PRODUCTION EFFICIENCY OF SMALL-SCALE TREE GROWERS IN MUFINDI DISTRICT, TANZANIA

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ABSTRACT

The demand for wood product is expected to double between 2013 and 2035 due to increasing demand driven largely by construction, furniture, population growth and paper sectors. Therefore there is a need for private sectors including small-scale farmers to counter balance the supply. However, the efficiency of small-scale farmers in production of trees is still unknown. Therefore this study investigated technical efficiency of small-scale tree growers and factors influencing production efficiency of small-scale farmers in Mufindi district. Structured questionnaire was administered to 244 respondents from randomly selected households. The collected data was analyzed using descriptive statistics data envelopment analysis and Tobit Model. Results indicate that small-scale tree growers were not fully technically efficient as the mean efficiency was 84.5% under Variable Return to Scale and 80% under Constant Return to Scale assumptions. Quality of seeds, farm size, extension services and marital status were major factors significantly influencing technical efficiency of the small-scale tree growers. The policy implication of the study is that technical efficiency of small-scale tree growers could be increased by 15.5% under variable return to scale and 20% under constant return to scale by improving the use of available resources also to encourage farmers to join farmer based organizations, better management of woodlots and Availability of quality seeds/seedling are options that would improve the efficiency of the small-scale tree growers.

DECLARATION

I, Neema Joseph Mathayo, hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own work done within the period of registration and that it has neither been submitted nor being concurrently submitted for a degree award at any other institution

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The above declaration is confirmed by:

_______________________ ___________________

Prof. J.M. Abdallah Date

(Supervisor)

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DEDICATION

I dedicate this dissertation to my beloved parents Mr. and Mrs. Joseph M. Hhayuma and my siblings, Daniel Hhayuma with his family, Yotham Hhayuma with family, Billington Lyimo and Christine Hhayuma family and to my brother Mathayo J Hayuma whom I can't thank enough. Together you have supported me throughout my entire academic life. God bless you abundantly.

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LIST OF ABBREVIATIONS

a.s.l	Above sea level
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
FDT	Forest Development Trust
SFA	Stochastic Frontier Analysis
TECRS	Technical efficiency under Constant Return to Scale
TECRS	Technical efficiency under Variable Return to Scale
TFS	Tanzania Forest Services Agency
WWF	World Wide Fund for nature

CHAPTER ONE

1.1 INTRODUCTION

Worldwide timber supply from natural and plantation forests is increasingly diminishing because of conservation, environmental and social concerns (FAO, 2007). Expansion of plantations is about 5% of the total forest area but provide 35% of the world's wood supply (FAO, 2001). WWF and TRAFFIC (2016), reported that there is increase in the consumption of wood and wood product in Tanzania due to interactions between demand by paper sectors, poles, furniture, population growth and urbanization. It is estimated that overall national wood consumption is about 62.3 million m^3 and the available wood for harvesting at sustainable level is 42.8 million m^3, therefore annually 19.5 million m^3 extra wood is consumed (NARFOMA, 2015). This implies that the supply of natural forest does not meet the demand from various uses such as construction, furniture and industries.

Forest plantation ownership varies significantly from governments and private companies to small tree growers or individual farmers. The management of these forest plantations varies from simple with low-input to very complex and intensive (Kanowski, 2018). About 52% of the plantations are publicly owned, 34% privately owned and 14% other ownership type from the non-industrial plantations, 62% are publicly owned, 9% privately owned and 29% others (FAO, 2001). Contrary to the large and medium scale tree growers, small-scales here are referred as famers who use traditional technology and have limited farm size (Scherr, 2004). Ngaga (2011), Chamshama and Nshubemuki (2011) reported that the total gross area of forest plantations in Tanzania is about 250 000 ha of which about 85 000 ha is owned by government, privately owned plantations are estimated to be 40 000 ha, while between 80 000 ha and 140 000 ha in total are owned in out-grower schemes and woodlots. According to Milledge *at el.* (2018), in Tanzania about 100 368 plantations are state / TFS owned, 51 327 ha are large scale privately owned plantation while 174 143 are small-scale tree growers in southern highland of Tanzania.

The main species in these plantations are Eucalyptus which is mostly planted genus covering 22.4% of all planted area, followed by *Pinus* (20.5%), *Hevea* (7.1%), Acacia (4.3%) and *Tectona grandis* (2.6%) (Abdallah *et al.*, 2014). In Tanzania the area covered by other broadleaved and other conifers is respectively 11.2% and 7.2%, while unspecified species cover 24.7%. Overall, the majority of planted trees are exotic species chosen for their capability of growing fast and producing wood of desired quality (FAO, 2001).

In Mufindi district tree planting is mainly for fuel wood, timber, poles, and transmission poles supply (URT, 2006 and mostly exotic species such as *Pinus patula* and Eucalyptus spp. Records from the District Natural Resources Office show that up to year 2005 about 23 million trees had been planted for production of timber, poles, transmission poles (URT, 2006).

1.2 Problem Statement and Justification of the Study

1.2.1 Problem Statement of the Study

Commercial timber production has potential to generate benefits at various levels. These benefits could be categorized into the upstream-flow effects and the downstream-flow effect (Harrison *et al.*, 2002). Example of the upstream-flow-effect is benefit to nursery operators through employment creation. The downstream-flow-effect includes opportunities created in harvesting, processing industries including tertiary processing such as furniture manufacturing (Harrison *et al.*, 2002).

In Tanzania, the government is the major supply of round wood by 70% but projections shows that in 2020 the supply will decrease to 40% and the private sector will dominate the market supply (Ngaga, 2011). According to Milledge *et al.* (2018), the demand for wood product is expect to double between 2013 and 2035 due to increasing demand by construction, furniture and paper sectors hence there is a need for private sectors including small-scale farmers to counter balances the supply. Meanwhile the Small-scale plantation forestry is expanding rapidly in southern highlands of Tanzania due to market demand and favourable policies (Kärkkäinen, 2005).

Although there is increasing number of small-scale tree growers in southern highland of Tanzania, data on the production efficiency at farm level are lacking. Despite the growing awareness of the need for tree growers to increase productive efficiency (Rowena, 2000; Milledge *et al.* 2018) in many developing countries, very little has been done in Tanzania especially in small-scale tree growing areas. Efficiency measures the farms success in producing as much as output possible from a given set of inputs. Studying production efficiency at farm level will determine economic productions and efficiency levels for the purpose of strengthening and improving sustainable use of forest raw materials. This study aims at opening a new dimension to tree growers and policy makers on how to increase timber production by determining the extent to which it is possible to raise efficiency of tree farms with the existing resource base and available technology in order to address demand deficit in the country and production challenges in Mufindi district, Tanzania.

1.2.2 Justification of the Study

Determining productivity and technical efficiency status of farmers is important for improvement of policies especially those focusing on tree plantations and utilization.

In an economy where technologies are lacking, technical efficiency studies show possibility of raising productivity by improving efficiency in the use of existing resources. It also helps to determine the underutilization or over utilization of inputs. Therefore this study provides empirical findings on the resource use efficiency of trees production so as to formulate development plans and provide an opportunity to ascertain the ground reality regarding the real cause of backwardness in tree production in Tanzania and fill in the timber supply gap in the country and east Africa in general.

1.4 Objectives

1.4.1 Overall objectives

The overall objective of this study was to assess production efficiency of small-scale tree growers in Mufindi district.

1.4.2 Specific objectives

Specifically the study wanted to:

i. Determine technical efficiency levels of small-scale tree growers in Mufindi,
ii. Identify factors influencing production efficiency of small-scale tree growers.

1.5 Research Questions

i. What are the technical efficiency of small scale tree growers?
ii. By how much can production be increased using available inputs and technology?
iii. What are the factors influencing production efficiency of small scale tree growers?
iv. What are the constraints hindering production efficiency in the area?

1.6 Conceptual Framework

The conceptual framework of the study is presented in Figure 1. According to Agad and Cruz (2012) inputs such as farm size, labor, fertilizer use, and number of cacao trees greatly affect the output. This study will adopt inputs variables such as farm size, labor, and education level, age of the farm head, management technique, rotation age, extension services, and type of species planted, seeds used (improved or not), and access to credit as the variables that greatly affect the output. Agad and Cruz (2012) also argued that any change in the levels of inputs used will result to changes in output. To empirically measure the productivity and technical efficiency of the farmers, the stochastic production frontier was estimated as specified by the Cobb Douglas production function (Agud and Cruz, 2012).

Therefore this study adopt this framework to explain input-output relationship on production efficiency of small-scale farmers in Mufindi district, where by farmer with the combination of inputs such as farm size, labor, education level, age of the farm head, management technique, harvesting time, extension services, and type of species planted, seedling, and access to credit should be able to produce as much output as possible hence its productively efficiency.

Output will be measured as the total number of tree in volume (m^3) produced by the farmer. Farm size will be measured as the total land area in hectares that is cultivated with trees. Labor will also be estimated as person-days worked. The socio-economic characteristics modeled in the inefficiency effect include the age of farmers (in years), farming experience (in years), years of formal education and household size.

Also other determinants of efficiency like access to credit and extension services are included to determine the production efficiency of small-scale tree growers in selected village of Mufindi district.

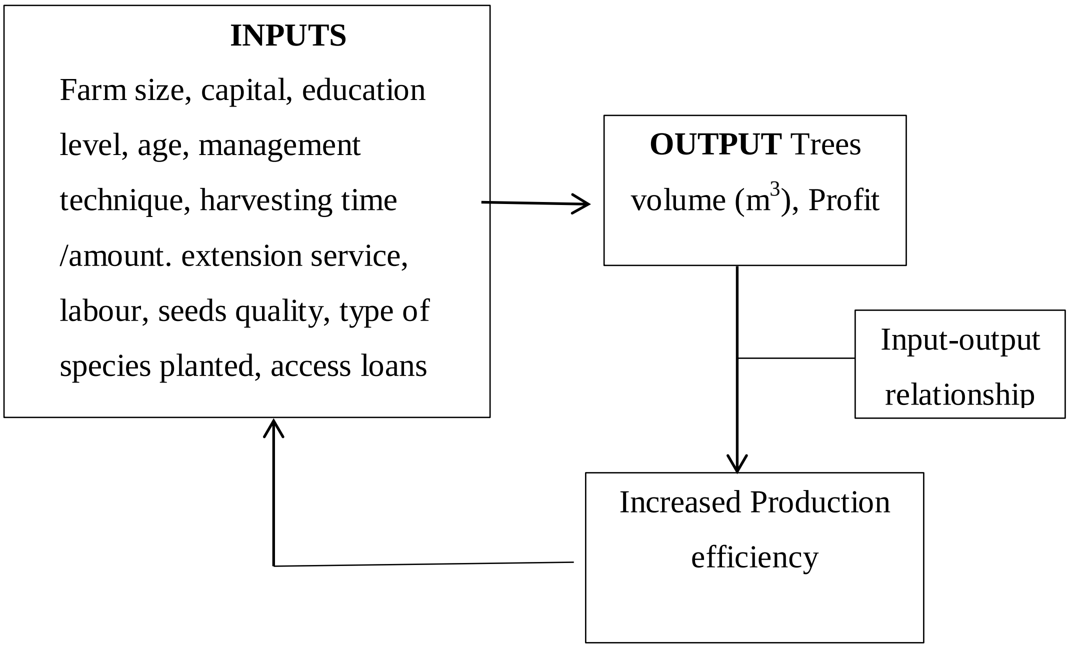


Figure 1: The relationship between inputs, output and production efficiency

Source: Adopted from Agad and Cruz (2012)

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Terms

2.1.1 Small-scale tree growers

These are woodlots with very limited land/farm sizes as well as different levels and type of inputs and outputs for given choices of individual enterprise. In Woodlots production activities depend on family labor, low capital input and variety individual innovations. Most of these small-scale tree farm productions are for subsistence and income of the family and that's between 500 million and one billion worldwide (Scherr, 2004).

2.1.2 Efficiency of Farms

The term efficiency as used in economics is defined as ideal distribution of resources in producing the most out of the inputs and hence minimizing waste use of scarce resources. Productive efficiency has two components. According to Dao (2013) efficiency is measured by comparing the actual ratio of outputs to inputs with the optimal ratio of outputs to inputs.

The technical component refers to the ability to use the production inputs effectively, by producing as much output as input usage allows, or by using as little input as output production allows. The allocative, or price component refers to the ability to combine inputs and outputs in optimal proportions in the light of prevailing prices. In this paper we only deal with the technical component of productive efficiency specifically efficiency of small-scale tree growers.

2.1.3 Technical efficiency

Kumbhakar and Lovell (2000) defined as the ability of a firm to produce maximum output from a given set of inputs or to produce an output using the lowest possible amount of inputs”. This means that for a producer to be technically efficient in order to increase the output there has to be a reduction of input involved in the production. Therefore when we involve/use a lot of input and produce same or less output automatically that production is technically inefficient. Technical efficiency can be differentiated for production efficiency regarding only one distinct factor which is the consideration of maximizing output using a mixture of input (Palmer and Torgerson, 1999). As it has been described by Kibara (2005), that the problem is not to adopt the technology to increase the output of farm production but rather it is the effective use of that technology to maximize production and that’s technical efficiency.

2.2 Efficiency of Small-scale Farmers in Developing Countries

Most of the studies done on small-scale farmers in the developing countries on efficiency were based on crops cultivation not tree. Study by Ojo and Ogundari (2007), on Cassava farmers to examine technical, economic and allocative efficiency of small farms. Also, there are several studies conducted to evaluate the performance of farmers and efficiency measures have focused on the estimation and explanation of agricultural efficiency in developing countries after paper by Farrell *et al.* (1957). These studies identify potential to improve efficiency of agricultural production. However most of these studies were carried out to estimate technical efficiency and only few studies looked at both technical and allocative efficiency of farms (Javed, 2009).

Moreover, technical efficiency focused more on estimation of agricultural crops (Farrell's *et al.,* 1957; Lerman and Willian 2006; Ojo and Ogundari 2007 and Abdallah *et al.,* 2014) but none has been done on small-scale woodlots efficiency hence this study will determine production efficiency of small-scale woodlots specifically technical efficiency of small-scale tree farms in Mufindi district using data envelopment model.

2.3 Approaches for Measuring Efficiency

Generally, non-parametric method data envelopment analysis (DEA) and the parametric method stochastic frontier analysis (SFA) have been widely used in the analysis of production efficiency in different fields. Parametric frontiers rely on a specific functional form while non-parametric frontiers do not. Non-parametric models, usually known as Data Envelopment Analysis (DEA) models, are based on mathematical programming techniques. DEA is a linear programming technique, which uses data on inputs and outputs to construct a best practice production frontier over the data points. The frontier surface is constructed by the solution of a sequence of linear programming problems (one for each firm in the sample). The efficiency of a firm is measured relative to the efficiency of all the other firms subject to the restriction that all firms are on or below the frontier. The focus is not on the estimation of an average technology production function used by all units analyzed, but to identify the best practice farms. The best-practice production frontier is constructed and all farms in the analysis are related to this frontier. Data Envelopment Analysis is based on the concept that a farm that employs less input than another to produce the same amount of output can be considered as more efficient. The efficiency frontier is constructed of linear segments that join up those observations with the highest ratio of output to input. The resulting frontier thus envelops all the other observations (Coelli *et al*., 2005).

Another important distinction between deterministic and stochastic frontiers is that the earlier model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise (Bravo-Ureta *et al.*, 1993). Broadly, two sets of approaches are used to estimate production efficiency, known as stochastic frontier approach (SFA) and Data Envelopment Analysis (DEA).

Both approaches, SFA and DEA, have their own strengths and weaknesses. The SFA method provides a basis for hypothesis testing but it is more prone to misspecification error. The DEA approach as a deterministic method takes no account of the possible influence of measurement error and other noise in the data. On the other hand, it has the advantage of removing the necessity to make random assumptions regarding the functional form of the frontier such as cost function, profit function and the distributional form of the errors (Coelli, 1995, Dao, 2013).

2.4 The choice of Data Envelopment Analysis

DEA is an accepted tool in economic analysis used in many empirical studies of efficiency (Hartwich and Kyi, 1999). DEA is used broadly to measure technical efficiency, as well as allocative efficiency and scale efficiency and studies with a DEA approach have become more widespread.

According to Gorton and Davidova (2004), the advantage of DEA in comparison to the parametric approach is that it can handle multiple-output and multiple-input situations simultaneously, as well as cases where inputs and outputs are quantified using different units of measurement. In fact, within the DEA approach, multiple inputs and multiple outputs are reduced to a single virtual input and virtual output and finally to a single summary relative efficiency score. DEA calculations are designed to maximize the relative efficiency score of each unit, subject to the condition that the set of weights for each unit must be feasible for all the other units included in the calculation. DEA involves the use of linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data. Efficiency measures are then calculated relative to this surface. This study uses multi output and input data; therefore DEA is more appropriate than SFA in the present study. Moreover, the applied DEA approach is more appropriate to analyzing production processes in developing countries where knowledge about underlying production technologies is weak (Kalirajan and Shand, 1985; Brázdik, 2006). The DEA approach used in this study avoids the specification bias from a choice of functional forms and distributional assumptions.

2.5 Determinants of Production Efficiency

2.5.1 Level of education

In literatures determinants of production efficiency, variables related to characteristics of the farm head have been used as measures of management skill. According to Dao (2013) the person who is responsible for managing the farm household is called the "farm head". The literature reviewed in this study indicates that the education of the farm head can be used as a proxy for managerial input. It is commonly believed that a higher level of education may lead to better management of farming practices. Many studies such as Dhungana *et al*. (2004), Javed (2009) and Mariano *et al*. (2010) used the year of schooling, also Dao add that year of schooling as a variable is known to be positively related to technical efficiency. This implies that farmers with more years of schooling are more technically efficient than those with less or no years of schooling. It is argued that better educated people adopt and use modern inputs more optimally and efficiently. Ahmad *et al*. (2002) argued that the educated farmers usually have better access to information about the state of technology and its use. Contrary to that, better educated farmers with a high level of education may have better access to non-farm jobs, thus reducing the intensity of engagement in farm management. Rio and Shively (2005) argued that efficiency falls with higher levels of education on small farms because education increases opportunities for off-farm work and thereby reduces on-farm management intensity. Therefore, education levels should be investigated as a determinant of technical efficiency.

2.5.2 Age of farm owner

Age of farm's owner may be an important factor in decision making. It is generally believed that age serves as a proxy for farming experience. The older farmers are likely to have more experience and hence be more productive. It is also possible that older farmers may be traditional and conservative and show less willingness to adopt new farming technology and therefore, be less efficient. The literature on rice-based farming suggests age of farm head has a negative impact of technical efficiency.

2.5.3 Access to off-farm income

Off-farm work of farmers is a determinant of technical efficiency in developing countries, Off-farm activity is usually measured by whether there is off-farm income. Raman and Rahman (2008) used the allocation of time to off-farm work as an independent variable to impact on technical efficiency. Another measure of non-farm work is the share of total income received from off-farm work. This variable is included to reflect the relative importance of non-agricultural work when farm households do not fully support themselves through agriculture. This variable was applied by Coelli *et al*. (2002); Chavas *et al*. (2005) and Vu *et al*. (2008).

Moreover, Shittu (2014) revealed that Increase in off-farm labour supply was found to be associated with significant reduction in production inefficiency among the rural farm households. The study also found that farm household production efficiency is significantly enhanced by increasing the share of tree crops and livestock in farm household farming activities, having access to land by leasing and operating a much more consolidated landholdings.

On the other hand off-farm work has a negative influence on technical efficiency in woodlots farming as well as in other cropping but this is inconsistent in the findings by Haji (2006) and Solis *et al.* (2009). Haji (2006) found that non-farm income had a significant and positive impact on technical efficiency in the context of crop diversification of vegetables. It is argued that off- farm may improve the experience and human capital of the farm operator and bring additional income that could be used for farm activities (Haji, 2006). According to Minot *et al.* (2006) income diversification including off- farm work plays important roles in household income of farm households hence the share of off-farm income is chosen to examine the impact on technical efficiency.

According to Nwaru *et al*. (2011) in Nigeria findings shows that household size, access to credit, membership of cooperatives and farming experience were positively and significantly related to allocative efficiency in Nigeria. The coefficients for farm size and gender has negative sign indicating that female farmers were more allocatively efficient than their male counterparts.

Poungchompu and Chantanop (2015) reported that all inputs (except chemical fertilizer) are major factors that have influenced the changes in the output of Para rubber production. In their study the mean technical efficiency index for the farmers is found to be 0.573 and the efficiency factors, which are comprised of age of farmers, education, gender and age of the rubber trees, were found to be the significant factors that affected the variation in technical efficiency among the farmers.

Study done by Maamor *et al*. (2016) in Malaysia revealed that the mean efficiency score is 0.576 indicating that many cocoa farmers in Malaysia are technically inefficient and this resulted into the low productivity in the Malaysian raw cocoa beans industry in recent years. This inefficiency is largely due to poor management and usage of inputs in the cocoa production.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location and administrative setup of the study area

The study was conducted in Mufindi District (Figure 2) which is one of the three districts in Iringa region, Tanzania. The district lies between Latitude 08° 42" S and 9° 11" S and longitude 34° 08" E and 35°20"E. Mufindi district is divided into the Eastern and Western zones. The Eastern zone which lies at altitude ranging from 1700 to 2200 m above sea level (a.s.l) is also termed as the highland zone. This zone is wet, having the annual rain fall of 1000 - 1200 mm. Its annual temperature ranges from 15°C to 20°C with minimum temperature of 13.5°C in June. The zone consists of Kibengu, Ifwagi and Kasanga divisions. The Western zone comprises of Malangali and Sadani divisions; it lies at altitude ranging from 1000 to 1600 m a.s.l with the maximum temperature of 20° C in February and the minimum of 13°C in July. Unlike the Eastern zone, the Western zone is dry with annual rainfall that ranges from 600 to 750 mm per year. Administratively, the district consists of five divisions namely Kibengu, Kasanga, Malangali, Ifwagi and Sadani. The district has 28 wards, 135 registered villages and 582 sub-villages.

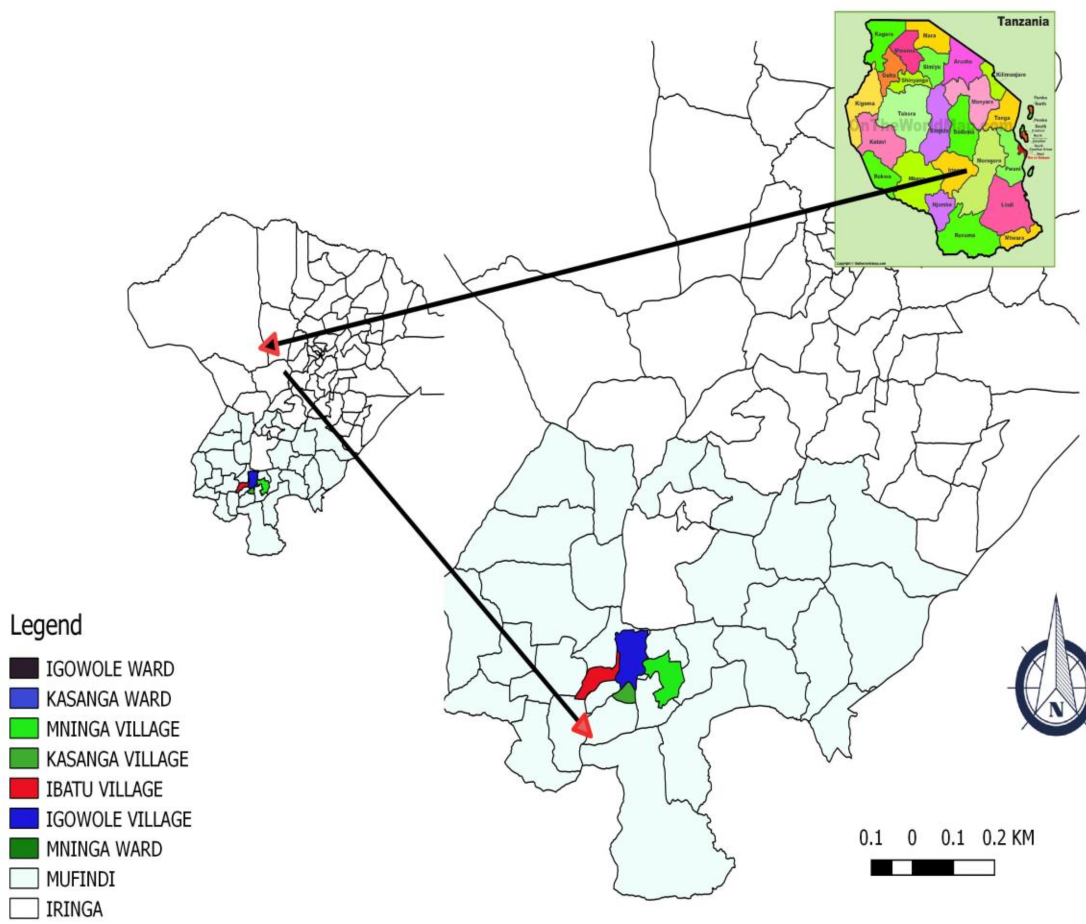


Figure 2: Map of the Study Area

3.1.2 Reasons for selecting study area

Mufindi district is among the leading district in woodlot production in Tanzania (Singunda, 2010). This is driven by the large number of small-scale tree growers (60 000 private growers) in Southern Highlands (FDT, 2017). According to PFP (2017) majority of forest plantations in the Southern Highlands are located in Njombe and Iringa regions where Mufindi, Makete, and Njombe Urban are the districts with the greatest forest plantation coverage.

It is reported that woodlots growers comprises 54% by area (68% in Southern Highland) and 43% by volume, also evidence shows that trend of small-scale tree growers in the Southern Highlands increase between 2013 to 2016 from 169 165 and 174 143 respectively (PFP, 2017). Mufindi District is the only district in Tanzania where forest activities rank second to agriculture in terms of income generation (URT, 2005).

3.2 Preliminary Survey

Prior to the main survey, a preliminary survey was carried out in one village. The main purpose was to pre-test questions to check for the validity and reliability. The questionnaire was administered by researcher to 20 respondents in the village. Minor modifications were made accordingly.

3.3 Sampling

The target population for the study was small-scale tree growers in Mufindi District whereby purposive sampling technique was employed to select Igowole, Ibatu, Mninga, and Kisanga villages. The villages were selected purposely because of the relative large number of woodlots, active involvement in woodlots farming and leading in selling of woodlot products. All small-scale farmers in selected villages were listed and used as sampling frame. The sampling unit of the study was household hence in each list of households) simple random sampling technique was used to select households for the survey. The sample size determination for this study was guided by Bailey (1994) who posited that thirty respondents per case are minimum number recommended to represent a population under study. Therefore 60 respondents from each village were interviewed making a total of 244 respondents.

3.4 Data Collection and Analysis

3.4.1 Determination of technical efficiency levels of small-scale tree growers in Mufindi

Data on production efficiency of small-scale tree growers was collected using questionnaire. Data collected was on outputs, inputs and prices of outputs and inputs which serve as basis for computing cost of materials used in the production. Other information collected are: labour used in man days, farm size in hectares (ha), age of farmer (yrs), average wage rate per man days of labour (Tshs).

Data Envelope Analysis was employed in computing efficiency for farmer or DMU using inputs, outputs and respective cost of inputs. Both constant return to scale (CRS) and variable return to scale (VRS) assumptions were used in calculating technical and scale efficiency. Data Envelopement Analysis (DEA) program software of version 2.1 package developed by Coelli (1996) was used for mathematical computations. Input – oriented DEA model which aims at reducing inputs with a given set of output was used in this study since in tree production activities, inputs are controlled by the firms or DMU comparatively to outputs.

The choice of DEA was based on the fact that the mathematical programming procedure is comparatively robust and can handle multiple data input and output scenarios (Seiford and Thrall, 1990). The study used multiple inputs such as capital, labour cost and total revenue as output. Given that farms convert multiple inputs into multiple outputs, we needed techniques to jointly analyze both inputs and outputs (Diaz-Balteiro *et al.*, 2006).

The DEA mode can be summarized in mathematical presentation as follows:

Where:

Decision making unit (DMU_j) = 244 Equals to number of small-scale farmers that was interviewed.

X = Inputs (cost of labor and capital)

Y= Output (Total revenue)

Uj and Vj = set of unknown weight corresponding to each DMUj

The efficiency of a specific DMU, the 'target unit' j0, is obtained by solving the model:

$$Maxho = \frac{\sum_{i=1}^{t} UrYrj0}{\sum_{i=1}^{m} ViXij0} \quad \text{..(1)}$$

Subject to the constraints:

$$Maxho = \frac{\sum_{i=1}^{t} UrYrj0}{\sum_{i=1}^{m} ViXij0} < 1 \quad J = 1, 2, 3\ldots n, \quad \text{.....(2)}$$

Such that Ur, Vi > ε, for all r and i.

Where:

ho = efficiency scores of the target decision making unit

Yrj = amount of output r from unit j

Xij = amount of input i to unit j

Ur = the weight given to output r

Vi = the weight given to input i

n = the number of units being compared

t = the number of outputs

m = the number of inputs

ε = a small positive number.

If DMUj0 is efficient, its outputs will be best produced using all of its own inputs. In this case Xj0 = 1, Xij = 0 for all ij ≠ j and w =1. On the other hand if DMUj0 is inefficient, its outputs will be best produced by a mixture of other DMUs using a fraction w of all its inputs. Therefore, If ho = 1, then the farmer is said to be efficient and if ho <1, then the farmer is said not to be efficient and output is below the maximum.

3.4.2 Inputs and outputs used in estimating efficiency of small-scale tree growers

In estimating technical efficiency of small-scale tree growers (DMU) several inputs and outputs was used. Total revenue was used as output while inputs included amount of capital (Capital investment) used (Tshs) and cost of labour used (Tshs). During household survey price, cost and information on all inputs used in tree production activities was recorded.

3.4.3 Identification of the factors influencing production efficiency of small-scale tree growers

Data on factors influencing production efficiency was collected from the respondents using questionnaire survey (Appendix A) and field observation. The information such as the quantity of fertilizer application, skills, motivation and experience of operators, management competence of the supervisors, species of trees and weather conditions are factors influencing productivity and production efficiency. Data collected were farming knowledge and experiences, farm size, expertise assistant received (level of extension services), tree diversity planted, technology used and infrastructure development and socio-economic data that influence production efficiency.

After measuring technical efficiency, socio-economic factors influencing efficiency of tree growers were identified using a censored regression model (Tobit model, 1958). STATA software version 13 was used to run the analysis. Factors considered in this analysis were age, gender, education level, household size, membership of association, farming knowledge, expertise assistant received, species planted, fertilizer, seeds and farm size. This study used Tobit model because the dependent variable- the technical efficiency values are bounded between 0 and 1 which means that it's a censored variable. According to Sigelman and Langche, (1999) efficiency variable is censored variable with an upper limit of one hence violating the basic assumptions of linear regression model.

$Y^*i = X\ i\ \beta + \varepsilon\ i$ …………………..………………..…………………..……………… (3)

Where; $Yi = 0$ if $Y^*i \leq 0$ and $Yi = Y^*I$ if $Y^*I > 0$ and $\varepsilon\ i \sim N\ (0, \delta 2)$, Xi is the vector of exogenous variables and β a vector for unknown parameters. Y*I denote the latent variable and Yi as DEA relative efficiency scores.

Applied to small-scale tree growers censored regression model for analysis was:

$EFF\ i^* = \beta 1 + \beta 2AG + \beta 3ED + \beta 4HSIZE + \beta 5EXTEN + \beta 6EXPE + \beta 7IMSEED +$

$\beta 8FASIZE + \beta 9GNER + \beta 10MESHIP + \varepsilon i$…………………………………………………(4)

Where:

EFF i * = Technical efficiency of firms or DMU,

AG = Age of respondents,

ED = level of education of respondent,

HSIZE = household size,

EXPE = Farming experience of respondent in years,

EXTEN = Extensions services received,

IMSEED = Access to improved seed

FASIZE = Farm size

MESHIP=Membership of Association

GNER=Gender of the respondent

3.5 Choice of Variables and their Measurement

For the dependent variable, information about the output in term of revenue earned from tree production for each farmer was collected. Information on inputs used by farmers was collected; the farm size cultivated by the household was measured in hactares. For the households who cultivated more than one plot, the size of total farmland was taken by adding up each plot planted by the household.

Labour was measured as the number of household members participating in farming activities plus the hired labour used as well as the cost of labour for each tree production activity i.e. (land preparation, planting, weeding, pruning and thinning). Capital was measured as the total capital investment used by the farmer (cost of land if any, seedling). Extension service details were asked directly to the farmer and were recorded as dummy, 1 for the farmers who received extension services and 0 for those did not. Information about social-economic characteristics of farmers; farmer's educational level, age, sex, household size, farm experience was recorded. Concerning the level of education, primary and secondary dummy variables were included to capture the effect of primary and secondary education in farming efficiency and forest resources extraction. Education below standard seven (primary level) was treated as reference level to avoid a dummy variable trap. The gender of the household head was recorded as a dummy variable, 1 for male and 0 for female household head. Farm experience was measured as the number of years the household cultivated the farmland. For the households who had more than one plot, farm experience was measured as the number of years the household spend on cultivating the largest plot.

Details about the access of the households to formal credit from financial institutions were also recorded. Households were asked on whether they could have access to formal credit or not. It was measured as dummy variable and recorded as 1 if the household can get credit and 0 otherwise.

3.6 Secondary data

Secondary data was collected by reviewing books, journals, research studies and dissertations at Sokoine National Agricultural Library (SNAL), documents and reports from Iringa Regional Commissioner's Office, Mufindi District Council Office, and National Bureau of Statistics.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Respondents

Table 1 indicates that (57.4%) of the tree growers were within the 39 to 59 years age. This was closely followed by the tree growers with age 18-38 years (34.8%). Tree growers that were in the minority constituted 7.8% and these tree growers were above the 60years age bracket. This implies that many of respondents in the survey area were mature people enough to be actively engaged in tree production and marketing to generate sufficient income to sustain their households. Furthermore according to Singunda (2010) found that more than half of the woodlot owners are young people between the age 15 to 45 years which is the prime and most energetic age class. It reflects on the level of awareness among young people on tree planting indicating a good sign for tree planting development.

Gender has implication on the roles and responsibilities in the society, and therefore can influence households' abilities to generate income. Gender result shows that male accounted 78.7% of the studied population while female accounted 21.3%. This could be due to the fact that traditionally most of the households are headed by men. On the other hand this tendency of female owning woodlots is a sign of cultural change, where by male patriarchy is losing dominance in the face of external forces carved in the principle of power with responsibility and economic realities of life (Yaro, 2006). The other reason for this may be more women attending schools and being employed before marriage hence economically able to own the woodlot (Quisumbing *et al.,* 2009). Marital status was categorized as single, married, divorced and widowed (Table 5).

Results (Table 1) also showed that most of the tree growers were married which accounted for 79.9% of the surveyed population. Only 10.2%, 7.4% and 2.5% of the tree growers accounted for single, widowed and divorced respectively. Marital status may induce someone to work hard due to family responsibilities. The situation can be further explained by the fact that married respondents engage in tree production activities in order to generate cash income to meet various household needs or requirement as well as expanding their household income base.

Table 1: **Socio-economic Characteristic of Respondents (n=244)**

Variables	Tree growers (%)
Age between 18-38 years	34.8
Age between 39-59 years	57.4
Age above 60 years	7.8
Male (%)	78.7
Female (%)	21.3
Married (%)	79.9
Single (%)	10.3
Widowed (%)	7.4
Divorced (%)	2.5
Household with 1-5 members (Numbers)	61.9
Household with 6-10 members (Numbers)	36.5
Household with 11-15 members (Numbers)	1.6
Farmers with farming experience between 0 - 20 years	86.9
Farmers with farming experience between 21 - 40 years	11.7
Farmers with farming experience Above 41 years	0.4
Farmer (%)	37.7
Civil servant (%)	2.5
Business (%)	0.8
Both farmer and Business (%)	46.7
Both Civil Servant and Farmer (%)	12.3

Household composition considered in the study area are small-scale tree growers engaging in tree production activities. A high proportion (61.9%) of the farmers had family sizes of less than 5 persons, 36.5% had between 6 to 10 persons while 1.6% had more than 11 people in their household. The mean family size of the tree growers was 5 persons. Effiong (2005) reported that a relatively large household size enhances the availability of family labour which reduces constraints on labour cost in production. Shayo (2005) observed that, household size is an important factor in determining the extent to which labour is available for tree planting and management of planted tree species on his study on the status and socio-economic aspect of trees in the Chagga homegardens of Rombo. Result shows that 86.9% of the farmers had one to 20 years of experience in tree production while the minority had between 21 to 40 years and above 41 years had 11.7% and 0.4% experience of tree growing respectively (Table 1) above. According to Agom *et al*. (2012), farming experience was found to influence farmers' productivity than their educational attainment.

Education level plays an immense role in ensuring household access to basic needs such as food, shelter and clothing. Skills and education amplify the working efficiency resulting into more income and food security. The distribution of the tree growers according to their educational level (number of years spent in school), shows (Figure 3) that majority (91%) of the farmers had attained one level of formal education or the other. The level of education (years spent in school) of the farmers in the area was 9% higher education, 22.1% secondary education, 66% primary education and 2.9% had no formal education. High percentage of people with primary, secondary, and tertiary education indicated that woodlot owners are relatively knowledgeable and that could influence appreciation of the value of trees hence establishment of woodlots (Singunda, 2010). Also they stand a good chance to adopt new technologies in the establishment of woodlots, processing and utilization of its products because they are equipped with formal knowledge and skills (Kajembe *et al.*, 1996).

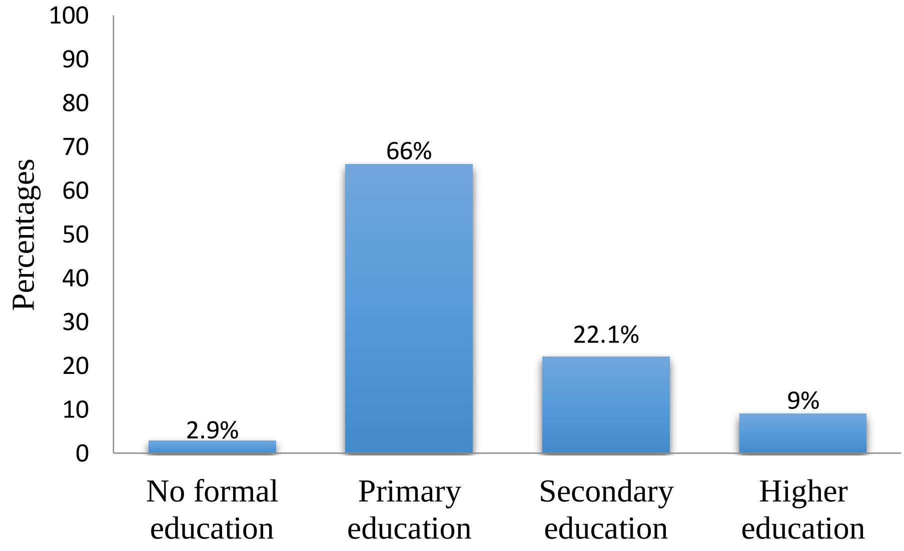


Figure 3: Education level of respondents in the study area

4.3 Input and Output Variables in Tree Production

The statistics of the production variables obtained from tree growers in the study area are summarized in the Table 2. Total revenue (output), capital, farm size, fertilizer, seed, labour (man-days and cost) and agrochemicals are the input variables that will be discussed.

Table 2: A summary of Cost of inputs variables in tree production

S.N	Inputs	Unit costs (Tshs)	Mean costs (Tshs)	Min (Tshs)	Max (Tshs)
1	Farm size	400 000	1 083 285.7	70 000	15 000 000
2	Labour	5 000	796 113.2	20 000	17 400 000

4.3.1 Revenue from trees production

Results (Figure 4) shows that majority (66.4 %) of respondents in tree production activities earn below 10 000 000 Tanzania Shillings while minority 13.5% earn between 10 000 000 to 20 000 000 and only 20.1% of the studied population earn above 20 000 000 from trees production activity (Figure 4). These results indicate that a tree production activity is good source of income to local communities of Mufindi district.

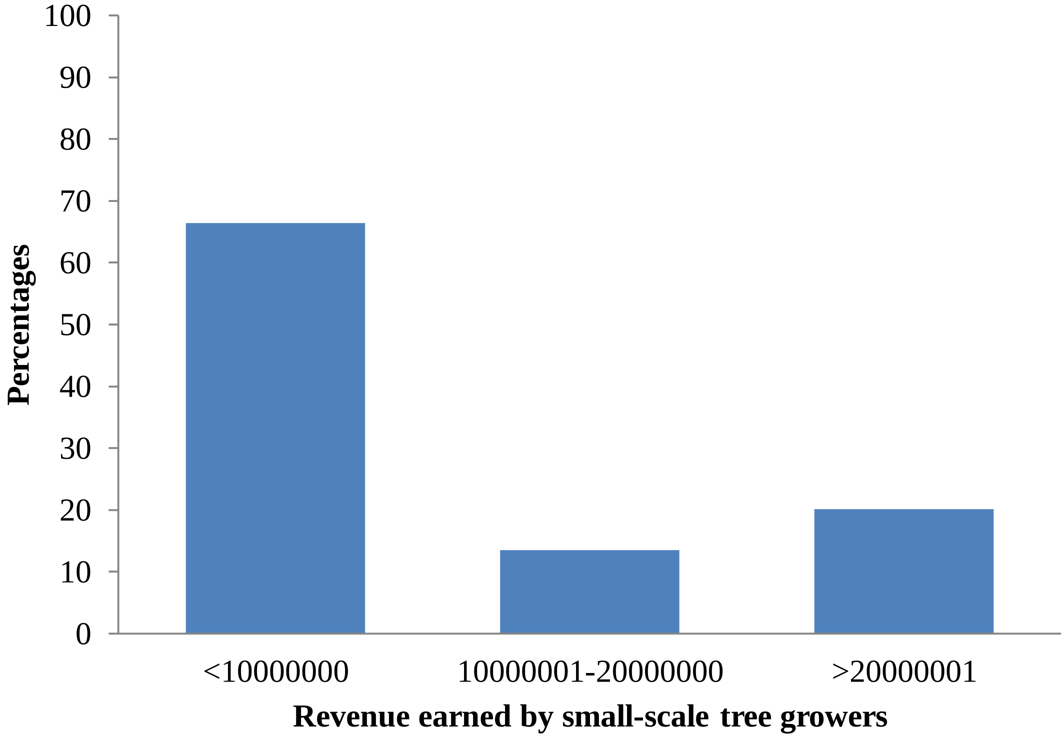


Figure 4: Distribution of income earned from tree production by farmer

In most African countries, farm sizes have been described as small, medium or large scale. According to Agom *et al.* (2012), less than 5ha can be considered small-scale, between 5 ha and 10 ha as medium scale, and more than 10ha, is considered as large scale farm. Findings revealed that most of the tree growers in the studied population are small-scale to medium scales categories.

It was observed that majority of the tree growers (93%) own between 1 to 5 hectares of trees, while the minority 5.3% and 1.6% own between 6 to 10 hectares and between 11 to 20 hectares of trees respectively. Moreover, majority of tree growers did not use fertilizer as input in tree production as the result shows that only 11.5% (Figure 5) used fertilizer while majority 88.5% did not use any fertilizer.

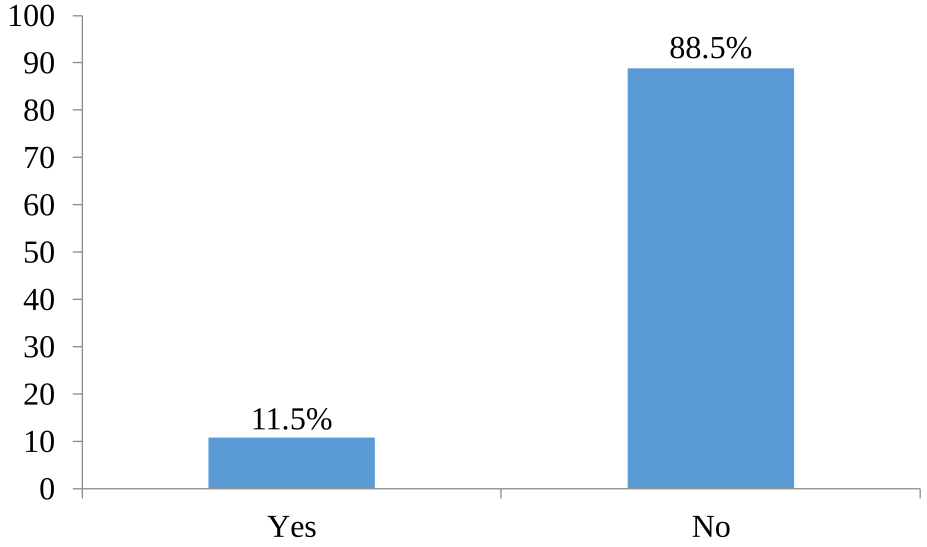


Figure 5: Fertilizer application by respondents in the study area

According to Ngaga (2011) the availability and use of quality seeds is one of the primary factors that influence success of tree farming activities. However, results show that only 16.8% use quality seeds in tree production while majority 83.2% use tradition seedling. Farmers in Tanzania mostly get seeds and seedlings from unreliable sources this is due to lack of knowledge, only a few farmers get their seeds from TTSA. The farmers usually obtain seeds dropped in big plantations and grow them in their local nurseries or sometimes the pick already growing seedlings in large plantation (SAO HILL plantations) to meet their own needs and sell the surplus seedlings to their neighbors, therefore this goes in line with inefficiencies in term of productions.

Most farmers lack the necessary knowledge and appropriate tools for nursery work such as capital and extension services. Pesticides and herbicides may be used in forests to control weeds, insects, animals and diseases which are normally used before or soon after new tree are planted so that young trees do not compete with weeds for moisture and nutrients. However only 9% of tree growers use agro-chemicals in tree farming while remaining majority (91%) do not use agrochemical in their production. This indicates that farmers are producing inefficiently as agrochemicals are one of the important inputs to increase efficiency and productivity. In tree productions machinery such as tractor, power tillers etc are important for farm preparations as an input. However, majority of tree growers (94.3%) do not use machinery as input for tree production.

4.4 Determination of Technical Efficiency of Small-scale Tree Growers

4.4.1 Technical efficiency estimation results for small-scale tree growers

Results derived from Data Envelopment Analysis models are presented in Table 6. It is evident from the results that a total technical efficiency index (TECRS) has a mean score of 0.80. The mean pure technical efficiency (TEVRS) of the woodlot is 0.845 indicating that small-scale tree growers are producing inefficiently hence improvement of efficiency by reduction of input usage is required. According to the theory of technical efficiency, a farm can reduce its inputs by (formula 5) without changing the level of its output (Vu, 2008). The results imply that if the average sample farm operated at full efficiency level it could reduce, on average, its input use by 18.3% (formula 6) and still produce the same level of outputs. Furthermore, technical efficiency of small-scale tree growers could be increased by 15.5% under variable return to scale and 20% under constant return to scale by improving the use of available resources

$$\frac{\mathbf{1}}{\boldsymbol{TEvrs}} - \mathbf{1} \qquad (5)$$

$$\frac{\mathbf{1}}{\mathbf{0.845}} - \mathbf{1} \qquad (6)$$

Table 3: Efficiency scores of small-scale tree growers in Mufindi

Variable (Model)	TE (VRS)	TE (CRS)
Mean Score	0.845	0.800
Std. Deviation	0.6485	0.6006
Minimum Score	0.698	0.627
Maximum Score	1	1

Also efficiency was determined based on the species of tree grown by the farmer, the analysis of efficiency was done following the three categories of tree growers such as Pine growers, Eucalyptus growers and both Pine and Eucalyptus growers.

Table 4: Efficiency scores for small-scale tree growers in the study area based on species planted

Variable(Model)	Mean score	Minimum score	Maximum score
Pinus patula			
TE (CRS)	0.824	0.63	1
TE (VRS)	0.874	0.711	1
SE	0.943	0.932	1
Eucalyptus Grandis			
TE (CRS)	0.875	0.771	1
TE (VRS)	0.923	0.813	1
SE	0.947	0.841	1
Both tree species (Pinus patula $ Eucalyptus)			
TE (CRS)	0.836	0.664	1
TE (VRS)	0.879	0.701	1
SE	0.952	0.868	1

The result indicates that small-scale tree growers are not efficiently. It is evident from the results in Table 4 that total technical efficiency indices (TECRS) of pine growers had mean of 0.824. The mean pure technical efficiency (TEVRS) of the sampled pine farmers is 0.874 with a mean scale efficiency of 0.943.

Small-scale tree growers that grow eucalyptus had a mean total technical efficiency (TECRS) of 0.875, Mean pure technical efficiency (TEVRS) of 0.923 and scale efficiency of 0.947. Moreover those farmers that grow both species of trees (Pine and Eucalyptus) had mean efficiency score of 0.836 under CRS and 0.879 mean efficiency score under VRS as well as 0.952 the scale efficiency.

Result shows (Figure 6) that Eucalyptus farmers are less inefficient as compared to farmers that grow both species i.e. pine and eucalyptus while pine farmers are most inefficient compared to the other small-scale tree growers. This may be due to less inputs required for the Eucalyptus to grow compared to other species especially pine.

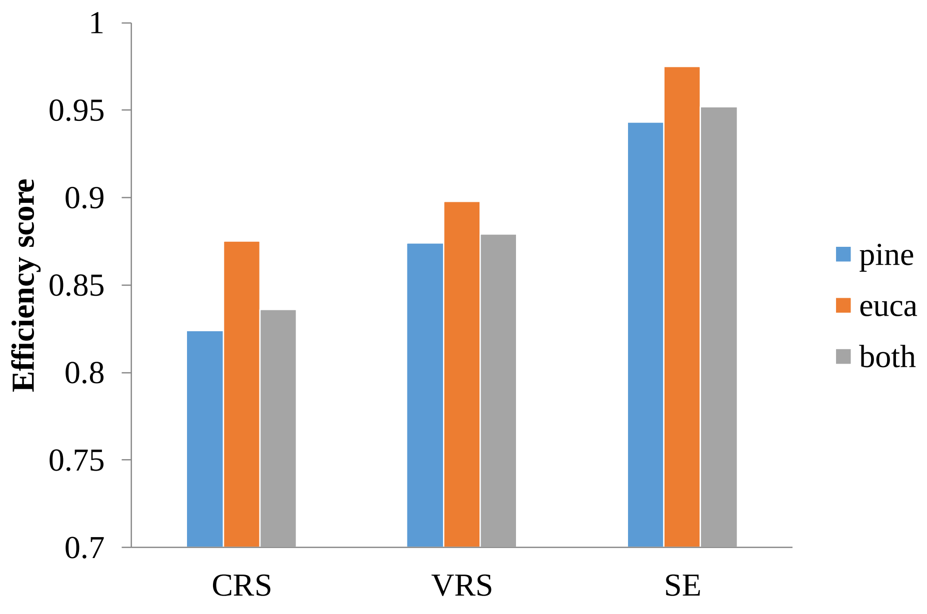


Figure 6: Mean efficiency score of small-scale tree growers in the study area

4.5 Factors Influencing Production Efficiency of Small-scale Tree Growers

Result shows presented in table 5 shows that Quality of seeds was statistically significant with positive coefficient under both CRS and VRS assumptions indicating that seeds quality has effect on tree production thus production using improved seeds or seedlings for tree production was more efficient and in turn increases production efficiency of farmer compared to using local seeds. These finding was similar to those by Sultan and Ahmed (2014) and Dessale (2019), who found that quality seeds had positive influence on production efficiency. Moreover, the positive sign of the estimated coefficients had important implications on the technical inefficiency of the tree growers in the selected villages, in Mufindi districts. It means that the tendency for any tree grower to increase his production depends on the type and quality of improved seed available at the right time of planting.

In tree production activities, farming experience are statistically positive with technical efficiency under VRS assumptions while it’s negative under CRS assumptions. Literature show that involvement of individual in tree production for many years increases economic and technical efficiency of a farmer.

These results agree with what was reported by Jude *et al.* (2011) that experience had positive effect on production unit efficiency. According to Alvarez and Crespi (2003) farming experience had positive effect on production efficiency. Furthermore, the more experienced a farmer is the more efficient his decision making processes and the more he will be willing to take risks associated with the adoption of innovations hence more productive and efficient (Onyenweaku and Okoye, 2007).

Table 5: Tobit Model regression results on factors influencing level of efficiency

Variables	Efficiency Score of VRS			Efficiency Score of CRS		
	Coefficients	**P-Value**	**T-statistics**	**Coefficients**	**P-Value**	**T-statistics**
Small-scale tree growers						
Gender/Sex	0.01	0.08	1.72	0.01	0.17	1.37
Marital status	0.01	0.06	1.87	0.01	0.01*	2.58
Age	-0.003	0.65	-0.45	-0.007	0.30	-1.03
Education	0.001	0.78	0.27	0.001	0.74	0.33
Household size	-0.001	0.65	-0.45	-0.001	0.42	-0.80
Farm/experience	0.000	0.98	0.02	-0.004	0.38	-0.87
Occupation	0.003	0.26	1.12	0.001	0.67	0.42
Seeds	0.03	0.002**	3.13	0.02	0.007**	2.71
Fertilizer	-0.01	0.28	-1.08	-0.02	0.10	-1.64
Agrochemicals	-0.002	0.67	-0.43	-0.004	0.42	-0.81
Farm size	0.03	0.002**	3.12	-0.002	0.85	-0.19
Tree species	0.001	0.52	0.64	-.002	0.24	-1.17
Training	0.01	0.37	0.88	0.01	0.32	0.98
Membership	0.01	0.55	0.59	0.01	0.36	0.92

*** Statistically significant at p<0.05; ** statistically significant at p<0.01**

The use of fertilizer and pesticides were not significant and had negative association with technical efficiency of tree production under both VRS and CRS assumptions (Table 5). Fertilizer application has several potentially harmful side effects on tree production (Hedwall *et al.*, 2014 which also support negative relationship with efficiency. On the other hand fertilizers are said to increase efficiency in the production of trees especially using during seedling and early stages of planting (Saarsalmi and Mälkönen 2001; Hedwall *et al.*, 2014) this disagree with the study findings. Furthermore Research support the fact by arguing on the fact that tree plantation usually have a challenge in soil nutrient balance as most of it is carbon dominant, therefore apply fertilizer will increase other nutrients concentration hence increase tree growth (Menegale *et al.*, 2016).

Gender of the farmer is positive significantly influencing technical efficiency of small-scale tree growers under VRS assumptions (Table 5). These results indicate that Gender of the household head or farmer has positive influence on the production efficiency and level of productivity of particular famers. Similar results were reported on the study by Agom *et al.* (20120 on analysis of technical efficiency of small-scale farmers where the findings show that among the major contributing factors to efficiency was Gender of farmer. Oluyole and Sanusi, 2009 obtained similar results that male farmers obtain higher levels of technical efficiency than their female counterparts in the area.

On the other hand small-scale sweet potato farmers' had the coefficients for gender of the household head (were negatively signed) had negative relationship with technical efficiency indicating that female farmers were more efficient than their male counterparts (Jude *et al.,* 2011).

Findings in this study (Table 5) reveal that there is positive association between education attainment of the farm heads and technical efficiency. Study done by Vitor *et al.* (2013) farmers indicates that with more years of formal schooling farmers tend to be more efficient in production possibly due to their enhanced ability to acquire knowledge, which makes them more efficient. Furthermore, farmers who attained some level of education respond readily to the use of improved technology. Similar result was also reported by Lockheed *et al.* (1980) and Ali, and Byerlee (1991). Therefore, more years of education or years of schooling brings about an increase in technical efficiency in small-scale production. On the other hand, Coelli *et al.* (2002) failed to identify a significant impact of education on technical efficiency and Lummani (2001) and Hasnah *et al.* (2004) reported a significantly negative impact of education on technical efficiency respectively. Efficiency falls with higher levels of education on small farms because education increases opportunities for off-farm work and thereby reduces on-farm management intensity (Rios and Shively, 2005).

The negative coefficient of age in Tobit regression models indicated in table 5 means that increasing age would lead to decrease in efficiency. Abaelu (1998), reported similar result that an ageing farmer would be less energetic to work in the farm (resulting in reduced efficiency, productivity and in turn revenues). Many studies have shown that younger farm heads are more technically efficient than older farm heads. (Villano and Fleming, 2006; Vu, 2008; Javed *et al*., 2010; Mariano *et al.*, 2010). In this study, the estimated coefficient of age is negative but close to zero and insignificant. This variable has little influence upon the observed efficiency differentials.

In agricultural production practices extension can be regarded as one of the important sources of information, particularly in developing countries where farmers have very limited access to information on Agricultural inputs.

Result shows that in tree production activities extension services were not significant but had a correlation with technical efficiency under both CRS and VRS assumptions (Table 5). This may be because majority of farmers didn't receive any form of training rather than depending on their experience and fellow farmers. Literature shows that technical inefficiency effect decreases with farmers having training on tree production where farmers with education on tree production tended to have lower inefficiency effects than farmers without training. Farmers with training were technically more efficient than farmers without training. This result is supported by Rahman and Rahman (2008) and Javed *et al.* (2010) that extension educations have influence on adoption of modern technologies.

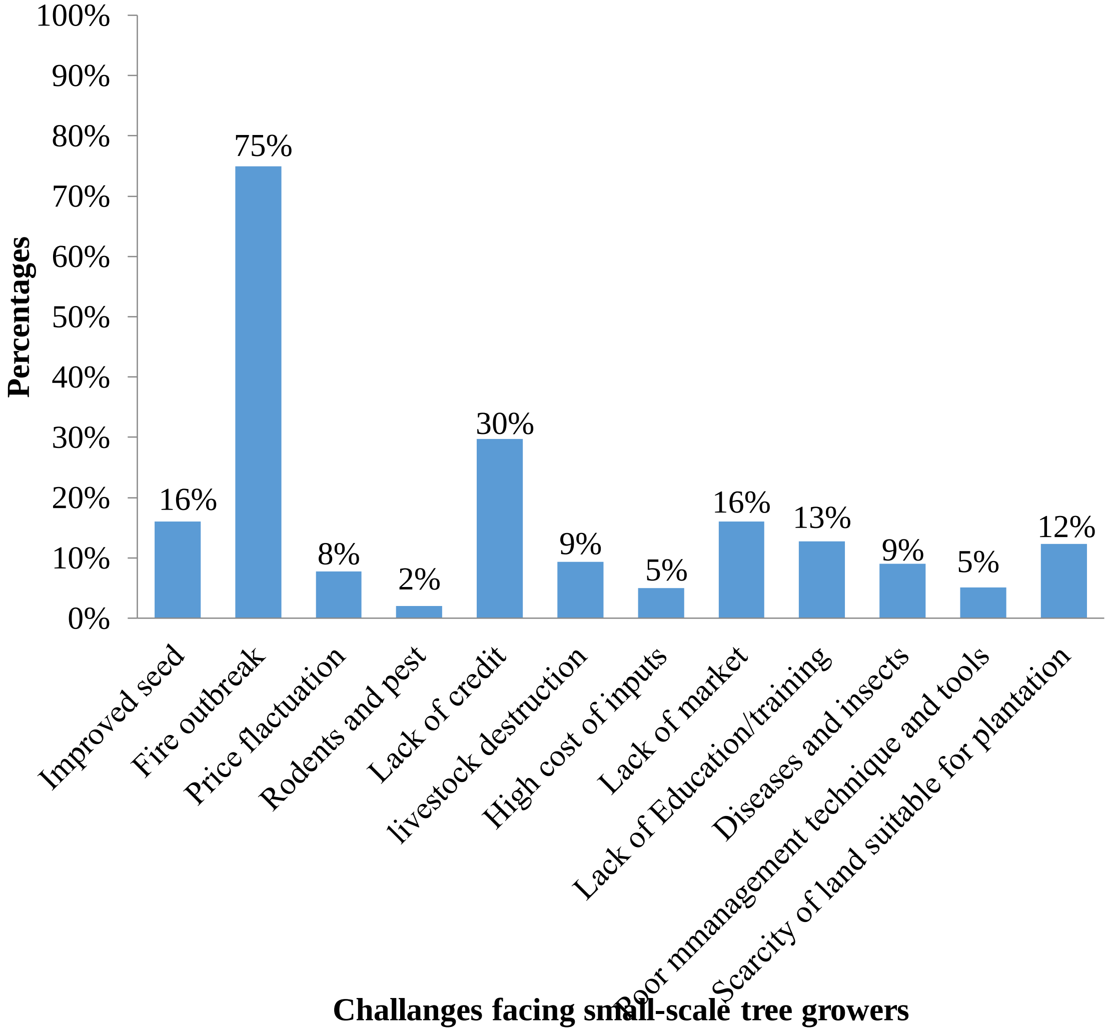
The coefficient for membership of farmers to association or societies was positive under technical efficiency. This result is consistence with a prior expectations and the report from Nwaru *et al.* (2006) who noted that membership of cooperatives and farmer associations is expected to increase the farmer's interactions with his fellow farmers as well as other entrepreneurs would increase farmers capacity to access current pieces of information on economic activities within his locality and even beyond. Okike (2000) a farmer belonging to association helps to get good sources of quality inputs, information and organized marketing of products therefore leading to reduction of inefficiency effects in the production.

The coefficient for household size had a negative sign and significant for technical efficiency. Results disagree with the report from Onyenweaku and Nwaru (2005), who noted that large household size eased labour constraints on the farms. Traditionally, rural households count more on their members than hired workers as sources of farm labour (Nwaru *et al.,* 2006), which is a reason for the persistence of subsistence farming in the rural economy.

Results from this study confirm that there is a significantly positive relationship between farm size and technical efficiency. The coefficient on farm size is positive and significant at 5 % level, thereby indicating that the larger the farm size the greater technical efficiency. The finding that farm size enhances technical efficiency is consistent with expectation and the positive effect of farm size on productivity reported by Rio and Shively (2005) and Dao (2013).

4.6 Challenges facing small-scale tree growers in Mufindi district

Among challenges identified, fire has been mentioned as the main problem for small-scale tree growers. In the study area about 75 % of the respondents claimed that fire seems to be a major problem in forest plantations (Figure 7). Strategies need to be in place to ensure that future losses due to forest fires are minimised. Measures are normally undertaken to prevent fire occurrences by constructing and cleaning fire breaks before the fire season, purchasing and maintaining firefighting equipment that they are in a good working condition ready for use in case of fire occurrence, keeping standby firefighting crews and vehicle(s) during the fire season. In addition to the above precautionary measures, forest guards should be employed for patrolling the forest and reporting any fire incidences. Moreover 30% claimed that lack of enough capital to purchase inputs such as seeds, polythene tubes and other technical materials are other major problems facing small-scale tree growers in Mufindi district.



Note: This is multiple response question

Figure 7: Challenges facing small-scale tree growers in the study area

About 16% (Figure 7) of the respondents claimed that poor quality seeds as another problem facing small-scale tree growers in the study area this is due to fact that most farmers depends on collecting seeds from forest plantations and in natural forest of which some have poor physical characteristics and unknown genetic viability because seeds are too expensive to purchase.

According to FBD (2005) and Ngaga, (2011) as tree planting became an embedded practice by people and when seedlings were not available from local authorities' nurseries, residents used seedlings self-geminating under existing trees. In the area few farmers also established small nurseries to produce seedlings for their own requirements and also for sale to other farmers.

Findings from this study show that 16% (Figure 7) of respondents identified lack of markets for small-scale tree growers to sell their product as a constraint in their operation. Small-scale tree growers lack proper market for their products due to lack of market information and price data on timber products in key markets both domestic and neighboring countries like Kenya. Lack of organised market outlets and bargaining power and poor quality of timber and end products, (Ngaga, 2011).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study dwelt on the determination of technical efficiency levels and factors influencing production efficiency of small-scale tree growers in Mufindi district, Tanzania. Small-scale tree growers in Mufindi are not fully technically efficient due to poor management and usage of inputs. Important factors related to production efficiency were quality and improved seeds or seedling, education, farm size, membership of farmers group association, extension visits and gender of the farmer. Policies that tend to reallocate land and inputs especially fertilizer and quality seeds to small-scale tree production and particularly to the female farmers are therefore necessary. The observed 85% mean efficiency under VRS and 80% under CRS indicates that in the short run, there is a possibility of increasing timber production by about 15% and 20% respectively by adopting the technologies and techniques practiced by the best tree growers in Mufindi district.

5.2 Recommendations

The following recommendations are made in light of the conclusions of this study so as to improve efficiency, performance and profitability of tree production activities in the study area.

Although tree production activities seems to be profitable activities in the study area, more efforts should be done on improving its production efficiency so as to reduce production cost and increasing productivity. All factors which were observed to influence production efficiency of tree production should be improved. Number of trainings, extension services and availability of improved seeds to communities should be improved for small-scale tree growers

In tree production activities these small-scale producers need to work in groups so as to have ability to access credit and loans. Most of the microfinance organ have policy on giving loans to groups rather than single individual due to its liabilities not only credit but also access to extension services and other supports. Hence strengthening of available groups and formulation of new groups/association is important as majority of stakeholders prefer provision of support in community groups compared to individuals.

The study shows the number of factors hindering the efficiency production some of them can be tackled by the improvement of policy such as; control of premature harvesting, the government has to setting of the marketing price of the poles, timber and associated product that will break the linkage between buyers, middleman and the producers.

Fire has been seen as one of the biggest challenges facing tree producers in the area due to its impact after occurrence. Fire causes fear to the small-scale producers to increase farm size and grow some varies that have less resilience on fire example Pine. Having good knowledge on fire management in forest plantation will fill the mention gap and enhance tree productivity in the area. Therefore TFS and associated agent must have that extension service reaching out small-scale producers and impart the needed knowledge in practices.

REFERENCES

Abdallah. J. M.,Woiso, D. A., Monela, G. C. and Phillip, R. (2014). Productive efficiency of small scale sawmilling industries in Mufindi district. *Tanzania Journal of Forestry and Nature Conservation* 82(2): 77 – 98.

Agad, J. S. and Cruz, E. D. (2012). Productivity and Technical Efficiency of Smallholder Cacao Farmers in Davao City.

Agom, D. I., Ohen, S. B., Itam, K. O. and Inyang, N. N. (2012). Analysis of technical efficiency of smallholder cocoa farmers in Cross River State, Nigeria. *International Journal of Agricultural Management and Development* 2(3): 177 – 185.

Ahmad, M., Chaudhry, G. M., Iqbal, M. and Khan, D. A. (2002). Wheat productivity, efficiency and sustainability: a stochastic production frontier analysis with comments. *The Pakistan Development Review* 41(4): 643 – 663.

Alemu, M. D., Tegegne, B. and Beshir, H. (2018). Technical efficiency in teff (eragrostisteff) production: The case of smallholder farmers in jamma District, South Wollo Zone, Ethiopia. *Journal of Agricultural Economics and Rural Development* 4(2): 513 – 519.

Ali, M. and Byerlee, D. (1991). Economic efficiency of small farmers in a changing world: A survey of recent evidence. *Journal of International Development* 3(1): 1 – 27.

Alvarez, R. and Crespi, G. (2003). Determinants of technical efficiency in small firms. *Small Business Economics* 20(3): 233 – 244.

Awunyo-Vitor, D., Bakang, J. and Cofie, S. (2013). Estimation of farm level technical efficiency of small-scale cowpea production in Ghana. *American Eurasian of Journal Agriculture and Environment Science* 13(8): 1080 – 1087.

Balcombe, K., Fraser, I., Latruffe, L., Rahman, M. and Smith, L. (2008). An application of the DEA double bootstrap to examine sources of efficiency in Bangladesh rice farming. *Applied Economics 40*(15): 1919 – 1925.

Begum I. A., Buysse J., Alam M. J. and Huylenbroeck G. V. (2009). An application of data envelopment analysis to evaluate economic efficiency of poultry farms in Bangladesh. *Presentation at the International Association of Agricultural Economists Conference,* Beijing, China, 16 – 22 August, 2009. pp. 1 – 19.

Brázdik, F. (2006). *Non-Parametric Analysis of Technical Efficiency: Factors Affecting Efficiency of West Java Rice Farms*. The Economics Institute of the Academy of Sciences, Czech Republic. 45pp.

Carter, D. R. and Siry J. P. (2003). Timber production efficiency analysis. In: *Forests in a Market Economy. Forestry Sciences*. (Editedby Sills, E. O., Abt, K. L.), Springer, Dordrecht. pp. 97 – 115.

Chamshama, S. A. O. and Nshubemuki, L. (2011). Plantation forest management in Tanzania: Current situation and future focus. *Paper Presented at the Forest Plantations Pests, Insects and Soil Problems Workshop, Kibaha, Tanzania*. 25pp.

Chavas, J. P., Petrie, R. and Roth, M. (2005). Farm household production efficiency: evidence from the Gambia. *American Journal of Agricultural Economics* 87(1): 160 – 179.

Coelli, T. J., Rahman, S. and Thirtle, C. (2002). Technical, allocative, cost and scale efficiencies in bangladesh rice cultivation: A non-parametric approach. *Journal of Agricultural Economics* 53(3): 607 – 626.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., and Battese, G. E. (2005). *An Introduction to Efficiency and Productivity Analysis.* Springer Science and Business Media, New York, USA. 348pp.

Coelli, T., Rahman, S. and Thirtle, C. (2002). Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: a non-parametric approach. *Journal of Agricultural Economics* 53(3): 607 – 626.

Coelli, T., Rao, D. S. P. and Battese, G. E. (1998). *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic, Boston. 275pp.

Dao, G. T. N. (2013). An analysis of the technical efficiency of crop farms in the Northern Region of Vietnam. Dissertation for Award of MSc Degree at, University of Canberra, 193pp.

Dessale, M. (2019). Analysis of technical efficiency of small holder wheat-growing farmers of Jamma district, Ethiopia. *Agriculture and Food Security* 8(1): 1 – 15.

Dhungana, B. R., Nuthall, P. L. and Nartea, G. V. (2004). Measuring the economic inefficiency of Nepalese rice farms using data envelopment analysis. *Australian Journal of Agricultural and Resource Economics* 48(2): 347 – 369.

Diaz-Balteiro, L., Herruzo, A. C., Martinez, M. and González-Pachón, J. (2006). An analysis of productive efficiency and innovation activity using: An application to Spain's wood-based industry. *Forest Policy and Economics* 8(7): 762 – 773.

FAO (2001). *Forest Resources Assessment: Main Report*. Forestry Paper No.140. Food and Agriculture Organization of the United Nations, Rome. 37pp.

FAO (2007). *State of the World's Forests*. Food and Agriculture Organization of the United Nations, Rome. 10pp.

Farrell, M. J. and Pearson, E. S. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society* 120(3): 253 – 281.

Gorton, M. and Davidova, S. (2004). Farm productivity and efficiency in the CEE applicant countries: A synthesis of results. *Agricultural Economics* 30(1): 1 – 16.

Haji, J. (2006). Production efficiency of small holder's vegetable dominated mixed farming system in eastern Ethiopia: A non-parametric approach. *Journal of African Economies* 16 (1): 1 – 27.

Harrison, S., Herbohn, J. and Niskanen, A. (2002). Non-industrial, smallholder, small-scale and family forestry: what's in a name? *Small-scale Forest Economics Management and Policy* 1(1): 1 – 11.

Hartwich, F. and Kyi, T. (1999). *Measuring Efficiency in Agricultural Research: Strengths and Limitations of Data Envelopment Analysis*. Institute of Agricultural Economics and Social Sciences, University of Hohenheim. 18pp.

Hedwall, P. O., Gong, P., Ingerslev, M. and Bergh, J. (2014). Fertilization in northern forests–biological, economic and environmental constraints and possibilities. *Scandinavian Journal of Forest Research* 29(4): 301 – 311.

Hulley, S. B., Cummings, S. R., Browner, W. S., Grady, D. G. and Newman, T. B. (2013). *Designing Clinical Research*. Williams and Wilkins, Lippincott. 117pp.

Javed, M. I. (2009). Efficiency analysis of cotton-wheat and rice-wheat systems in Punjab, Pakistan. Thesis for Award of PhD Degree at University of Agriculture Faisalabad, Pakistan, 130pp.

Javed, M. I., Adil, S. A., Ali, A. and Raza, M. A. (2010). Measurement of technical efficiency of rice-wheat system in Punjab, Pakistan using DEA technique. *Journal of Agricultural Research* 48(2): 227 – 238.

Kajembe, G. C. and Luoga, E. J. (1996). *Socio-Economic Aspects of Tree Farming in Njombe District. Consultancy Report to the Natural Resource Conservation and Land-Use Management Project*. Faculty of Forest and Nature Conservation, Sokoine University of Agriculture, Morogoro. 98pp.

Kalirajan, K. and Shand, R. T. (1985). Types of education and agricultural productivity: A quantitative analysis of Tamil Nadu rice farming. *Journal of Development Studies* 21(2): 232 – 243.

Kanowski, P. (2018). *Afforestation and Plantation Forestry for the 21st Century.* Working Paper No 12. Australian National University, Canberra, Australia. 84pp.

Karkkainen, J. P. (2005). *Enabling Environment for Forestry and Forest Industries in Tanzania-The Private Sector View*. Embassy of Finland, Dar es Salaam. 17pp.

Khaine, I., Woo S. Y. and Kang, H. (2014). A study of the role of forest and forest-dependent community in Myanmar. *Forest Science and Technology* 10(4): 197 – 200.

Kibaara, B. W. (2005). Technical efficiency in Kenyan's maize production: An application of the stochastic frontier approach. Dissertation for Award of MSc Degree at Colorado State University, 84pp.

Kumbhakar, S. C. and Lovell, K. C. A. (2000). *Stochastic Frontier Analysis*. Cambridge University Press, New York. 15pp.

Lerman, Z. and Sutton, W. R., (2006). *Productivity and Efficiency of Small and Large Farms in Moldova.* Discussion Papers No. 7133. Washington DC. 34pp.

Lockheed, M. E., Jamison, T. and Lau, L. J. (1980). Farmer education and farm efficiency: A survey. *Economic Development and Cultural Change* 29(1): 37 – 76.

Maamor, W. R., Aziz, M. I. A., Mat, S. H. C. and Fadzim. (2016). Estimating the technical efficiency of smallholder cocoa farmers in Malaysia. *International Journal of Economics and Financial Issues* 6(7): 1 – 5.

Maluccio, J. A., Hoddinott, J., Behrman, J. R., Martorell, R., Quisumbing, A. R. and Stein, A. D. (2009). The impact of improving nutrition during early childhood on education among Guatemalan adults. *The Economic Journal* 119(537): 734 – 763.

Mariano, M. J., Villano, R. and Fleming, E. (2011). Technical efficiency of rice farms in different agroclimatic zones in the Philippines: An application of a stochastic metafrontier model. *Asian Economic Journal* 25(3): 245 – 269.

Menegale, M., Rocha, J., Harrison, R., Goncalves, J., Almeida, R., Piccolo, M. and Michelsen-Correa, S. (2016). Effect of timber harvest intensities and fertilizer application on stocks of soil C, N, P, and S. *Forests* 7(12): 319 – 345.

Milledge, S., Singo, I. and Sangalali, E. (Experience in commercial forestry development: Achievements challenges and opportunities. *Tanzania Forest Research Institute 1st Scientific Conference on Forestry Research for Sustainable Industrial Economy*. 24 – 25 April, 2018. pp. 1 – 16.

Minot, N. (Ed) (2006). *Income Diversification and Poverty in the Northern Uplands of Vietnam*. International Food Policy Research Institute, Washington DC. 145pp.

Minot, N., Epprecht, M., Anh, T. T. T. and Trung, L. Q. (2006). *Income Diversification and Poverty in the Northern Uplands of Vietnam*. Research Report No. 145. International Food Policy Research Institute, Washington DC. 138pp.

Ngaga, Y. (2011). Forest plantations and woodlots in Tanzania. *African Forest Forum* 1: 1 – 16.

Nwaru, J. C., Okoye, B. C. and Ndukwu, P. C. (2011). Measurement and determinants of production efficiency among small-holder sweet potato (Ipomoea Batatas) farmers in Imo State, Nigeria. *European Journal of Scientific Research* 59(3): 307 – 317.

Nwaru, J. C., Onyenweaku, C. E. and Nwosu, A. C. (2006). Relative technical efficiency of credit and non-credit user crop farmers. *Journal of African Crop Science* 14(3): 241 – 251.

Ofogba, C. J., Agbomo, F. U., Abdul-Kareem, F. B., Abaelu, A. M. and Alatishe, K. (1998). Effect of Bridelia ferrugubea stem bark on blood chemistry and histology of some organs in rats.*Nigerian Journal of Natural Products and Medicine* 2(1): 26 – 28.

Ojo S. O. and Ogundari, K. (2007). An examination of technical, economic and allocative efficiency of small farms: the case study of cassava farmers in Osun State of Nigeria. *Bulgaria Journal of Agriculture Science* 13: 185 – 195.

Okike, I. (2001). *Agricultural Intensification and Efficiency in the West African Savannahs: Evidence from Northern Nigeria.* Working Paper No. 33. International Livestock Research Institute, Nigeria. 41pp.

Oluyole, K. A. and Sanusi, R. A. (2009). Socio-economic variables and cocoa production in Cross River State, Nigeria. *Journal of Human Ecology* 25(1): 5 – 8.

Onyenweaku, C. E. and Effiong, E. O. (2005). Technical efficiency in pig production in Akwa Ibom State, Nigeria. *International Journal of Agriculture and Rural Development* 6(1): 51 – 57.

Onyenweaku, C. E. and Nwaru, J. C. (2005). Application of a stockastic frontier production function to the measurement of technical efficiency in food crop production in Imo State, Nigeria. *Nigeria Agricultural Journal* 36(1): 1 – 12.

Onyenweaku, C. E., Okoye, B. C. and Okorie, K. C. (2007). *Determinants of Fertilizer Adoption by Rice Farmers in Bende Local Government Area of Abia State, Nigeria.* Munich Personal RePEc Archive, Abia State, Nigeria.17pp.

Palmer, S. and Torgerson, D. J. (1999). Economic notes: *Definitions Of Efficiency* 318(7191): 1136 – 1139.

Poungchompu, S. and Chantanop, S. (2015). Factor affecting technical efficiency of smallholder rubber Farming in Northeast Thailand. *American Journal of Agricultural and Biological Sciences* 10(2): 83 – 89.

Rahman, S. (2008). Determinants of crop choices by Bangladeshi farmers: A bivariate probity analysis. *Asian Journal of Agriculture and Development* 5(1362): 29 – 41.

Rios, A. R. and Shively, G. E. (2005). Farm size and nonparametric efficiency measurements for coffee farms in Vietnam. *Paper Prepared for Presentation at the American Agricultural Economics Association Annul Meeting Providence* Rhode Island 24 – 27 July, 2005. pp. 1 – 21.

Rowena J., Gale, H. F., Capehart, T. C., Zhang, P. and Jha, P. (2000). The supply-side effects of tobacco control-policies. In: *Tobacco Control in Developing Countries.* (Edited by Jha, P. and Chaloupka, F.), Oxford University Press, Oxford, UK. pp. 311 – 341.

Saarsalmi, A. and Mälkönen, E. (2001). Forest fertilization research in Finland: A literature review. *Scandinavian Journal of Forest Research* 16(6): 514 – 535.

Saarsalmi, A., Mälkönen, E. and Piirainen, S. (2001). Effects of Wood ash fertilization on forest soil chemical properties. *Silva Fennica* 35(3): 355 – 368.

Scherr, S. J. (2004). Building opportunities for small-farm agroforestry to supply domestic wood markets in developing countries. *Agroforestry Systems* 61: 357–370.

Seiford, L. M. and Thrall, R. M. (1990). Recent developments in DEA: The mathematical programming approach to frontier analysis. *Journal of Econometrics* 46(2): 7 – 38.

Shayo, J. F. (2005). Assessment of the status and social-economic aspect of trees in the chagga homegardens of Rombo District. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 126pp.

Shittu, A. M. (2014). Off-farm labour supply and production efficiency of farm household in rural Southwest Nigeria. *Agricultural and Food Economics* 2(1): 1 – 8.

Singunda, W. T. (2010). Economic contribution of private woodlots to the economy of Mufindi district Tanzania. dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 142pp.

Solís, D., Bravo-Ureta, B. E. and Quiroga, R. E. (2009). Technical efficiency among peasant farmers participating in natural resource management programmes in central America. *Journal of Agricultural Economics* 60(1): 202 – 219.

United Republic of Tanzania (2006). *Tanzania National Forest Programme 2001-2010*. Ministry of Natural Resource and Tourism, Dar es Salaam, Tanzania. 134pp.

Villano, R. and Fleming, E. (2006). Technical inefficiency and production risk in rice farming: evidence from Central Luzon Philippines. *Asian Economic Journal* 20(1): 29 – 46.

Vu Tseng, Y. P. H. and Wilkins, R. (2008). Dynamic properties of income support receipt in Australia. *Australian Economic Review* 41(1): 32 – 55.

Vu, H. L. (2008). Essay on the economics of food production and consumption in Vietnam. Thesis for Award of PhD Degree at University of Minnesota, USA, 267pp.

Wassie, S. B. and Economics, D. (2014). Efficiency of Agricultural Production.

William, M. K. T. (2002). Non probability sampling. [http://www.socialresearchmethods.net/kb/sampnon.htm] site visited on 23/12/2013.

Yaro, J. A. (2006). Is deagrarianisation real? A study of livelihood activities in rural northern Ghana. *The Journal of Modern African Studies* 44(1): 125 – 156.

APENDICES

My name is Mathayo Neema Joseph. I am postgraduate student at Sokoine University of Agriculture currently enrolled for the MSc environmental and natural resources economics. According to the nature of my course I am required to do a research on the production efficiency of small-scale tree growers in Mufindi district. Your contribution and opinions to this research is of great importance so please help me by answering the questions as directed. All the information provided will be treated with confidentiality and used for the purpose of this research only**.**

Farm Level Survey Questionnaire In Northern Tanzania on production efficiency of small-scale tree growers

Questionnaire ID……………………………….

District……………………. Region……………………………

Ward………………. Village…………….

A) Background Information

1) Respondent's Names…………….….……..

(2) Sex (1) Male (2) Female ………………..

3) Marital status (1) Married (2) single (3) Widowed………

4) Age……….. (1) 18-38 (2) 39-59 (3) Above 60

(5) Education level

1) No formal education 2) Primary 3) Secondary 4) Higher education…………..

6) Household size ……………

7) How long have been growing trees? 1) 0-10 2)10-20 3) 20-30 4)30-40 5) Above 40

8) Which species do you grow on your farm? 1)………… 2) ………3)……………

A) Production Information on Trees

9) Do you use the following inputs in your tree production?

A) Improved seeds Yes ( ) No ( )

B) Fertilizer Yes ( ) No ( )

C) Agro- chemicals Yes ( ) No ( )

D) Heavy machinery Yes ( ) No ().

E) What is the size of your farm? 1) 1-5 2)6-10 3)11-20 4) Above 20

F) Do you have access to capital? Yes ( ) No ( )

G) If yes how much ……………

H) what kind of tree species do you usually plant.? 1) ………………., 2) ………………..

13) Do you access inputs from government agencies Yes ( ) No ( )

14) If yes, how much was received……….

15) Have you received any form of training on use of input in trees production? A) Yes ( ) b) No()

16) If yes, who provided the training?

1) Extension agent (2) NGO (3) Farmer (4) other specify……..

15) For the above service provider, fill the table below on the number of times they rendered service per year.

Services provider	Per year
Extension agent (TFS/DFO etc)	
NGO	
Farmer	
Other specify	

B) Labour Inputs in Tree Production

16) What is the main source of labour for trees production?

1) Family labour (2) Hired labour (3) Both ……………..

17) How many labour units in total worked in the woodlot field in the last year of 2017-2018?

Type	Men	Women	Children	Tractor
Family labour				
Hired labour				
Both				

18) Activity labour demands in woodlot farming for last season

Activity	Type of worker											
	Man			Woman			Children			Tractor		
	No.	Days	cost	No.	Days	cost	No.	Days	cost	No.	Days	Cost
Land pre 1st ,2nd ploughing												
Planting												
Fertilizer application												
1st weeding												
2nd weeding												
Pruning												
Harvesting												
Transport to market												

Key: men/women=>18more

C) Output

19) For how long does it take for you to start harvesting your produce? ………….

20) With this size of farm and the input incurred what amount of produce are you expecting? ………….

21) Do you sell tree produced on you farm a) Yes ( ) b) No ( )

22) If yes, please fill the table below.

Season	Harvested area (acres)	Quantity harvested (m3)	Quantity sold ()	Price/ unit (Tshs)	Point of sale	Cost of sale (tax, transport) (Tshs)
Last year						
This year						

24) Do you belong to any group or Association? A) Yes ( ) b) No ( )

25) If yes, what service do you receive from such association?

……………………………………………………………………………………………

……………………………………………………………………………………………

26) How many times did you meet last month……………………………………………

27) What problems do you face while producing trees?

……………………………………………………………………………………………

……………………………………………………………………………………………

27) How do you solve the problems?

……………………………………………………………………………………………

……………………………………………………………………………………………

28) What do you think should be done so as to improve your production efficiently?

……………………………………………………………………………………………

……………………………………………………………………………………………

29) Do you receive any loan (i) yes ( ) (ii) No, ( )

If yes, please state the amount of loan received, year received and from where?

……………………………………………………………………………………………

……………………………………………………………………………………………