SOCIO-ECONOMIC FACTORS AFFECTING TECHNICAL EFFICIENCY OF SMALL HOLDERS MAIZE PRODUCTION IN RWANDA

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The thesis submitted in the partial fulfilment of the award of the degree of Masters of Science in Agribusiness Management and Trade in the School of Agriculture and Enterprise Development of Kenyatta University

May, 2017
DECLARATION

I, MULINGA Narcisse (A103/EA13604/2009), declare that this thesis is my original work and it has not been presented for the award of a degree in any other University or any other award.

Signature  .............................................................................................................

Date  .....................................................................................................................

Supervisors’ approval

We confirm that the work reported in this thesis was carried out by the candidate under our supervision and has been submitted with our approval as university supervisors.

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DEDICATION

Special dedication to my wife Bayizere Gerardine for her sincere love and commitment.
To our beloved son Lenny Logan, I missed your formative years, but I hope this sacrifice will improve the quality of your life in the future.
To my uncle Kayisire Callixte, who gave me the inspiration to pursue postgraduate studies and his selfless effort in educating me.
To my sister Eugenie Umumararungu, my late parents and other family who lost their lives during the Rwanda Tutsi Genocide of 1994. I am really honoured to have been a part of your family.
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This research is a result of joint efforts from various people, who contributed to its completion in one or another way.

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I cannot forget to thank Musanze and Bugesera, citizens for being close and kind to me during data collection. As it is not possible to put all names of people who contributed to my education in this space, I take this opportunity to address my special consideration with much regard to my Uncle Kayisire Callixtie and to all those not mentioned, and recognize that they were equally important in completion of my studies.
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<th>Full Form</th>
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<tr>
<td>CIAT</td>
<td>International Center for Tropical Agriculture</td>
</tr>
<tr>
<td>COLS</td>
<td>Corrected Ordinary Least Squares method</td>
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<tr>
<td>C-D</td>
<td>Cobb Douglas</td>
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<td>DEA</td>
<td>Data Envelopment Analysis</td>
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<td>FAO</td>
<td>Food Agriculture Organization</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>MINAGRI</td>
<td>Ministry of Agriculture</td>
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<tr>
<td>NIS</td>
<td>National Institute of Statistics</td>
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<tr>
<td>NGOs</td>
<td>Non Governmental Organizations</td>
</tr>
<tr>
<td>GoR</td>
<td>Government of Rwanda</td>
</tr>
<tr>
<td>ISAR</td>
<td>Institut de Sciences Agronomiques au Rwanda</td>
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<tr>
<td>RAB</td>
<td>Rwanda Agriculture Board</td>
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<tr>
<td>SACCOs</td>
<td>Saving and Credits Cooperatives</td>
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<td>WFP</td>
<td>World Food Program</td>
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DEFINITION OF TERMS

**Efficiency:** is the success with which a farm uses its resources to produce output

**Technical efficiency:** is the effectiveness with which a given set of resource input is used to produce the maximum possible output

**Data envelopment Analysis:** is a linear programming method that is used to estimate technical efficiency scores level within a farm.

**Production efficiency:** refers to how well farmers utilize the available resources in the production process otherwise referred to as efficiency of production.

**Productivity:** It is a measure of efficiency of production computed herein as a ratio of maize output to the inputs required to produce it, output is in kilograms per hectare of land under maize.

**Smallholders:** farm households that own or and cultivate less than 2 hectares of land
ABSTRACT

Maize is still largely a subsistence food crop under promotion as a food security crop and source of income for smallholders. In a bid to attain self-sufficiency, Rwanda made remarkable efforts to develop the subsector. These were mainly directed towards the expansion of the area under maize, organisation of farmers’ cooperatives and easy access to inputs. In improving maize productivity and marketing of maize several both public and private interventions were added in Musanze and Bugesera districts those interventions include breeding, distributions of improved seed that are pest and diseases resistant and promotion good agricultural practices. Despite efforts put up by the Government of Rwanda and other stakeholders, maize still faces low productivity compared to the expected potential yields and the actual yield. The objectives of this study were to estimate the technical efficiency level in maize production in both Musanze and Bugesera districts and to determine some socio-economic factors affecting technical efficiency of maize producers in Rwanda. Primary data was used. Stochastic Frontier Analysis (SFA) with the Cobb-Douglas functions on a random sample of 276 maize farmers. The findings indicated that the mean technical efficiency for maize production in both districts is 23% which means that farmers can increase their output through efficient use of available resources and existing technology if they are to be technically efficient. The study concluded that age, educational level, fertilizers, labor, land size, seeds, visit of agent of extensions and access to credit were significant variables leading to technical inefficiency in Rwanda. On the other hand, family size, type of seeds, and experience, had no significant impact on farmers’ inefficiency. To increase technical efficiency for maize production in the Rwanda, the study recommended improvement in education level of the farmers and availability of funds in the optimum time.
CHAPTER ONE: INTRODUCTION

1.1 Background

Agriculture is the most important sector of the Rwandan economy; contributing 41% of Gross Domestic Product (GDP) and employing around 90% of the Rwandan population living in rural areas (NIS, 2008). Agriculture is important for sustainable development, poverty reduction, and enhanced food security, and supplies over 90% of the food consumed in the country, while manufacturing accounts for only 13% of GDP (FAO, 2008). Indeed, promoting agriculture is imperative in achieving the Millennium Development goals (World Bank, 2008).

Maize is the most important cereal crops in Rwanda (ISAR, 1998). It is grown in the lowland, mid-altitude and highland zones ranging from 900m to over 2400m above sea level. Maize is becoming popular throughout the country and is consumed in several traditional food preparations (Nyirigira et al., 2005). Maize is still largely a subsistence food crop under promotion for a food security crop especially in urban areas and source of income (Nyirigira et al., 2005)

1.2 Maize production in Rwanda

Maize is an indigenous crop in Rwanda which is concentrated in the highland areas of North–Eastern Rwanda. The districts of Bugesera and Musanze are assumed to have a comparative advantage in maize production due to the favourable ecological conditions. (Nyirigira et al., 2005).

Maize comes as a first strategy to reduce poverty (MINAGRI, 2006). The Rwandan government classified maize as a priority crop for development and food security that can serve as an example to the rest of the agricultural sector of how rapid transformation can take place (MINAGRI, 2006). To promote maize, Rwanda Agriculture Board has developed high yielding varieties. In recognition of the major role of maize in food security and as source of income for smallholders maize growers especially in Musanze and Bugesera districts Rwandan government
introduced subsidies inputs policy was introduced since 2006.

1.3 Variability in maize production

Area under Maize production has been increasing from 12,000 ha in 2006 to 15,000 ha in 2010 but the annual average yield per hectare has been decreasing from 0.8 tons per ha in 2006 to 0.3 tons per hectare in 2010. (Sallah et al., 2010)

In improving maize productivity and marketing of maize several both public and private interventions were added in Musanze and Bugesera districts those interventions include breeding, distributions of improved seed that are pest and diseases resistant and promotion good agricultural practices. Despite efforts put up by the government of Rwanda and other stakeholders, maize still faces low productivity compared to the expected potential yields and the actual yield. The expected potential yield for the introduced varieties is 6-8 tons per ha but farmers have only realized production of up to 1.6 tons per hectare. (Sallah et al., 2009)

Variability in production is in function of difference in scales of operation, production technologies, operating environment and operating efficiency (Fried et al., 2008). Production increase is not in proportional of the adoption rates of new technologies but efficient use of available technology (Chiona, 2011). To improve efficiency in production allows farmers to increases the output and changing production technologies resulting in increased productivity (Chimai, 2011). According to the same author smallholder farmers, variation in production due to difference in efficiency may be affected by various regional and farm specific socio economic factors.

To increase productivity, technology innovation is required but not sufficient. Efficient use of old technology is necessary (Chiona, 2011). If farmers are not efficient in using the existing technologies then improving efficiency will be more cost effective in short run than introducing another technology. Technical inefficiency may arise primarily due to managerial incompetence and therefore and therefore efficiency differences could be explained in the context of management characteristics such as: training, experience and motivation (Ahmed et al., 2005).
1.4 Problem statement

Maize is the most important cereal crop in Rwanda. It is grown in the lowland, mid-altitude and highland zones ranging from 900m to over 2400m above sea level. Maize is becoming popular throughout the country and is consumed along with other traditional foods. Maize is still largely a subsistence food crop under promotion for a food security crop especially in urban areas and source of income.

Despite investment aimed at boosting maize production in Rwanda, the objective of attaining potential production and self-sufficiency in maize has not been reached. The yield remains very low and the potential of 8 tons per hectare is still not achieved in the majority of maize producing areas including Musanze and Bugesera districts assumed to have a comparative advantage in maize production. However, in a country like Rwanda where production resources (particularly land) are extremely scarce, the achievement of maximum technical efficiency at farmer level would be the best complement to all efforts made for self-sufficiency in maize production. Technical efficiency though being that important in Rwanda, there is no research so far conducted to provide empirical information on the matter. Therefore, there is need to examine the technical efficiency of maize production in Musanze and Bugesera Districts and factors affecting technical efficiency.

1.5 Objectives

The aim of this study was to estimate and determine factors affecting technical efficiency of smallholder maize producers in Musanze and Bugesera Districts of Rwanda.

1.5.1 Specific Objectives

The specific objectives were:

1. To assess the determinants of maize production among the inputs used in Musanze and Bugesera Districts
2. To determine the technical efficiency level of smallholder maize farmers in Musanze and Bugesera Districts so as to understand resource use efficiency.
3. To analyze the effect of socioeconomic factors technical efficiency of that influence technical efficiency farmers in the study areas.

1.6 Hypotheses

The hypotheses to be tested were:

1. All Inputs used in production at farmer level are the significant determinants of maize output in Musanze and Bugesera Districts. In other words, there are no inefficiency effects in the specified stochastic production function and the value of sigma \[ \gamma = (\sigma_\mu^2/\sigma^2) \] equals to zero; \( H_0: \gamma = 0 \).

2. There is no significant effect of the socio-demographic, economic and institutional factors on technical efficiency in the study area. This null hypothesis is then written as \( H_0: \sigma_1=\sigma_2=...=\sigma_7=0 \), where \( \sigma \) represent the parameters of the considered factors. It specifies that the considered variables have no significant effect on technical efficiency.

1.7 Significance of the Study

This study is important in a way that it will contribute to the development of maize subsector by providing key information on efficiency in resource utilisation and factors which need to focus on for an increased production.

The information generated from the present study is intended to be communicated to farmers and policy makers. To the farmers, it will mainly help them in the management of resources in maize production. The information from this study will also be useful to the policy makers in designing and implementing the informed policies and strategies based on the factors limiting productivity. Moreover, the findings from this study will benefit researchers and extension service providers as well as different NGOs in indicating the area of advantage for what should be done to improve the maize production through technical efficiency at farm level. Finally, this study could serve as a source for further studies for the development of maize subsector in Rwanda.
1.8 Conceptual framework

The conceptual framework was based on production theory (Figure 1) where \( y = f(x_s) \), \( y \) being the output (yield) and \( x_s \) are production factors (Cobb and Douglas, 1928). The conceptual framework was organized in terms of influence and feedback mechanisms of farm level production efficiency. The framework focuses on input-output transformation efficiency, policy recommendations, and effects thereof. Production factors (seed, land size, fertilizers, labour) were used as inputs maize production process. It was anticipated that as more inputs were used by the farmer, fruit yields would increase on one hand but this may have a negative effect in cases of overuse. Therefore, optimality was crucial in deciding the level of inputs to be applied. Yield levels were affected by efficiency of production of a farmer. This perspective was supported by the notion that for a production process to be efficient, the manner of utilization of the available resources is important in realization of maximum output from a given set of inputs (its technical efficiency). The production function was presented as:

\[
Y = \beta_0 + \beta_i X_i + \mu + v \quad \text{(1)}
\]

Where: \( Y \) is the maize output, \( x \) are inputs utilized, \( \beta \) are the unknown parameters, \( \mu \) is the non-negative random variable which is assumed to account for technical inefficiency in production (one-sided), and \( v \) being a random variable (which is symmetric in nature).

Socioeconomic and institutional factors were expected to influence farmers’ efficiency. Socioeconomic factors that were anticipated to influence technical efficiency included age of the decision maker and gender, farming experience, education level, and. Institutional factors such as amount of credit used, extension service contact, and cooperative or association membership were hypothesized to influence TE. The influence relationship was expected to follow equation 2.

\[
\mu_i = \delta_0 + \delta_i Z_i \quad \text{(2)}
\]

Where: \( \mu_i \) being technical inefficiency, \( \delta_0 \) and \( \delta_i \) the unknown parameters that were to be estimated while \( Z_i \) represented the inefficiency variables of farmer \( i \).
The management practices of farmers were hypothesized to play an important role in the conceptualized efficiency model but were embedded in the production, institutional, and socioeconomic aspects. The technical efficiency and its influencing factors as well as management practices across the study areas were expected to influence policy which the study had proposed to recommend. Once the policies were recommended the outcome was expected to have a feedback effect in improving technical efficiency and production levels. Ultimately, improved income levels and livelihoods were anticipated. Improved incomes among the purple passion fruit farmers were expected to have a feedback effect on production, socioeconomic and institutional factors through informed and improved use of inputs, accessibility of institutional services and alteration of the current socioeconomic aspects of the farmers.
Input - output

Feedback effect

Direction of influence

Stochastic frontier production function

Production factors:
Seed and type of seed (loc and improved) farm size, fertilizer (inorganic or organic) labour

Institutional factors:
Access to credit and use, extension services, association or cooperative membership

Socio-economic factors:
Age, gender, farming experience, education level, status, family size

Technical Efficiency levels

Productivity levels

High income

Improved live hoods
1.8 Scope of Study

The study covered two districts namely Musanze district situated in the Northern Province of Rwanda and Bugesera district located in the Eastern Province of Rwanda. It targeted maize producers in both districts who grew maize during the period of 2011 and 2012.
CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter is a review of literature on efficiency in resources use. It begins by introducing the concept of efficiency and its different component which are: technical efficiency and allocative efficiency since the study focus on the productive efficiency

2.1 The concept of efficiency

Yotopolous et al (1967) defines the efficiency of the firm by comparing observed and optimal values of its outputs and inputs. If the optimum is defined in terms of production possibilities, the resulting comparison measures technical efficiency. If the optimum is defined in terms of behavioral goals of the firm (e.g. profit maximization and cost minimization), then efficiency is economic and is measured by comparing a firm’s observed and optimum achievement of goals (e.g. profit, revenue and cost) subject to the appropriate consideration of technology and maize.

Farrell (1957) proposed that the economic efficiency of a firm consists of two components: technical (or physical) efficiency and allocative (or maize) efficiency. Technical efficiency refers to the ability of a firm to produce maximal potential output from a given amount of input or to use a minimal amount of inputs in order to produce a given amount of output. Allocative efficiency represents the ability of a firm to utilize the cost-minimizing input ratios or revenue-maximizing out-put ratios. A firm is allocatively efficient if it uses the optimal combination of inputs with respect to their maize. First-order conditions from revenue maximization can be used to determine optimal output ratios based on output maize and marginal costs.

Headley (1952) defines the efficiency of resource use as the point at which net returns from a
single technical unit are at a maximum when the marginal cost of the resource is equal to the marginal value product of the resource. He further states that farmers do not always extend resource use to this point of efficiency use. This inability to equate marginal cost of resources, either for technical unit or for the farm as a business includes three considerations;

i. Lack of knowledge or principles

ii. Lack of knowledge of the relevant input-output relationships and cost structures

iii. The uncertainty of future maize and yields and the existence of severe capital limitations

Efficiency is defined relative to some notion of best practice at a particular point in time. This notion is referred to as the best practice or the efficiency frontier.

2.2. Measuring technical efficiency

Different methods for measuring technical efficiency have been developed and currently, two approaches namely the Stochastic Frontier Analysis (SFA) and the Data Envelopment Analysis (DEA) are mostly used in measuring TE. These approaches are qualified as bases or primary models in the analysis of technical efficiency (Coelli, 1996; Thiam et al., 2001).

2.2.1. Data Envelopment Analysis

The model uses mathematical linear programming to construct an efficient frontier by using the best performing production units commonly known as Decision Making Units (DMUs) in the sample. The DMUs are then compared to the best performer (belonging to the frontier) whose efficiency score equals to 1 (Cesaro et al., 2009). The DMU below the frontier are all considered as technically inefficient and contrary to the SFA, this method attributes to the inefficiency, all deviations from the production frontier.

DEA can be used under Constant Return to Scale (CRS) or Variable Return to Scale (VRS) assumptions (Charnes et al., 1978). The former assumes that in the process of production, inputs increase proportionally with the outputs whereas VRS incorporates scale efficiency assuming that output does not proportionally increase with an increase in inputs (Kelly et al., 2012).
2.2.2. Stochastic Frontier Analysis

This is a parametric method that has been independently introduced by Aigner et al. (1977) and Meeusen and van Den Broeck (1977). The Stochastic Frontier Analysis (SFA) is based on econometric model using functional forms such as Cobb-Douglas, Translog or the Zellner-Revankar generalised production function (Coelli, 1995).

According to Amaza et al. (2006), the stochastic frontier production function used in TE measurement differs from the production function in that the former has a composite error term while the latter has one. The composite disturbance term of a Stochastic Frontier Production Function is a sum of two error components, one representing the effects of errors which cannot be controlled by the production unit (weather, statistical errors, etc.) another accounting for the existence of technical inefficiency (i.e. errors that could be avoided by the producing unit).

In SFA approach, the production frontier refers to the lowest quantity of the necessary mix of inputs for the production of one or more outputs or, the highest level of output with a given combination of inputs considering the current technology (Constantin et al., 2009). Given the assumption that farms are not operating at the production frontier, measuring TE consists of identifying the level at which a particular farm is located from the so called frontier. Thus in SFA, the deviation from the frontier production of a specific firm is due to technical inefficiency. The producing units who operate under the frontier production are considered as technically inefficient while those operating on the production frontier are considered to be efficient.

2.2.3. Data envelopment versus stochastic frontier analysis

There are contradictions on the effect of using one or another method. For instance, Sharma et al. (1999) found almost similar results using DEA and SFA in efficiencies analysis in swine production in Hawaii. On the other hand, Theodoridis and Annwar (2011) have found weak correlation between the SFA and DEA results in their study comparing the two methods in farm households in Bangladesh. Iráizoz et al. (2003) specified that the results on similarity or variability of DEA and SFA are not conclusive given the existing contrasts in the literature.
2.4 Review of Studies Analysing Technical Efficiency

Production is defined as the transformation of goods and services into finished products (that is input output relationship) and this is also applied to every production process, maize production inclusive. Olayide and Heady (1982) define production process as one whereby some goods and services called inputs are transformed into other goods and services called output. In agriculture, the physical inputs which we use are: land, labor, capital and management. Pitt and Lee (1981) have estimated stochastic frontiers and predicted firm-level efficiencies using these estimated functions, and then regressed the predicted efficiencies upon firm –specific variables such as managerial experience, ownership characteristics etc in an attempt to identify some of the reasons for differences in predicted efficiencies between firms in an industry. This has long been recognized as useful exercises, but the two-stage estimation procedure has also been long recognized as one, which is inconsistent in its assumptions regarding the independence of the inefficiency effects in two estimation stages. The use of robust standard errors minimizes this bias.

Although studies by Amos (2007), Raghbendra, Nagarajan and Prasanna (2005), and Barnes (2008) found the relationship between land holding size and efficiency to be positive, a clear-cut conclusion on the influence of this variable on efficiency has not been reached as discussed in the work of Kalaitzadonakes et al (1992). On the other hand, influence of the number of plots on efficiency has been reported by Raghbendra et al (2005) to be negative. This implies land fragmentation (as measured by number of plots) have a negative impact on yields. There are conflicting results on the influence of socio-economic variables such as gender on efficiency. An integrated producer scheme is a setup that operates an integrated system that links production, extension services, transportation, processing and marketing. Tchale and Sauer (2007) point out that, while some studies (in Lesotho) report gender of the farmer has no significant influence on efficiency, other studies found that gender plays an important role.
According to Skarstein (2005) and Msuya (2007), producer associations are very important in transforming the agricultural sector into one with high productivity and high quality output. While referring to Tanzania, Skarstein (2005) stress that, if the agriculture sector is to be transformed, producer associations (in form of farmers’ cooperatives) are needed first and foremost to give the smallholders bargaining power in the input, output and credit markets. Msuya (2007) and R&AWG (2005) went a step further and showed integrated producer schemes are more suited than cooperatives in assisting smallholder farmers to address most of the constraints they face including low production and productivity. An integrated producer scheme is a setup that operates an integrated system that links production, extension services, transportation, processing and marketing. With this in mind we include in the inefficiency model a variable that takes into account involvement of smallholders in farmer cooperative.

Banik, (1994) carried out a study on technical efficiency of irrigated farms in a village of Bangladesh and used a stochastic production frontier. He used a Cobb-Douglas function and used the Maximum Likelihood estimates (MLE) method to estimate the parameters of the stochastic frontier Cobb-Douglas production function. The index of the technical efficiency level for each individual farm was calculated estimating the one side error component. The results showed that 88 out of 99 farms had a technical efficiency of 71 percent or above. A very interesting finding was that ten out of thirteen most efficient farms belonged to the category of small farms. The study also revealed that owner-tenant farms were technically more efficient than owner farms.

Panda (1996) used a frontier production function which he derived from Cobb-Douglas production function and estimated by Corrected Ordinary Least Square (COLS) method. Corrected Ordinary Least squares (COLS) models is among the most commonly used parametric methods such as Ordinary least squares (OLS), and Stochastic Frontier Analysis (SFA). The main difference between these models is that COLS attributes all the deviations to inefficiency while SFA. In other words, the SFA models take both inefficiency and random noise
into account. When using COLS it is good practice to perform quantile analysis. Quantile analysis helps to overcome the possible effect of outliers on the estimated mean allowing the analyst to detect the presence of performers on specific or extreme quantiles such as the lower (25%) or the upper (75%) quartiles. From the estimated equation, Timmer’s measure of technical efficiency and Copp’s measure of allocative efficiency of various resources utilized in sericulture farms were examined. The study revealed that the economics of sericulture was highly profitable both in the traditional and non-traditional areas. The study also identified major constraints in sericulture development as being inadequate trained manpower.

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. Further, the Belbase and Grabawoskis’ study did not deal with allocative inefficiency. Ahmed et al., (2004) carried out a study on Cotton Production Constraints in Sudan: Economic Analysis Approaches. The main objective of the economic study was to identify, analyze and evaluate the major constraints of cotton production in the Gezira Scheme. To analyze technical efficiency the study employed a stochastic frontier model. Stochastic Production Frontier Analysis results revealed that 48 % of cotton yield variability was due to tenant and scheme management specific factors. And that 25 % of the variability was due to the tenants’ technical inefficiency and 23 % is due to the scheme management’s inefficiency.

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 reducing
on the frontier.

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 more inefficient than large-scale producers and concluded that the
size of farm operation affects level of efficiency attainable.

Abedullah (2006) did a study on Technical Efficiency and its Determinants in potato
Production, Evidence from Punjab, Pakistan using Cobb-Douglas stochastic production frontier
approach. The result showed that potato farmers are 84 percent technically efficient implying
significant potential in potato production that can be developed.

Obwona (2000) estimated a Trans-log production function to determine technical
efficiency differentials between small- and medium-scale tobacco farmers in Uganda using a
stochastic frontier approach. The estimated efficiencies were explained by socioeconomic and
demographic factors. The results showed that, credit accessibility extension services and farm
assets contribute positively towards the improvement of efficiency. One major drawback of this
study is the inability of the author to show in clear terms whether there is any difference in
efficiency between the two groups of farmers.

Chirwa (2007) using SFA one stage simultaneous estimate approach in estimating
technical efficiency of smallholders farmers in southern Malawi, he found out many households
were technically inefficient with average of 46.23% and as low as 8.12% technical efficiency.
Use of hybrids and cooperatives membership increased the efficiency he focused on maize which
is input intensive and he also used one stage estimation which has been argued or being very
Elibariki et al (2008) explained productivity variations among smallholder maize farmers in Tanzania. In their study they found out that the efficiency ranged from 0.011-0.910 with mean of 0.606. Around 40% loss of output was due to technical inefficiency. Farmers’ age, education level, access to credit, family size and access to fertilizer were the most important factors affecting technical efficiency. They therefore recommended that the government should improve provision of agricultural credit and extension services to increase technical efficiency.

According to Nchare (2007) in the study of estimating technical efficiency levels among Arabica coffee producers in Cameroon, technical efficiency ranged between 0.24-0.98 with the average of 0.90. Approximately 10% loss in output was due to inefficiencies. Education level and access to credit were the most socio-economic variables affecting technical efficiency. He concluded by recommending the government should increase farmers’ education and access to credit to improve technical efficiency.

In the study conducted in three districts of Kenya by Ngeno et al (2011) on technical efficiency among the bulrush millet producers, they found TE could be increased by 28 to 56% through better use of resources. They recommended that new policies should focus on effective and efficient use of inputs by using the available technology in order to enhance farmers’ capacity to efficient use of inputs.

Kibaara (2005) carried out a study on the technical efficiency of smallholder maize Producers in Kenya. The Tobit model was used to derive efficiency indices as a function of a vector of socio-economic characteristics and institutional factors. The results show decreasing returns to scale in production, education, access to extension, access to credit and membership in a farmers association positively and significantly influence economic efficiency.

According to literature reviewed, there exists very little information on technical efficiency in Rwanda. One study conducted by Byiringiro and Reardon (1996) investigated the effects of farm size, soil erosion and soil conservation investments on land and labour productivity and allocative efficiency in Rwanda. The authors concluded that there is a strong inverse relationship between farm size and land productivity. Furthermore, for small farms, there
was evidence of inefficiency in the use of land and labour, the cause being attributed to factor market access constraints.

Seyoum *et al.* (1998) considered the technical efficiency and productivity of maize producers in Ethiopia and compared the performance of farmers within and outside the program of technology adoption. Using Cobb–Douglas stochastic production functions, their empirical results show that farmers who participated in the program were more technically efficient with a mean technical efficiency equal to 94% compared with those outside the project whose mean efficiency equalled 79%.

Also in Ethiopia, Weir (1999) investigated the effects of education on farmer productivity of cereal crops using a stochastic production function. Their study finds substantial internal benefits of schooling for farmer productivity in terms of efficiency gains but finds a threshold effect that implies that at least four years of schooling are required to lead to significant effects on farm level technical efficiency. Using different specifications, average technical efficiencies range between 0.44 and 0.56, and raising education from zero to four years in the household leads to a 15% increase in technical efficiency. Moreover, the study finds evidence that average schooling in the villages (external benefits of schooling) improves technical efficiency. The impact of education externalities on production and technical efficiency of farmers in rural Ethiopia is the subject of Weir and Knight (2000). They find evidence that the source of externalities to schooling is in the adoption and spread of innovations that shift out the production frontier. Mean technical efficiencies of cereal crop farmers are 0.55. A unit increase in years of schooling increases technical efficiency by 2.1 percentage points. One limitation of the Weir (1999) and Weir and Knight (2000) is that they investigated the levels of schooling as the only source of technical efficiency.

Using data envelopment analysis, Townsend *et al.* (1998) investigated the relationships among farm size, returns to scale and productivity for wine producers in South Africa. They found that most farmers operated under constant returns to scale, but the inverse relationship between farm size and productivity was weak. Mochebelele and Winter-Nelson (2000) assessed the impact of
labor migration on the technical efficiency performance of farms in the rural economy of Lesotho.

Using the stochastic production function (trans-log and Cobb–Douglas), the study found that households that sent migrant labor to South African mines were more efficient than those that did not, with mean inefficiencies of 0.36 and 0.24, respectively. In addition, there was no statistical evidence that the size of the farm or the gender of the household head affected the efficiency of farmers. These authors concluded that remittances facilitated agricultural production, rather than substituted for it. Their study did not, however, consider the many other household characteristics that may affect technical efficiency such as education, farmers’ experience, access to credit facilities (capital) and advisory services, and the extent to which households that export labor received remittances. The authors’ interpretation that it was remittances that explain differences in technical efficiencies was based on the presumption that migrant laborers remit to their exporting households. Sherlund et al. (2002) investigated the efficiency of smallholder maize farmers in Côte d’Ivoire while controlling for environmental factors that affected the production process. Apart from identifying factors that influenced technical efficiencies, the study found that the inclusion of environmental variables in the production function significantly changed the results: the estimated mean technical efficiencies increase from 36% to 0.76%.

Binam et al. (2004) examined factors influencing technical efficiency of groundnut and maize farmers in Cameroon. They used a Cobb–Douglas production function to find mean technical efficiencies to be in the range of 73% and 77%. They also concluded that access to credit, social capital, and distance from the road and extension services were important factors explaining the variations in technical efficiencies.

Kalirajan and Shand (1985) argued that although schooling was a productive factor, farmers’ education was not necessarily related significantly to their yield achievement. Illiterate farmers,
without the training to read and write, could understand a modern production technology as well as their educated counterparts, provided the technology is communicated properly. Using Tamil Nadu maize farmers as a case study, Kalirajan and Shand (1985) conducted a quantitative analysis of various types of education in relation to productivity in order to determine whether schooling of farmers had a greater influence on yield than non-formal education (defined as a farmer’s understanding of the technology). The findings revealed that schooling (education) of farmers had an independent effect on yield, but it was not significant. On the other hand, a farmer’s non-formal education was found to have a significant and greater influence on yield. Kalirajan and Shand concluded that farmers’ schooling and productive capacity need not be significantly related under all circumstances.

The impact of agricultural extension on farm production has received considerable attention in the farm efficiency literature. Agricultural extension represents a mechanism by which information on new technologies, better farming practices and better management can be transmitted to farmers. Kalirajan (1981b) explained that extension workers’ limited contact with the farmers and farmers’ misunderstandings of the technology were responsible for the difference between the actual and maximum yields among the farmers. The researcher stressed the need for policy makers in a South Indian state to focus on extension work in order to increase maize production and reduce inefficiency.

2.5 Factors Influencing Technical Efficiency

In efficiency analysis, identification of the implications of different policies on the level of efficiency is not enough but identification of the factors that influence it. Many studies measured technical efficiency and its determinants among farmers. However, efficiency in those studies is relative and tends to be specific to the farmers groups and country under study. Many studies have attempted to investigate the relationship between technical efficiency and socio economic such as: level of education, age, family size, access to credit experience, and extension services. (Chavas et al, 2005, Kibaara, 2005, Chiona, 2011). However, technical efficiency is influenced by many factors like: training, experience and motivation (Chavas et al.,
2005) others such as: membership to agricultural club, land ownership, use of input.
CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter highlights the key aspects of the research methodology for this study. It covers the study area, sampling design, research instruments and data analysis. Importantly, the chapter identifies and justifies the study area selected as well as tools used in the research and analysis.

3.1 The Study Area

The present study was conducted in Musanze and Bugesera Districts (Figure 3). Musanze district is situated in the Northern Province of Rwanda with 512.5 square kilometers. The population of Musanze District is estimated at 368,000 persons while 99 percent live in rural areas (District report, 2007). Bugesera district is situated in the Eastern Province of Rwanda with 1,334 square kilometers. The population of Bugesera district is estimated at 274,113 persons while 99 percent live in rural areas (District report, 2006). Agriculture is the main activity in the two districts dominated by maize. Both Musanze and Bugesera are the major maize growing districts of Rwanda with more than 8,241 ha of land under maize cultivation. Mean maximum temperature is 15°C for Musanze and 18°C for Bugesera and the mean minimum temperature ranges between 10 to 16°C respectively. The climate is conducive to rich and varied agricultural production where agro-ecological situations are very diverse and include rich soils derived from the volcanic chain.
Figure 2: Map of Rwanda highlighting the study area

Source: Minaloc, 2011
3.2 Sampling Method

Smallholder farmers involved in maize farming in each district were the target population of the study. To get the sample size, \( n \), an estimated proportion of the population, \( p \) is needed. The following formula by Edriss, (2003) was used to compute the sample size:

\[
n = \frac{z^2(1 - p)p}{e^2}
\]

Where \( n \) is the sample size in each district, \( z \) is the desired Z-value yielding the desired degree of confidence, \( p \) is an estimate of the population proportion, and \( e \) is the absolute size of the error in estimating \( p \) that the researcher is willing to permit. In this study a p-value of 0.1 was used. Since almost 90% of smallholder farmers in every district of the study area produce maize. The study used 95 percent level of confidence (\( Z = 1.96 \) for a two tailed test), with an allowable error of 0.05. The sample in one district was calculated as shown in the equation below;

\[
n = \frac{1.96^2(1 - 0.1)0.1}{0.05^2} = 138
\]

This means that the primary data of this study was collected using questionnaires from 276 farmers growing maize selected randomly.

3.3 Data Collection

This research used both primary and secondary data. Primary data gathered from farmers through face-to-face interviews using multi-stage and pre-tested questionnaires. A multi-stage survey was used to gather primary quantitative data of selected households through a household survey. Secondary data was obtained from the internet, published books and journals, and records of Ministry of Agriculture, Rwanda. Data was collected on socio-demographic factors such as age, gender, education level, credit access, land size, family size, experience, participation in extension services, membership to farmers Associations/Cooperatives societies and number of livestock in the farm area.
3.4. Analytical framework

3.4.1. Estimation of the stochastic frontier model

According to Batesse and Coelli (1995), the first researchers analysing TE and its determinants used a two-stage approach. The first stage involves the specification and the estimation of the stochastic frontier production function with the assumption that the inefficiency effects are identically distributed. The second stage of this approach concerns the specification of a regression model for the inefficiency effects. However, this approach has been subject to the criticism that it contradicts the assumption of identically distributed inefficiency effects in the stochastic frontier and Wang and Schmidt (2002) identified the results biasness related to this two-step analysis.

Recently, a one-stage approach has been proposed by various researchers including Batesse and Coelli (1995) and Belotti et al. (2012) who specifically created command syntax for the simultaneous estimation of both the stochastic and the inefficiency models parameters in Stata package. In this model, the parameters of the stochastic frontier and the inefficiency function are estimated simultaneously through the maximum likelihood estimation (MLE) method. It is noted that the one stage model by Batesse and Coelli (1995) though initially proposed for panel data, its variant has been used in cross sectional data by numerous authors such as Ezeh, et al., (2012), Rahman, et al., (2012) and Tijani (2006). In the present study, same simultaneous analysis approach was used.

3.5 Model Specification

To achieve both second and third objective which were to assess the determinants of maize production among the inputs used and to determine the technical efficiency levels the Cobb-Douglas function was used due to its simplicity and ease of estimation and interpretation.
A Cobb-Douglas production function was specified as:

Where:

\[ \ln Y_i = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + V_i - U_i \]

- \( Y_i \): maize output (T/ha)
- \( \beta_0 \): lnInefficiency effect
- \( X_1 \): total area grown to maize (ha)
- \( X_2 \): amount of labour (man days)
- \( X_3 \): total fertilizer used (kg)
- \( X_4 \): total Seed used (kg)
- \( V_i \): random error related to non-included factors
- \( U_i \): random error term of measurement

The data on socio economic effect which was the last objective of this study was analyzed using Stata to obtain the maximum likelihood estimates of parameters order to estimate the technical inefficiency effects. The specification model was as follows:

\[ | \mu_i | = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \epsilon \]

Where

- \( \mu_i \): Inefficiency
- \( \alpha_0 \): Intercept term
- \( Z_1 \): Education level of household head
- \( Z_2 \): Experience (years)
- \( Z_3 \): Access to credit (Dummy: 1= YES, 2= No)
- \( Z_4 \): Age of farmer (years)
- \( Z_5 \): Household Size (numbers)
- \( Z_6 \): Number of visits by an extension agent
- \( Z_7 \): sex of household head (Dummy 1=Male, 2 =Female)
- \( Z_8 \): Type of seed used (Dummy: improved=1 local =2)
- \( \epsilon \): Random error
3.6. Data analysis

The collected data was first entered and cleaned in Microsoft Access. For the Maximum Likelihood Estimation (MLE), data was imported and analysed using Stata 11. The unknown parameters of the stochastic frontier production and the inefficiency effects were estimated simultaneously. From the estimation of the stochastic frontier production function, the effects of the production inputs on maize output were obtained and statistical tests at this level revealed the significant determinants. The fourth objective was achieved by the estimation of the inefficiency model while for the third objective; the levels of TE were predicted after the estimation of the two models.

3.7. Tests for appropriateness of the econometric model

As stressed by Maddala (1992), it is not reasonable to assume that a model specified at the very outset is the best for a particular estimation. Actually in most of econometric studies, the model choice is definitely made after preliminary analyses. As the Cobb-Douglas (C-D) and the transcendental logarithmic (translog) production functions are the commonly used in stochastic frontier analysis (SFA), the following section describes the tests which have been performed to confirm an appropriate model for the present study.

3.7.1. Test for omitted variables

The first test was done to check for omitted variables. This study used the test of Ramsey also called Regression Specification Error Test (RESET) proposed by Ramsey (1969) for checking whether no relevant explanatory variable has been omitted in the models. The test is based on the F-distribution and the null hypothesis to be tested was: Ho: model has no omitted
variables. The results from the regression of the paddy rice produced on the considered inputs namely land, labor, fertilizer, seeds and pesticides gave a value of \( F = 2.2 \) and \( F=1.28 \) respectively for the C-D and the Translog. This value being less than the \( F_{\text{table}} \) at 95% of confidence interval, the null hypothesis that no relevant variable was omitted in each model has been accepted.

3.7.2. Test for heteroskedasticity and multicollinearity

Heteroscedasticity is a situation in which the assumption of equal variance of residuals in the classical linear regression model is violated. In this situation, the estimators are unbiased but inefficient and the estimates of the variances are biased, leading to invalid tests of significance results (Maddala, 1992). There exist several tests for heteroscedasticity detection among others the Koeker Basset, the PBPG, the White’s and the Breusch-Pagan tests as listed by Gujarati (2004). This study used the Breusch-Pagan under which the null hypothesis is \( H_0: E(U_i^2) = \sigma^2 \) with \( i=1,2,\ldots,n \), \( n= \) number of observation.

As shown in Table 4, the results from this test gave a Chi square test \( (\chi^2) \) values which are equal to 0.45 and 2.04 in the C-D model and Translog model respectively. As the \( \chi^2 \) table is 12.592 (i.e more than the calculated value), the null hypothesis of equal variance was accepted concluding that there is homoscedasticity in both models.

A test for the presence of multicollinearity in the models has been also performed using the Variance Inflation Factor (VIF). Multicollinearity is a situation where the independent variables are highly inter-correlated. The VIF calculated for each model showed that a mean of 1.76 for C-D model and 319.44 for the Translog. The latter VIF value shows a presence of high multicollinearity in the Translog model because, as the value of VIF is much more superior to 20.

The problem of multicollinearity being not a sufficient factor for the Translog model to be dropped, a Likelihood Ratio (LR) test was done to select between the two models and as reported in Table 4 based on the calculated chi2 value of 19.64, the hypothesis that C-D model is the
appropriate for this study was accepted. Hence, the C-D model was confirmed for the following step of stochastic frontier analysis.

**Table 1: Summary of model specification test**

<table>
<thead>
<tr>
<th>Variable</th>
<th>C-D model</th>
<th>Translog Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y: Production, Xs: Land, Pesticide, Fertilizer, Labor and Seed</td>
<td></td>
<td>Y: Production, Xs: land, pesticide, fertilizer, labor, seed, land<em>pesticide, land</em>fertilizer, land<em>lab, land</em>seed, Pesticide<em>Fertilizer, Pesticide</em>labor, Pesticide<em>seed, Fertilizer</em>labor, Fertilizer<em>seed, labor</em>seed, Land^2, Pesticide^2, Fertilizer^2, Labor^2, Seed^2</td>
</tr>
</tbody>
</table>

**Model test results**

- Ramsey: 2.20 - Ramsey: 1.28
- Breusch-Pagan: \( \chi^2 = 0.45 \) - Breusch-Pagan: \( \chi^2 = 2.04 \)
- Mean VIF: 1.76 - Mean VIF: 319.44

**Conclusion**

- No missing variable,
- No heteroscedasticity,
- No multicollinearity
- No missing variable,
- No heteroscedasticity,
- High multicollinearity

**Comparison**

Likelihood Ratio Test: LR=19.64, \( \chi^2(15, Z_{0.05})=25 \)
CHAPTER FOUR: RESULTS

4.0 Introduction
The chapter reports the results from data analysis. Descriptive and inferential statistics were used in the analysis. Descriptive statistics results for the production, socioeconomic and institutional characteristics, technical efficiency and management practices scores are presented in this chapter. Further, validation tests, stochastic frontier production functions and inefficiency models results are also presented.

4.2. Characteristics of smallholder maize farmers’

4.2.1. Maize farmers’ characteristics

4.2.1.1. Gender and marital status among respondents
Table 4.1 gives the number of sampled farmers by gender and marital status from the study area. In this study sample, 53.26% were male while 46.74% were female and 97.1% of total number of respondents was married. Generally in Rwanda, women are more involved in marketing of agricultural production at the proportion of 60% of the total retailers than in farming where only 45% are the female (MINAGRI, 2011). Specifically in the study area, the total maize farmers are comprised of 65% of men and 35% of women. The findings therefore confirm the worldwide situation whereby women are significantly involved in maize farming activities only as casual labor but not as land owners given their limited access to agricultural resources (Huvio, 1998; Fonjong & Mbah, 2007).
Table 4.1: Distribution of respondents by gender and marital status

<table>
<thead>
<tr>
<th></th>
<th>Number of respondents</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>147</td>
<td>53.26%</td>
</tr>
<tr>
<td>Female</td>
<td>129</td>
<td>46.74%</td>
</tr>
<tr>
<td>Total</td>
<td>276</td>
<td>100%</td>
</tr>
<tr>
<td><strong>marital status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>268</td>
<td>97.1%</td>
</tr>
<tr>
<td>single</td>
<td>5</td>
<td>1.81%</td>
</tr>
<tr>
<td>Separated</td>
<td>3</td>
<td>1.09%</td>
</tr>
<tr>
<td>Total</td>
<td>276</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Computed by author based on Smallholder Farmer Survey, 2011

4.2.1.2 Age and household size of respondents

The mean age in the study sample was found to be 40.5 and the number of persons per household was 6 as given in Table 4.2. The respondents were majorly young and therefore expected to be highly productive as young farmers are more likely to adopt new agricultural technologies and innovations for improved outputs (Feder and Umali, 1993).

Table 4.2: Mean age and household size

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>276</td>
<td>40.5</td>
<td>9.7</td>
<td>17</td>
<td>56</td>
</tr>
<tr>
<td>Household size</td>
<td>276</td>
<td>6</td>
<td>2.16</td>
<td>1</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: Computed by author based on Smallholder Farmer Survey, 2011

And according to the above results the average household size was six members. The smallest household had one member while the largest had 15 members.
4.2.1.3. Education level, extension contact, type seed and farming experience.

According to Ministry of Education (2002), Education and trainings are considered as critical elements to sustainable development and poverty reduction in Rwanda but the results presented in table 4.3 showed that the higher percentage of maize farmers never went to school, 89.5% while 1.8% of respondents did not finished primary school, 2.5% of respondents finished primary school, 2.2 % of respondents did Professional school, 2.2 % of respondents did not finished Secondary school, finally 1.8% of respondents finished secondary school. This is due to its agricultural development and the country that did not synthesize people’s education many years back.

Despite that the majority of the respondents have been involved in maize farming more than ten years only 22% receive extension services at least once a month and 78% never received extension services. The same results showed, that In Rwanda, small scale farmer’s maize growers’ face a problem of quality seed where the majority73.91% of farmers used local seed.
### Table 4.3: Education level, extension contact, type seed and farming experience.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories</th>
<th>Frequencies</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Seed</td>
<td>Local</td>
<td>204</td>
<td>73.91</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>72</td>
<td>26.09</td>
</tr>
<tr>
<td>Extension contact</td>
<td>Once a month</td>
<td>61</td>
<td>22.10</td>
</tr>
<tr>
<td></td>
<td>Not at all</td>
<td>215</td>
<td>77.90</td>
</tr>
<tr>
<td>Experience</td>
<td>One year</td>
<td>5</td>
<td>1.81</td>
</tr>
<tr>
<td></td>
<td>Five years</td>
<td>48</td>
<td>17.39</td>
</tr>
<tr>
<td></td>
<td>ten Years</td>
<td>55</td>
<td>19.93</td>
</tr>
<tr>
<td></td>
<td>More ten years</td>
<td>168</td>
<td>60.87</td>
</tr>
<tr>
<td>Education level</td>
<td>Never went to school</td>
<td>247</td>
<td>89.49</td>
</tr>
<tr>
<td></td>
<td>Not finished primary school</td>
<td>5</td>
<td>1.81</td>
</tr>
<tr>
<td></td>
<td>Finished primary school</td>
<td>7</td>
<td>2.54</td>
</tr>
<tr>
<td></td>
<td>Professional school</td>
<td>6</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td>Not finished Secondary school</td>
<td>6</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td>Finished secondary school</td>
<td>5</td>
<td>1.81</td>
</tr>
</tbody>
</table>

*Source: Computed by author based on Smallholder Farmer Survey, 2011*

#### 4.2.1.4 Labor and other key production inputs

In this study, the key production inputs considered were human labour, seed, fertilizer. Table shows the findings on each of these production factors and on average, respondents from study area used greater amount of the considered inputs per hectare.
Table 4.4: Labor and other key production inputs

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed (kilograms /ha)</td>
<td>17</td>
<td>95</td>
<td>47.98</td>
</tr>
<tr>
<td>Fertilizer (kg/ha)</td>
<td>0</td>
<td>90</td>
<td>28.13</td>
</tr>
<tr>
<td>Labor number of family labour and hired labor per hectare (man days)</td>
<td>2</td>
<td>273</td>
<td>39.86</td>
</tr>
<tr>
<td>Yield (T/ha)</td>
<td>1.2</td>
<td>6.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Source: Computed by author based on Smallholder Farmer Survey, 2011

In this study an average yield of 2.8 t per ha of maize was recorded in the study area. This was realized by using on average 47.98 kg of seeds and 28.13 kg of fertilizers per hectare of land with an average of 39.86 man days of labour.

4.3. Empirical results from the stochastic frontier analysis

This section present the results obtained from the econometric analysis of the stochastic production frontier of the Cobb-Douglas functional form. It firstly, shows the results from estimation of the production frontier function with an emphasis on the significant parameters and their partial or marginal effects on maize output. In the second part, the results from TE prediction are given while the factors affecting TE are given in the last sub-section.

4.3.1. Parameters estimation of the production factors

In determining the factors which influence maize production among the sampled farmers in study area the stochastic frontier production function results were used and were reported on Table 4.5. The land size under maize cultivation was significantly affecting maize output at 5% level. Its estimated coefficient was 1.16 meaning that 1% increase in land area would lead to
1.16 \% increase of yield. Results also showed that results of the input elasticities for each input in the Cobb-Douglas production function. A one percent increase in the quantity of organic fertilizer applied increase maize output by 0.13\% and a one percent increase in the quantity of inorganic fertilizer applied increase maize output by 0.23\%. In addition, a one percent increase in improved seed rate increased output by 0.86\%. On the other hand, a one percent increase in labor will probably increase maize yield by one percent.

The value of lamda (\lambda) and gamma (\gamma) were different to zero and equalled to 1.17 and 0.56 respectively which showed the presence of technical inefficiency in Musanze and Bugesera. The value 50.67 which is a likelihood ratio (LR) test of chi-squared distribution was significant at 1\% level proving the existence of the inefficiency effects. The value of Log likelihood and the significant Wald value showed that the specified model fits stochastic frontier estimation.
Table 4.5: stochastic frontier production function results

| Variables                | Coeff | S.E  | P>|z|  |
|--------------------------|-------|------|------|
| Constant                 | 0.35  | 0.35 | 0.00 |
| Organic fertilizer (kg)  | 0.13**| 0.19 | 0.001|
| Inorganic fertilizer     | 0.23**| 0.08 | 0.013|
| Improved seed (kg)       | 0.86**| 0.16 | 0.004|
| Local seed (kg)          | 0.02  | 0.08 | 0.184|
| labor (man-days/ha)      | 0.27**| 0.12 | 0.001|
| land (ha)                | 1.16**| 0.17 | 0.002|
| Insig2v                  | 2.65  | 0.34 | 7.701|
| /Insig2u                 | 1.77  | 0.38 | 8.625|

**Diagnostic test**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>sigma_v</td>
<td>0.34</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>sigma_u</td>
<td>0.40</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>sigma2</td>
<td>0.27</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>lambda</td>
<td>1.17</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>gamma (γ)</td>
<td>0.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>50.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wald chi-square</td>
<td>197**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chibar^2(0)</td>
<td>24.4**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prob&gt; chi^2=0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***significant at 1%; **significant at 5% and *significant at 10%.

*Source: Computed by author based on Smallholder Farmer Survey, 2011*
4.4. Technical efficiency levels among maize farmers

The results also indicated that nearly 11.59% of the farmers had over 51-75% technical efficiency. Majority of farmers 51.81% recorded a technical efficiency of 0-25% with the lowest portion followed 26.45 ranged between 26-.50 only 10.15% of the farmers had 76-100% TE The wide variation in technical efficiency estimates is an indication that most of the farmers are still using their resources inefficiently in the production process and there still exists opportunities for improving on their current level of technical efficiency.

Table 4. 6: Frequency Distribution of Technical Efficiency Estimates.

<table>
<thead>
<tr>
<th>Technical efficiency Range (%)</th>
<th>Freq.</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>143</td>
<td>51.81</td>
</tr>
<tr>
<td>26-50</td>
<td>73</td>
<td>26.45</td>
</tr>
<tr>
<td>51-75</td>
<td>32</td>
<td>11.59</td>
</tr>
<tr>
<td>76-100</td>
<td>28</td>
<td>10.15</td>
</tr>
<tr>
<td>Total</td>
<td>276</td>
<td>100</td>
</tr>
<tr>
<td>Mean TE</td>
<td></td>
<td>23%</td>
</tr>
<tr>
<td>Minimum TE</td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>Maximum TE</td>
<td></td>
<td>79%</td>
</tr>
</tbody>
</table>

Source: Computed by author based on Smallholder Farmer Survey, 2011
4.4. Inefficiency results from the model

In the assessment of factors affecting TE, the variables age of farmer, household size, education level of the farmer, farming experience, use of credit in and the number of visits by an extension agent to farmers were considered and regressed to the error term (u) representing the technical inefficiency. Thus, the results in the Table show the relationship between those factors and technical inefficiency.

Table 4.7: Inefficiency Effects Model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Stand Error</th>
<th>Z</th>
<th>P&gt;z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.76</td>
<td>1.32</td>
<td>0.91</td>
<td>0.98</td>
</tr>
<tr>
<td>years of Education for the farmer</td>
<td>-0.24**</td>
<td>0.018</td>
<td>13.00</td>
<td>0.13</td>
</tr>
<tr>
<td>Experience (Number of years of experience in farming)</td>
<td>0.037</td>
<td>0.021</td>
<td>0.53</td>
<td>0.599</td>
</tr>
<tr>
<td>Use of Credit (amount)</td>
<td>-0.08**</td>
<td>0.049</td>
<td>1.71</td>
<td>0.028</td>
</tr>
<tr>
<td>Family size (numbers)</td>
<td>0.006</td>
<td>0.004</td>
<td>1.41</td>
<td>0.158</td>
</tr>
<tr>
<td>Number of extension services visit</td>
<td>-0.124**</td>
<td>0.0134</td>
<td>2.29</td>
<td>0.026</td>
</tr>
<tr>
<td>Age (years)</td>
<td>-0.042**</td>
<td>0.008</td>
<td>5.38</td>
<td>0.000</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>21.84</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** and * means statistically significant at 1% and 5% a significance level

Source: Computed by author based on Smallholder Farmer Survey, 2011
The results presented in Table 5 reveal that, the number of years in school, access to credit, age and extension service contact reduce technical inefficiency or increase technical efficiency. The negative sign on the years of school indicates that an increase in the number of school years decreases technical inefficiency which means that as years of school increases technical efficiency; this relationship is significant at both 1% and 5% level. However, the quadratic structure of age is positive implying that farm technical efficiency increases with an increase in the number of school years of the farmers.

The role of education enables farmers to understand the socioeconomic conditions governing their farming activities and to learn how to collect, retrieve, analyse and disseminate information. Moreover, with higher levels of education, farmers are able to organize themselves into farmer groups or associations, thereby enabling them to source funding from lending institutions, especially from non-government organizations (NGOs) engaged in micro credit delivery. Education also enhances farmers’ understanding of extension recommendations:
CHAPTER FIVE: DISCUSSION

5.0 Introduction

This chapter covers the interpretation of the results of the study. The results of the study are discussed from individual Counties context and in general. The chapter also looks at the findings in view of what has been reported in literature with the aim of trying to assess the underlying factors that possibly explain the observed trends and outcomes. In the chapter existing gaps are identified and sets a basis for recommending the necessary policies to address the identified gaps.

5.1 Determinants of maize production and hypotheses testing

The first hypothesis corresponds to the second objective that aimed at identifying the determinants of maize production in the study area. For this study the considered inputs used maize production in was: seed quantity, fertiliser, land size and labor. Moreover, the study hypothesized that all of those factors were significant in the production of maize. Results in Table 3 confirm this hypothesis.

From those results, the land size was revealed to be the most important inputs in the production of maize for both studied schemes. Based on the signs of coefficients, the input was found positive and significant at both 1% and 5% level in the study area. These findings also revealed that farmers are currently operating below the optimal land scale in maize production as the increase in area under maize would lead to higher output quantity and farmers would thus benefit more from maize production by increasing land size under the crop.

The results on the relationship between land size and maize production in this study were consistent with the findings by Tijani (2006) in his analysis of technical efficiency of maize farms in Osun-Nigeria,( Khan et al. 2010) on maize farming in Bangladesh, and Baruwa and Oke (2012) in their study on cocoa yam in Nigeria. On the other hand, these results were in contradiction with the findings by Chirwa (2003) which revealed that land size had negative
influence on maize yields in Malawi. In the latter study, negative effect was explained by operating beyond the optimal land scale where the production was being done on larger lands than what farmer could manage. Thus in Rwanda, the size of maize farms is still manageable and the area expansion would contribute in increasing the production. However, this expansion should be done carefully as some studies have found that land size may inversely increase with TE (Anyaegbunam et al. 2012; Masterson, 2007). Moreover, the country’s reality about the arable land scarcity should not be ignored. Thus, supporting measures like using improved technologies should rather be considered instead of relying on land size.

Besides on land size other factors such as fertiliser, the amount of seed and the labour used in maize farming activities were found significant to maize production in the study area (Table 3). Thus if the findings showed that all inputs were significant at both 1% and 5% levels (see table 3). The study accept the first hypothesis. The conclusion was that all the inputs used in the production significantly determine the maize output in the study areas.

5.2 Hypotheses testing

This study had two hypotheses to be statistically tested. The first one was about the absence of inefficiency effects in the studied maize production area while the second specified the absence of joint effect of the considered socio-demographic, economic and institutional factors on the inefficiency component.

According to Coelli et al. (2005) for the half-normal and the exponential models, the null hypothesis about the absence of inefficiency effects involves one parameter often noted as sigma ($\sigma_\mu$). The parameter represent the variance related to the inefficient effects in the stochastic frontier model. As the variance inefficiency effects is concerned, Batesse and Coelli (1995) specified another parameter gamma ($\gamma$) which is associated to the two error terms of the stochastic frontier functions. The parameter $\gamma$ measures the output deviation from the frontier caused by inefficiency effects and it equals to $\sigma_\mu^2/ (\sigma_v^2 + \sigma_\mu^2)$ where $\sigma_v^2$ and $\sigma_\mu^2$ respectively standing for the variances related to inefficiency and statistical noise. In this study, $\gamma$ values were found different to zero being 0.56. The values thus indicated that 56% of the variations in the
composite error terms was caused by inefficiency effects. The first hypothesis testing was conducted to check if these effects were statistically significant. Findings in Table 4.8 showed that the calculated chi-squared values ($\chi^2$) for the estimated model exceeded the critical values from the statistical table which lead to the rejection of the first null hypothesis. Hence, there is inefficiency effects in maize production in both studied schemes and the farmers have not yet attained the production frontier.

Table 4.8: Tests of hypotheses in the estimated models

<table>
<thead>
<tr>
<th>hypotheses</th>
<th>Null hypotheses</th>
<th>Log-likelihood</th>
<th>chi-square statistic</th>
<th>Critical value($\alpha=0.05$)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis 1</td>
<td>$\gamma = 0$</td>
<td>50.67</td>
<td>24.4</td>
<td>$\chi^2_{(1)}=2.71$•</td>
<td>Rejected</td>
</tr>
<tr>
<td>Hypothesis 2</td>
<td>$\gamma = 0$</td>
<td>21.84</td>
<td>16.19</td>
<td>$\chi^2_{(1)}=15.507$</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

•: The chibar-squared values calculated for the test of $\gamma$ (Table) follow chi-squared distribution and the values are taken from Kodde and Palm (1986).

The second hypothesis stated that there is not joint effect of age, household size, maize farming experience, education level, use of credit in maize farming, maize training and visit of extension agent was not significant. The results in Table 4.8 showed that this hypothesis was rejected based on the value of chi-statistics which exceeded the critical values. This lead to the conclusion that the joint effect of the seven variables is significant though some individual influence may not be statistically significant.

According to Coelli et al.(2005) for the half-normal and the exponential models, the null hypothesis about the absence of inefficiency effects involves one parameter often noted as sigma ($\sigma_u$). The parameter represent the variance related to the inefficient effects in the stochastic frontier model. As the variance inefficiency effects is concerned, Bateesse and Coelli (1995) specified another parameter gamma ($\gamma$) which is associated to the two error terms of the
stochastic frontier functions. The parameter $\gamma$ measures the output deviation from the frontier caused by inefficiency effects and it equals to $\sigma^2_\mu / (\sigma^2_v + \sigma^2_\mu)$ where $\sigma^2_\mu$ and $\sigma^2_v$ respectively standing for the variances related to inefficiency and statistical noise. In this study, $\gamma$ values were found different to zero being respectively 0.56 for the study area. The value of lamda was different to zero revealing the existence of inefficiencies and significant gamma value of 0.56 showed that 56% of the observed deviation of maize output from the frontier was a consequence of inefficiency.

5.3. Technical efficiency levels

According to Coelli et al. (2005), for the half-normal and the exponential models, the null hypothesis about the absence of inefficiency effects involves one parameter often noted as sigma ($\sigma_\mu$). The parameter represents the variance related to the inefficient effects in the stochastic frontier model. As the variance of the inefficiency effects is concerned, Bateesse and Coelli (1995) specified another parameter gamma ($\gamma$) which is associated to the two error terms of the stochastic frontier functions. The parameter $\gamma$ measures the output deviation from the frontier caused by inefficiency effects and it equals to $\sigma^2_\mu / (\sigma^2_v + \sigma^2_\mu)$ where $\sigma^2_\mu$ and $\sigma^2_v$ are respectively standing for the variances related to inefficiency and statistical noise. In this study, $\gamma$ value was found different to zero being respectively 0.40 and this values thus indicated that 40% of the variations in output was caused by inefficiency effects. The second hypothesis testing was conducted to check if these effects were statistically significant. Findings in Table 5 showed that the calculated chibar-squared values ($\chi_{\text{bar}}^2$) for the estimated models exceeded the critical values from the statistical table. This led to the rejection of the second hypothesis. Hence, there are significant inefficiency effects in maize production in Musanze and Bugesera and the farmers have not yet attained the production frontier.

Table 3 showed the TE mean of 23% this indicated that an average farmer was operating at 23% below the frontier production due to inefficiency effects. This also complemented the results.
from the hypothesis testing showing that on average, the frontier production is not yet attained due to significant inefficiency effects. This could be attributed to misuse and/or wastage of inputs. Those results are similar to those reported by Sibiko (2012) and Nyagaka et al. (2010). Alternatively, the average farmer should produce the same amount by reducing the inputs.

5.4. Factors influencing technical efficiency

The results in Table 4.8 showed that this hypothesis was rejected based on the value of $\chi^2$ statistics which exceeded the critical values. This led to the conclusion that the joint effect of the seven variables is significant though some individual influence may not be statistically significant.

The analysis of socio-economic factors effects on TE, several of them were found significant. For instance age, the number of years in school, access to credit and extension service contact reduce technical inefficiency or increase technical efficiency. This implied that age had a negative influence on TE; an increase of age by 1% would lead to 0.042% increase in inefficiency effects. This also indicated that the older a farmer was, the lower the technical efficiency in maize production and the lower the productivity.

The negative sign on the years of school indicates that an increase in the number of school years increases technical efficiency; this relationship is significant at both 1% and 5% level. This finding is related to those reported by Awudu, et al., (2001) in their study on technical efficiency during economic reform in Nicaragua found that education increases production efficiency). A study by Seyoum, et al., (2000) on technical efficiency and productivity of maize producers in Eastern Ethiopia concluded that farmers more educated adopt rapidly the new technology and produces closer to the frontier output.

In the inefficiency model, various researchers discussed that the variable age may take either a negative or a positive sign (Wang, 2002; Villano and Fleming, 2004). Age may take a
negative sign when older farmers are willing to adopt better techniques reducing inefficiency effects or when the knowledge and the experience acquired over their farming years contribute in increasing efficiency. It may also take a positive sign like in this study, indirectly indicating that older farmers resist to the adoption of new technologies or/and they do not have physical and mental capacity to efficiently participate in farming activity. This could be the case for maize farmers in Rwanda as long as the positive effect of labour in production has been found significant.

In this study education level was found to have a negative but significant effect on technical inefficiency implying that it has positive relationship with technical efficiency. This meant that the more farmers are educated on the appropriate methods of farming as well as resource use the higher the level of technical efficiency. Maize related trainings or education level of farmers to farmers could allow them to access innovative and up to date production techniques. It could also increase pioneer spirit in agricultural technology adoption, thus better decision making in production process. The findings on education level are similar to those about the extension agent’s visits which revealed a negative and significant relationship between number of visits and technical inefficiency among maize farmers in Rwanda. This indicated positive relationship between extension contact times and technical efficiency. This implied that the visits of the extension officers to maize farmers contribute to TE in maize production. The positive relationship between technical efficiency and extension contacts frequency could be attributed to knowledge and information that maize farmers receive which is complementary to the trainings.

Regarding the access to extension services, the findings of this study were consistent with those of Simonyan et al. (2011) in their study on gender differentials in technical efficiency among maize farmers in Nigeria. Nchare (2007) and Muhammad-Lawal et al. (2009) found the same relationship respectively in their studies on Arabica coffee production in Cameroon and technical efficiency of youth participation in agriculture. In contrast, Tijani (2006) and Ezeh et al. (2012) found out that extension contact had an unexpected negative relationship with TE and they recommended further investigations on the issue.

Finally, results showed that the gender was negatively affecting technical inefficiency then
contributing to TE though not significantly. Maize farming experience and family size were found positive but insignificantly affecting technical inefficiency.
CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

The chapter presents the conclusion and recommendations for the study. The conclusions are based on the study findings for each objective. Recommendations are made based on the gaps identified and weaknesses established in resource use and management on purple passion fruit orchards. Conclusions and recommendations are targeted towards the policy makers, farmers, public and private sectors.

6.1 Conclusion

The study found that despite the long history of government investment in the agriculture sector through extension services and promotion of technology, smallholder maize farming remains uneconomic and technically inefficient. TE of maize farmers varied due to many factors that change technical efficiency which lead to a decrease of maize production. Thus there is a great chance for farmers to increase their level of efficiency in maize production.

As the number of years in school, squared number of years in school, access to credit, age, squared age, extension service contact and squared experience of operators were significant variables greatly influencing TE of maize growers. Therefore, agricultural policy makers need to look for alternative means of strengthening the socio and economic basis of maize producers in order to address resources constraints and low productivity in maize production in the study area.

Finally, since an increase in age would lead to a decrease of efficiency levels in maize production, these results call for policies aimed at encouraging the youths who are agile and stronger to grow maize and those policies would make the youths to return to the land and take
up maize farming would yield positive dividends economy in particular of the study area and Rwanda in general.

Above discussed results indicate: First, there is need to promote government policy of subsidizing inputs among smallholder maize farmers. Second, there is need to enhance that improvement in provision of agricultural credit to smallholders with extension services are likely to lead to improved smallholder technical efficiency.

Other policy implications drawn from the results include a review of agricultural policy with regard to renewed public support to revamp the agricultural extension system, which has been neglected since long time. For all these to take place, it is high time that agriculture sector receive due attention and input from the government so as to advance the country’s objectives of growth and poverty reduction.

The study set out to provide estimations of technical efficiency levels of maize producers in Rwanda and to explain why those variations technical efficiency among farmers in relationship with socio-economic variables.

6.2 Recommendations

Given that the results of the study showed that technical efficiency was significantly influenced by extension contact, access to credit, level of education, and age but also inputs (seeds, fertilizers, labour and land) then policies targeting these variables among others might have a positive impact on small scale maize production and productivity.
For government and other agencies:

1. To increase technical efficiency, the contact between extension officers and the farmers should be intensified. Therefore, policy makers should focus on pioneering effective institutional arrangements that would enhance extension access by farmers through
deployment of participatory methods such as lead-farmer model, use of group training approach; farmer-driven extension demand and or intensification in the use of the extensive mass media available in the regions that would supplement and complement the efforts of the few extension workers.

2 The positive influence of access to credit used on technical efficiency provides a basis for provision and use of credit. The high initial capital consumption and running costs by maize farmers can be provided through credit where farmers are unable to raise the required funds. Such funds include inputs costs. Therefore, credit access should be enhanced to increase use for those farmers and the government should probably influence borrowing rates on credit and loans for agricultural development because currently those rate are still high.

3 Based on the findings of this study emphasis on both formal and informal education would have a huge impact of attaining higher efficiency levels in maize production. However, since there are some farmers who have not acquired formal education and its impact is not immediate, therefore, provision of non-formal agricultural education could supplement or complement formal education. This can be done through regular training of farmers, farmer forums and on-farm practical demonstrations. The education should range from input access and use of inputs efficiently.

4 Most important findings of this study reveals that determinants of inefficiencies are the fragmented structure of farm land. Therefore a comprehensive land consolidation plan may help to increase maize production and hence improving efficiencies.

5 This study only evaluated the technical aspect of production efficiency of maize production. From the study, overuse and underuse of production factors was evident. Therefore, the study recommends an assessment of allocative efficiency of maize farmers in Rwanda. This would avail information on optimal levels of inputs use by farmers specifically on how to choose and employ the inputs in the maize production to the level where their marginal returns equals their factor maize.

For further research:
1. To identify the external factors that would indirectly affect maize production in Rwanda such as linkages to market and policy environment. The future research should analyse the maize value chain to shed the light on possible gaps in the whole process of maize production.
REFERENCES


Marek W., Marek C., Katarzyna B., Jan R., (2007), Milk production efficiency as dependent on the scale of production and cow management systems on dairy farms


Producers in Kenya: A Case of Nyandarua North District


APPENDIXES

Appendix 1: Data collection Questionnaire for maize producers

The purpose of this study is to evaluate the Technical efficiency of maize production in Musanze and Bugesera Districts. Please note that your responses will remain confidential.

A. HOUSEHOLD SURVEY QUESTIONNAIRE

<table>
<thead>
<tr>
<th>QUESTIONNAIRE</th>
<th>NUMBER</th>
<th>NAME OF ENUMERATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTOR ___________________________  FAMILY NAME OF RESPONDENT
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

73
VILLAGE (UMUDUGUDU)

DATE OF INTERVIEW: DAY_______ MONTH _______ ENTERED BY ___________________________ DAY

_________Month_______

DURATION OF INTERVIEW (MINUTES) ________________ MIN

B. CHARACTERISTICS HOUSEHOLD

B1A. Number of persons in the household __________________________________________________________
<table>
<thead>
<tr>
<th>Name of household</th>
<th>B2A. <strong>sex</strong></th>
<th>B3A. <strong>Age (years)</strong></th>
<th>B4A. <strong>Marital Status</strong></th>
<th>B5A. <strong>Education level</strong></th>
<th>B6A. <strong>Main activity for the household head:</strong></th>
<th>B7A. For how long have you been growing maize (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Male</td>
<td></td>
<td>Single=1</td>
<td>Never went to school=1</td>
<td>1=agriculture, 2=rearing, 3=commerce, 4=craftsman, 5=labor, 7=none,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Female</td>
<td></td>
<td>Married =2</td>
<td>Not finished primary school =2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Divorced/separated =3</td>
<td>Finished primary school =3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Professional school = 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not finished Secondary school =4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Finished secondary school=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not Finished university=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Finished university=7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>specify numbers that you spent in school).................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3. C. LAND

**CIA.** What is the total size of your farm?

- [ ] half of hectare = 1
- [ ] Hectare = 2
- [ ] More than hectare = 3
- [ ] Less than acre = 4

Specify how big is your land under maize cultivation.

---

**2. What are the main problems that you experience in Maize production?**

---

76
<table>
<thead>
<tr>
<th>C2B Is it your own land</th>
<th>C2C If is yes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is it inherited = 1</td>
</tr>
<tr>
<td></td>
<td>You Purchased it = 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C2D if NO</th>
<th></th>
<th>C2D if NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it your rented = 1</td>
<td>Is it your borrowed = 2</td>
<td>1 &amp; 2 = 3</td>
</tr>
</tbody>
</table>

4. D LABOUR USE IN MAIZE

D 1A. LABOUR USE IN MAIZE

<table>
<thead>
<tr>
<th>Activity</th>
<th>D1A. Land preparation</th>
<th>D1B. Planting</th>
<th>D1C. Weeding</th>
<th>D1D. Fertilizer/manure application</th>
<th>D1E. Harvesting</th>
<th>D1F. Transportation</th>
<th>D1G. others</th>
</tr>
</thead>
</table>

77
<table>
<thead>
<tr>
<th>Did use the Family labour</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes= 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No = 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many hours – days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many person-days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The maize person – day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The total labour cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### D 4.2 LABOUR USE IN CROPS OTHER THAN MAIZE

<table>
<thead>
<tr>
<th>Crop</th>
<th>D.2 A Maize of Land preparation</th>
<th>D.2 B Maize of Planting</th>
<th>D.2 C Maize of Weeding</th>
<th>D.2D Maize of Fertilizer application</th>
<th>D.2E Maize of Harvesting</th>
<th>D.2F Maize of Transportation</th>
<th>D.2 G Did use the Family labour</th>
<th>D.2 H How many hours – days</th>
<th>D.2 I The total labour cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Irish Potato</td>
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<td>2. Beans</td>
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<td>4. Others</td>
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</tbody>
</table>
5. E. Do you belong to any Association, Cooperative of maize production? Yes=1 No = 2
MEMBERSHIP TO FARMER AND COMMUNITY GROUPS OR COOPS IN THE LAST 2 YEARS

<table>
<thead>
<tr>
<th>Type of institutions (Association, Coop, Group or Local Admin)</th>
<th>Association or group functions (Codes B) Rank 3</th>
<th>Year joined</th>
<th>Entry fee</th>
<th>Annual subscription Fee</th>
<th>Role in the institution (codes C)</th>
<th>Still a member now (Codes D)</th>
<th>If not a member now then year stopped being member</th>
<th>Reason(s) stopping to be a member (codes E) Rank 3</th>
</tr>
</thead>
</table>
### 6. F. MAIZE PRODUCTION

<table>
<thead>
<tr>
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<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
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<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1A. What was the yield (in kilograms) from last 2 season’s crop?</td>
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<td>1. Season A</td>
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<td>2. Season B</td>
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<td><strong>Total</strong></td>
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</tbody>
</table>
### 7. Input Use in Maize

Did you use inputs (fertilizers, manure, pesticides, others) in your Maize last seasons? Yes/No………………

<table>
<thead>
<tr>
<th>Plot code (From Table 6.0; Column 1)</th>
<th>Manure (dry equivalent) A</th>
<th>Fertilizer</th>
<th>Seed</th>
<th>Field chemical</th>
<th>Hired oxen (p maize)</th>
<th>Total Labour (person-days/oxen-days)</th>
<th>Production (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bought</td>
<td>DAP</td>
<td>Other?</td>
<td>Bought</td>
<td>DAP</td>
<td>Other?</td>
<td>Bought</td>
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<td>1</td>
<td>Own (kg)</td>
<td>kg</td>
<td>Value (?)</td>
<td>Own (kg)</td>
<td>kg</td>
<td>Value (?)</td>
<td>Amount (kg)</td>
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</tbody>
</table>

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### 8. H. SEED USE IN Maize

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1A What variety(ies) of maize did you grow last season?</td>
<td>Improved =1, Local =2</td>
</tr>
<tr>
<td>H3A Which seed did you grow last year?</td>
<td></td>
</tr>
<tr>
<td>H4A How many kilograms of seed did you plant?</td>
<td>Improved =1, Local =2</td>
</tr>
<tr>
<td>H5A Did you apply fertilizers on the plot of maize last season?</td>
<td>Yes=1, No=2</td>
</tr>
<tr>
<td>H6A If Yes, how many?</td>
<td></td>
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</tbody>
</table>

| How many kilograms of seed did you plant?                               | Improved =1, Local =2         |
|                                                                           | Improved =1, Local =2         |

| Where did you get the seed that you planted from?                       | Own =1, Neighbor =2, Government assistance =3, other = 4 |
|                                                                           | Own =1, Neighbor =2, Government assistance =3, other = 4 |

| If Yes, how many?                                                       | Improved =1, Local =2         |
|                                                                           | Improved =1, Local =2         |
11. **K. ACCESS TO CREDIT**

K1A Do you access credit to enhance maize production? (1) Yes…… (0) No……

K2 A If yes, Please fill the table below:

<table>
<thead>
<tr>
<th>K2B Source of credit</th>
<th>K2C Amount</th>
<th>K2D Repayment period</th>
<th>K2C.Interest rate</th>
<th>K2D. Did the credit assist you to grow the maize?</th>
<th>K2E. How did you utilize it?</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

**K2F** If no, why not:
The banks and Micro finance institutions are far = 1
Access to credit require to grantee =2
The rate of interest rate is high=3
Other=4

**12. L. EXTENSION SERVICES**

<table>
<thead>
<tr>
<th>Question</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1A Do you receive extension office visit you about maize production</td>
<td>Yes = 1</td>
<td>No= 2</td>
<td></td>
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<tr>
<td>last season?</td>
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<tr>
<td>K2A If Yes , How many times in a month</td>
<td>1)Once a month</td>
<td>2) 3 times a month</td>
<td>3)Once in 6 months</td>
<td>4) Not at all</td>
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<tr>
<td>29. If visited, what message did they bring to you?</td>
<td>Message</td>
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</tbody>
</table>
**K4A.** If No, How do you acquire extension information?

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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</table>

THANK YOU FOR YOUR PATIENCE. BE BLESSED.