component in the country's economy, the agriculture sector in Tanzania and its performance still has a significant impact on output and corresponding income and poverty level (ACT, 2010; Parrish, 2005). At best, most people in rural areas are just poor and the performance of this sector is not as good as it should be since more than a third of the population live below the poverty line.

Despite the Structural Adjustment Program (SAP) and economic liberalization policies that were introduced in 1986 which have caused coffee production to decline in different regions (Ikeno, 2007), these policy changes have important implications for farmers, as they directly affect their welfare. How farmers adapt to these changes, and how they ensure a better crop production, are ultimately dependent on the efficient use of production resources on the farm as well as in the adoption of better strategies in resource use in coping with the changes (Amara, *et al.*, 1999).

In Tanzania, coffee production and export remains to be a major contributor to Tanzania's economy. Conversely, coffee is yielding about 250Kgs to 300Kgs per hectare far below the average yield attained in other places such as Uganda, Asia and Latin America (TACRI, 2008 and UCDA, 2007). This is extremely low compared to the potential output of 1 250 kg/ha as noted by Mwakalobo (2000). However, the declining coffee production (Fig. 1) and export from Africa has been such that coffee export volume decreased by more than 50% from 31.5% to 10.5% by the year 1977 and 2008 respectively.

A recent report by the Tanzania Coffee Board (TCB) recommends that the country should increase her coffee cultivation land area to 300 000 hectares in total from the current 250 000 in an attempt to revive and boost productivity. Currently, Tanzania produces an average of 45 000 tons of coffee per annum which is a drastic drop from close to 55 000 tons that the country used to produce in the 1980s (TACRI, 2008 and TCB, 2009).

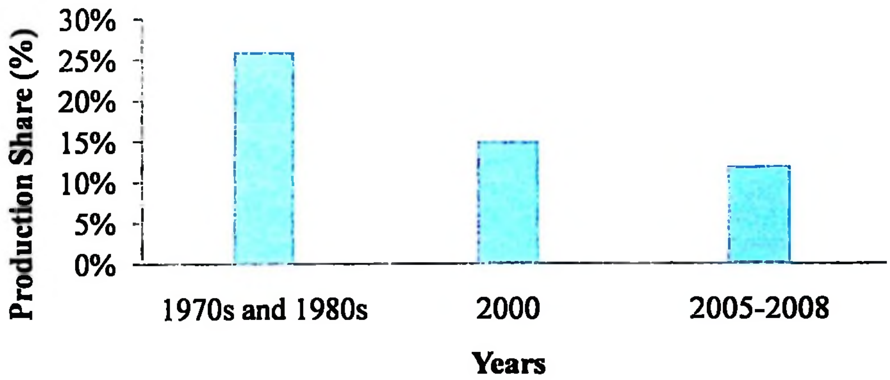



**Figure 1: Africa coffee production share in the world**

**Source:** IACO (2011)

Accordingly, inefficient use of inputs could be the probable reason for the poor yield of Tanzania's coffee. Furthermore, farms which have high productive efficiency provide opportunities for farmers to produce more farm income (Havnevik, 2009; Ojo *et al.*, 2009). Consequently, the measurement of productive efficiency has important implications for both economic theory and economic policy (Farrel, 1957). Measuring productive efficiency allows one to test competing hypotheses regarding sources of efficiency or differentials in productivity (Farrell, 1957; Lovell, 1993). Thus, this study strived to show the relationship between farm size and productive efficiency among Mbinga coffee farmers.

### 1.3 Problem Statement and Justification

The old debate on the relationship between farm size and productivity has been revived and productivity and inputs efficiency of large and small farms are still debatable (Kuhnen, 2010 and Kausar, 2008). The debate on the relationship between farm size and productivity in Tanzania has not gone through a complete circle. According to Shenggen and Connie (2005), literature has failed to provide consensus on whether there exists an inverse relationship between farm size and productivity. Currently, there is an undoubtful consensus on the need for increasing agricultural output and improving nutritional standards (Oyewo *et al.*, 2009). However, whether and how small farms which characterize Tanzania's agriculture can survive under globalization is a hot debated.

This study was an attempt to contribute to this debate and find out whether inefficient resource use was a problem. It was anticipated that the findings would shed light on matters of production inefficiencies and their impact on productive efficiency of coffee farmers under analysis. In this regard, the focus was at farm level where an assessment of coffee farms productivity was done. The assessment included how to improve it;

identify inefficiency subsist and factors affecting productivity change with a focus on farm size; efficiency and profitability.

Furthermore, productive efficiency measurement is very important both in developed and developing agriculture. Its role in increasing agricultural output is widely recognized by researchers and policy makers; this has been revealed by studies such as those by, Bravo-Ureta and Evenson (1994). The relevance of efficiency in increasing agricultural production has been widely recognized and variously investigated by researchers such as Bravo-Ureta (1993); Ashok *et al.* (1995); Seyoum (1998); Abay *et al.* (2004); Chavas *et al.* (2005).

### 1.4 Objectives of the Study

#### 1.4.1 General Objective

To assess coffee farms productivity and the relationship between farm size and productivity.

#### 1.4.2 Specific Objectives

i. To estimate coffee production efficiency among Mbinga small scale coffee farmers.
ii. To assess the determinants of productive/profit efficiency among the coffee farmers.
iii. To determine the impact of farm size on coffee farms' productivity
iv. To examine how coffee production can pull smallholder farmers out of poverty.

## 1.5 Hypotheses of the Study

**Null Hypothesis (Ho)**

H1: There is no significant relationship under farm size and coffee productivity

H2: Coffee production cannot generate significant income to reduce poverty among farmers' communities.

H3: Coffee farmers do not produce and allocate inputs efficiently.

## 1.6 Organization of the Study

Chapter two begins with a discussion of the concept of economic efficiency. The rest of the chapter covers issues concerning model development, and factors associated with measurement of economic inefficiency. The chapter concludes with a review of recent empirical studies pertaining of measuring allocative and technical efficiency.

Chapter three provides a detailed presentation of the methodology adopted for this study. This includes the empirical model used in the study and data sources. Both descriptive and econometric results and findings of this study have been discussed in chapter four. The chapter is divided into a number of sections which include structure of coffee production, profit efficiency and distribution, profit-loss estimation, coffee farm sizes and their distribution, profit trend and farm size relationship, contribution of coffee production to the livelihood of farmers and poverty reduction, and alternative crops grown while conclusions and recommendations are presented in chapter five.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Coffee Production

### 2.1.1 Coffee Production Status in the World

Based on the International Coffee Organization (ICO) data of 2011, coffee is produced in more than 65 countries of which three of them i.e. account for more than half of the world's production, namely: Brazil, Vietnam and Colombia. Exporting members of the ICO are responsible for over 97% of world output. Brazil is the major producer of coffee in the world with an average share of 32.8% of total world's production for 2005 to 2010 periods. In the same period, Vietnam and Colombia are countries which are next in terms of production capacity. Whereby, they have been contributing 14.0% and 8.6% of total coffee produced in the world respectively. According to TCB and TACRI (2010), the large market share of these countries is explained by corresponding low costs of production which have been historically revealed hence they enjoyed a competitive advantage over African nations. Generally, coffee production in the world has been increasing overtime (Fig. 2). However, slight fluctuations were revealed in some years. Arabica coffee, the fine-flavoured, aromatic type makes up 60-65% of the total production and usually fetches the highest prices. The other variety, Robusta, is easier to produce and is more resistant to diseases. Around 75% of all coffee produced in the World is exported. Only Brazil and Ethiopia enjoy high domestic consumption.

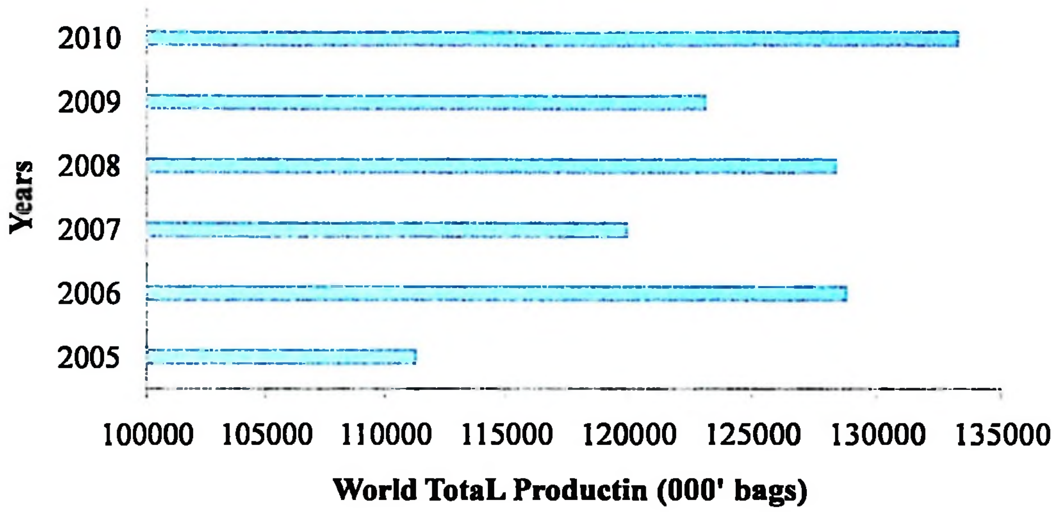



**Figure 2: World annual coffee produced 2005-2010 (000' bags)**

**Source**: ICO (2011)

### 2.1.2 Africa's Coffee Production Performance

According to the African Development Bank (ADB) Group report (2010), coffee producers in Africa accounted for about 12% of the global supply and less than 11% of global exports of the product for the 2009/10 season. Comparatively, these contributions to the global coffee market are almost equal to one country's contribution: Colombia, which is the third largest world producer of the commodity (ICO, 2011). Despite the small contribution of African countries to the global coffee market, the commodity constitutes a large proportion of both GDP and exports share in some of the continent's small economies. For example, Fig. 3 shows that the average share of coffee exports in total export earnings, in Burundi, Ethiopia, Rwanda and Tanzania, coffee exports generated about 59%, 33% , 27%, and 5% respectively, in export revenue in 2009/10

(TCB and TACRI, 2010; ICO, 2011). Particularly notable, coffee production is predominantly undertaken by small scale farmers in most African countries including Tanzania. Conversely, in 2010 total coffee sector employment was estimated at about 26 million people in 52 coffee producing countries. Thus, global coffee market conditions have important implications for growth and poverty reduction in any coffee growing country.

For many countries, coffee exports are not only a vital contributor to foreign exchange earnings but also account for a significant proportion of tax income and gross domestic product (Fig. 3). For seven countries, the average share of coffee exports to total export earnings exceeded 10 percent in the period 2000 to 2010. However the importance of coffee for many countries is diminishing over time as their economies diversify. This can be demonstrated by the fact that during the period 1996 to 2000, there were 15 countries which fell into this category, such as the average share of coffee exports in their total export earnings exceeded 10 percent (ICO, 2011). According to the ICO projections (2011), African coffee production is projected to fall by 17.8% in 2011 and 2012 in the face of drought conditions. The largest decline was expected in Ethiopia, which has been the most severely affected by drought. On the other hand, coffee production in East Africa is also expected to be hit by an increased incidence of pest infestation.

In East African countries, coffee is also one of the major exports mainly Burundi (Figure 3). Uganda chiefly produces Robusta, but Kenya, Tanzania, Burundi and Rwanda sell mostly Arabica coffee. However, Tanzania's farmers are also producing part of the Robusta variety.

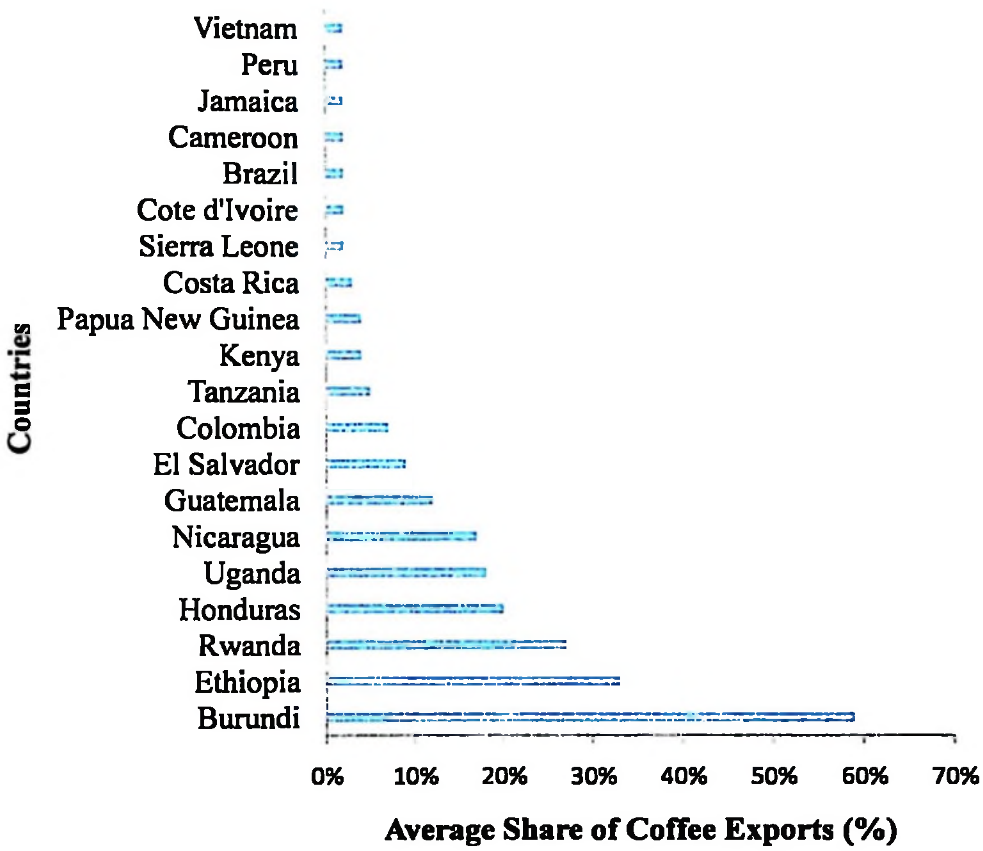



**Figure 3: Average share of coffee exports in total export earnings**

**Source:** ICO (2011)

Fig. 4 presents East African countries' coffee production levels for the 2005 to 2010 periods. According to five years ICO data, total production of these countries has been slightly fluctuating over time. However, individual country average growth rate of production is positive in these periods. Conversely, most countries experienced a negative growth rate for 2007 and 2009 except Uganda and Kenya respectively.

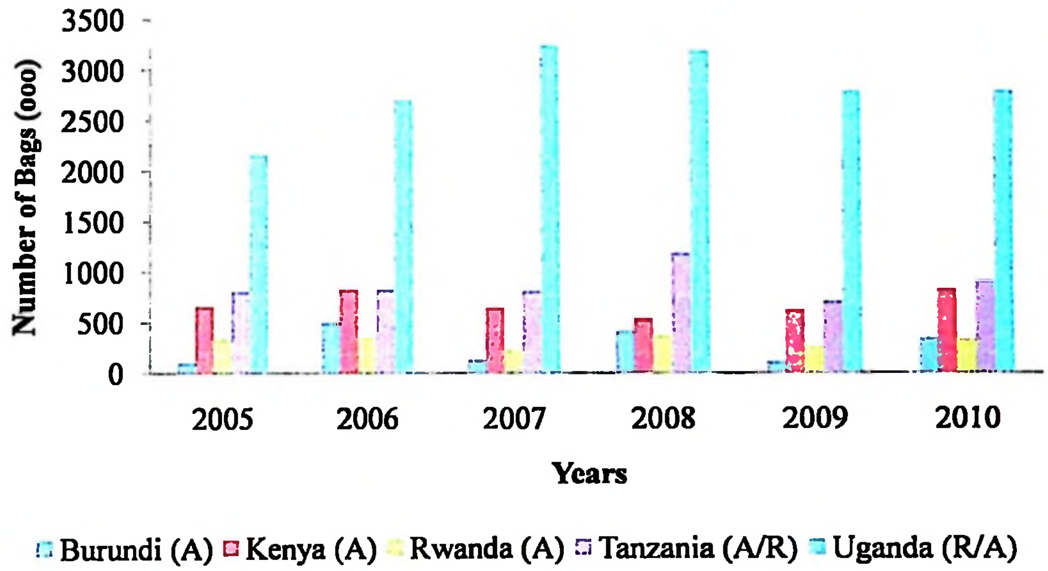



**Figure 4: East African countries coffee production levels**

**Source:** ICO (2011)

Note: (A) represent Arabica and (R) represent Robusta coffee varieties.

Based on data given in Fig. 4, Burundi has had the highest average growth rate of 131.6% in the five year period compared to other East African countries. Its production level has been increased more than twice in 2006, 2008 and 2010 production seasons. While, the average growth rates of production for Kenya, Rwanda, Tanzania and Uganda were 7.1%, 6.3%, 7.3% and 6.3% respectively. However, Uganda has more than 55% production share in the East African countries. Followed by Tanzania and Kenya which have 17.6% and 13.9% production shares based on five years periods. Despite significant contribution of coffee exports on Burundi and Rwanda economies (Fig. 3), their production share in East African countries have been small, i.e. 5.4% and 6.3% respectively. This is likely due to limitations of farm size farmer's visage in these small economies.

### 2.1.3 Coffee Production in Tanzania

Coffee is one of Tanzania's primary agriculture export crop, representing about 5% of total exports (Fig. 3), 24% of traditional cash crops and generating export earnings averaging USD 100 million per annum and this has been so for the last 30 years (TCB and TACRI, 2010). More than 90% of Tanzania coffee comes from smallholder farmers (Lazaro and Makindara, 2008). The industry provides direct income to more than 400 000 farmer families and also benefits indirectly the livelihoods of 2.4 million Tanzanians. Average yearly production over the past thirty years has stagnated at 47 thousands metric tons, characterized by biannual troughs and production has swung between 33 000 and 68 000 metric tons. Generally, Tanzania is endowed with abundant land with appropriate altitude, temperature, rainfall and soil suitable for high quality Arabica and Robusta production. The major Arabica growing regions are Arusha, Kilimanjaro, Mbeya, Ruvuma and Robusta in the Kagera region. Other potential growing regions include Tanga, Iringa, Morogoro, Kigoma, Manyara, Mwanza, Rukwa and Mara (TCB and TACRI, 2010).

According to TACRI annual report (2008), Mbinga is a leading district in terms of not only producing coffee but also maintaining high quality of their coffee output (Fig. 5). In terms of inputs use, low use of industrial inputs such as inorganic fertilizers was revealed. Most farmers use below the recommended rates; the average was 150 grams per tree in Mbinga. However, very small rates were revealed in other parts such as 50 grams per tree in Kilimanjaro. This could be attributed to the rapid increases in fertilizer prices rendering them unaffordable to farmers hence affecting productivity of their farms. The TACRI's report pointed out that more than 95% of Mbinga coffee farmers were practicing a mono cropping farming system while in other parts of the country, such as Moshi and Hai, intercropping system was typical.

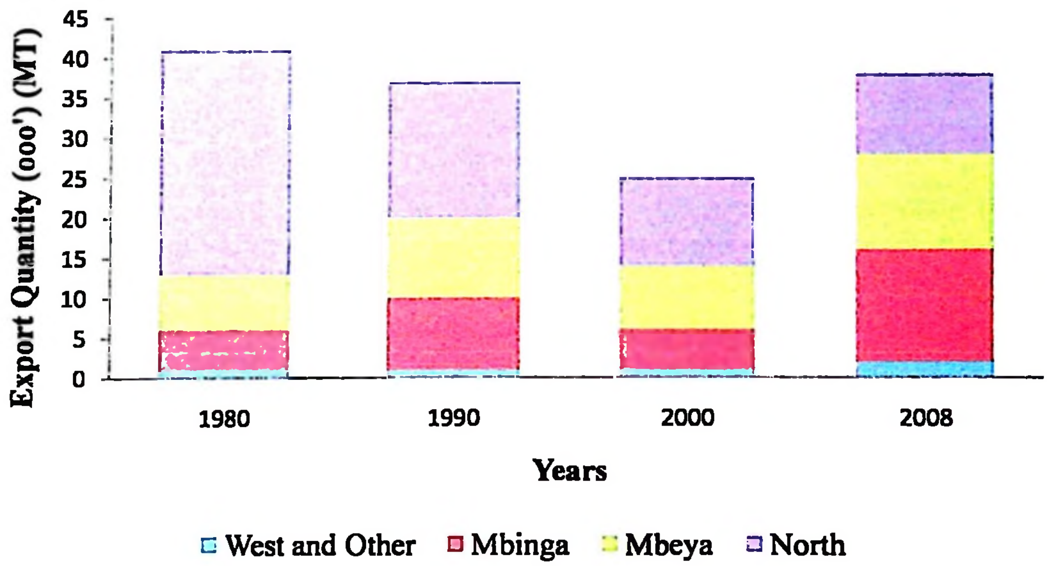



**Figure 5: Tanzania Arabica export by growing area**

(*Thousands of Metric Tons Green Coffee, Crop Years 1980 to 2008*)

**Source**: TCB Analysis and TACRI (2010).

Despite the increase of Mbinga coffee production over time (Fig. 5), overall exports particularly for the Arabica variety has been declining due to a drastic drop in production in the North part of Tanzania. Accordingly, the compound annual growth rate of Mbinga and Mbeya production was 2%, while for the West and other parts was 3%. Conversely, the North region's annual growth rate has been decreasing by 4%. Coffee production in Mbinga would increase because coffee farmers in the area reported to be "own experts" and seemed to adhere to instructions given by their extension officers (TACRI, 2008).

## 2.2 Conceptual Framework

Productive efficiency is usually analyzed by using two components, technical and allocative efficiency. According to Ozkan *et al.* (2009), productive efficiency or economic efficiency is determined as production of maximum amount of outputs by utilising minimum amount of inputs under a given technological structure. Yet, the determinants of productive efficiency are related to the production process and allocation of resources.

In a production context, technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs (an output oriented measure), or uses the minimum feasible level of inputs to produce a given level of output (an input oriented measure). Allocative efficiency, on the other hand, relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices (Coelli *et al.*, 2002). The popular approach to measure efficiency, the technical efficiency component, makes use of frontier production function (e.g. Battese and Coelli, 1995 and Battese, 1992).

However, Yotopoulos *et al.* (1973) argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments. This led to the application of stochastic profit function models to estimate farm specific efficiency directly (e.g., Ali and Flinn, 1989; Rahman, 2003 and Ogundari, 2006). Coelli, (1996); Battese and Coelli (1995) extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. According to Reddy (2003), farm profitability can be affected by production cost changes or total revenue changes (both are function of coffee output). Figure 6 shows the determinants of farm profitability among coffee farmers. It is assumed that, farmers can raise farm profit if they manage the factors within their control as shown in Fig. 6. These include raising farm efficiency and productivity, and reducing costs by using optimal levels of inputs.

The advantage of Battesse and Coelli (1995) model is that it allows the estimation of farm specific efficiency scores and the factors explaining efficiency differentials among farmers in a single stage estimation procedure. This study will utilize Battesse and Coelli (1995) model by postulating a profit function, which is assumed to behave in a manner consistent with the stochastic frontier concept. Profit efficiency is a broader concept since it takes into account the effects of the choice of vector of production on both costs and revenues.

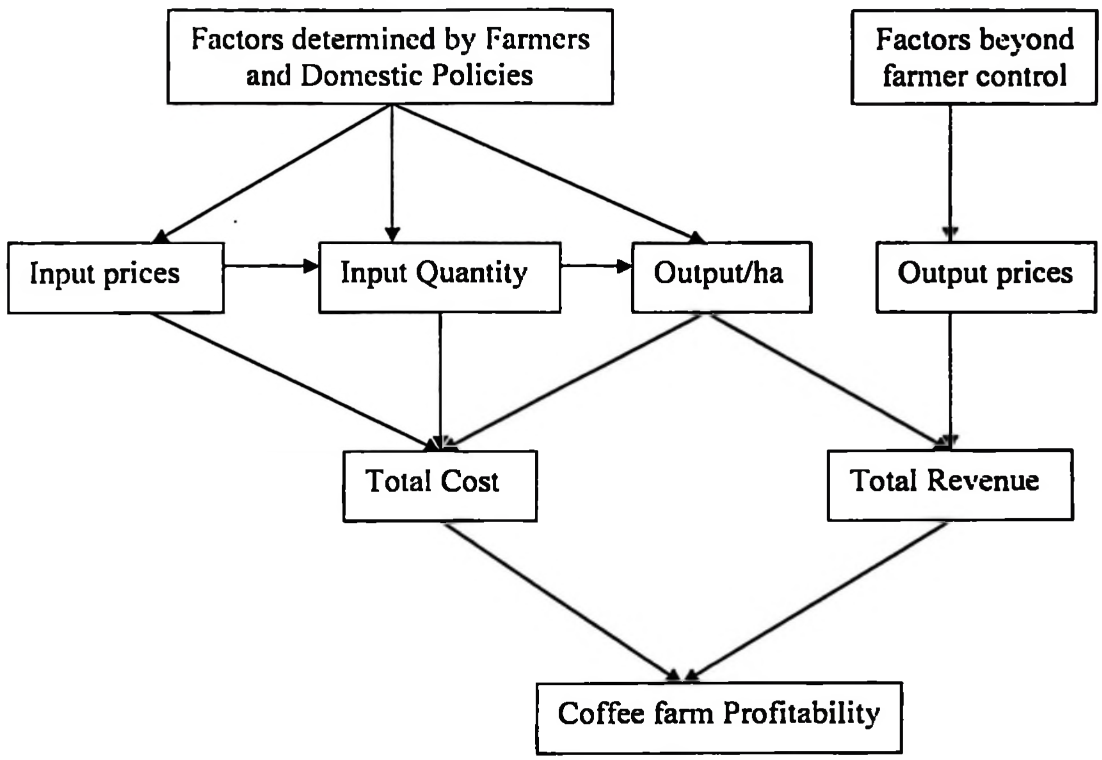



**Figure 6: Determinants of coffee farm profitability**

**Source:** Modified from Reddy (2003)

## 2.3 Measures of Efficiency

### 2.3.1 Technical, Allocative and Economic Efficiency

Measurement of economic efficiency requires an understanding of the decision making behaviour of the producer. A rational producer, producing a single output from a number of inputs, $x = x_1......x_n$, that are purchased at given input prices, $w = w_1.....w_n$ and operating on a production frontier will be deemed to be efficient. But if the producer is using a combination of inputs in such a way that it fails to maximize output or can use less inputs to attain the same output, then the producer is not economically efficient. A given combination of input and output is therefore economically efficient if it is both technically and allocativelly efficient; that is, when the related input ratio is on both the isoquant and the expansion path. These contentions are best illustrated in the Figure 1 by Coelli (1995).

In Fig. 7, AB is an isoquant, representing technically efficient combinations of inputs, i.e. $X_1$ and $X_2$, used in producing output Q. AB is also known as the 'best practice' production frontier. DD' is an isocost line, which shows all combinations of inputs $X_1$ and $X_2$ such that input costs sum to the same total cost of production. However, any firm intending to maximize profits has to produce at Q', which is a point of tangency and representing the least cost combination of $X_1$ and $X_2$ in production of Q. At point Q' the producer is economically efficient.

In measuring the technical, allocative and economic efficiency, the same Fig. 7 is used. Suppose a farmer is producing its output depicted by isoquant AB with input combination level of ($X_1$ and $X_2$) in Fig. 7. At this point (P) of input combination the production is not technically efficient because the level of inputs needed to produce the same quantity is Q on isoquant AB. In other words, the farmer can produce at any point on AB with fewer inputs ($X_1$ and $X_2$) in this case at Q in an input-input space. The degree of technical efficiency of such a farm is measured as OQ/OP. OQ/OP is the proportional reduction of all inputs that could theoretically be achieved without any reduction in output.

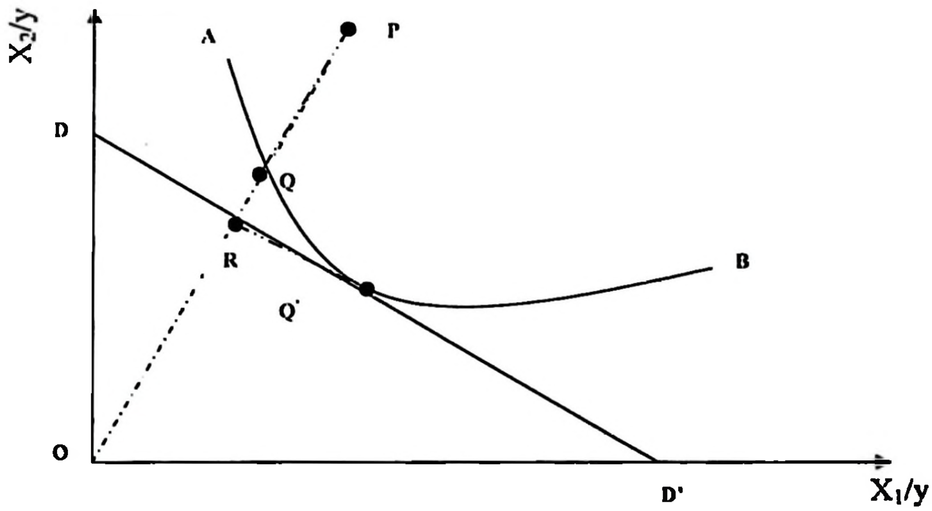



**Figure 7: Stochastic production frontier**

**Source**: Coelli (1995)

In Fig. 7, DD' represent input price ratio or iso-cost line, which gives the minimum expenditure for which a firm intending to maximize profit should adopt. The same farm using ($X_1$ and $X_2$) to produce output P would be allocatively inefficient in relation to R. Its level of allocative efficiency is represented by OR/OQ, since the distance RQ represents the reduction in production costs if the farmer using the combination of input ($X_1$ and $X_2$) was to produce at any point on D D', particularly R instead of P.

The overall (economic) efficiency is measured as the product of OQ/OP and OR/OQ, which is OR/OP. This follows from interpretation of distance RP as the reduction in costs if a technically and allocatively inefficient producer at P were to become efficient (both technically and allocatively) at Q'. These forms reflect alternative behavioral objectives (i.e. profit maximization or cost minimization) and can account for multiple outputs (Coelli, 1995).

### 2.3.2 Profit Function

A profit function is an extension and formalization of the production decisions taken by a farmer. According to production theory, a farmer is assumed to choose a combination of variable inputs and outputs that maximize profit subject to technology constraint (Sadoulet and De Janvry, 1995). The underlying production function can be generalized as h (q, x, z) = 0 where q is a vector of output, x is a vector of variable inputs, z is a vector of fixed inputs and h is a technology. Assuming the technology to be homogeneous across farms, restricted profit function is specified as follows:

$$\text{Max } p.q-wx, \ldots\ldots\ldots\ldots\ldots\ldots, \text{ s.t. } \quad h(q,x,z) = 0 \tag{1}$$

Where: p is a vector of prices of outputs and

w is a vector of prices of variable inputs

Considering a set of inputs and outputs the profit maximizing input demand and output supply functions are generally respectively expressed as:

$$X = x\,(p, w, z) \tag{2}$$

$$Q = q\,(p, w, z) \tag{3}$$

Substituting equation 2 and 3 into1 gives a profit function which is the maximum profit that the farmer can obtain given prices of p and w, availability of fixed factors z and production technology h. The profit function can be written as

$$\pi \quad = \quad p'q(p,w,z) - w'x(p,w,z) \qquad (4)$$

This study used the normalized profit function outlined in equation 5 given the fact that the study dealt with a single output, that is, rice (Sadoulet and De Janvry, 1995). Hence for rice, we have:

$$\pi_i \quad = \quad f(P_{ij}, Z_{ik}).\ \exp(e_i) \qquad (5)$$

This makes profit non-linear in its error term. However, the profit function can be loglinearized to obtain the form: $\ln \pi_i = \ln f(P_{ij}, Z_{ik}) + e_i$.

where:

$\pi_i$ = normalized profit on firm $_i$ defined as gross revenue minus variable cost divided by the output price.

$P_{ij}$ = prices of variable input j on firm i divided by the output price.

$Z_{ik}$ = level of fixed input on firm $_i$ where k are a number of fixed inputs.

i = 1……….. n number of farms in the sample.

$e_i$ = error term assumed to behave in a manner consistent with the frontier concept (Ali and Flinn, 1989).

Fig. 8 shows the stochastic profit frontier function adopted from Ali and Flinn, (1989). The stochastic profit frontier function is an extension of the frontier production function incorporating farm level prices and input use. The incorporation of the farm specific level prices leads to the profit function approach formulation (Ali and Flinn, 1989; Wang *et al.*, 1996a). A production approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowment (Ali and Flinn, 1989). Hence the use of stochastic profit functions to estimate farm specific efficiency directly (Ali and Flinn, 1989; Ali *et al.*, 1994; Wang *et al.*, 1996).

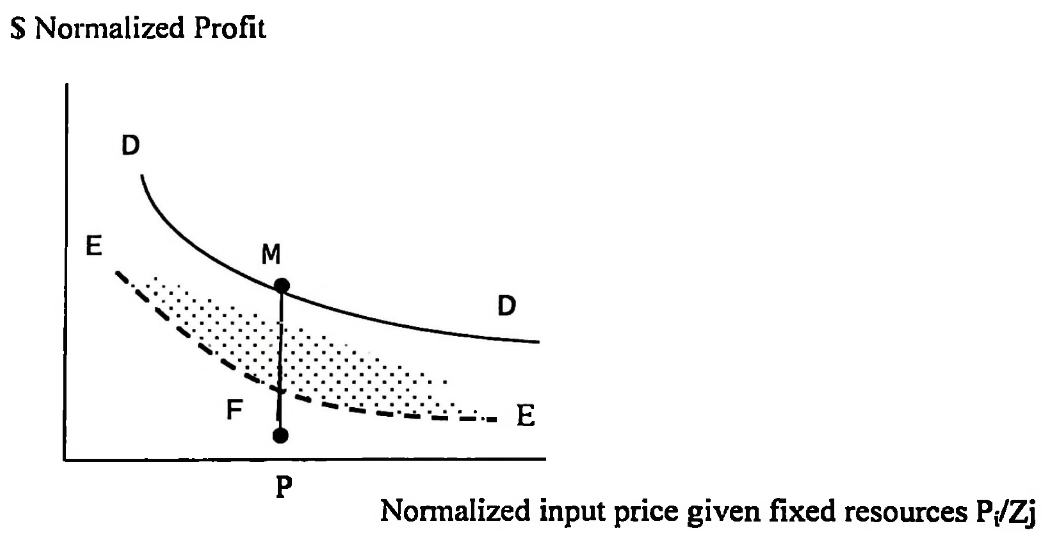



**Figure 8: Frontier MLE and OLS stochastic profit function**

**Source**: Ali and Flinn (1989)

The profit function approach combines the concepts of technical, allocative and scale inefficiency in the profit relationships and any errors in the production decision translate into lower profits or revenue for the producer (Rahman, 2003). Profit efficiency is defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm and profit inefficiency in this context is defined as the loss of profit from not operating on the frontier (Ali and Flinn, 1989).

In the context of frontier literature, DD in Fig. 8 represents profit frontier of farms in the industry (the best practice firm in the industry with the given technology). On the other hand EE is the average response function (profit function) that does not take into account the farm specific inefficiencies. All farms that fall below DD are not attaining optimal profit given the prevailing input and output prices in the product and the input markets. They are producing at allocativelly inefficient point F in relation to M in Fig. 8. Profit inefficiency is defined as profit loss of not operating on the frontier. In Fig. 8, a firm operating at F is not efficient and its profit inefficiency is measured as FP/MP (Ali and Flinn, 1989; Sadoulet and Janvry, 1995).

### 2.4 Recent and Empirical Studies

This section presents a review of some recent empirical studies on technical efficienc. Lingard *et al.* (1983) applying a two-component model to panel data, estimated a bias free agricultural production function for the Philippine rice farmers in Luzon district. The study revealed that the area was dominant in earlier years when the technology was introduced, while other variables (such as irrigation, fertilizers and chemicals) became significant overtime, reflecting full adoption of the technology.

A stochastic profit frontier analysis was conducted by Kolawole (2006) in 50 rice farms per each of the four agriculturally oriented regions of Nigeria. The stochastic frontier estimation produced more sound outcomes compared to the OLS estimation, in which the random inefficiency impact is neglected. The average profit efficiency of rice farms was found out to be 60.1 %. Besides, the reasoning of the profit efficiency was attributed to both technical and allocation of resources inefficiencies.

Belbase and Grabowski (1985) used corrected ordinary least squares (COLS) technique to measure technical efficiency of farmers in Nuwakot District in Nepal. The appropriately adjusted (removing the outliers) results showed that the Nepalese farmers were operating close to the technical frontier. The factors contributing positively to technical efficiency were: nutrition levels, family incomes and education. The structure (farm size) of the farms was taken as given, yet as noted by Mbowa (1996), the variable bears a significant influence on technical efficiency. However, the Belbase and Grabawoskis' study did not deal with allocative inefficiency.

Taylor and Shonkwiler, (1986) used both deterministic and stochastic frontier production function to study the impact of agricultural credit programs on farmers in south eastern Brazil. They used both models (deterministic and stochastic) to test the effectiveness of the programme. The results showed that both groups (participants and non participants in the programs) consistently had higher technical efficiency from stochastic than deterministic frontier specifications. Yet in applying both specifications (deterministic and stochastic) to analyse the effect of the credit programme to both participants and non-participants, the results showed that the participants had higher technical efficiency than the non-participants in deterministic specification. The two specifications, therefore, yielded conflicting inferences regarding the effectiveness of the programs. In their conclusion the authors noted that "such results place considerable importance on the subjective beliefs of the researcher. Any definitive inference must, in the end, rest in the gray area of determining which specification is the most realistic on both theoretical and empirical grounds" (Taylor and Shonkwiler, 1986).

A deterministic model attributes any deviation from the frontier as resulting solely from inefficiency measured by $\mu$. The major weakness with this model is that any measurement error and any other source of variations in the dependent variable is embedded in $\mu$ and can't be separated. As a result, outliers may have profound effects on the estimates and also, any shortcomings in the specification of the model could translate into inefficiency estimates.

Two different stochastic frontier functions were estimated by Xu and Jeffrey (1995) in China in order to interpret productive efficiency of conventional and hybrid rice. Conventional production was found more technically effective and it was understood that education and farm land (acreage) is positively correlated with the technical efficiency of hybrid rice production. However, in a study based on profit function approach for interpretation of agricultural inefficiency in Russia by Arnade and Trueblood (2002), cost functions are used in order to set forth relationships between technical inefficiency and distance functions, relationship between input demand and output supply and to demonstrate technical inefficiency scores constituting the profit function. The system also applied to combine allocation efficiency scores relationship between the translog production function and debt and subsidies was surveyed and the production values and subsidies were found to be inversely related to each other.

A stochastic model on the other hand, takes into account random factors, which are outside the control of the farmer. The model addresses the noise problem characterizing deterministic frontier. In other words, the model enables the researcher to provide more explanation of the inefficiency observed than before. This was not possible before because of the violation of certain maximum likelihood regularity conditions. The coefficients estimated this way are expected to be more efficient parameters and its popularity by researchers may be due to this held view (Thiam *et al.*, 2001). However, the model has its own shortcomings. It lacks a priori justification for the selection of a particular distributional form for the one sided inefficiency term $\mu$. In this study a stochastic approach is adopted due to the earlier pointed out reasons: the provision of better explanation on observed inefficiency at farmer level and getting more efficient parameter estimates.

Unlike the previous studies reviewed, Kalirajan and Shand, (1988) estimated technical efficiency for multiple crops (rice-corn) and multiple outputs using stochastic translog production frontier for a sample of farmers operating in rain-fed areas of India. The results showed that levels of crop-specific and farm-specific efficiency varied widely among small farmers, but on the whole only 24% of the sample was found to be technically efficient in growing all the crops. The causes of variation in technical efficiency at farm level were found to differ across crops. In the case of rice, farming experience and extension officials' visits were found to be important whereas financial availability was the most crucial to maize production. The authors concluded that a mere choice of high yielding technology was not sufficient to increase the production of rice, what is important is the proper use or application of the technology.

Acknowledging the fact that measurement of efficiency is sensitive to methodology used, the data, period, and sample, Dawson and Lingard (1991) employed two different approaches to estimate technical efficiency of rice farms in The Philippines (Luzon Province) namely, covariance analysis (CA) and stochastic frontier approaches. The CA was used to pull together the cross-sectional and panel data. The CA produced biased results, confirming observation made by Timmer (1971). Furthermore, the estimation using cross-sectional data set produced a wide range of coefficients while those of panel data had better results. The range of technical efficiency ratings was narrower, with 14 farms being over 90% or more efficient. The major strength of this study was that it succeeded in showing that efficiency estimates are sensitive to methodology, type of data, and sample size. More crucial to the current study, is the fact that Dawson and Lingard (1991) pointed out that there was a need to go beyond identification and develop methodologies that explain sources of differences in farm efficiency.

Besides stochastic approaches, the non-stochastic frontier approach is one of the methods that can be employed to estimate relative efficiency. Ali and Byerlee (1991) revealed that the studies which used non-stochastic approaches, concentrated on non-conventional inputs, such as education. Most of the studies reviewed showed that education had positive and significant effect on productivity. The variable contributed up to 9.5% increase in productivity in a modernizing (countries that have undergone green revolution) agriculture. However, the unsolved puzzle is about which level of education matters in farm management. Some studies have indicated that basic formal education of up to 4 years is essential, particularly the farm manager, irrespective of gender (Appleton and Balihuta, 1996; Weier, 1999).

Building on other studies, and still in quest to find a better and efficient approach to measure efficiency, other researchers such as Phillips (1994) and Thiam *et al.* (2001) reviewed studies on technical efficiency using a method called meta-analysis. The method uses empirical estimates of some indicator from several studies; the average technical efficiency in this case serves as the dependent variable, and attempts to explain the variation of the estimates based on differences across studies as explanatory variables in a regression model. Thiam *et al.* (2001) were the first to use this approach to analyze technical efficiency.

The issue that empirical measures of efficiency depend on the choice of the model adopted still remains controversial. Thiam *et al.* (2001) conclude, that "despite this array of applied work, the extent to which empirical measures of efficiency are sensitive to the choice of methodology remains a matter of controversy". But this is not limited to efficiency studies. Many other results are sensitive to methodology; data and time the data were taken. Even though the study by Thiam *et al.* (2001) covered 32 frontier studies, using farm level data from 15 different developing countries, none of the method was superior to the other in terms of robustness. Thiam *et al.* (2001) concluded that the groundwork remained a challenge to researchers.

Indeed, earlier on, Kalirajan and Obwona, (1994) investigated the appropriateness of the use of stochastic frontier methodology to estimate efficient utilization of the inputs for a given the technology. The authors argued that by nature of its generic assumptions, that is, the potential frontier being a neutral shift frontier from the realized production function, input-specific technical efficiency measures could not be obtained without contradictions. They further argued that even with identical levels of inputs, outputs would differ due to differences in the methods of application of inputs by the farmer. Thus it would be necessary to use a different model, which reflects the method of application of inputs by individual farmers.

Kalirajan and Obwona (1994) therefore went ahead and developed a Cobb-Douglas type of production function to address these concerns and computed actual response coefficients for individual observations. The results obtained showed that there were variations in the farm-specific and input-specific actual response coefficients across sample farms. The authors therefore rejected the assumptions of the conventional stochastic frontier production function approach and used a non-stochastic frontier Cobb-Douglas (C-D) type of modeling of the production behavior of farmers. The authors concluded that the developed model was appealing because it made it easy to draw policy recommendations for the estimated results indicate the type of input being over or underutilized. Secondly, it was possible to set targets for different inputs to produce a given level of output.

Mwakalobo (2000) presented empirical findings of 90 smallholder coffee farmers on resource productivity and allocation efficiency in Rungwe district, Tanzania. He used Cobb-Douglas function and results indicated that farmers would increase farm productivity by the use of adequate capital-intensive input levels in order to maximize their efficiency.

In a profit inefficiency analysis of vegetable producers of Samsun province between 2002 and 2003, the reasons of inefficiency were analyzed by Bozoglu and Ceyhan (2006). It was understood at the end of the frontier estimation of Cobb Douglas production function through data retrieved from 75 producers that the vegetable producers could produce 18% more with their existing resources and technology. In this study, education, experience, credit use opportunities, women participation to farm activities and level of knowledge were found as determinants of technical inefficiency.

A latter study by Sharma *et al.* (1999) on Hawaiian swine farmers, applying the parametric stochastic and nonparametric approach Data Envelopment Analysis (DEA) method, produced results that were also robust. The method differs from the parametric method in that the researcher does not have to make arbitrary assumptions about the functional form of the frontier and distributional form of the $\mu$. Additionally, DEA does not make assumptions about the efficiency of farms since it measures relative efficiency of farms, given a set of inputs. DEA also differs from Farrell's single-input, single output efficiency analysis to multi-input, multi-output efficiency analysis. However, according to Coelli (1995) the method also suffers from the same weaknesses as that of the deterministic model covered before.

Studies estimating technical efficiency in Africa are limited. A review of some of them is as follows. Yilma (1996) used three different approaches to estimate smallholder efficiency in coffee and bananas namely, deterministic parametric, stochastic frontier approaches and DEA in Masaka district, Uganda. The deterministic parametric approach showed differences in mean scores of efficiencies in coffee and generally food production. The coefficients estimated under deterministic parametric frontier model showed lower efficiency than the stochastic frontier model, agreeing with many earlier studies (Kalirajan and Obwona, 1994 and Lingard *et al.*, 1983). Nevertheless, irrespective of the approach used, all farmers were found not to be producing on the frontier.

DEA was also used by Philip (2009) to test if size of the sugarcane farms matters to improve farmer's profitability. His findings revealed that medium farms of more than 5 hectares tended to be more productive hence gave higher profits than small farms. Based on his analysis, sugarcane out-growers would run out of poverty if they increased their farm size up to 4 hectares and above. Not only that but also, Mbowa (1996) used DEA to examine resource use farm efficiency on small and large-scale farms in sugarcane production in Kwazulu-Natal. The study results showed that small-scale farmers were technically inefficient than large-scale producers and concluded that the size of farm operation affects level of efficiency attainable.

Seyoum *et al.* (1998) used a two step procedure proposed by Coelli (1996) to estimate separate stochastic frontier production functions for the two groups of maize farmers (within and outside Sasakawa Global (SG) 2000 project) in Ethiopia. Empirical results of the study showed that technical efficiency levels for the participating group were higher than that of the non-participants. Furthermore, the participating group also registered higher mean frontier output than those outside the project. The inefficiency model showed that there exists technical inefficiency in the production of maize. The contributing factors were education, age, and extension contact. Education and extension services had a negative influence on technical inefficiency for those participating in the project. The authors therefore concluded that in order to promote agricultural productivity the government could introduce projects such as SG 2000 which appear to have had a positive impact on technical efficiency.

Appleton and Balihuta, (1996) studied the impact of education on agricultural productivity. Using the national household survey data, they found that education of at least 4 years of formal schooling of the farm manager appears to raise production by 7%. They also found that there were large effects of education on other farmers in the neighborhood. However, the analysis was limited in scope since they focused on agricultural production only. This study intends to focus on estimating profit function which takes into consideration prices of outputs and inputs.

Weier (1999) examined the benefits of schooling upon farmer productivity and efficiency employing both average production function and a two-stage-stochastic frontier production functions in rural Ethiopia. As in the case of Appleton and Balihuta (1996), the authors used household budget data set. The analysis revealed that at household level farmers in rural Ethiopia were not operating on the frontier. The results suggested that education has a role to play in increasing agricultural production.

According to Forsund *et al.* (1980) and Amara *et al.* (1999), a probabilistic production frontier which was put up by Aigner *et al.* (1977), was used by Timmer (1971) who took the problem of outlier into account. This was estimated with mathematical programming technique. A similar frontier production function called deterministic stochastic frontier function was later suggested by Amara *et al.* (1999) may be estimated using Maximum Likelihood Estimation (MLE) procedures or any other econometric technique. The deterministic approach as argued by Forsund *et al.* (1980) ignores the fact that farms' performance can be affected by factors such as bad weather, poor performance of machinery or breakdown of input supply which are all beyond the farmer's control (Amara *et al.*, 1999). This indicates that deviations from the efficiency frontier may be of two origins: inefficiency in input-use or random-variations in the frontier across different farms. On the other hand according to Philip (2009), Kibaara (2005) and Thiam *et al.* (2001) the stochastic approach allows for statistical noise.

## 2.5 Measuring Efficiency Using Frontier Profit Function

This section reviews some of the studies conducted in Asia and Africa using profit analysis approach. Saleem (1988) tested the Marshallian theory in Sudan to find out which system (sharecropping or fixed rent) operating on irrigated cotton farms was efficient. Marshallian theory on sharecropping states that farmers operating under fixed rent should be more efficient than those under sharecropping (Saleem, 1988). According to this theory, farmers who have to pay rent tend to equate the Marginal Value of Product (MVP) of a variable factor to market price of that factor whereas those on share cropping have no incentive to do so. They may instead equate a fraction of MVP to its market price. This may happen when the input is subsidized. This is not true in many developing countries, where subsidies don't exist.

Applying Lau and Yotopolous (L-Y) profit function model to the data, Saleem (1988) found out that the two farmer groups both growing medium staple cotton, respectively in Gezira (shared) and Rahad (fixed) schemes were equally technically and price efficient, in other words economically efficient. The results therefore did not support Marshallian theory on rent and suggested that both groups had identical profit functions. The author was not able to estimate farm-specific differences in profit efficiency among these farmers. In light of this, this study uses an identical profit function for the farmers in Doho and Olweny rice schemes. Farmers in Doho either rent or own plot(s) whereas in Olweny Scheme, farmers use plots without paying rent because it is a government owned scheme.

The relationship between firm size and efficiency has major implications to policy options for agricultural development in Africa. Previous studies carried out in Asia gave conflicting results on which size is more efficient -large or small (Akinwumi and Djato, 1996). But, in the case of Africa. the superiority (more efficient) of large-scale farms was apparently artificial because (according to the authors). the large-scale farmers had in the past been given preferential treatment over the small scale-farmers. For instance. the latter group tended to have restricted access to certain markets for their commodities and as such they could not demonstrate their efficiency in growing the crop in question. Indeed, in their study of rice farms in Ivory Coast, Akinwumi and Djato (1996) found no significant differences in economic efficiency between small and large rice farmers in Cote d'Ivoire. But in general, they found absolute allocative inefficiency within the rice sector. However, based on sugarcane farms evidence in Tanzania, Philip (2009) observed low farm profitability at very small farm sizes and recommended a policy reorientation in favour of relative larger farms in the country.

Yotopoulos and Lau, (1973) extended their 1971 study with the major purpose of isolating the causes of observed differences in economic efficiency between large and small scale farmers. Using a stochastic profit frontier approach, the authors reaffirmed their earlier findings that small farms had relatively higher economic efficiency than large farms and that both groups of farms succeeded in maximizing profits. Nevertheless, small farmers were found to be more technically efficient than large scale farmers. But, the authors were not able to provide an explanation for the observed differences in technical efficiency (Yotopoulos and Lau, 1973).

Even though it is very instructive to have knowledge on farm efficiency levels, under different production system, what is equally important, from the policy point of view, is to pinpoint the causes of the observed efficiency levels. Ali and Flinn (1989) adopting the theoretical model formulated by Yotopoulos and Lau (Y-L), and using techniques proposed by Jondrow *et al.* (1982) to estimate farm-specific efficiency among the Basmati rice producers in Pakistan Punjab, found that farmers exhibited a wide range of profit inefficiency ranging from 87% less than maximum profit to 5% less than maximum profit. The results also showed that the variance ratio parameter λ proposed by Battese and Corra (1977) was statistically greater than zero, implying that the variation in actual profit from maximum profit between farms arose from differences in farmers' practice rather than random variability.

The study also found that the major determinants for profit loss among the Basmati rice producers were both socio-economic and institutional factors. The former accounted for 52% profit loss and, of these, education alone accounted for 31%. The latter accounted for 25% of profit loss. However, factors associated with resource base were not significant in explaining the profit loss and only explained 12% while institutional factors explained 25%. Rahman (2003) estimated a stochastic profit function for Bangladesh rice farmers. The results showed that there existed a high level of inefficiency in rice farming because γ was close to one. The average profit efficiency scores were 60%, which implied that the farmers could improve their profitability by as much as 40%. The farmers also exhibited a lot of profit inefficiency. The farm-specific factors responsible were poor access to input markets, unfavorable tenancy arrangements, and off farm employment.

A slightly different but as yet unsettled proposition is whether female farmers are as efficient as male farmers in agricultural operations. Quoting FAO (1985), Akinwumi and Djato (1997) observed that the argument used to discriminate against female farmers in projects is that they are not efficient. Yet, Moock (1976) showed that female managers in Vihiga district in Kenya were as efficient as men. Nkonya *et al.* (2004) found Ugandan women farmers to be more efficient. Other studies give mixed results. This is attributed to reliance on the production function, which suffers from simultaneous bias (Akinwumi and Djato, 1997). The authors used profit function approach for rice farmers in Cote d'Ivoire to settle this debate empirically. They found that the relative degree of economic efficiency of women rice farmers is similar to that of men rice farmers in Cote d'Ivoire. The authors concluded that there was no economic rationale for biasing rice development strategies towards male farmers in Cote d'Ivoire because when the two groups have equal access to inputs; they would exhibit equal levels of economic efficiency.

A review of literature by Ali and Byerlee (1991) on economic efficiency of small farmers in a changing world revealed a need for sharpening conceptual and methodological problems to derive useful policies. On methodological level, the authors suggested widening the specification of production function to include environmental factors such as soil types and rainfall when measuring economic inefficiency. These factors, they argued, are normally left out by economists, which lead to misspecification of the model. Yet, including environmental factors helps to reduce the usually overestimated technical inefficiency. On the conceptual level, the authors argued that the distinction drawn by economists between allocative and technical inefficiency is not meaningful because it may be dictated by aggregation of purchased inputs and level of application. Most of the studies reviewed by the authors were from Asia, efforts are required to generate information on Africa. As Akinwumi and Djato (1996) observed, "studies in Asia cannot be used directly to inform an agrarian policy in Africa".

The popular approach to measure efficiency, the technical efficiency component, is the use of frontier production function (e.g., Tzouvelekas *et al.*, 2001; Wadud and White, 2000; Sharma *et al.*, 1999; Sharif and Dar, 1996; Battesse and Coelli, 1995, Battesse, 1992; Russell and Young, 1983). However, Yotopolous and others argue that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Ali and Flinn, 1989). This led to the application of stochastic profit function models to estimate farm specific efficiency directly since (e.g., Rahman, 2003, Ali and Flinn, 1989; Kumbhakar and Bhattacharya, 1992; Ali *et al.*, 1994; and Wang *et al.*, 1996). In contrast with the widespread use of frontier production functions to estimate efficiency, use of profit frontier approach is highly limited hence adopted by this study.

The profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any errors in the production decision are assumed to be translated into lower profits or revenue for the producer (Ali *et al.*, 1994). Profit efficiency, therefore, is defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm and profit inefficiency in this context is defined as loss of profit from not operating on the frontier (Ali and Flinn, 1989).

Based on the reviewed literatures, MLE of stochastic frontier production/profit function model is a strong analytical tool for measurement of technical efficiency in agricultural production, because it allows joint estimation of Cobb-Douglas profit function and efficiency model. This study adopted MLE approach for the estimation of Stochastic Frontier Profit Function Model, in order to examine farm size and productive efficiency and profitability of Mbinga coffee farmers under mono-cropping farming system. This study adds to the plethora of literature on efficiency studies by modeling several variables into the efficiency model and also considers possible inefficiency effects.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Study Area

This study was carried out in Mbinga District (Fig. 9) in Ruvuma region of Tanzania. The district is famous for coffee production especially in villages such as Ugano, Matekela, Ilela, Mitambotambo and Mbuji. All the interviewed farmers reported that they had been attached to cooperative societies such as Mkuhi, Mapinduzi, Mikaranga and Mlandizi.

### 3.1.1 Economic Activities

Over 50% of the total area of Mbinga district area is suitable for agriculture and majority of people depend on agriculture, which accounts for a large part of the income generated in the District. Farmers grow a range of food crops including maize, cassava, potatoes and wheat. Other food crops grown as relish are beans and cowpeas. A major cash crop grown in Matengo highland is coffee but other crops like maize, beans and finger millet are also important in generating income (Yanda *et al.*, 2000).

Due to a high population density in the Matengo highlands, intensive farming system that include the ngoro system, contour and terracing are widely practiced (URT, 1997). Most farmers apply the ngoro system to grow crops like beans, maize, sweet potatoes and cassava. Terracing is used in coffee farms and shifting cultivation is practiced in Litumandyosi, Liparamba and Luhekei wards. These are areas where migrants from Matengo highlands tend to move in.

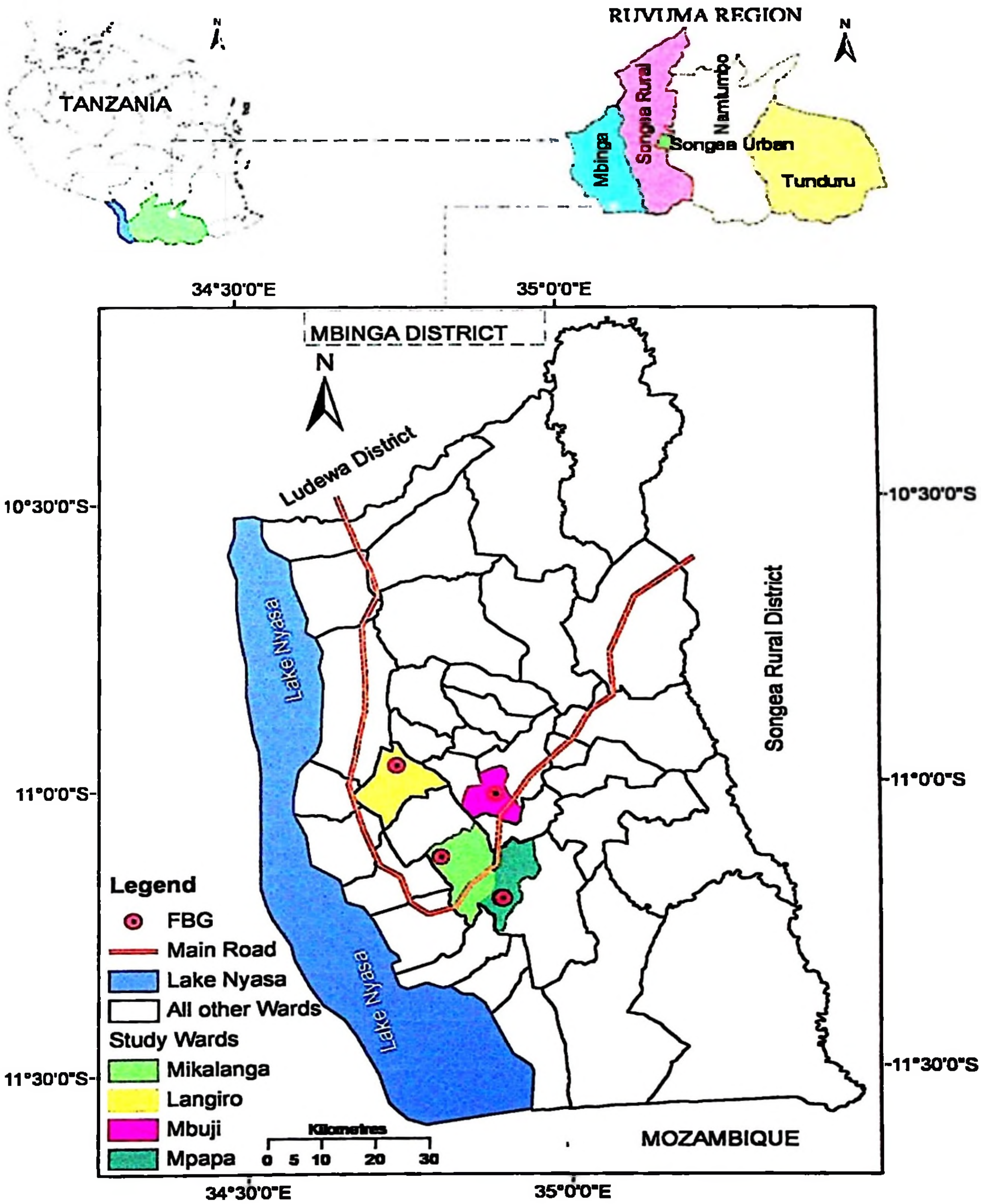



**Figure 9: A map of Mbinga District showing physiographic features**

Livestock production in Mbinga District does not contribute much to the economy of the people although there is a report which suggests an increase in number of livestock (MOA, 1993). Cattle and goats are mainly kept for dowry, while pigs and chicken are kept on a very small scale.

### 3.1.2 General Climatic Condition

The climate of Mbinga District is described as temperate to cool tropical climate with a unimodal rainfall pattern. The average annual rainfall for this district is 1224 mm, which ranges from 1000 – 1600 mm (Ellis-Jones *et al.*, 1994). The onset of rains is normally at the end of November whereas the wet season extends from December to April, a period that is generally humid. The growing season extends from six to seven months in the low altitude and up to nine months in the high altitude areas and the plateau (Lyimo and Kangalawe, 1997; Kangalawe and Lyimo, 2006).

The average minimum and maximum temperatures for the district are 19-23$^0$C and 29-31$^0$C respectively (Brown and Cochene, 1975). Considerable variations are common due to the broken topography of the area, which creates small microclimates in some places. Generally the months of May to October are dry with peaks of the dry season between June and October (ICRA, 1991).

### 3.1.3 Topography and Agro-ecological Zones

Mbinga District is composed of mountains, valleys and plateaus that extend from 800 to 1900 metres above sea level. The district is divided into four major agro-ecological zones representing combinations of unique altitude ranges that have variable characteristic (Appendix 1). To a large extent the Livingstone ranges fall within the "mountainous areas" agro-ecological zone of the district (ICRA, 1991; Lyimo and Kangalawe, 1997).

### 3.1.4 Soils

Soils of Mbinga District are generally classified as Haplic or Humic acrisols oxisol, ultisols depending on their position in the toposequence or soil catena or topography (ICRA, 1991). At higher elevations the most common soils used for crop production are of granitic and gneissic origin, deeply weathered, highly leached and well-drained red sandy clays. On the plateau the soils tend to be shallower with impeded drainage in some places. At lower elevations soils are less leached reddish brown sandy clay loams and sandy clays (Ellis-Jones *et al.*, 1994). These soils are very susceptible to erosion because they are very friable and become softened by rain (ICRA, 1991).

At both high and low elevations the major difference in soil type is the presence or absence of top soil horizon due to soil erosion. Where topsoil is present the organic matter content is high, while it is very low where topsoil is absent. In the latter case farmers cultivate the red subsoil. The general perception amongst farmers is that soil fertility has been progressively declining, resulting in poor crop growth coupled by changes in soil colour, from brown to red (Ellis-Jones *et al.*, 1994). This may be explained by loss of organic matter due to intensive cropping, burning and/or soil erosion (Lyimo and Kangalawe, 1997; Kangalawe and Lyimo, 2006).

### 3.1.5 Vegetation

The natural vegetation of Mbinga District in general. is largely miombo woodland type of vegetation that include tree species like *Brachystegia spp. Julbernadia glabiflora. Burkea Africana. Uapaca kirkiana. Parinaria exerlsa. Parinaria curatefollia. Afzelia quenzesis. Pterocarpus angolensis. Adina. Vitex. Syzygium. Acacia albida. Acacia polyacantha.* and many other species found in miombo woodland. This vegetation type has almost completely disappeared from the Matengo highlands except for low density remnants on the top of some mountains. At low elevation the dominant vegetation type is secondary wooded grassland. The most dominant grass species are the thatch grass (*Hyperrhenia spp)* and *Hypetheha spp.* Other vegetation types are the Zambezian swamp and afromontane type of forest. In valleys and along streams. creeks and wetland areas the dominant species comprise of *Khaya nyasica. Macaranga capensis. Bridelia micranta* and *Treculia africana.* Others include *Fragnitas maritariana* (ICRA, 1991; Ellis-Jones *et al.,* 1994).

### 3.1.6 Demographic Characteristics

Mbinga district comprises of three main ethnic groups, namely the Matengo, Ngoni and Nyasa. The Matengo occupy the highland areas in the centre of the district, the Ngoni mainly in the north-eastern lowland areas, while the Nyasa are found along the coast of Lake Nyasa (Lyimo and Kangalawe, 1997).

According to the Bureau of Statistics (1988) Mbinga district had a total population of 271 845 people in 1988. It was then projected that by 1994 the population would have increased to 320 000 people (Ellis-Jones *et al.*, 1994). Reports from the 2002 population and housing census show that Mbinga district had 403 819 people, including 206 030 females and 197 789 males (URT, 2003). As a result of high agricultural potential Mbinga District has the highest population in Ruvuma Region. The population of Mbinga District is very unevenly distributed with concentrations in the mountainous areas, especially in the Matengo highlands. In these highlands population densities of up to 120persons/km$^2$ are common (Mattee, 1991). Such high population densities give rise to increased land pressure. As a consequence the latter gives rise to intensive agricultural practices and considerable out migration especially of young persons and/or families in an attempt to acquire land. Migration is mainly towards the north and south of the district, creating pockets of more dense population in otherwise sparsely populated forested areas, such as Mpepo, Mpepai and Liparamba (Mattee, 1991; Lyimo and Kangalawe, 1997).

The villagisation programme in Mbinga District did not have a strong impact on settlement patterns as in other parts of the country, probably because of the topography (ICRA, 1991). Another plausible explanation to such observation would be because of the permanent coffee plantations that have made the population to be well established especially in the Matengo highlands. This programme undertaken during the 1970s had the objective to concentrate Tanzania's population on existing or newly created ujamaa villages and/or development villages, a programme that was later abandoned in 1980s (Lyimo and Kangalawe, 1997; Kangalawe and Lyimo, 2006).

### 3.1.7 Land Ownership, Tenure and Farm Sizes

Land ownership in Mbinga District does not differ much from what is observed in other parts of the country. Land is publicly held and the maintenance and improvement of the quality of land depend upon the user. Customary land ownership is strong and it is the family that owns land and inheritance patterns are patrilinear. Because of an increasing population pressure in these highlands, there has been a continued decline in the average farm size and increased fragmentation of crop fields. Following this, Matengo people have started to value land where land transactions are now not uncommon. The average farm size ranges between 5-8 acres per household (Lyimo and Kangalawe, 1997).

## 3.2 Sampling Procedure

Mbinga coffee farmers were the target respondents for this study. Both small and medium scale coffee farmers were considered in obtaining the sample for this study. Smallholder coffee farmers who are the majority in Tanzania (Lazaro and Makindara, 2008) constituted a large part of the study sample. Based on Technoserve baseline survey, a total of 116 farmers were selected randomly from particular villages, where by a total of 102 and 14 farmers represented small and medium size farms respectively on the basis of number of coffee trees available.

The sampling technique employed was a multistage stratified random sampling technique. The first stage involved purposive selection of the area and mono-cropping farmers where mono cropping farming system revealed to be practiced by 96.7% of coffee farmers in Mbinga (TACRI, 2008).

The second stage involved proportionate stratified sampling and simple random sampling through random selection of 116 coffee farmers in the study area. This number was according to respondents selected by TechnoServe to be involved in Farmers Business Groups (FBG).

### 3.3 Research Instruments

Both questionnaire and interview schedules were used in this study to collect required data from the coffee farmers (Appendix 2). The questionnaire consisted of a set of structured questions which reflected the study objectives. Sampled farms were used to collect data related to yield, a unit cost of labour per man day, land area under cultivation (trees), input prices such as price per kg of fertilizer, and average price per litre of agro-chemicals. Also, data were collected on the socioeconomic variables such as age, educational level (years of schooling), farming experience (years), number of extension contacts and household size. The data collected (on quantity of coffee harvested and output price) were used to compute farm total revenue as P×Q, where P is the price of the output and Q is the quantity produced while the farm level profit ($\pi$) was computed as difference between the total revenue and total variable cost expended on producing the coffee *i.e.* [Gross Margin ($\pi$) = TR - $WX_i$].

### 3.4 Data Analysis

The data obtained from the field were subjected to analysis using descriptive and inferential statistics in which the latter involved testing hypotheses. The stochastic profit function as suggested by several scholars as an appropriate measure of efficiency when farmers face different prices level and factor endowments was defined as

$$\pi_i = f(P_{ij}, Z_{ik}).\exp(\varepsilon) \tag{6}$$

The error term $\varepsilon_i$ is assumed to behave in a manner consistent with the frontier concept (Ali and Flinn, 1989), *i.e.* $\varepsilon_i = V_i + U_i$ where $\pi_i$ is normalized profit of the $i^{th}$ coffee farm defined as gross revenue less variable cost. divided by farm specific output price: $P_{ij}$ is the price of $j^{th}$ variable input faced by the $i^{th}$ farm divided by output price; $Z_{ik}$ is level of the $k^{th}$ fixed factor on the $i^{th}$ farm. $V_i$'s are assumed to be identically and normally distributed with mean zero and constant variance as N (0, $\delta^2 v$). $U_i$ is the one-sided disturbance form used to represent profit inefficiency and it is independent of $V_i$; and i = 1, 2 ...n, is the number of coffee farms in the sample.

The production/profit efficiency of farm *i* in the context of the stochastic frontier profit function is defined as

$$EFF = E[\exp(U)] / \varepsilon_i = E \exp \delta_o \sum_{d=1} \delta_d W_{di} / \varepsilon_i \tag{7}$$

Where: $W_{di}$ is the $d^{th}$ explanatory variable associated with inefficiencies on farm *i*, $\delta_0$ and $\delta_d$ are the unknown parameters and E is the expectation operator. This is achieved by obtaining the expressions for the conditional expectation $U_i$ upon the observed value of $\varepsilon_i$. The method of maximum likelihood was used to estimate the unknown parameters, with the stochastic frontier and the inefficiency effects functions estimated simultaneously.

The likelihood function is expressed in terms of the variance parameters, $\sigma^2 = \sigma v^2 + \sigma u^2$ and $\gamma = \sigma u^2 / \sigma^2$ (Battesse and Coelli, 1995). The parameter $\gamma$ represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favour of OLS estimation.

### 3.5 Stochastic Profit Frontier Model Specification

Profit efficiency in this study is defined as profit gained from operating on the profit frontier, taking into consideration farm-specific prices and factors. Given a farm that maximizes profit subject to perfectly competitive input and output markets and a singular output technology that is quasiconcave in the (n x 1) vector of variable inputs, and the (m x 1) vector of fixed factors (farm size), Z the actual normalized profit function which is assumed to be well behaved can be derived as follows:

Coffee farm profit was measured in terms of Gross Margin (GM) which equals the difference between the Total Revenue (TR) and Total Variable Cost (TVC).That is:

$$GM(\pi) = TR - TVC = P.Q - WX_i \tag{8}$$

To normalize the profit function, gross margin ($\pi$) is divided on the both sides of the equation above by P which is the market price of the output (coffee).That is:

$$\frac{\pi(p,z)}{P} = \frac{(PQ - WX_i)}{P} = Q - \frac{WX_i}{P} = f(X_i, Z) - P_i X_i \tag{9}$$

Where: TR represents total revenue from sale of coffee product(s), TVC represents total variable cost spent in coffee production (i.e. hired labour, fertilizer, e.t.c). It was obtained by multiplying quantity of resources by their corresponding unit price. P represents price of output (Q). X represents the quantity of optimized input used. Z represents price of fixed inputs used. $P = W / p_i$ = which represents normalized price of input $X_i$ while f ($X_i$, Z) represents production function.

An analysis of GM per acre and t-test statistics was employed to evaluate the relative profitability of the coffee crop grown by farmers. They were also used to estimate the cost of production and returns to hired labour, and other farm inputs such as fertilizer used in coffee cultivation. The analysis of gross margin is important because it enables to find out whether the crop provides economic benefits to farmers who are involved in producing the same.

The Cobb-Douglas profit function in implicit form which specifies production efficiency of the farmers is expressed as follows:

$$\pi = f(P_{ij}, Z_{ik}).\exp(V_i + U_i),\ \mathrm{i} = 1, 2....\mathrm{n} \tag{10}$$

Where: $\pi$, $P_i$, Z, $V_i$ and $U_i$ are as defined above. The profit efficiency is expressed as the ratio of predicted actual profit to the predicted maximum profit for a best-practiced coffee farmer and this is represented as follows:

Profit Efficiency

$$(E\pi) = \frac{\pi}{\pi^{\max}} = \frac{\exp\left[\pi(p, z)\right]\exp(\ln\ V)\exp(\ln\ U)\theta}{\exp\left[\pi(p, z)\right]\exp(\ln\ v)\theta} \tag{11}$$

Firms specific profit efficiency is again the mean of the conditional distribution of $U_i$ given by $E\pi$ and is defined as: $E\pi = E\left[\exp(U_i)/E_i\right]$ $E\pi$ takes the value between 0 and 1. If $U_i = 0$ *i.e.* on the frontier, obtaining potential maximum profit given the price it faces and the level of fixed factors. For $U_i > 0$, the farm would be inefficient, and losses profit as a result of inefficiency.

Regarding this study, Coelli (1996) model was used to specify the stochastic frontier function with behaviour inefficiency components and to estimate all parameters together in one step Maximum Likelihood Estimation (MLE). The production/profit efficiency of coffee farm $i$ in the context of the stochastic frontier profit function was defined as:

$$\ln\pi' = \beta_o + \sum_{j=1}^{6}\beta_j \ln P'_j + \frac{1}{2}\sum_{j=1}^{6}\sum_{k=1}^{6}\beta_{jk}\ln P'_j \ln P'_k + \sum_{j=1}^{6}\sum_{l=1}^{1}\beta_{jl}\ln P'_j \ln Z_l + V - U \qquad (12)$$

Where:

$\pi'$ = restricted profit (computed as total revenue less variable cost) normalized by price of specific average coffee output ($P_y$)

$P'$ = price of the $j$th input ($P_j$) normalized by the average coffee output price ($P_y$)

$j$ = 1, fertilizer price; 2, insect treatment price; 3, disease treatment price; 4, herbicide price; labour wage

$Z_l$ = quantity of fixed input, $l$

$l$ = farm size (number of coffee trees)

$v$ = two sided random error

$u$ = one sided half-normal error

$ln$ = natural logarithm

$\beta_0$, $\beta_j$, and $\beta_{jk}$ are parameters to be estimated

Moreover, the analysis of Cobb-Douglas profit function was used to examine the influence of factor inputs on coffee production. The Cobb-Douglas function is specified in such a way that, its regression coefficients equal the elasticities of output with respect to various inputs. These elasticities are also independent of the unit of measurement. In addition this model provides a compromise between an adequate fit of data, computation feasibility and sufficient degrees of freedom for statistical testing (Khana, 2006).

In this C-D function the coefficients of the variable (elasticity) indicate the responsiveness of the quantity (output) obtained as a result of a unit change in input used which are "fertilizer, area, labour''. Assuming that errors are small and normally distributed such a logarithmic transformation of variables presumes a nearly normal distribution of errors in the data. By using this model, it was expected that more than one factor used by coffee farmers have would positive influence on the coffee production.

### 3.6 Inefficiency Model (Profit Loss Sources)

Profit-loss is defined by Rahman (2003) as the amount that has been lost due to inefficiency in production given prices and fixed factor endowments and is calculated by multiplying maximum profit by (1 – PE). The maximum profit per coffee trees grown is computed by dividing the actual profit per coffee trees of individual farms by its efficiency score. To identify factors associated with profit-loss, a multiple regression model was estimated as follows:

The inefficiency model (Ui) is defined by:

$$U_i = \delta_0 + \sum \delta_i L_{ni} \tag{13}$$

$$U_i = \delta_0 + \delta_1 L_{1i} + \delta_2 L_{2i} + \delta_3 L_{3i} + \delta_4 L_{4i} + \delta_5 L_{5i} + \delta_6 L_{6i} + \delta_7 L_{7i} + \delta_8 L_{8i} + \delta_9 L_{9i} \tag{14}$$

Where: $\delta_0$ is a constant, $\delta_i$ are model coefficient and $L_1$, $L_2$, $L_3$, $L_4$, $L_5$, $L_6$, $L_7$, $L_8$ and $L_9$ represent household size (number), farming experience (years), age of coffee trees (years), level of education (years), extension contact (number) (dummy variable to measure the influence of agricultural extension on efficiency. Value 1 is if the farmer has had contact with an Agricultural Extension Officer in the past year, and 0 meant otherwise). Moreover, the capital amount was given in TAS, estimated time movements from one farm to another was in minutes, estimated slope was in percentages and estimated shade given was also in percentages as well. These socio-economic variables were included in the model to indicate their possible influence on the profit efficiencies of the coffee farmers (determinants of profit efficiency).

The estimate for all parameters of the stochastic frontier profit function and the inefficiency model were simultaneously obtained using the program FRONTIER VERSION 4.1c (Coelli, 1996).

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Summary Statistics

The summary statistics of the variables used have been presented in Table 1. A number of points can be noted from the Table. First, it has been shown that the farms were small, with average sizes of 1 489 coffee trees which is equivalent to more than one hectare. The average level of education of the farmers was less than 8 years of schooling. On the other hand, the average age of coffee trees was more than 27 years and the average estimated slope for coffee farms was 25%. It was also found out that farmers spend an average time of more than 12 minutes to move from one farm (coffee) to another (other crops).

## 4.2 The Structure of Coffee Production

The Maximum-Likelihood Estimates (MLE) of the parameters of translog stochastic frontier profit function defined by equation (12) and homogeneity were automatically imposed because a normalized specification was used. Moreover, the specifications for the inefficiency effects defined by equation (14) were obtained using FRONTIER 4.1 (Coelli, 1996). The results of the profit frontier function are presented in Table 2.

**Table 1: Summary Statistics**

**Table 1a: Output, Profit and Prices**

| Variables | Mean | Standard Deviation |
|---|---|---|
| Coffee Output (Kg)-Home Process | 307.76 | 351.26 |
| Coffee Output (Kg)- Cherry | 897.69 | 1 195.78 |
| Profit (TAS) | 867 128 | 1 090 408 |
| Coffee Price-Home Process (TAS/Kg) | 1 537 | 353 |
| Coffee Price-Cherry (TAS/Kg) | 292 | 118 |
| Fertilizer Price (TAS) | 104 962 | 64 716 |
| Insect-Treatment Price (TAS/Unit) | 30 996 | 13 987 |
| Disease-Treatment Price (TAS/Unit) | 17 600 | 1 350 |
| Herbicide Price (TAS) | 15 309 | 2 065 |
| Hired Labour Pay (TAS) | 27 393 | 39 253 |
| Farm Size (# of Trees) | 1 489 | 852 |

**Table 1b: Farm-Specific Variables**

| Variables | Mean | Standard Deviation |
|---|---|---|
| Number of Household | 3.78 | 2.38 |
| Experience (Years) | 24.7 | 16.14 |
| Coffee Trees Age (Years) | 27.3 | 12.37 |
| Education Level (Years) | 7.55 | 2.54 |
| Extension Contact Number | 2.3 | 1.51 |
| Capital Amount | 76 075 | 70 964 |
| Time Movement (Minutes) | 12.6 | 11.86 |
| Estimated Slope Grade (%) | 25.29 | 9.54 |
| Estimated Shade Given (%) | 19.56 | 11.03 |
| Total Observation | 116 | |

Note: Exchange rate: 1 USD = 1512.46 TAS (BoT, 2011) and 1 ha = 1262 coffee trees

Furthermore, Table 2 indicates results for testing hypothesis that the efficiency effects jointly estimated with profit frontier function are not simply random errors. The key parameter is $\gamma = \sigma_u^2/\sigma_u^2+\sigma_v^2$, which is the ratio of the errors in equation (6) and is bounded between zero and one, where if $\gamma = 0$, inefficiency is not present, and if $\gamma = 1$, there is no random noise. The estimated value of $\gamma$ is close to 1 and is significantly different from zero, thereby, establishing the fact that a high level of inefficiencies seemed to exist in Mbinga coffee farming.

### 4.2.1 Input Use and their Frequency

On the basis of basic features of production structure, namely, the input and output shares and profit with respect to changes in variable input prices and fixed factors, shown in Table 2. Fig. 10 presents frequencies of which major inputs had been used by coffee farmers in the production. It was revealed that, the frequency of using fertilizer and insecticides were high as they were presented by 94.8% and 96.6% respectively.

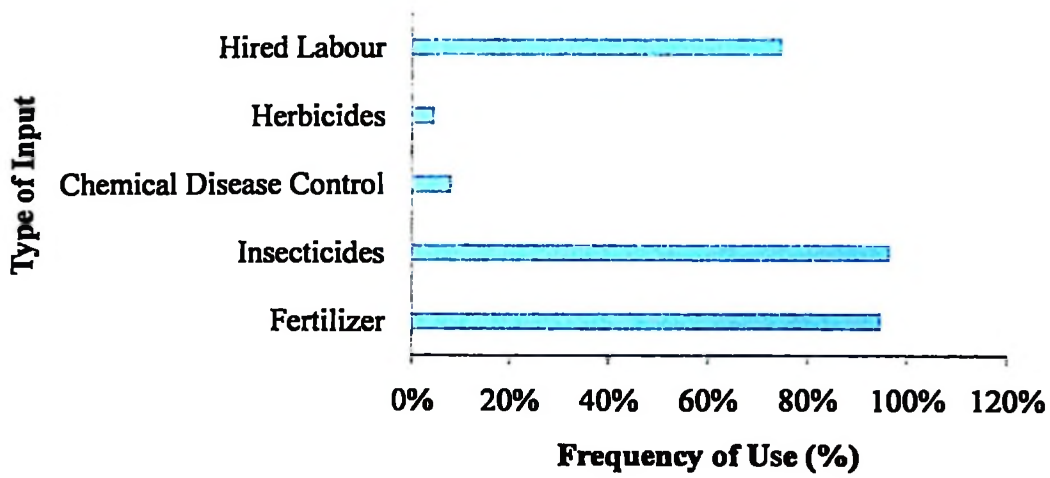



**Figure 10: Farmer's inputs use frequency**

**Table 2: Maximum Likelihood Estimates (MLE) of Translog Stochastic Frontier Profit Function and Inefficiency Model for Mbinga Coffee Farmers**

**Table 2a: Profit Function**

| Variable | Parameter | Coefficient | Std Error | T-ratio |
|---|---|---|---|---|
| Constant | $\beta_0$ | 6.947*** | 0.629 | 11.043 |
| lnFsize | $\beta_1$ | 0.603*** | 0.251 | 2.404 |
| lnFert | $\beta_2$ | 0.246 | 0.223 | 1.097 |
| lnInse | $\beta_3$ | -0.271 | 0.212 | -1.278 |
| lnDis | $\beta_4$ | -0.973 | 1.046 | -0.930 |
| lnHerb | $\beta_5$ | -0.318 | 0.263 | -1.207 |
| lnLab | $\beta_6$ | -0.357** | 0.183 | -1.951 |
| 1/2lnFsizeXlnFsize | $\beta_7$ | 0.038 | 0.083 | 0.463 |
| 1/2lnFertXlnFert | $\beta_8$ | -0.037 | 0.031 | -1.192 |
| 1/2lnInseXlnInse | $\beta_9$ | 0.071** | 0.035 | 2.008 |
| 1/2lnDisXlnDis | $\beta_{10}$ | 0.108 | 0.828 | 0.130 |
| 1/2lnHerbXlnHerb | $\beta_{11}$ | 0.067 | 0.065 | 1.029 |
| 1/2lnLabXlnLab | $\beta_{12}$ | 0.100*** | 0.030 | 3.338 |
| lnFsizeXlnFert | $\beta_{13}$ | -0.004 | 0.069 | 0.061 |
| lnFsizeXlnInse | $\beta_{14}$ | 0.025 | 0.088 | 0.288 |
| lnFsizeXlnDis | $\beta_{15}$ | -0.170 | 0.148 | 1.147 |
| lnFsizeXlnHerb | $\beta_{16}$ | -0.161** | 0.077 | 2.087 |
| lnFsizeXlnLab | $\beta_{17}$ | -0.044 | 0.049 | -0.891 |

**Table 2b: Inefficient Effects**

| Variable | Parameter | Coefficient | Std Error | T-ratio |
|---|---|---|---|---|
| Constant | $\delta_0$ | 2.040*** | 0.876 | 2.330 |
| Household Size | $\delta_1$ | -0.086 | 0.110 | -0.786 |
| Farmer's Experience | $\delta_2$ | 0.012 | 0.014 | 0.865 |
| Age of Coffee Trees | $\delta_3$ | 0.005 | 0.012 | 0.420 |
| Education Level | $\delta_4$ | 0.000088 | 0.060 | 0.001 |
| Extension Contacts | $\delta_5$ | -0.152* | 0.102 | -1.493 |
| Capital Amount | $\delta_6$ | -0.000024*** | 0.0000033 | -7.274 |
| Time Movements | $\delta_7$ | -0.016 | 0.015 | -1.119 |
| **Variance Parameters** | | | | |
| $\sigma^2=\sigma_u^2+\sigma_v^2$ | $\sigma^2$ | 0.718*** | 0.195 | 3.678 |
| $\gamma=\sigma_u^2/\sigma_u^2+\sigma_v^2$ | $\Gamma$ | 0.771*** | 0.073 | 10.516 |
| Log Likelihood | LLF | 104.880 | | |
| Number of Observations | | 116 | | |
| Mean Technical Efficiency | | 52.4% | | |

Note: *** Significant at 1 percent level ($P<0.01$)

** Significant at 5 percent level ($P<0.05$)

* Significant at 10 percent level ($P<0.10$)

Also, Fsize = farm size, Fert = fertilizer, Inse = insect control units, Dis = disease control units, Herb = herbicide, Lab = labour

Furthermore, out of 75% of the rate that was spent on hired labour, 73.3% of the same was used to pay for harvesting costs while the rest was used to pay for planting, mulching, weeding, pruning, and spraying activities. This phenomenon could be attributed to the use of family labour in most of the activities and significant importance of harvesting rather than other activities in coffee production.

Generally, coffee farmers seemed to apply inputs below the recommended rate. As noted by Mwakalobo (2000), Mbinga farmers were found to use insecticides and herbicides for insects and weed control below the recommended rate. Additionally, the study revealed that, the average rate of 29.9 and 32.9 instead of 40 milliliter/knapsack were used by farmers for controlling insects and weeds respectively. Credit could be significantly important in increasing their purchasing power during the production season. Moreover, improvement of inputs services provided by the cooperative societies would be important as well (Fig. 11).

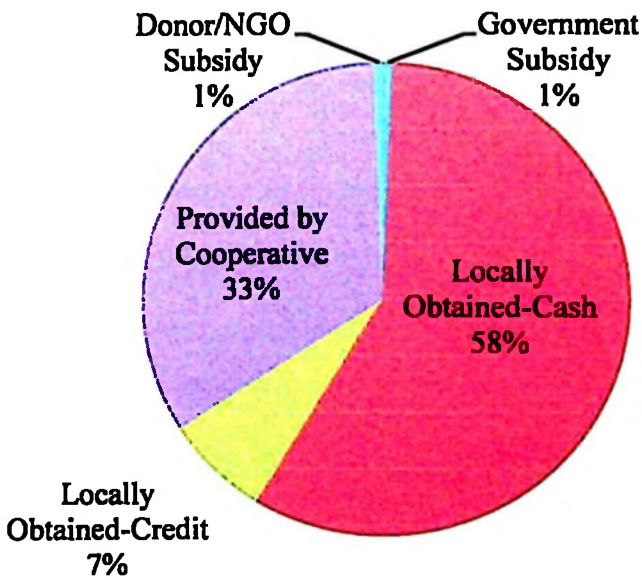



**Figure 11: Coffee farm's inputs sources**

### 4.2.2 Sources of Farms Inputs

Fig. 11 shows different sources of inputs to coffee farmers. Most of the surveyed farmers (58%) obtained their inputs by buying locally. Through farmer's cooperatives and inputs services provision systems, only 33% of respondents obtained their inputs from these sources. However, this call upon further improvements of the related services to farmers since it is easy to get inputs through already established systems to cooperatives members and pay in credit through post-harvest sales deductions. Since most farmers are operating under FBG and corresponding cooperatives and buy inputs locally, the frequency of farmers to use inputs from NGO/donor and government in form of subsidy was revealed to be very poor. Furthermore, the locally obtained inputs provided in the form of credit accounted for only 7% of use. In order to improve both production and productivity, government subsidies provision to coffee farmers should be improved and the system to ensure the same should be sustainable.

### 4.3 Production/Profit Efficiency and Distribution

The distribution of profit efficiency of coffee farmers is presented in Table 3. The average profit efficiency score was 52.4% implying that the average farm producing coffee could increase profits by 47.6% through improving their technical and allocative efficiency. This average TE or PE does not differ significantly with that of 49.2% of Rungwe coffee farmers as presented by Mwakalobo (2000). Farmers exhibited a wide range of profit inefficiency in the production season, ranging from 97.7% less than the maximum profit to 6% less than the same. Observation of wide variation on profit is not surprising and similar results were found in Bangladesh, Pakistan and China. For example, Rahman (2003) and Ali and Flinn (1989) reported the mean profit efficiency level of 0.77 (with a range from 16.8 to 94.1%) and 0.69 (with a range from 13 to 95%) for rice producers in Bangladesh and Pakistan respectively. Wang *et al.* (1996) reported the mean profit efficiency level of 0.62 (with a range from 6 to 93%) for rural farm households in China. Despite the wide variation in efficiency, more than 32% of farmers had less than 40.1% efficiency level. In this regard, most of the farmers seemed to be skewed towards profit efficiency of less than 60%. Nevertheless, the results imply that a considerable amount of profit can be obtained by improving technical an allocative efficiency in Mbinga coffee production.

**Table 3: Frequency Distribution of Frontier 4.1c Technical Efficiency Scores**

| Efficiency Score (%) | Number of Farmers | Percentage |
|---|---|---|
| 2.0-21.0 | 15 | 12.93 |
| 21.1-40.1 | 23 | 19.83 |
| 40.2-59.2 | 29 | 25.00 |
| 59.3-78.3 | 21 | 18.10 |
| 78.4-97.4 | 28 | 24.14 |
| **Total** | **116** | **100** |

Note: Average score (TE or PE) is 52.4%

Moreover, it was not a surprise for 12.9% of farmers being below 21% of efficiency score in developing country's agriculture (Table 3). Related findings from elsewhere have revealed that maize smallholder farmers were reported to have the highest frequency for efficiency score below 20% while 79% of farmer's plots had efficiency score below 70% (Chirwa, 2007).

### 4.4 Profit-Loss Estimation and Factors Explaining Inefficiency (Socio-economic Variables)

An estimation of profit-loss given prices and fixed factor endowments revealed that coffee farmers were losing to the tune of TAS 787 696 per mean index of coffee trees equivalent to more than one hectare which could be recovered by eliminating technical and allocative efficiency (Table 4).

The impact of socio-economic factors accounting for this inefficiency in coffee production is presented in the lower panel of Table 2. On the basis of the presented statistics, it is important to point out prior assumptions which guided investigation of the stated variables.

It was expected that household size, experience of growing coffee, education level, extension services, capital, and shade would be positively related to efficiency, while age of coffee trees, time movements, and slope would be associated with lower efficiency levels. Results of this study revealed that coefficients of six (out of nine variables) were significantly weak.

For instance, the poor effect of education on coffee production was not surprising. Similar results had been reported in the past analyses of technical efficiency in

Bangladesh agriculture (see Rahman, 2003). The average education levels of less than eight years (Table 1) seemed to clearly explain the role of education.

It was further noted that farmers with no education seemed to incur higher profit loss and performed at significantly lower levels of profit efficiency, hence their effect was not captured in the regression analysis.

It was also shown that household size performed better than it was expected. This was largely due to availability of family labour for coffee production. Table 4 shows that, farms with household size of more than 3 persons performed well with higher levels of profit efficiency.

On the other hand, farmer's experience in growing coffee seemed to perform well as expected in the study. It was found that farmers with more than twenty four years of experience in growing coffee earned higher profits. They also seemed to operate at higher level of profit efficiency compared to those who had up to twenty four years of experience (Table 4).

The age of coffee trees was included to reflect the relative importance of younger trees in terms of increasing farm profit. The positive sign on the estimated coefficient implied that the more aged trees had reduced farm profit. Table 4 clearly shows that coffee farms with trees older than 40 years, operated at lower levels of efficiency. Hence farmers incur high profit-loss.

**Table 4: Profit Loss in Coffee Farming and Key Constraints**

| Farm-Specific Characteristic | N | Average Profit | Estimated Profit Loss[1] | Farm Size (# Trees) | Average PE (%) |
|---|---|---|---|---|---|
| **Profit loss by household size** | | | | | |
| More than 3 household | 53 | 1 127 297 | 748 405 | 1 580 | 60.1 |
| Up to 3 household members | 63 | 648 257 | 745 844 | 1 428 | 46.5 |
| **Profit loss by farmer's experience** | | | | | |
| More than 24 years of experience | 47 | 972 873 | 733 921 | 1 581 | 57.0 |
| Up to 24 years of experience | 69 | 795 099 | 807 923 | 1 442 | 49.6 |
| **Profit loss by age of coffee trees** | | | | | |
| More than 40 years | | 812 965 | 863 252 | 1 381 | 48.5 |
| Up to 39 years | 97 | 877 737 | 762 280 | 1 521 | 53.52 |
| **Profit loss by level of education** | | | | | |
| Some education | 114 | 1 227 050 | 520 884 | 1 725 | 70.2 |
| Zero education | 2 | 860 813 | 788 254 | 1 494 | 52.2 |

[1] Estimated loss from maximum profit obtained given prices and fixed factor endowments; maximum profit is computed by dividing the actual profit of individual farms by its efficiency score.

| Farm-Specific Characteristic | N | Average Profit | Estimated Profit Loss[a] | Farm Size (# Trees) | Average PE (%) |
|---|---|---|---|---|---|
| **Profit loss by extension contacts** | | | | | |
| Farmers having extension contacts | 116 | 867 128 | 787 696 | 1 498 | 52.4 |
| Farmers not having extension contacts | 0 | - | - | - | - |
| **Profit loss by capital amounts** | | | | | |
| More than 76 000 TAS | 48 | 1 529 660 | 512 609 | 1 760 | 74.9 |
| Up to 76 000 TAS | 68 | 399 458 | 680 158 | 1 313 | 37.0 |
| **Profit loss by time movements** | | | | | |
| More than 12 minutes | 39 | 865 899 | 653 222 | 1 330 | 57.0 |
| Up to 12 minutes | 77 | 867 750 | 850 567 | 1 583 | 50.5 |
| **Profit loss by farm's slope** | | | | | |
| More than 25% | 51 | 931 424 | 816 088 | 1 485 | 53.3 |
| Up to 25% | 65 | 816 680 | 747 841 | 1 507 | 52.2 |
| **Profit loss by shade given** | | | | | |
| More than 20% | 39 | 770 328 | 776 515 | 1 720 | 49.8 |
| Up to 20% | 77 | 916 156 | 777 293 | 1 385 | 54.1 |
| **All farms** | 116 | 867 128 | 787 696 | 1 498 | 52.4 |

Note: # represents number of, and N represents number of respondents, while categories of household size, farmer's experience, capital amounts, time movements and slope are based on the mean index score while the rest are based on TACRI (2008) recommended rates.

The capital amounts used by farmers seemed to play the expected roles in increasing efficiency in coffee production. Regarding this, it was revealed that farmers whose capital amounts were more than TAS 76 000, performed significantly better in terms of earning actual profit. This is because they incurred more profit and operated at higher levels of efficiency.

Time spent by farmers to move from one farm to another was expected to have a significant management impact on coffee farms hence affecting yields. The weak significance of the coefficient was not expected for this variable. It was revealed that, farmers who spent less than 12 minutes to move from coffee farm to other farms obtained higher actual profits. Conversely, these farmers were found to have less efficiency with more profit-loss as shown in Table 5.

Similarly, farmers located at relative higher slopes performed better than their counterparts in areas with gentle slopes. Furthermore, farmers with more shade in their farms (more than 20%) operated at lower levels of efficiency and earned less actual profit and incurred high profit-loss. These results do not differ from those of TACRI (2008) in which open grown coffee was found to yield more than the shaded coffee.

### 4.5 Coffee Farm Sizes and their Distribution

Coffee farm sizes and their distribution among Mbinga farmers are presented in Table 5. It was revealed that, more than 75% of farmers owned farms that had less than 2000 coffee trees which is equivalent to 1.58 hectares. However, the average farm size among respondents was 1498 trees. This concurs with the national averages since agriculture in

Tanzania is dominated by smallholder farmers and peasants cultivating farms of average sizes of between 0.9 and 3.0 hectares (URT, 2008). Despite the wide variation of farm sizes (Table 5), coffee farmers seemed to be skewed towards lower farm sizes of below 1500 trees which were not economically profitable (Fig. 12).

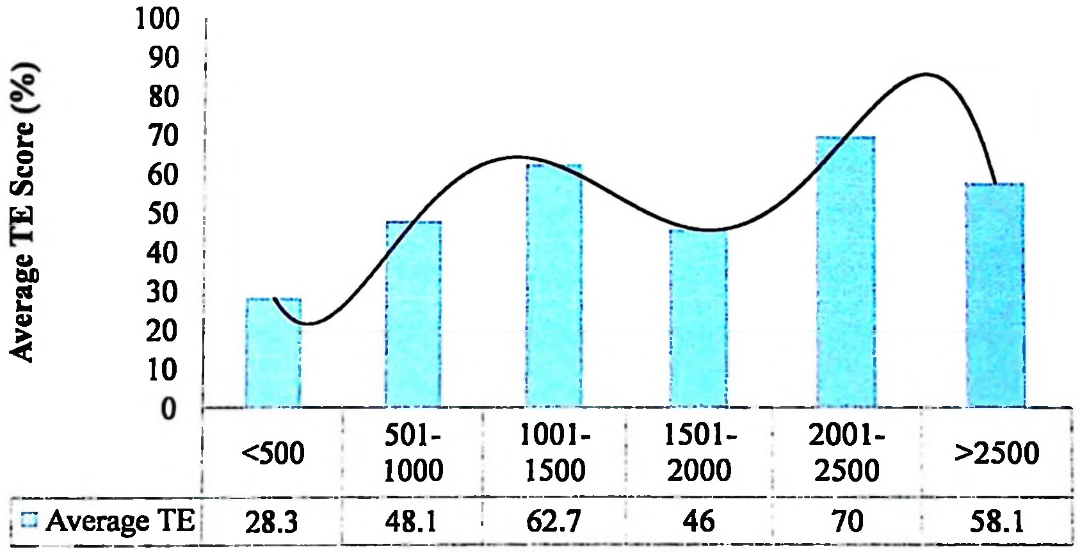
**Table 5: Coffee Farms and Farm Size Distribution**

| Farm Size (# Trees) | Number of Farms | Percentage |
|---|---|---|
| <= 500 | 12 | 10.3 |
| 501-1 000 | 24 | 20.7 |
| 1 001-1 500 | 33 | 28.4 |
| 1 501-2 000 | 24 | 20.7 |
| 2 001-2 500 | 9 | 7.8 |
| >= 2 500 | 14 | 12.1 |
| **Total** | **116** | **100** |

Note: # represents number of trees per coffee farm and average farm size is 1498 trees.

### 4.6 Profit Efficiency and Farm Size Relationship

As presented in Fig. 12, the relationship between profit (technical) efficiency and farm size show some fluctuations. It can be noted clearly from the findings that, the average TE/PE score for small farms (less than 2 hectares or less than 2524 coffee trees) was relatively less efficient than farms measuring above 2 hectares (medium farms). It was noted that, small farms and medium farms revealed the average TE/PE score of 51.96% and 58.08% respectively.




Note: *Values in x-axis indicate the number of coffee trees (farm size)*

**Figure 12: Average profit efficiency scores and farm size**

The observed tendency of increasing farm efficiency when moving from very small or small farms to relatively medium farms could also be attributed to factors as shown in Table 4 and discussed in section 4.4.

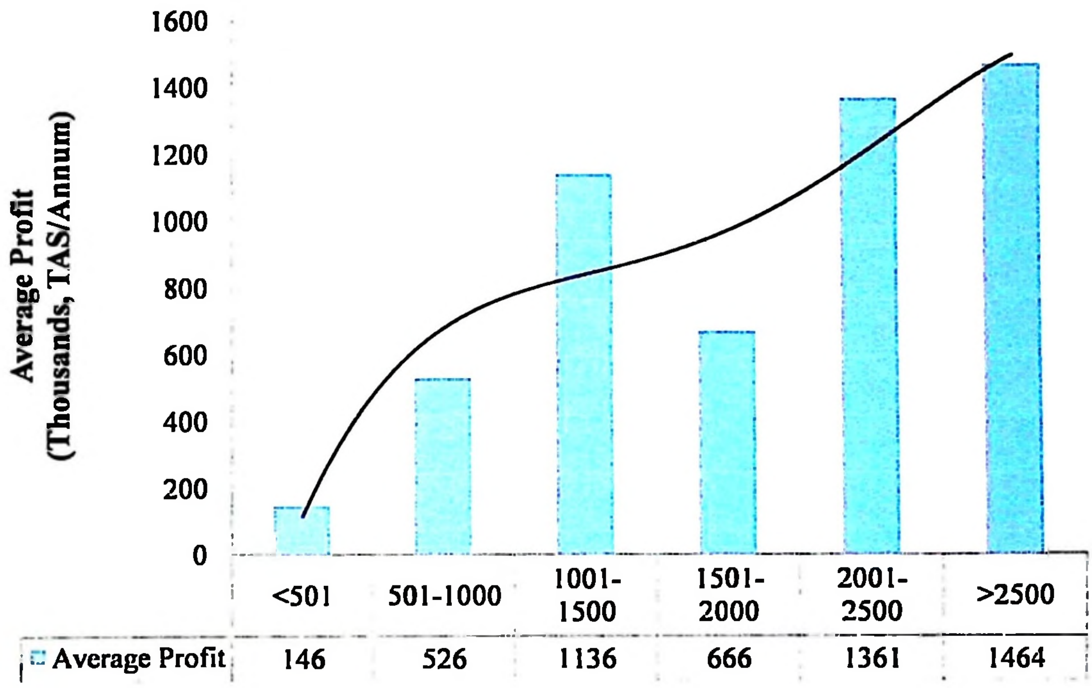
### 4.7 Profit Trend and Farm Size Relationship

Fig. 13 presents relationship between average profit and farm size among coffee farmers. It indicates that the average profit per coffee trees increases steadily after a sharp increase from less than 501 trees per farm to less than 1500 trees per farm. The increase in the average farm profit is associated with an increase in farm size when there is an increase from more than 1500 coffee trees. This could be attributed to factors such as household size, age of trees, education level, time management and access to capital (Table 4). Conversely, it was also found that yields of 0.198 kg/tree and 1.66 kg/tree were obtained for home processed coffee and coffee cherry respectively. The ratio of one to eight was revealed for cherry and processed coffee bean, which is slightly less than the recommended rate. This was probably due to inefficiency of individual farms.

It was also noted with concern that, there was an increase in the average profit per unit area among coffee farmers resulting from farm size increases (Fig. 13). The findings indicated clearly that medium farms (more than 2524 trees) had significantly higher profit ratios than small farms. Small and medium sized farms seemed to have average profit ratios of 35% and 65% respectively. On the basis of this evidence, it can be confidently stated that the increase in profitability was associated with the increasing farm size. In other words, it means that small size farms are associated with more profit-loss compared to medium size farms.

## 4.8 Contribution of Coffee Production to the Livelihood of Farmers and Poverty Reduction

According to Tanzania's Poverty and Human Development Report (2009), Poverty levels in Tanzania are still high in rural areas where 37.6% of rural households live below the poverty line compared with 24.1% of urban households. In this study, coffee farming revealed to have the ability to increase farmer's income and hence reduce poverty significantly. Philip (2009), in his study on productivity, used a similar approach to examine if the size of sugarcane was an important variable in determining productivity. The variations of coffee farmer's income per capita are shown in Fig. 14.




Note: *Values in x-axis indicate the number of coffee trees (farm size)*

**Figure 13: Average profit against farm size**

As presented in Fig. 14, farmers with more than 500 coffee trees had income per person higher than the international poverty line. For the farmers to earn more than 13 998 TAS per 28 days which is the 2007 poverty line level as stipulated by Policy Forum (2011), they should be encouraged and supported to increase their farm sizes to at least 0.39 hectares. Based on farmers' responses on new plantings, only 19.8% and 54.3% were realized by those who wanted to expand and replant respectively. In this regard, a support should be provided to them especially in terms of seedlings of the new varieties.

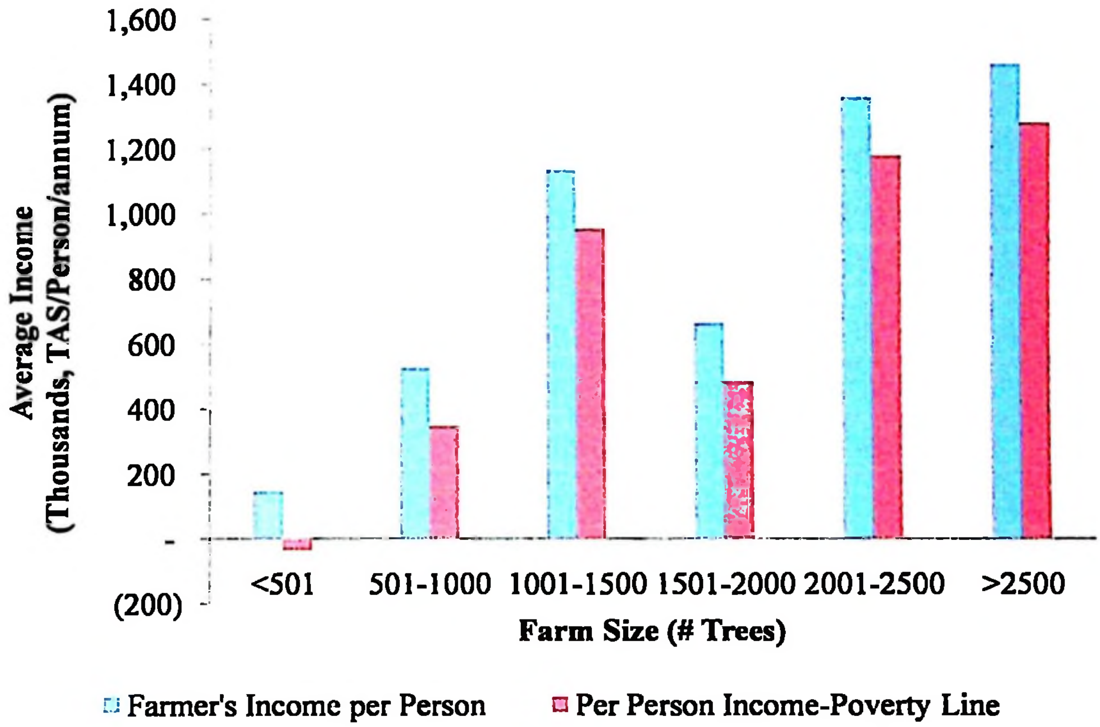



**Figure 14: Discrepancy of coffee farmer's income per person**

### 4.9 Alternative Crops Grown

In an attempt to spread risk, coffee farmers were found to grow other crops as well. Fig. 15 presents other crops grown by coffee farmers and it was revealed that, more than 60% of farmers grew other crops. Maize and Cassava seemed to be grown by most farmers, 58% of respondents grew both maize and cassava, and 12% and 26% grew maize and cassava respectively. This is not surprising because maize was reported to be a major food crop in the district (Table 6). Cassava which is a drought resistant crop has started gaining importance in recent years because of climate changes specifically less rain.

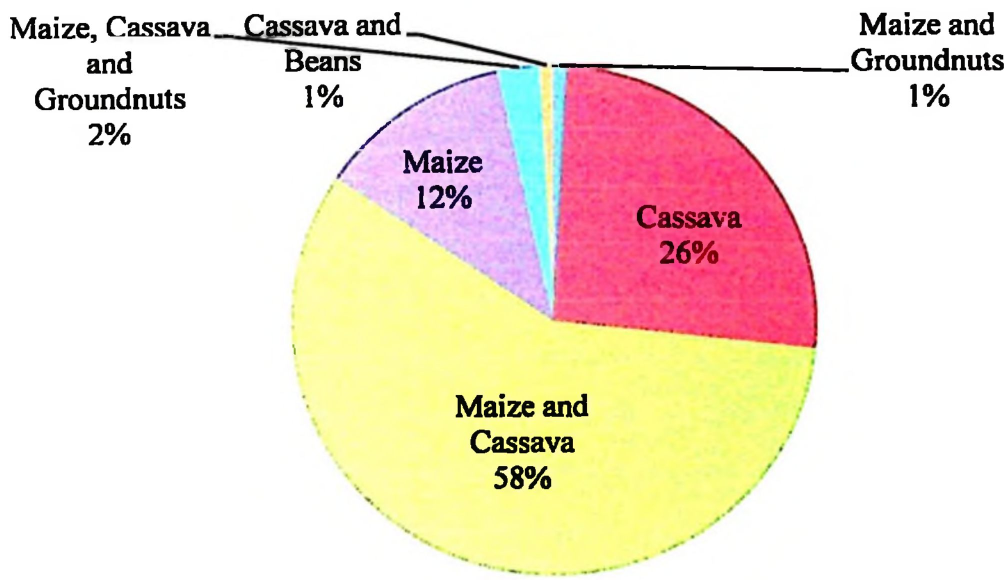



**Figure 15: Alternative crops grown by coffee farmers**

According to Amani (2004) and DALDO (2011), both maize and cassava are used as staple crops and cash crops in areas which produce in surplus. Apart from maize and cassava, other crops cultivated by farmers though in small percent include beans, and groundnuts. The big challenge was however on how to support processing and other value addition activities to these major alternative crops such as maize and cassava.

**Table 6: Actual Food Crop Production for 2009/10 Season and Projection for 2010/11**

| Crop | Average Households in Production | Actual Production 2009/10 (tons) | Estimated Area 2010/11 (ha) | Production Estimates 2010/11 (tons) | Actual Area 2010/11 (ha) | Actual Production 2010/11 (tons) |
|---|---|---|---|---|---|---|
| Maize | 49 283 | 144 635 | 59 082 | 165 430 | 60 321 | 166 669 |
| Beans | 34 540 | 17 724 | 19 844 | 20 382 | 19 850 | 20 388 |
| Paddy | 7 256 | 24 100 | 14 200 | 39 050 | 11 425 | 31 418.7 |
| Cassava | 47 098 | 96 348 | 48 773 | 110 800 | 47 414 | 107 712 |
| Wheat | 5 872 | 2 207 | 3 012 | 2 538 | 3 018 | 2 543 |
| Banana | | 2 653 | 80 | 3 216 | 72 | 2 894.4 |
| **Total** | | **340 083** | **159 335** | **401 696** | **154 167** | **382 336.1** |

Moreover, coffee farmers grow maize and cassava not only because they are major food crops in their area but also due to cheap production costs. For instance, costs of producing one kilogram of each produce is low compared to other crops such as beans (Table 7). Since most of the farmers have small plots of these food crops, it is easy for them to manage at relatively low costs. It was also found out that, farmers used an average time of 12.6 minutes to move from one plot to another. Thus, it seemed that it was profitable for them to be engaged in both cash (coffee) and food crop production, especially maize and cassava.

**Table 7: Summary and Estimates of Maize, Beans and Cassava Costs of Production**

| Cost Items | Maize | Beans | Cassava |
|---|---|---|---|
| Labour Costs (TAS/ha) | 130 000 | 45 000 | 101 000 |
| Material/Intermediate | | | |
| Inputs (TAS/ha) | 220 200 | 88 600 | 258 000 |
| **Total Variable Costs** | | | |
| TAS per ha | 350 200 | 133 600 | 359 200 |
| TAS per kg | 80 | 120 | 75 |
| **Fixed Costs** | | | |
| TAS per ha | 25 800 | 24 400 | 24 500 |
| **Total Costs** | | | |
| TAS per ha | 326 000 | 158 000 | 383 500 |
| TAS per kg | 80 | 120 | 75 |

Note: Exchange rate: 1 USD = 1512.46 TAS (BoT, 2011) and 1 hectare = 1262 coffee trees

# CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The study used stochastic profit frontier functions to analyse farm size and productive efficiency of Mbinga coffee farmers. Using detailed survey data from 116 coffee farms in 2010, measures of profit inefficiency were computed, indicating a wide variation among farmers. The mean level of efficiency for coffee farming was 0.524 indicating that there are potential opportunities for increasing profits by improving technical and allocative efficiency.

The farm-specific variables which were used to explain inefficiencies indicated that farmers who had some education, more household size, more experience in growing coffee, younger coffee trees, better capital, and less shade provided to farms seemed to be more efficient. Due to the gap of 47.6% inefficiency level, generally, farmers are losing to the tune of TAS 787 696 per mean index of coffee trees which is 1.18 hectares.

On the basis of findings of this study, it can be concluded that inefficiency in coffee farming can be reduced significantly by increasing farm size: that is increasing number of trees. Increasing size of farms could not only increase farm's efficiency but also contribute in alleviating poverty among the farmers. In addition, capital amounts and extension services need to be improved in order to increase efficiency. It was also found that, cooperative services and government subsidy programs should be strengthened so as to bring more positive impact on farm's productivity.

As an attempt to overcome risks, farmers were found to grow alternative crops such as maize and cassava. The crops were preferred for two major reasons: first their production costs were relatively low and apart from using them as food crops, the surplus could be sold as well. Increased productivity and efficiency, in conjunction with rational government policies, would dramatically alter positively the economic contribution of coffee sub sector to trade, food security and livelihoods of important stakeholders along the chain.

**5.2 Recommendations**

Results of this study have clearly revealed that farmers were general responsive to changes in farm size which are also coupled with changes in output and inputs prices. In addition, it seemed that profitability increased substantially with increases in farm size under cultivation in terms of number of coffee trees. In this regard, it is recommended that coffee farmers should increase their farm size at least to medium farms of more than 1262 coffee trees.

Since most of the farmers had small farms, cooperatives societies, private sector, and government should put in place initiatives which will create conducive environment for improving efficiency and profitability in coffee production business.

Since, most of agricultural inputs are often imported and are expensive (particularly fertilizers, herbicides and insecticides). The government should continue to provide input subsidies to farmers. The already established mechanism for provision of subsidy should be reviewed in a bid to improve coffee productivity. It is also recommended that, private sector should join hands with government efforts to ensure timely availability of farm inputs at affordable prices.

Lastly, a special attention should be directed on alternative crops which do not only spread risks of farmers but also play a significant role in improving farmers' income, hence stabilizing their economic positions. In this regard, the production of various crops should be emphasized since they have positive impact on the efficiency of coffee farms.

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# APPENDICES

## Appendix 1: Description of Agro-ecological Zones of Mbinga District

| Agro-ecological Zone | Altitude (m.a.s.l.) | Annual Rainfall (mm) | Descriptive Features |
|---|---|---|---|
| Mountain areas | | | This zone is characterized by strong dissected mountains with steep slopes and narrow valleys. Because of altitude and local microclimatic condition this agro-ecological zone is very suitable for coffee production |
| High altitude | 1 600-1 900 | 1 400-1 600 | |
| Low altitude | 1 400-1 600 | 1 000-1 400 | |
| The Hagati Plateau | 1 500 | 1 400-1 600 | The agro-ecological zone is characterized by gently rolling plateau at the top of mountains. This zone is located between the mountain zones west of Mbinga and ranges down to Lake Nyasa. The main differences between the plateau and other zones are the shallow soils and unique microclimate (ICRA, 1991). This zone is also suitable for coffee. |

| | | | |
|---|---|---|---|
| Rolling Hills | 1 200-1 300 | 1 000-1 200 | This is the largest agro-ecological zone covering an area of flat to undulating intra-mountain plains between 1 100 and 1 400m and intermixed with mountain ranges up to peaks of 1 600m. The landscape is dissected by creeks and streams that give origin to flat and V-shaped valley bottoms. This agro-ecological zone is found in the north and south of the district. |
| Lakeside | 500-600 | 900-1 400 | This agro-ecological zone comprises mainly of a flat narrow coastal strip with undulating hilly slopes rising to steep escarpment adjoining the mbinga Highlands west of the Hagati plateau. It has a hot and humid climate, very different from the rest of the Mbinga district. |

Source: Ellis-Jones *et al.* (1994); Kangalawe and Lyimo (2006)

## Appendix 2: Mbinga Coffee Farmers Questionnaire

### Personal Information and Socio-Economic Characteristics Of Farmers

| Questionnaire Number | Farmer First Name | Farmer Surname | Gender of Respondent | Farm Owner (Y/N) |
|---|---|---|---|---|
| | | | | |
| Farm Owner Gender (M/F) | Head of Household (Y/N) | Gender House Head (M/F) | Cooperative Name | Village |
| | | | | |
| Household Size | Farmer's Age (yrs) | Years in Farming (yrs) | Coffee Variety(ies) | Age of Trees |
| | | | | |

| Level of Education (1= No; 2= Adult; 3= Primary; 4= Secondary; 5= Other, specify…) | Number of Extension Contacts |
|---|---|
| | |

### Yield Data-Previous Season

| Home Process (Y/N) | Kg Home Process Sold | Tsh/Kg Home Process | Wet Milled (Y/N) | Kgs Cherry Sold | Tsh/Kg Cherry |
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### Nutrition and Soil Management

Fertilizer (s) Used (1=DAP; CAN; 3=NPK; 4=Composted Manure; 5=Raw Manure; 6=Urea; 7=Foliar; 8=Composted Cherry Pulp; 9=Raw Cherry Pulp; 10=Misc Compost; 11=Boron (e.g. Solubar); 12=Zinc)

| Fertilizer (s) Used | Application/Season | Application Month (s) | Total Quantity (Kg) | Quantity per Tree | Price (Tsh/Kg) |
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| Fertilizer Records (Y/N) | Mulching Practices (1=Full; 2=Drip Line; 3=Poor; 4=None | | Mulch Material | Green Mulching (Y/N) | Green Mulch Material |
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| **Erosion Control** | | | | | |
| Erosion Control (1=None; 2=Contours; 3=Stabilizing Grasses; 4=Terracing; 5=Water Traps; 6=Physical Barriers; 7=Mulching) | | | | | |
| Est. Slope Grade (%) | | 1st Control Method | 2nd Control Method | 3rd Control Method | |
| | | | | | |
| **Insect Control** | | | | | |
| Problem Pests (1=Antestia; 2=Berry Borer; 3=Mealy Bug/Scales; 4=Stem Borer; 5=Berry Moth; 6=White Borer) | | | | | |
| Control Methods (1=Chemical; 2=Mechanical; 3=Trap; 4=None) | | | Chemical Type (1=Dursban; 2=Pyrethroids; 3=Thiodan; 4=Sumithion; 5=None) | | |
| Problem Insect | Severity (1=Minimal; 2=Moderate; 3=Severe) | Control Method | If Chemical, Type Used | ml/Knapsack | Treatment Price (Tsh/Unit) |
| | | | | | |
| | | | | | |
| Decision Process (1=Routine; 2=Treat/Spray on Scouting; 3=No Action-Cost; 4=No Action-Availability; 5=No Action-Unknown; 6= Claims non Issue) | | | | | |
| **Disease Control** | | | | | |
| Diseases (1=CBD; 2=Leaf Rust; 3=None) | | Control Methods (1=Copper Sprays; 2=Systemic Sprays; Mechanical; 4=None) | | | |

| Problem Disease | Severity (1=Minimum; 2=Moderate; 3=Severe) | Control Method | If Chemical, Brand Used | Liters per Knapsack | Treatment Price (Tsh/Unit) |
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| Decision Process (1=Routine; 2=Treat/Spray on Scouting; 3=No Action-Cost; 4=No Action-Availability; 5=No Action-Unknown; 6= Claims non Issue) | | | | | |
| **Weed Control** | | | | | |
| Hand Weeding (Y/N) | Chemical Weeding (Y/N) | Weed Status (1=Clean; 2=Some Weed; 3=Very Weedy | | | |
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| Herbicides (1=Gramoxone (paraquat); 2=Roundup (glyphosate), 3=None) | | | | | |
| Herbicide Used | Application/Season | ml/Knapsack | Price (Tsh) | | |
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| **Irrigation** | | | | | |
| Irrigation Used(Y/N) | Irrigation Method (1=Bucket/Basins; 2=Open Furrow; 3=Piped) | Month (s) Required | | | |
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| **New Plantings** | | | | | |
| Replanting (Y/N) | Expansion (Y/N) | Decision Process (1=Disease Resistance; 2=Increase Income; 3=Unproductive; 4=None) | | | |
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| Hired Labour | | | | |
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| Hired Labour (Y/N) | Uses (1=Planting; 2=Mulching; 3=Weeding; 4=Pruning; 5=Spraying; 6=Harvesting; 7=Irrigation) | | | |
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| Weeding Pay | Pruning Pay | Spraying Pay | Harvesting Pay | Other Labour and Pay |
| | | | | |

| Finance and Credit | | |
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| Input Type (1=CAN; DAP; 3=Dursban; 4=Folia; 5=Folia Boron (e.g Solubar); 6=Gramoxone (Paraquat); 7=NPK; 8=Pyrethoids; 9=Roundup (Glyphosate); 10=Urea; 11=Zinc; 12=Sumithion) | | |
| Source of Inputs (1=Government Subsidy; 2=Locally Obtained-Cash; 3=Locally Obtained-Credit; 4=Provided by Cooperative; 5=Donor/NGO Subsidy) | | |
| Input Type | Source of Inputs | Est. Amount of capital and/or loan used for the last coffee season |
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| Alternative Crops Grown | |
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| Other crops grown by coffee farmer | Est. Time used by the farmer to move from one farm to another (mnts) |
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