ADOPTION OF BEST AGRONOMIC PRACTICES, TECHNICAL EFFICIENCY AND PROFITABILITY OF SUGARCANE PRODUCTION AMONG SMALLHOLDERS IN MALAVA SUB-COUNTY OF KAKAMEGA COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

AE	Allocative Efficiency
AFA-SD	Agriculture and Food Authority-Sugar Directorate
BAP	Best Agronomic Practices
COMESA	Common Market for Eastern and Southern Africa
DEA	Data Envelopment Analysis
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistical Database
GDP	Gross Domestic Product
GM	Gross Margin
GR	Gross Revenue
KESREF	Kenya Sugar Research Foundation
KSB	Kenya Sugar Board
NACOSTI	National Commission for Science, Technology and Innovation
SFA	Stochastic Frontier Approach
TE	Technical Efficiency
UN	United Nations
VC	Variable Costs
VMP	Value of Marginal Product

DEFINITION OF TERMS

Allocative efficiency This refers to the ratio of total cost of producing a unit of output to cost of producing the same amount of output, while using optimal factor combinations in a technically efficient manner (Sihlongonyane, Masuku, & Belete, 2014). This study refers to allocative efficiency as a measure of farmers' ability to use inputs in the amounts that minimize the cost of production at given input prices while maintaining or increasing the amount of outputs.

Best agronomic practices This refers to the farming practices that farmers incorporate to improve soil quality, manage crops and improve environment (Jamoza *et al*., 2013). These are recommended practices by KESREF to improve the productivity of sugarcane production.

Contract farming Igweoscar (2014) defined contract farming as a covenant between farmers and buyers about the farming and the supply of agricultural products under pre-established conditions, and often at pre-determined costs. This study refer to contract farming as the arrangement between smallholder sugarcane farmers and sugar production factories for supply of sugarcane at a certain price.

Economic efficiency A measure of farmers' ability to yield a predetermined quantity of output at a least cost for certain level of technology. It is the product of allocative and technical efficiency (Thabethe & Mungatana, 2014).

Gross margin This refers to the difference between the value of sugarcane enterprise's gross output and variable costs.

Performance Refers to increase in profitability, technical and allocative efficiency of smallholder sugarcane production (Sihlongonyane *et al.*, 2014).

Productivity Refers to the ability of sugarcane production system to produce more economically and efficiently. It is the measure of efficiency in sugarcane production system that employs inputs used in production.

Profitability This refers to the gross margin of sugarcane production. It is the ability of the farm to generate income in excess of its expenses (Wawire & Ouma, 2013).

Smallholder Farmers with land holding of less than 10 acres (Thong *et al.,* 2014)**.**

Technical efficiency Sihlongonyane *et al.* (2014) defined Technical efficiency as the ability of a farm to produce a certain amount of output with a given minimum quantity of input under given technology. It is the measure of farmers' ability to produce maximum output from a given set of inputs.

ABSTRACT

Sugarcane crop (*Saccharum officinarum*) is one of the important industrial crops that are major employers and contributor to the Kenyan economy. Despite the importance attached to this subsector, sugarcane production is dismally performing in Kenya. In a bid to attain self-sufficiency in sugar production, Kenya has made remarkable efforts to develop the subsector. Despite efforts put up by the Government of Kenya and other stakeholders, sugarcane production still faces low productivity, comparing the expected potential yields and the actual yield. The objective of this study was to evaluate the effect of adoption of best agronomic practices, socioeconomic factors and factory contracted services on performance of sugarcane production in Malava Sub-county. Primary data were collected using structured questionnaires from a sample of 384 farmers through systematic random sampling and proportional sampling allocation technique. Descriptive statistics including mean, percentages and standard deviation were used to summarize socioeconomic factors, agronomic practices and factory contracted services which affect efficiency, production and profitability among smallholder sugarcane farmers. Cobb-Douglas production function was applied to analyze the effect of adoption of the best agronomic practices on production. The study applied stochastic frontier model to analyze technical efficiency and tobit regression model to explain the effect of socioeconomic factors on efficiency. One way ANOVA was applied to determine if there is a significant difference between profitability of contracted and non-contracted farmers. Gross margin was used as proxy for profitability where the effect of contracted services on gross margin among contract farmers was analyzed using multiple linear regression model. Use of improved seed-cane varieties, soil testing before planting, type of fertilizer used, harvesting at recommended time and recommended number of weeding per season were found to be positive and significantly affecting sugarcane production. The results showed that technical efficiency of sugarcane farmers ranges from almost zero to 0.9829, with mean value of 0.7069, implying that an average farmer could increase sugarcane productivity by 29.31% at the existing level of resources. Maximum likelihood estimate of technical efficiency depicted that use of fertilizer, labour, seed-cane and farm size are positive and significant at 1% level in determining technical efficiency. Tobit regression analysis showed that education, farming experience, family size, credit access and extension services were positive and significant in contributing to technical efficiency. However, age of the farmer, farm distance from home and contract engagement were negatively influencing technical efficiency. Moreover, the study showed that non-contracted farmers are more profitable than contracted farmers and that profitability between the two groups of farmers is statistically and significantly different. Multiple linear regression analysis showed that participation in contracted labour services, extension services and cash credit services have a significant effect on gross margin. Based on the results, the study recommends the need to increase awareness among smallholder farmers on soil testing to guide the type of fertilizer to apply and adoption of the recommended number of times to weed sugarcane farms in order to increase productivity. The Kenyan government should formulate policies to ensure provision of quality extension services, increased credit access and education among smallholder sugarcane farmers. The need for a review of the existing contract engagement policies among sugarcane farmers is also evident in this study.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Sugarcane growing is one of the biggest agricultural activities in the world. The world annual cane sugar production was estimated to be 188.25 million metric tonnes in 2018 (FAOSTAT, 2018). Cane sugar represents about 80 percent of the sugar production in the world (Rumánková & Smutka, 2013) of which Latin America and Asia accounts for about 85 percent of the cane sugar production (Rumánková & Smutka, 2013). Asia, Australia and Africa shows the highest dynamics of growth in the production of cane sugar. Brazil is the largest producer of sugarcane with an annual production of about 768,678,382 metric tonnes (FAOSTAT, 2018) followed by India which produces 348, 448,000 metric tonnes per year. The other countries are; China, Thailand, and Pakistan with annual production of 123,059,739; 100,100,000 and 65,450,704 metric tonnes respectively (FAOSTAT, 2018).

Africa contributes about 5 percent of the total global sugar cane production with Sub-Saharan Africa accounting for about 80 percent (Travella & Oliveira, 2017). Six Sub-Saharan African countries: South Africa, Sudan, Swaziland, Zambia, Mauritius and Kenya accounts for more than half of African total sugarcane production (Travella & Oliveira, 2017). Zambia, Zimbabwe, Malawi, Swaziland and South Africa have been constantly ranked among the lowest cost sugar producers in the world (Travella & Oliveira, 2017). Therefore, despite the little contribution to the world sugar production, Africa can be considered a promising region for continued expansion.

In Kenya, sugarcane production is one of the major employers and contributors to the national economy alongside tea, coffee, horticulture and maize (Waswa *et al.,* 2012). By far, the largest contribution of the sugarcane industry is its contribution to the communities and rural economies in the sugar belts. The sugarcane subsector contributes about 15 percent of the nation's agricultural GDP and an approximately 25 percent of the people rely on the subsector for their living (Wekesa *et al.,* 2015). Sugarcane is grown both on large and small-scale, however in terms of profitability large scale sugarcane farming is more profitable due to economies of scale (Waswa *et al.,* 2012). Sugarcane growing counties in Kenya include Kakamega, Bungoma, Busia, Kisumu, Homabay, Migori, Kericho, Kisii, Narok (Transmara) and Kwale County. The production of sugarcane is mainly in Western Kenya where it is dominated by smallholder farmers.

This sector has however, continued to perform dismally over the years despite its importance to the economy. Mulianga *et al.* (2015), in their study to assess the effect of climate change on sugarcane productivity in Kenya indicated that sugarcane production has been in constant decrease over time. Kenya Sugar Board (2014) found out that on average, cane production stands at 60.52 tonnes per hectare. This concur with a study by Wolfgang and Owegi (2012) who found a reduction of 33 percent from the 1996 level of 90.86 tonnes per hectare. Kenya's sugar sector has been very uncompetitive and largely survives on high tariff and non-tariff trade protection (Waswa *et al.*, 2012). The domestic demand for sugar is higher than production capacity in the Country (Wekesa *et al.*, 2015). During the year 2018, the local sugar production was about 490,704 tonnes which is only 57% of the domestic demand that currently stands at 850,000 tonnes (Republic of Kenya, 2020). The deficit is met through importation from Common Market for East and Southern Africa (COMESA) countries. However, some of this imported sugar has had several debates, where it was debated to be unfit for human consumption as a result of traces of lead, mercury and copper (Wanjohi, 2018).

As such, the Kenyan government has been heavily investing in this sector in order to obtain the optimum production and become self-sufficient in sugar production. The Kenya Sugar Research Foundation (KESREF) was formed with objectives of generating and introducing new sugarcane varieties, new cane management policies and agronomic practices, and distribute this information to relevant stakeholders where the most important ones are the smallholder farmers (Jamoza *et al*., 2013). Adoption of these research technologies is important for the improvement of sugarcane and sugar production in Kenya. However, studies such as Odilla *et al.* (2013) showed that majority of farmers were not applying the recommended sugarcane agronomic practices. Additionally, few studies had been done to determine the effect of adopting these recommended practices on production of sugarcane. The problem of this not having been done is that the research institution could be using resources in terms of land, labour and capital to generate technologies, which may not add value to the sugar sector. This study would seal this gap by providing an empirical evidence on the effect of these practices on production of sugarcane

Moreover, the achievement of technical efficiency at farm level could be one of the best complement to all efforts to meet the objective of optimal sugarcane production. Efficiency in agricultural production refers to the choice of using the limited agricultural resources in an optimal way. The scope of production in crop farming can be sustained through efficient use of scarce resources in the economy. It has been widely argued that efficiency is the center of farm production (Awunyo-Vitor *et al.*, 2016; Severini & Sorrentino, 2017). Empirical studies carried out in the past concerning farm performance, specifically efficiencies of production are however very limited especially in sugarcane farming. Mulwa *et al.* (2014) in their study to determine the inefficiencies in maize production and their causes in Western Kenya found out that farmers could reduce the use of inputs by approximately 20 to 30 percent and still achieve the same results. However, their study did not analyze in depth the socioeconomic factors affecting efficiencies to give smallholder farmers and policy makers an insight for intervention.

Sugarcane production in Kenya is largely carried out through contract farming. The introduction of contract farming in Kenya was expected to offer great chances for commercializing smallholder agricultural production thereby improving their productivity, and hence increasing their income (Musungu & Sorre, 2017). The objective of introducing contract farming among smallholder farmers was to solve certain problems and limitations that small scale farmers face in farming activities (Bijman, 2008; Eaton & Shepherd, 2001; Singh, 2002). Some studies have indicated that there are different reasons for the smallholder farmers and factories to engage in contracted services. A study by Singh (2002) showed that producers and processors are likely to select contract farming instead of vertical integration or spot market exchange to minimize risks and transaction costs. The main potential reasons why farmers enter into contract farming are market security, access to technical assistance, access to capital, skill transfer and income stability (Eaton & Shepherd, 2001; Freguin-Gresh, d'Haese, & Anseeuw, 2012).

Despite contracted services offered by contracting firms aimed at improving sugarcane productivity, experiences from various smallholder sugarcane farmers in Kenya indicated deteriorating effects on production and their livelihoods (Musungu & Sorre, 2017). Practical observations have shown that most of the sugarcane farmers have discontinued production under contract terms (Waswa *et al.*, 2012), while others have completely changed to other crops. Majority of the remaining smallholder sugarcane growers now grow it privately without engaging into contract terms with the factories (Wolfgang & Owegi, 2012; Republic of Kenya, 2020). This study offers research-based recommendations on how the benefits of factory contracted services can be enhanced in Kenya.

1.2 Statement of the problem

Sugarcane is one of the most important crop in Kenya. The government has had several incentives to improve productivity, particularly of smallholders. Despite the heavy government investment in sugarcane production, the objective of attaining optimum production and becoming self-sufficient in sugarcane production has not been achieved. The yield remains very low and the potential output of 90.86 tonnes per hectare is still not achieved in the majority of sugarcane producing areas including Malava Sub-county. New and improved technologies have been introduced in sugarcane production and smallholder farmers encouraged to engage in factory contracted services with an aim of improving their productivity however this objective has not been achieved. In a country like Kenya, where production resources are extremely scarce, the adoption of the best agronomic practices, achievement of technical efficiency at farm level and participation in effective factory contracted services would be the best complement to all efforts made to attain optimum and self-sufficiency in sugarcane production and profitability. Although information on the effect of best agronomic practices, technical efficiency and farmers' participation in factory contracted services on production and profitability is important in production planning and allocation of resources, there is insufficient research carried out on the same. Therefore, there was need to evaluate the effect of adoption of best agronomic practices, selected socioeconomic factors and participation in factory contracted services on production, technical efficiency and profitability in order to provide empirical information to guide in decision making among sugarcane farmers in Malava Sub-county.

1.3 Objectives

1.3.1 General objective

To evaluate the effect of best agronomic practices, socioeconomic factors and farmers' participation in factory contracted services on performance of smallholder sugarcane farmers in Malava Sub-county, Kakamega County.

1.3.2 Specific objectives

The specific objectives of this research are:

1. To determine the effect of adoption of best agronomic practices on production of sugarcane among smallholder farmers in Malava Sub-county, Kakamega County.
2. To determine the effect of selected socioeconomic factors on technical efficiency of smallholder sugarcane farmers in Malava Sub-county, Kakamega County.
3. To assess the effect of farmers' participation in factory contracted services on profitability of smallholder sugarcane production in Malava Sub-county, Kakamega County.

1.4 Hypotheses

H_{01} Adoption of best agronomic practices has no significant effect on production of sugarcane among smallholder farmers in Malava Sub-county, Kakamega County.

H_{02} Selected socioeconomic factors have no significant effect on technical efficiency of smallholder sugarcane production in Malava Sub-county, Kakamega County.

H_{03} Farmers' participation in factory contracted services have no significant effect on profitability of smallholder sugarcane production in Malava Sub-county, Kakamega County.

1.5 Justification of the study

Sugarcane is the most important crop grown in Malava Sub-county of Kakamega County in terms of area coverage and hence the study focused on this crop only. This study is important in the economic development of Kakamega County which mainly relies on sugarcane production as the main cash crop. The study contributes significantly in the development of sugarcane subsector by providing key information on best agronomic practices, the efficient resource utilization and effect of farmers' participation in factory contracted services on profitability. The information generated from the study is useful to both farmers and policy makers. To the farmers, it mainly help them to understand the effect of adopting the recommended best agronomic practices on their production, the management of resources to optimize production of sugarcane and the effect of participating in factory contracted services on their profitability. The information is also useful to the policy makers in designing and implementing informed policies and strategies based on factors limiting productivity. Moreover, the findings is of beneficial to the researchers and extension service providers as well as NGOs in indicating area of advantages on what needs to be done to improve the sugarcane production through technical efficiency at farm level, agronomic practices and other services provided. Finally, this study serves as a source for further studies on the development of sugarcane subsector in Kenya.

1.6 Scope of the study

This research covered Malava sub-county in Kakamega County focusing on smallholder sugarcane farmers. The study aimed at determining the effect of best agronomic practices, selected social economic factors and farmers' participation in factory contracted services on performance of sugarcane production.

CHAPTER TWO

LITERATURE REVIEW

2.1. Overview

This chapter presents a review of the literature related to the study. The chapter covers the empirical and theoretical review of the study, and conceptual framework. The empirical review includes a discussion on sugarcane productivity, effect of best agronomic practices on production, effect of socioeconomic factors on technical efficiency and effect of farmers' participation in factory contracted services on profitability. This review also identifies the research gaps from the previous studies.

2.2. Sugarcane production in Kenya

The sugar industry supports the livelihoods of about six million Kenyans directly or indirectly, contributing to rural household economies (Mati & Thomas, 2019). There are about 250,000 small-scale sugarcane farmers who supply most of the cane milled in Kenya. Sugarcane is among the top commercial crops in Kenya, alongside tea, coffee, flowers, vegetables and maize (Wolfgang & Owegi, 2012). This industry contributes around 7.5 percent of the Kenya's GDP and mainly affect the economies of Western Kenya and Nyanza regions (Waswa *et al.*, 2012). However despite these benefits, the productivity of this subsector has been declining over time (Wolfgang & Owegi, 2012).

The average yields of sugarcane have been declined from about 66.4 tonnes per hectare in 2015 to 55.1 tonnes per hectare in 2018 (Mati & Thomas, 2019). This compares poorly with the global average of 63 tonnes per hectare (Republic of Kenya, 2020). The declining production has been attributed to low quality sugarcane varieties, poor agronomic practices, high cost of inputs practices, low level of farm efficiency and poor contracted services among other factors (Waswa *et al.,* 2012). In recent years, production of milled sugar has dropped from about 635,700 tonnes in 2015 to about 491,100 tonnes in 2018 (Mati & Thomas, 2019). The annual domestic demand is over 850,000 tonnes, indicating that the country is a net importer of sugar (Republic of Kenya, 2020). Even then, Kenya exports small quantities of sugar mostly to South Sudan and Somalia (Mati & Thomas, 2019). Marketed sugar is mostly for domestic consumption, generating about five billion

US dollars annually (Mati & Thomas, 2019), underpinning the importance of the sugar industry.

The cost of sugar production in Kenya is higher than in some other sub-Saharan African countries such as Sudan, Zambia and Malawi (Wawire & Ouma, 2013). The cost of production of sugar in Sudan is estimated to be KES 23,000 per tonne of sugar (Wekesa *et al.*, 2015). The productivity of sugarcane for Zambia and Malawi is 115 tonnes per hectare per year and 105 tonnes per hectare per year respectively which is almost double the productivity of sugarcane in Kenya (Wekesa *et al.*, 2015). The low cost of sugar production and increased productivity per hectare positively affect the profitability of smallholder farmers.

A study carried out to assess profitability in sugarcane production by use of cost benefit and net present analysis in Kenya showed that farmers were not maximizing their profits (Wawire & Ouma, 2013). The study indicated that farmers could increase their profitability in case they utilize their resources optimally to lower production costs. However, in their study, they compared a model farm in Kibos with farmers practice in Nyando which is likely to differ due to the socioeconomic influence that was not considered in their study.

2.3. Effect of adoption of the best agronomic practices on sugarcane production

Adoption of best agronomic practices (BAPs) is considered an important method to achieve sustainable crop production. The problem of inappropriate farming agronomic practices is ascribed to many factors including insufficient organizational structure at the local farmer level (Beth & Cher , 2007), inefficient provincial extension level and the absence of education and training among farmers (Ahmad *et al*., 2005). The other constraints include lack of capacity, financial resources and knowledge about appropriate management practices (Ahmad *et al*., 2018). There exists a substantial potential for making paradigm shift from input-intensive conventional farming to conservation agriculture, thereby improving productivity and increasing profitability (Kamiloglu, 2012), while reducing environmental externalities (Amolo *et al*., 2017). In this context, adoption of best agronomic practices is the promising option available to help farmers achieve objectives of higher profitability and lower environmental externalities (Ahmad *et al*., 2018). Sugarcane production involves substantial use of inputs such as water, fertilizer and pesticides. Adoption of the best agronomic practices in sugarcane is considered to reduce burden on scarce resources.

A study on economic evaluation of best agronomic practices in Canadian agriculture showed that soil testing was among the top performing best agronomic practices (Beth & Cher , 2007). They indicated that BAPs generally produced increased yields that offset any increases in operating costs. Beth and Cher (2007) indicated that soil testing, nutrient management planning, minimum tillage and no-till was the top performing BAPs. These practices generally produced increased yields that offset any increases in operating costs. Moreover, a study conducted by Cullum et *al.* (2005) on the Combined effects of best management practices on water quality in oxbow lakes from agricultural watersheds showed that water quality prior to the implementation of management practices of lakes was ecologically damaged due to excessive in-flow of sediments. The study demonstrated that the three lakes improved water quality through farm management practices that were designed to control erosion, organic matter and agricultural chemicals.

In Kenya, the Kenya Sugar Research Foundation (KESREF) has been carrying out technological solutions to low sugarcane productivity reported in sugarcane zones including Malava Sub-county. Since 2002, KESREF has established and released various improved sugarcane varieties (Jamoza *et al*., 2013), which include KEN 00-13, KEN 00-3548, KEN 00-3811, KEN 00-5873 among others. However, despite the release of these new varieties, production is still low. The low production has been associated to low adoption of new sugarcane varieties (Odenya *et al.*, 2010). In addition, KESREF has developed best agronomic practices for sugarcane farmers in sugarcane growing zones. Jamoza *et al*. (2013) indicated that these best agronomic practices are site-specific, which give optimum production potential and improve input efficiency. Some best agronomic practices (BAPs) recommended by Jamoza *et al.* (2013) include early maturing varieties, soil tests before planting and proper fertilizer use. Soil testing is important in improving nutrient use, thereby sustaining yields and reducing nutrient loss to the environment (Amolo *et al*., 2017). Integrated weed control is one of the best agronomic practices recommended by KESREF to provide management of troublesome perennial weeds such as couch grass. The recommended number of times a farmer should weed his or her farm is at least 4 times depending on the type of weeds and the nature of the farm (Odilla *et al*., 2013).

2.4. Efficiency and the effect of socioeconomic factors on technical efficiency

Efficiency in agricultural production refers to the choice of using the limited agricultural resources in an optimal way function (Thabethe & Mungatana, 2014). The scope of production in crop farming can be sustained through efficient use of scarce resources in the economy. It has been widely argued that efficiency is the center of farm production (Awunyo-Vitor *et al.*, 2016; Severini & Sorrentino, 2017; Umoh, 2006). The success of a farm enterprise is evaluated through efficiency analysis in terms of effective use of farm resources which include land, labour and capital. Technical efficiency refers to the capability of the farmer to produce at maximum yield given quantities of inputs and production know-how (Ali & Jan, 2017).

A study carried out on the use of inputs among sugarcane farmers in Central Negros showed that small scale farmers in Central Negros could upturn their output by 22 percent through improved use of available resources by rationalizing the use of nitrogen fertilizer, and seed inputs (Fernandez & Nuthall, 2014). Similar results were found by Ahmad *et al.* (2018) in India who indicated that resource inputs were inelastic and poorly utilized. Their study found out that the maximum and sustainable output could still be raised by 8 percent. This case of inefficiency may be similar to Kenya where it is not very clear on the level of economic efficiency that smallholder farmers are operating at.

An evaluation of influence of education on the productivity of small scale farmers in Ethiopia showed that there is a positive relationship between education and small scale farmers' efficiency (Weir & Knight, 2007). Their study however focused on education as the only basis of technical efficiency which is a great drawback as efficiency has been argued to be influenced by other socioeconomic characteristics other than education. Binam *et al.* (2004), conducted a study on factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. Their result also concluded that educated farmers were more efficient. Education, availability of credit to farmers, gender of the farmers and off farm income have been identified to positively affect efficiency of the smallholder farmers (Kibaara, 2005; Sulaiman *et al.*, 2015).

A study conducted to analyze efficiency in sugarcane production comparing men and women headed householders in Sony outgrower zone in Kenya, showed that women headed households were more efficient in both technical and allocative efficiency as compared to men headed households (Nyanjong' & Lagat, 2012). Male headed households were found to have an average economic efficiency of 58.0 percent while women headed households indicated 62.5 percent on average. This shows that both men and women were below the potential production output although women were more efficient as compared to men in their production. However, their study focused on contracted farmers and could not indicate empirical evidence on non-contracted farmers.

An analysis of economic efficiency using a stochastic efficiency analysis and a two-limit Tobit model in Irish Potato production in Kenya showed that farming experience positively and significantly affect economic efficiency (Nyagaka *et al.*, 2010). This finding was similar to those of Mulwa *et al.* (2014) and Mburu *et al.* (2014), who showed high productivity for farmers with wide range of farming experience. Similarly, a study carried out to analyse technical efficiency in paddy rice production in Nigeria using stochastic function showed that the size of household was a significant determinant of technical efficiency (Kadiri *et al.*, 2014). Their study showed that the coefficient of size of household was negative on efficiency and significant indicating that increase in household size result to decline in efficiency. Similar results were obtained by Ahmad *et al.* (2018) and Sulaiman *et al.* (2015) who used the same model to analyze resource use efficiency in sugarcane production in India and Nigeria respectively. However, Mailena *et al.* (2014) in their study to determine efficiency of rice farms and its determinants, found out that there was no significant effect of household size on technical efficiency. Kenyan sugarcane production is labour-intensive activity and hence may not reveal similar result as large household size are assumed to provide cheap labour.

The correlation between farm size and economic efficiency has had various discussions in literature. Various statistical tests have been done on the relationship between farm size and productivity though not enough. Evaluation of economic efficiency and farm size among wheat farmers in Nakuru County showed that large scale farms had high technical efficiency as compared to small scale farms (Mburu *et al.*, 2014). Their study found that there were significant differences in allocative efficiencies between large farms and small farms. This therefore indicated a significant relationship between economic efficiency and size of the land. A study carried out by Bhatt and Bhat (2014) which employed a non–parametric DEA to estimate the technical efficiency and the relationship between farm size and productivity efficiency, showed existence of a positive correlation between the size of the farm and technical efficiency. They found that farm efficiency rise with increase in the size of the farm. Similar results were shown by Ajah and Nmadu (2012) who applied multiple regression analysis and descriptive statistics to analyse socioeconomic factors affecting the output of small scale farmers in Nigeria.

2.5. Effect of factory contracted services on profitability

Smallholder sugarcane farmers engage in production contracts with sugar factories with expectation of increasing their income (Hu, 2013; Igweoscar, 2014). Production contracts define and focus on the compensation, contractor responsibilities and services provided to the farmer (Freguin-Gresh *et al.,* 2012). Contractors usually hold ownership of the contracted commodity (sugarcane) and provide key inputs such as transport, seedlings, extension services, credit among other inputs. In developing countries such as Kenya, the common idea is that a commercial firm provides inputs to resource-poor smallholder farmers who agree to deliver their crops to the contracting factory. Control over the production process is usually shared between the contracting factory and the farmer. The engagement typically stipulate items such as time, quality, quantity and price determination (Singh, 2002).

The contracting factories benefit mainly through increased control over the supply of raw materials. The factories are able to approximate the amount of raw materials they can expect and when (Chamberlain & Anseeuw, 2017). Contract farming is also seen as beneficial to the factory's social image as it is considered to be of developmental impact to the contracted smallholders (Baumann, 2000). On the other hand, smallholder farmers benefit from the contracts through access to markets, improved technology and inputs for production (Simmons *et al*., 2005; Vellema, 2002). Knowledge and skills gained by smallholder farmers through improved technology in production provided by contracting firms enable the smallholder to increase production yields (Miyata *et al*., 2009). The knowledge can also be applied by farmers to other crops other than the contracted crop. In addition, input supply by the contracting factories enables smallholders to overcome their financial constraints in production (Nagaraj *et al*., 2008).

For the two parties engaged in the contract however, there is need for complete contract and availability of enforcement controls to prevent contract breach (Barrett *et al*., 2012; Chamberlain & Anseeuw, 2017). Contracting factories encounter high transaction costs in managing and monitoring a large number of spatially dispersed smallholder farmers (Kirsten & Sartorius, 2002). These costs are subsequently transferred to the smallholder farmers through increased interest rates, high priced services among others.

Well organized contract farming provides potential solution to many of development issues of the agricultural sector in Africa. A study carried out on effect of contract farming on productivity and welfare of cassava farmers by Igweoscar (2014) using Chow's test showed a significant effect of contract farming on productivity of farmers in Nigeria. However, the expectation of smallholders from contract farming has not been met since income they get is far below their expectation (Musungu & Sorre, 2017; Sopheak, 2015). Sopheak (2015) in his study to determine the effect of rice contract farming on smallholder farmers' income in Cambodia, indicated that contracted farmers were facing a challenge of low contract prices, delayed input supply and irregular supply of inputs. His findings concur with those of Musungu and Sorre (2017) and Waswa *et al.* (2012) who argued that input costs affect the net income of the sugarcane farmers in Kenya.

Some of the contracted services rendered to farmers by contracting firms include provision of labour, provision of sugarcane cutting, provision of fertilizer, provision of agrochemicals, extension services, transport services and credit services. Nyanjong' and Lagat (2012), found out that access to credit facilities by smallholder sugarcane farmers had a significant impact to farmers' profitability. They found that very few farmers had access to credit facilities. Their results were in line with few other studies that were carried out on the effect of credit access on profitability (Abdulai & Eberlin, 2001; Nchare, 2007). A number of researchers determined the effect of extension services by considering the extension factors like number of extension visits and total hours of extension worker time on crop production per acre and found that extension services positively and significantly improved the economic efficiency and the value of farm production (Pan *et al*., 2018).

Extension services is key factor in developing the rural set up, and it has been found to contribute to poverty and hunger reduction through dissemination and increased adoption of improved technologies (Elias *et al.*, 2013).

2.6. Theoretical framework

This study is grounded on the farm theory of production where production function is a model applied to estimate the relationship between the quantity of output and quantity of input used. Mathematically this function is expressed as:

$$Y = f(X_1, X_2, X_3, \dots, X_n) \qquad (2.1)$$

Where Y is the quantity of output and $X_1, X_2, X_3, \dots, X_n$ are quantities of input.

Production function indicates the maximum amount of goods that can be produced using alternative combination of inputs. It expresses the functional correlation between the quantities of resources and outputs (Jhingan, 2007). Oluwatayo *et al.* (2008), in their study indicated that farm producers attempt either to maximize output given level of cost or minimize the cost of producing a certain amount of output. The basic production decision of how much to produce is guided by factor-product relationship.

The Cobb-Douglas model is used to estimate stochastic frontier production function. Cobb-Douglas production function is mostly used due to its ability to satisfy economic, statistical and econometric criteria (Erkoc, 2014). The application of this function assumes that the production elasticities are constant. Production can be explained as mathematical equation showing the maximum amount of output that can be attained using a certain level of inputs (Jhingan, 2007). The Cobb-Douglas production function is as shown:

$$Y = AK^{\beta}L^{\alpha} \qquad (2.2)$$

Where Y, K, L and A refer to the total output, capital input, labour input and total factor productivity respectively. β and α are the output elasticities of labour and capital respectively.

Several approaches have been developed to estimate efficiency of farms which includes econometric and mathematical programming approaches. There are two frontier model that are commonly applied which include the Stochastic Frontier Model (SFM) and Data

Envelopment Analysis (DEA). The choice of a specific model depends on the objective of the study, kind of data and the farms assumptions (Erkoc, 2014). A Stochastic Frontier model have been commonly used in determination of agricultural efficiency since DEA have been widely criticized due to its assumption that all deviation from the frontier are associated with inefficiency. These assumptions are hard to be accepted due to inherent variability of agricultural production as a result of weather variation, pest and disease outbreak (Coelli *et al.*, 2005). Stochastic frontier model which was first introduced by Aigner *et al.* (1977) is prefered due to its abilility to measure efficiency in the presence of statistical noise. This model has got two error terms where one accounts for the existing measurement error in production in the specification and the other one is as a result of the estimation of frontier production function. According to Aigner *et al.* (1977), the parametric frontier is presented as;

$$Y_i = f(X_i, \beta) + V_i - U_i \qquad (2.3)$$

Where V_i is the error component which account for the measurement error in the output variable due to the weather, the combined effect of the unobserved input on production, errors in the observation and measuring of data and U_i is the error component that account for the existence of inefficiency in production. Y_i is the quantity of outputs, X_i refers to inputs, β is the unkown parameter to be estimated which represent elasticities of inputs while f represent the production frontier function.

2.7. Conceptual framework

Conceptual framework was developed from independent and dependent variable. Figure 2.1 shows the relationship between the socioeconomic factors, contracted services and best agronomic practices as independent variables and performance as the dependent variable. Performance of sugarcane production which is the dependent variable is measured by production yield, technical efficiency, and profitability. The adoption of the best agronomic practices, socioeconomic factors and participation in factory contracted services were hypothesized to affect production, technical efficiency and profitability. The level of production and technical efficiency were also hypothesized to affect profitability of sugarcane smallholder farmers. There are intervening variables including climatic conditions and agricultural policies which were not related to the purpose of this study but were likely to affect the dependent variable.

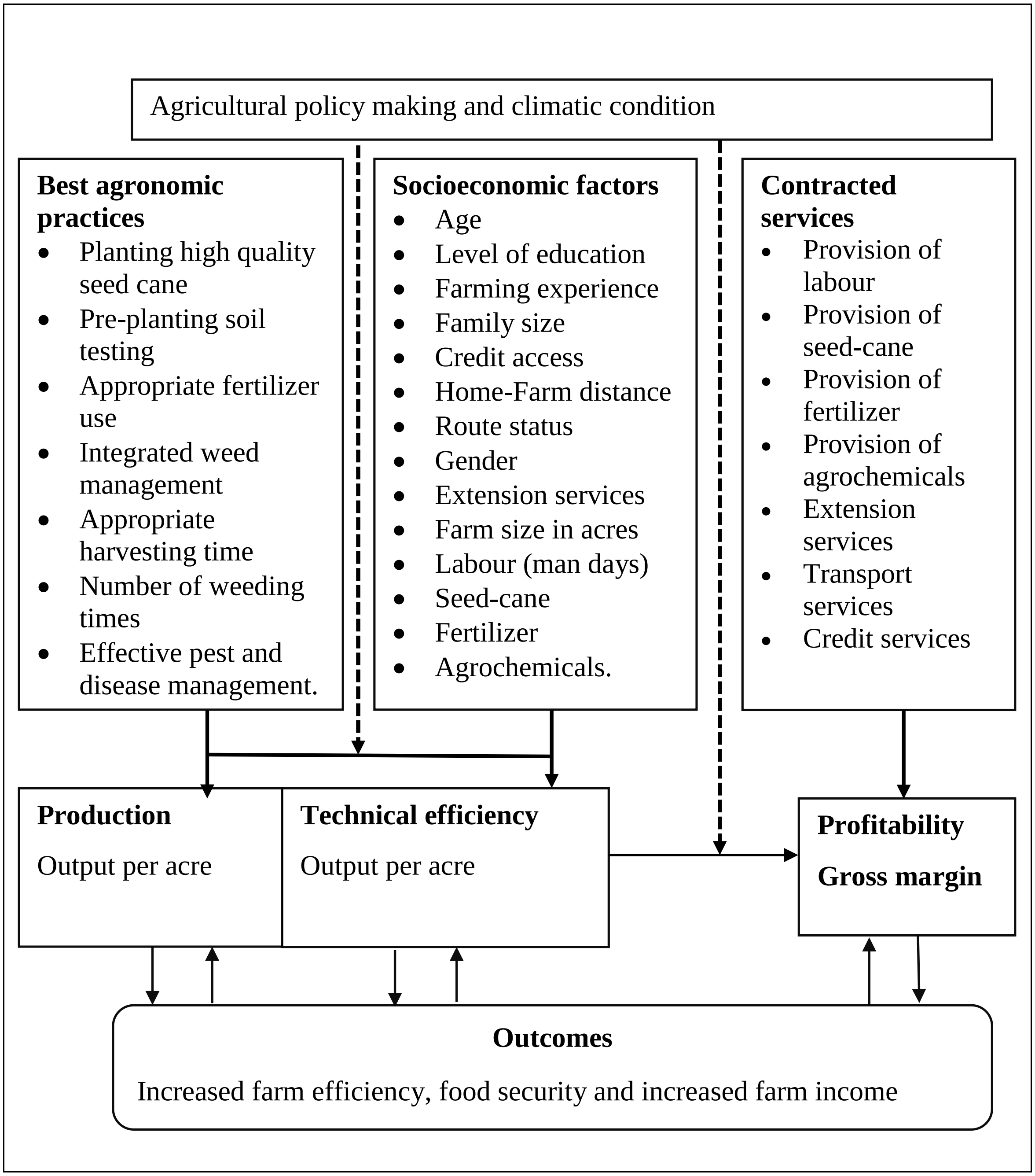

Figure 2.1. Conceptual framework

Source: Modified from Sihlongonyane *et al.* (2014) and Thabethe & Mungatana (2014)

2.8. Summary of Literature review and research gaps

Literature review in this study revealed that socioeconomic factors, contracted services and agronomic practices had an influence on technical efficiency, profitability and production that together contribute to performance. A number of studies attempted to measure productivity in farm production and factors affecting productivity. Studies carried out in Kenya about sugarcane production efficiency and factors affecting performance were also very limited as most of the studies were from other countries such as West African and Western countries. Furthermore, most of the studies cited concentrated on food crops other than industrial crop such as sugarcane in Kenya and there was no similar study found to have been done in Malava Sub-county. A number of studies had been done on adoption of best agronomic practices and awareness of farmers on these practices, however, none of them had analyzed the effect of adopting these practices on production. Additionally, there was lack of enough empirical evidence on how participation of farmers in factory contracted services influence profitability at farm level. The review had also shown that there was limited adoption of stochastic frontier model in determination of production efficiency in Kenya despite the fact that this model captures measurement error and other exogenous shocks that lie beyond a farm's production unit. This study therefore intended to use this model to generate information about influence of socioeconomic factors, factory contracted services and best agronomic practices on efficiency, profitability and production in order to fill these gaps in Kenyan sugarcane production.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Description of the study area

The area of study was Malava Sub-county. According to the Kenya National Bureau of Statistics (2019), the total population of Malava Sub-county is 238,093 people with approximately 51,083 households. Malava Sub-county covers an area of 529.00 square kilometers with a population density of 502.94 persons per square kilometer. The area has an average temperature of 20.5°C. Rainfall ranges between 1,250–1,750 mm per annum. This Sub-county has good weather patterns and fertile soils making agriculture a major economic activity (Kenya National Bureau of Statistics, 2019). Malava Sub-County is mainly located in Lower Midland (LM) Zone 2-3 and Upper Midland (UM) Zone 4 Agro-ecological zones (Jaetzold *et al*., 2005) where the main economic activity is the growing of sugarcane as a cash crop. The area experiences two distinct rainy seasons. Long rains is experienced from March to July while short rains occur from September to December, with a short dry season that occur from January to February. Other crops grown are maize, millet, beans, sorghum, cassava and vegetables. There are seven wards in this Sub-county which include West Kabras, Chemuche, East Kabras, Butali/Chegulo, Manda-Shivanga, Shirugu-Mugai and South Kabras. The geographical map of study area is shown in Appendix 2.

3.2. Target population

The target population for this study was 51,083 households. Sampling of the units was conducted in every ward of the Malava Constituency targeting smallholder sugarcane farmers. Farmers in this Sub-county were targeted for they have been in sugarcane farming activity since the inception of West Kenya Sugar Factory in 1981 and hence were in better position of providing reliable information.

3.3. Sampling procedure and sample size

The sample size for this study was 384 respondents who were determined through Fischers formula given by Kothari (2004) as indicated in Equation 3.1.

$$n = \frac{z^2(p)(q)}{\varepsilon^2} \tag{3.1}$$

Where, n is the sample size, z is equal to 1.96 which is the tabulated Z value for 95% confidence level, p is the sample proportion where 0.5 is the highest that can produce at least the desired precision while ε is the margin of error which is 0.05 since the estimate of the study will be within 5% of the true value.

Using Equation 3.1 above and assuming 50 percent probability that the respondent has the characteristic being measured, the sample size was determined as shown below;

$$n = \frac{1.96^2(0.5)(1-0.5)}{0.05^2} = 384 \tag{3.2}$$

All the seven administrative units (Wards) in Malava Sub-county were purposively selected due to their agrarian potential for sugarcane production. The sample size of respondents from each administrative unit was selected through a proportional sampling allocation technique (Cochran,1977) as shown below.

$$n_i = \frac{N_i \times n}{N} \tag{3.3}$$

Where, n_i is the number of sugarcane farmers interviewed in the selected wards, N_i is the total number of the sugarcane farmers in the selected Ward, n is the sample size for the study while N is the total number of sugarcane farmers in the area of study.

Table 3.1 below shows the sample size of respondents from each administrative unit determined using Equation 3.3.

Table 3.1 Study population and sample size of respondents from each administrative unit.

Administrative units	**Sampling frame**	**Sample size**
West kabaras	28041	45
Chemuche	30745	50
East kabaras	27659	45
Butali/chegulo	36876	59
Manda-shivanga	39194	63
Shirugu-mugai	32055	52
South kabaras	43523	70
Total	238093	384

A systematic random sampling technique was applied to select farmers to be interviewed in each Ward.

3.4. Research design

This study adopted a cross sectional survey research design. This design was chosen due to its ability to measure prevalence for all factors to be investigated. This design involves collection of data on all variables at once hence it is quick, easy to conduct and good for generating hypotheses.

3.5. Data collection procedure

This study used structured questionnaire to collect primary data from respondents on sugarcane production. Trained enumerators were employed to facilitate the process of data collection under the supervision of the researcher. Detailed information from the selected farm households were collected on demographic and socio-economic factors, farm characteristics, input use, production, institutional, contract farming, agronomic practices, revenues and policy related variables. The survey was carried out from July to August, 2019. All data obtained were treated with utmost confidentiality and was only used for the purpose of the study.

3.6. Data analysis

The study applied descriptive statistics including mean, percentage and standard deviation to summarize socioeconomic factors of smallholder sugarcane production. Quantitative analysis was then carried out for each objective using econometric models including Cobb-Douglas production model, stochastic model, tobit regression analysis, profit model and linear multiple regression.

3.8.1 Determination of the effect of best agronomic practices on production of sugarcane

This study employed Cobb-Douglas Production function to determine the impact of farm input and the best agronomic practices on sugarcane yield (Adil *et al*., 2014). This is due to its wide acceptability and suitability in agriculture related data. Cobb-Douglas production function is mostly used due to its ability to satisfy economic, statistical and econometric criteria (Erkoc, 2014). The application of this function assumes that the production elasticities are constant. Cobb-Douglas production function can be written as follows;

$$Y_i = \delta \sum_{i=1}^{n} X_i^{\beta_i} Exp\ \mu_i \tag{3.4}$$

The Cobb-Douglas production function indicated in Equation (3.4) was transformed into log linear form by taking natural log on both sides. Advantage of taking log is that coefficients of variables give direct elasticity and usual ordinary least square method is used (Adil *et al*., 2014). Log linear form of Cobb Douglas production function is as shown below;

$$lnY_i = \alpha + \beta \sum_{i=1}^{n} lnX_i + \delta D_i + \mu_i \tag{3.5}$$

Where lnY_i is natural log of sugarcane yield of ith farmer, lnX_i is a vector of farm inputs used by ith farmer and D_i are dummy variables used to include the effect of adoption of different best agronomic practices on sugarcane production. α, β and δ are parameters to be estimated.

3.8.2 Determination of the effect of socioeconomic factors on technical efficiency

Stochastic frontier technique which was first introduced by Aigner *et al.* (1977) was applied due to its abilility to measure efficiency in the presence of statistical noise. The model has got two error terms where one accounts for the existing measurement error in production in the specification and the other one is as a result of the estimation of frontier production function. According to Aigner *et al.* (1977), the parametric frontier is presented as;

$$Y_i = f(X_i, \beta) + V_i - U_i \tag{3.6}$$

Where V_i is the error component which account for the measurement error in the output variable due to the weather, the combined effect of the unobserved input on production, errors in the observation and measuring of data and U_i is the error component that account for the existence of inefficiency on production. Y_i is the quantity of outputs, X_i refers to inputs, β is the unkown parameter to be estimated which represent elasticities of inputs while f represent the production frontier function.

Production can be explained as mathematical equation showing the maximum amount of output that can be attained using a certain level of inputs (Jhingan, 2007). The model for technical efficiency was applied within the framework of Cobb-Douglas production function due to its ability to satisfy economic, statistical and econometric criteria as applied by Erkoc (2014), Fernandez and Nuthall (2014), Getahun and Geta (2017), and Mamo, *et al*. (2018). The application of this function assumes that the production elasticities are constant.

Following the specification of the stochastic Cobb-Douglas production model, the data was fitted as below;

$$\ln Y_i = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + V_i - U_i \qquad (3.7)$$

Where; ln = logarithm to base e, β_0= constant which represents the intercept of production function, β_1 to β_4 = unknown parameter that were established which are also the output elasticities of amount of fertilizer, labour, seed-cane and farm size respectively. Y_i = quantity of sugarcane in tonnes, V_i = two sided random error representing stochastic effect beyond farmer's control, measurement errors and other statistical noise and U_i = a non-negative random variable representing technical inefficiency of sugarcane farmer. X_1, X_2, X_3 and X_4 are the amounts of fertilizer, labour, seed-cane and farm size respectively. The *a priori* expectation was that β_1 to β_4 would be greater than zero.

The parameters were estimated by the maximum likelihood method (Bi, 2004). The maximum likelihood estimate fit the surface over data where it measures the best practice as compared to ordinary least square that fit a line through the centre of the data using regression method where it measures the average practice. Furthermore, maximum likelihood method provides better estimation which statistically shows the significance of lambda (λ), gamma (Υ) and sigma squared (σ^2) which are able to show the the exixtence of technical inefficiency in the data. U_i is a non–negative truncated half normal random variable which is associated with farm technical inefficiency and it is from zero to one. Following Greene (2005) the log likelihood model is specified as indicated in Equation 3.8. The unknown parameters were estimated through iterative optimization procedure until the value maximizing the function was obtained (Coelli *et al.*, 2005).

$$\ln L\ (Y/\beta, \sigma, \lambda) = -\frac{1}{2}\ln\left(\frac{\pi\sigma^2}{2}\right) + \sum_{i=1}^{l} ln\Phi\left(-\frac{\varepsilon_i\lambda}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{l}(\varepsilon_i^2) \tag{3.8}$$

Where Y = quantity of output in tonnes, β = parameter to be estimated, Φ = Cumulative density function of the standard normal distribution, $\lambda = \sigma_u/\sigma_v$ where σ_u and σ_v are standard deviations of error term U_i and V_i respectively while σ^2= total variance parameters given by $\sigma_u^2 + \sigma_v^2$, where σ_u^2 is the variance for non-negative error term U_i while σ_v^2 is a constant variance for symmetric error term V_i.

Socioeconomic factors were used to explain the efficient effect model whereby tobit regression model was applied as shown in Equation 3.9. Tobit regression model was considered suitable to analyze the effect of socioeconomic factors on technical efficiency since it is a limited depended variable model and that technical efficiency ranges from zero (0) to one (1) . Censoring of the tobit model on the left was done at zero (0) and at one (1) on right.

$$TE_i = \delta_0 + \delta_1 Z_1 + \cdots + \delta_{11} Z_{11} + \omega \tag{3.9}$$

Whereby TE_i is technical efficiency, δ_0 is the intercept of the function while $\delta_1, \delta_2 \ldots \delta_{11}$ are unknown scalar parameters to be estimated. $Z_1, Z_2, Z_3, Z_4, Z_{5,} Z_6, Z_7 Z_8, Z_9, Z_{10}$ and Z_{11} are age, gender, education, family size, farming experience, credit access, farm distance from home, extension services, contract engagement, soil testing before planting and farm record keeping respectively. ω is the error term which is assumed to be normally distributed.

3.8.3 Effect of factory contracted services on profitability

Gross margin refers to the profitability of a production process in the short run when some inputs are fixed. Gross margin is the difference between the value of gross output and variable cost of an enterprise (Ergano & Nurfeta, 2006). The formula below was applied in calculating the gross margin:

$$GM = GR - VC \tag{3.10}$$

Where GM is the Gross Margin per acre, GR is gross revenue per acre while VC is the variable costs associated in production per acre.

The analysis of variance (ANOVA) was applied to determine whether there was a significant difference between the profitability of contracted and non-contracted farmers. The determination of factory contracted services affecting profitability of smallholder sugarcane production was done using multiple linear regression analysis (Ordinary least squares regression) where gross margin per acre was used as proxy for profitability. The model is shown in the Equation 3.11:

$$Y_i = \delta_0 + \delta_1 C_1 + \delta_2 C_2 + \delta_3 C_3 + \delta_4 C_4 + \delta_5 C_5 + \delta_6 C_6 + \delta_7 C_7 + e_i. \qquad (3.11)$$

Where Y_i is profitability measured by gross margin per acre, δ_0 is the intercept of the function while δ_1, δ_2, δ_3, δ_4, δ_5, δ_6, δ_7 are vectors of unknown scalar parameters to be estimated. $C_1, C_2, C_3, C_4, C_5, C_6$and C_7 are dummy variables for the provision of labour, provision of sugarcane cutting, provision of fertilizer, provision agrochemicals, extension services, transport services and credit services respectively while e_i = disturbance term.

3.7. Operationalization of variables

This section describe variables including dependent and independent variables of the study. Table 3.2 shows the description of variables, how they were measured and the priori expectation of independent variables of the study.

Table 3.2: Operationalization of variables

Dependent Variables	**Description**	**Measurement**	**Sign**
Technical efficiency	Farmers' ability to produce maximum output from a given set of inputs.	Deviations from the maximum production possibility frontier	None
Gross margin	The gross margin of sugarcane production.	The difference between the gross output value and variable cost.	None
Production	Total yield of sugarcane produced.	Output per acre in tonnes	None
Independent variables			
Age	Length of time that household head has lived	Number of years	+-
Gender	A social condition of being a male or female	Dummy (1 if male, 0 if female)	+-
Literacy level	Indicates the level of education of the household head	Number of years of formal education	+
Household size	This represents the number of family members in the household	Number of persons living within the household	+
Farming experience	Refers to the number of years that smallholder farmer have been in sugarcane farming activity	Number of years	+
Farm size	The number of acres of sugarcane farm owned by a smallholder	Total number of acres	+
Sugarcane cuttings	Amount of sugarcane setts in tonnes used to plant	Tonnes	+-
Fertilizer	Total amount of organic and inorganic fertilizers	Kilograms	+
Agrochemicals	Amount of fungicide, herbicide and pesticide used in production	Litres	+-
Credit access	Access to credit facilities which is an important source of capital	Dummy (1 if yes, 0 if no)	+
Extension & training service	Are technical services offered to farmers about sugarcane production	Dummy (1 if yes, 0 if no)	+
Planting high quality seed cane	Type of variety planted	Dummy (1 if new variety, 0 if no new variety)	+
Pre-planting soil testing	Soil test before sugarcane planting	Dummy (1 if yes, 0 if no)	+

CHAPTER FOUR

RESULTS AND INTERPRETATION

4.1 Introduction

This chapter presents the results of descriptive and inferential analyses of the study. Descriptive analysis included the demographic and socioeconomic characteristics, summary of agronomic practices and contracted services among smallholder sugarcane farmers. Econometric results of the effect of agronomic practices on production, effect of socioeconomic factors on technical efficiency and the effect of factory contracted services on the profitability are also presented in this chapter.

4.2 Descriptive analysis

4.2.1 Demographic and socio-economic characteristics of sampled households

The study identified characteristics of the respondents. The frequency, percentage and mean values are presented in different tables and charts below. Table 4.1 gives the descriptive statistics of the respondents' family size and farming experience.

Table 4.1 Family size and farming experience of the respondents

Variable	Observations	Mean	Std. Dev.	Min.	Max.
Family size	384	5.81	3.25	1	13
Farming experience	384	15.94	8.69	1	36

From Table 4.1, results indicated that on average the size of the family is 5.81 people per household. This implies that the mean family size in the study area is relatively higher than the national average household size which is about 3.9 persons per household. Large family size is a greater challenge for family resource distribution than an asset as source of cheap labour in the agricultural production. This ultimately reduces agricultural productivity and causes rural-urban migration. The results showed that on average respondents have 16 years of experience in sugarcane farming implying that most farmers could provide a reliable information and have deep understanding of sugarcane farming. Years of experience amongst respondents ranged from 1 year to 36 years.

Other demographic and socioeconomic factors of the respondents in the area of study were as shown in Table 4.2.

Table 4.2 Socioeconomic characteristics of the respondents

Variable	**Categories**		**Frequency**	**Percentage**
Ages of respondents	21 – 30 years		55	14.32
	31 – 40 years		89	23.18
	41 – 50 years		135	35.16
	Above 50 years		105	27.34
Gender of respondents	Male		275	71.61
	Female		109	28.39
Level of education of respondents	No formal education		48	12.50
	Primary		136	35.42
	Secondary		139	36.20
	Tertiary		61	15.89
Credit access	Required	Yes	162	42.19
	credit	No	222	57.81
	Got credit	Yes	105	64.81
		No	57	35.19
Farm distance from home	Less than 1 Km.		284	73.96
	2 – 4 Km.		71	18.49
	Over 4 Km.		29	7.55
Route status	Muddy road		86	22.40
	Murram road		298	77.60
Route maintenance length	Yearly		30	7.81
	After 1 – 2 years		177	46.09
	After 3 – 5 years		169	44.01
	Over 5 years		8	2.08
Get extension services	Yes		165	42.97
	No		219	57.03
Member of farmer association	Yes		12	3.16
	No		368	96.84
Land ownership	Owned		349	90.89
	Rented/Hired		35	9.11

The results given in Table 4.2 showed that both the youth and elderly are engaged in sugarcane farming. Majority of respondents were between 21 and 50 years of age which is the most productive age group with active farmers. On the other hand, 27.34% of the respondents were above 50 years of age implying that some areas had less active farmers involved in sugarcane production.

The study indicated that 71.61% of the respondents were male while 28.39% were female indicating that the sugarcane crop is important for both gender. However, most of the respondents were male indicating that decisions in sugarcane production at farm level are mostly made by male gender who are the head of the household.

The results in Table 4.2 showed that only 12.50% of the respondents had no formal education. Majority of the farmers had formal education where 35.42% had primary education, 36.20% had secondary education and 15.89% had tertiary education. This high percentage of farmers with formal education imply that majority of farmers are capable of increasing sugarcane productivity through quick understanding of trainings given on the crop management such as best practices, pests and diseases control and the adoption of new techniques of production.

The results demonstrated that only 42.19% of the respondents required credit in their production. The majority representing 57.81% of the respondents did not require credit in their production. This imply that majority of farmers were capable of purchasing inputs for sugarcane production and that lack of finance was probably not a limiting factor to most of the smallholder farmers. However, for those who required credit for production, only 64.81% got the credit that they requested for while 35.19% did not get the credit. This imply that some farmers who were in need of credit could not access credit services to enable them purchase production inputs and increase farm productivity.

Most of the farmers representing 73.96% have their sugarcane farms less than 1 kilometer from home, making it easier for management and supervision of the farm. Additionally, short distance of sugarcane farms from home implies that help from the family in terms of labour and crop security can easily be provided. About 18.49% of the farmers have their farms located between 2 and 4 kilometers from home. Few famers of about 7.55% indicated that their farms are over 4 kilometers away from home which makes it difficult for proper farm management.

The study also found out that about 22.40% of the roads leading to the farms are muddy roads and hence not very accessible. However, most of the farms represented by 77.60% have murram roads, indicating that most farms are accessible making supply of inputs and transportation of produce easier. The study also established the length of maintaining feeder roads where majority of farmers (46.09%) showed that roads are maintained after every 1 to 2 years implying that most of the farms are accessible.

The results in Table 4.2 also indicated that only 42.97% of the farmers have access to extension services with majority having no access implying that new technologies in sugarcane farming are not disseminated to most farmers. It was however noted that most farmers who have no access to extension services are non-contracted farmers. Most of the respondents representing 96.84% are also not members of any farmers' association where information on sugarcane farming could easily be shared. Result also showed that farmers represented by 90.89% own their sugarcane farms which could have a positive impact on farmers' long term investments in sugarcane production.

4.2.2 Descriptive results for agronomic practices

Descriptive analysis of the best agronomic practices amongst the sampled household was carried out as indicated in the Figure 4.1 and Table 4.3.

The results in Figure 4.1 shows that, 9.11% of the farmers have not adopted new varieties and they plant traditional varieties indicated as 'Others' in the figure below. However, most of the respondents had adopted various new varieties where KEN 00-3548 had been adopted by 2.08% of the respondents, KEN 00-98530 by 0.78%, KEN 98-367 by 4.43%, KEN 82-121 by 1.82%, D8484 by 32.29%, KEN 82-601 by 0.78, KEN 82-216 by 6.77% and KEN 82-401 which was adopted by 6.77%. Other new varieties adopted include KEN 00-13, KEN 00-5873, KEN 00-98533, KEN 8362, EAK 73-335, KEN 83-737, KEN 82-472, KEN 82-808 and KEN82-493 which were adopted by 1.82%, 0.26%, 2.60%, 9.38%, 10.68%, 2.86%, 0.78%, 5.47% and 1.30% respectively. Results showed that most farmers have adopted D 8484 variety, which could be attributed to among other factors its ability to mature as early as 14 to 16 months and produces high yield per acre.

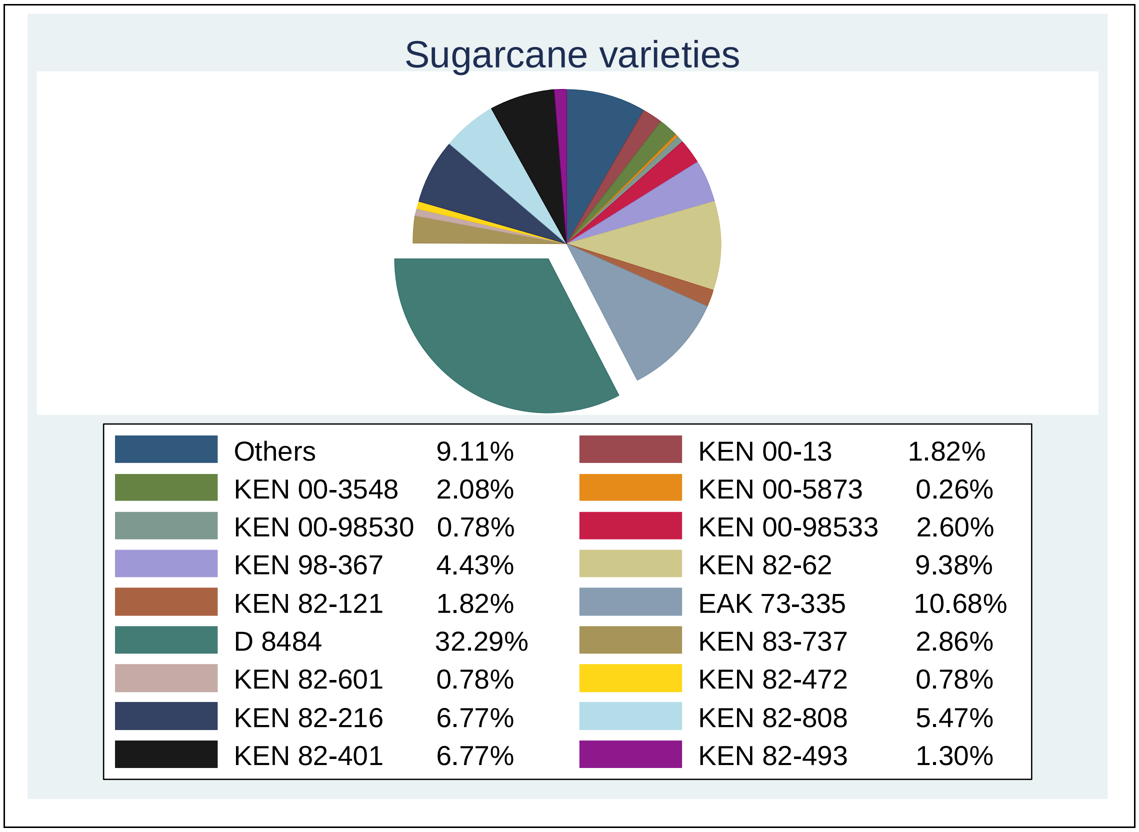

Figure 4.1. Proportions of sugarcane varieties grown by farmers

From Table 4.3, it is shown that 90.89% of farmers are using improved varieties implying that most farmers are capable of harvesting their canes within the shortest time possible and have good yield since most of the improved varieties are characterized by early maturity, high yield, and disease and pest resistance among other factors. However, 9.11% of the farmers have not adopted the new varieties. This indicates that few farmers in the study area are still using other traditional varieties that are attributed to low productivity, take long to mature and prone to pest and diseases and adverse weather conditions.

It was found out that very few farmers of about 16.67% carry out soil testing before planting of sugarcane. This implies most farmers are not able to know the types and amount of nutrients that are lacking in their soils for enhanced productivity. Knowledge on the soil nutrient status would guide the farmers on the type of fertilizer to apply. Additionally, the results demonstrated that 6. 25% of the farmers were applying DAP fertilizer only during their production, while 3.13% and 1.04% of the farmers were using Urea fertilizer only and CAN fertilizer only respectively. Most of the farmers were using both DAP and Urea or CAN fertilizer where 60.68% use both DAP and Urea while 28.91% applied both DAP and CAN during their production. Use of more than one type of fertilizer is recommended in improving the sugarcane productivity. However, it was indicated that most farmers use Urea combination in their production implying that most of the farms could be acidic due to continuous or long term use of urea fertilizer which is acidic.

The results in Table 4.3 indicated that only 40.62% of respondents were keeping farm records. Most of the farmers (59.38%) do not keep records on the revenues generated and expenses incurred in the farm activities. This implies that most of the farmers could not determine whether their enterprises were profitable or not.

From the results, only 5.73 % of farmers control pests and diseases in their farms where 94.27% of the farmers have no mechanism of controlling pests and diseases. This indicates that pests and diseases may not be a major issue among smallholder sugarcane farmers in the study area. However, this may also imply that most farmers have no ability to detect the signs and symptoms of diseases that affect their crops due to low access to extension services.

The study demonstrated different methods of weeding and from the results, it was indicated that most the respondents (93.23%) were using manual weeding while 5.21% use biological method of weeding which may not be effective in controlling most of the weeds. Only 2.34% of farmers were using integrated method of weeding which is the recommended method due to its cost effectiveness and ability to get rid of all kinds of weeds as some are resistant to manual weeding during rainy seasons. However, some farmers indicated that they were not aware of the integrated method implying that information on this method had not been disseminated adequately.

The findings in Table 4.3 show that only 2.86% of farmers weed their farms four times per season. Over half of the farmers represented by 41.41% and 13.80% indicated that they weed their farms twice and once per season respectively which is below the recommended number of times for manual method of weeding. This indicates that some of these farms were affected by weeds which could lower their productivity.

Table 4.3 Agronomic practices employed in sugarcane production

Name of the variable	Categories	Frequency	Percentage
Improved seed cane variety	Yes	349	90.89
	No	35	9.11
Soil test	Yes	64	16.67
	No	320	83.33
Type of fertilizer used	DAP only	24	6.25
	Urea only	12	3.13
	CAN only	4	1.04
	Both DAP and Urea	233	60.68
	Both DAP and CAN	111	28.91
Keep farm records	Yes	156	40.62
	No	228	59.38
Pest and disease control	Yes	22	5.73
	No	362	94.27
Weeding method	Manual weeding	358	93.23
	Biological weeding	20	5.21
	Chemical weeding	0	0
	Integrated weeding	6	1.56
Number of times of weeding	Four times	11	2.86
	Three times	161	41.93
	Two times	159	41.41
	Once	53	13.80

4.2.3 Descriptive statistics on contracted services

The results in Table 4.4 indicates the distribution of farmers participating in contract farming. The results indicated that majority of the respondents (65.89%) were non-contracted with only 34.11% engaging in contract farming. This implies that the terms of contracts engagement may not be favorable to farmers or is associated with low profits.

Table 4.4. Contract engagement of sugarcane farmers

Factory	Freq.	Percent.
Contracted farmers	131	34.11
Non-contracted farmers	253	65.89
Total	384	100

Table 4.5 below shows a summary of contracted services offered to 131 farmers who engage in contract farming. The results show that majority of farmers who engage in contract farming are provided with labour, seed-cane and fertilizer which is represented by 69.47, 80.15 and 72.52 percent of respondents respectively. The other services provided to majority of farmers are extension services, transport services and cash credit with 64.89, 72.52 and 70.23 percent of respondents respectively. This imply that majority of farmers who engage in contract farming are provided with key inputs and services to improve their productivity. The results also showed that only 2.29% of respondents receive agrochemicals implying that this input may not be useful to majority of the farmers in the study area.

Table 4.5. Factory contracted services

Variable	**Participation**	**Frequency**	**Percent**
Contracted labour provision	Yes	91	69.47
	No	40	30.53
Contracted provision of seed cane	Yes	105	80.15
	No	26	19.85
Contracted provision of fertilizer	Yes	95	72.52
	No	36	27.48
Contracted provision of agrochemicals	Yes	3	2.29
	No	128	97.71
Contracted provision of extension services	Yes	85	64.89
	No	46	35.11
Contracted provision of transport services	Yes	95	72.52
	No	36	27.48
Contracted provision of cash credit	Yes	92	70.23
	No	39	29.77

4.2.4 Descriptive results for production function variables

The summary statistics for the variables used in estimation of production function, efficiency and profitability are presented in Table 4.6. The production function and technical efficiency for this study were estimated using four types of inputs including the amount of land, labour, fertilizer and agrochemicals variables.

Table 4.6. Descriptive statistics for the model variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Amount of fertilizer (Kgs per acre)	384	308.2943	138.8531	50	650
Labour (man days per acre)	384	20.58333	5.576745	7	41
Sugarcane cuttings (tonnes per acre)	384	2.270052	1.201333	0.5	9
Agrochemicals (litres per acre)	384	0.3776042	3.813624	0	50
Farm size (acres)	384	2.804818	2.583494	0.25	33
Sugarcane yield (tonnes per acre)	384	18.69401	10.00291	1.5	63

The results in Table 4.6 show that on average small scale sugarcane farmers produce 18.69 tonnes of sugarcane per acre which is below the national average yield of about 24 tonnes per acre. This imply that farmers in the study area are producing below their production potential. The minimum yield of sugarcane obtained is 1.5 tonnes per acre and the maximum is 63 tonnes per acre implying that farmers have a potential of producing up to 63 tonnes per acre. The average values for fertilizer, labour and seed cane are 308.29 kilogrammes, 20.58 man days and 2.27 tonnes per acre respectively. The average land allocated to sugarcane production for households was 2.80 acres. This implies that sugarcane in the study area is on average grown in small scale farms. The amount of agrochemicals used from planting to harvesting ranged from 0 to 50 litres per acre indicating that this may not be a key variable in production of sugarcane.

4.3 Empirical analysis results

This section present the results obtained from multicollinearity and heteroscedasticity diagnostic tests and parameter estimates of the Cobb-Douglas model, stochastic production function, tobit regression, one way ANOVA and ordinary least square.

Test for the appropriateness of the model and the explanatory variables included in the model is a critical step before empirical analysis and drawing of implications. Taking into account the nature of the data used was cross sectional, two tests were conducted which included tests for multicollinearity and heteroscedasticity.

4.3.1 Test for multicollinearity

Multicollinearity problem arises when at least one of the independent variables is a linear combination of the others. The existence of this problem can cause the estimated regression coefficients to have the wrong signs and smaller t-ratios that might lead to wrong conclusions. A strong correlation coefficient might be an indicator of collinearity problems and can be investigated further by calculating Variance Inflation Factor (VIF) for each of the explanatory variables (Rabe-Hesketh & Everitt, 2000). The 'Rules-of-Thumb' for evaluating the existence of multicollinearity problem in the model states that if VIF values are larger than 10 or if a mean of the factors (1/VIF) considerably larger than one, then there is a multicollinearity problem that calls for concern (Chatterjee & Price, 1991). Accordingly, VIF values were computed for key explanatory variables and they were ranging between 1.09 and 3.60 as shown in Table 4.7.

Table 4.7. Test for Multicollinearity problem using VIF

Variable	**VIF**	**1/VIF**
Age	3.60	0.277556
Farming experience	3.55	0.281515
Family size	2.58	0.388311
Labour use	2.39	0.419165
Amount of fertilizer	1.89	0.527883
Education	1.64	0.608939
Amount of sugarcane cuttings	1.55	0.644030
Keep farm records	1.54	0.648076
Contract engagement	1.54	0.650754
Farm size	1.44	0.692876
Get extension services	1.34	0.744254
Got credit	1.25	0.800168
Soil test before planting	1.23	0.813063
Gender	1.09	0.914175
Farm distance from home	1.09	0.918561
Mean VIF	1.85	

The values of mean of the factors (1/VIF) in Table 4.7 were found be between 0.278 and 0.919. Hence, multicollinearity was not a problem among the explanatory variables. Furthermore, the mean VIF of 1.85 shows the problem of multicollinearity in the model is not a serious problem.

4.3.2 Test for heteroscedasticity

Heteroscedasticity is a situation in which the assumption of equal variance of residuals in the classical linear regression model is violated. There exists several tests for heteroscedasticity detection such as the Koeker Basset, the White's and the Breusch-Pagan tests among others (Gujarati & Porter, 2009). This study used the Breusch-Pagan with null hypothesis of constant variance for homoscedasticity. Breusch-Pagan is a chi-squared test whereby if the test statistic has a p-value that is below appropriate threshold of 0.05 then the null hypothesis of homoscedasticity is rejected (Gujarati & Porter, 2009). Table 4.8 show the results for the Breusch-Pagan test for heteroskedasticity. The calculated chi square value of 0.39, with a P value of 0.5308 is greater than 0.05 indicating that the data had no heterogeneity problem.

Table 4.8. Breusch-Pagan test for heteroscedasticity

Ho: Constant variance
Variables: fitted values of lnYield
chi2(1) = 0.39
Prob > chi2 = 0.5308

4.3.3 Effect of best agronomic factors on sugarcane production

The study applied Cobb-Douglas production function to determine the effect of the recommended best agronomic practices on sugarcane production. The Cobb-Douglas multiple regression results are as shown in Table 4.9. From the results in Table 4.9, it is indicated that the production function used in the study is statistically significant as indicated by significant value of 0.0000. Further, the value of R^2 implies that explanatory variables included in the production function explain 70.19 percent variation in the dependent variable which is the yield of sugarcane. The mean Variance Inflation Factor of 1.62 indicated that there was no problem of multicollinearity among explanatory variables in the model. Four production inputs were included in production function. Out of these variables, fertilizer and farm size were statistically significant at 1 percent level while the amount of labour and seed-cane were insignificant.

Table 4.9. Cobb-Douglas multiple regression results on the effect of best agronomic practices on production.

Variables	Coef.	Std. Err.	t-value	P value	VIF
Inputs					
Lnfertilizer	0.235***	0.0507	4.63	0.000	2.01
Lnlabour	0.166	0.0964	1.72	0.086	2.32
Lnseed-cane	0.021	0.0420	0.50	0.614	1.48
Lnfarm size	0.0817***	0.0315	2.59	0.010	1.91
Best agronomic practices					
Use improved seed variety	0.183***	0.0679	2.70	0.007	1.26
Soil testing before planting	0.00597***	0.0510	0.12	0.007	1.19
Type of fertilizer applied	0.0903***	0.0202	4.47	0.000	1.33
Harvested recommended time	0.113**	0.0507	2.24	0.026	2.12
Integrated weeding	0.105	0.183	0.57	0.567	1.13
Pest and disease control	0.0873	0.0821	1.06	0.288	1.20
Keep farm record	0.0283	0.0430	0.66	0.510	1.47
Frequency of weeding per season	0.326***	0.0328	9.92	0.000	1.98
Constant	-0.490	0.302	-1.62	0.105	
Prob > F = 0.0000					
R-squared = 0.7019					
Root MSE = 0.34119					
Mean VIF = 1.62					

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

The best agronomic practices in sugarcane production were introduced in order to estimate their impact on sugarcane productivity. The results in Table 4.9 showed that use of improved seed variety, soil testing before planting, type of fertilizer applied and frequency of weeding per season were significant and positive at 1% level while harvesting at the recommended time was positive and significant at 5% level. This implies that farmers adopting these best agronomic practices receive higher sugarcane yield as compared to non-adopter. On the other hand three practices including integrated weeding, pest and disease control, and farm record keeping were found to be statistically insignificant implying that adoption of these practices may not have an impact on the sugarcane yield among smallholder farmers.

4.3.4 Estimation of parameters of the stochastic frontier production function

The parametric frontier production function that the current study used to measure technical efficiency was a stochastic Cob-Douglas production function. The study used maximum likelihood to estimate the parameters of the stochastic Cob-Douglas frontier function and the results are given in Table 4.10.

Table 4.10. Stochastic frontier production function results

Variables	**β-coef.**	**Std. Err.**	**Z-Value**	**P>|z|**
Lnfertilizer	0.267***	0.0308	8.67	0.000
Lnlabour	0.626***	0.0774	8.08	0.000
Lnseed cane	0.155***	0.0279	5.57	0.000
lnfarm size	0.146***	0.0232	6.26	0.000
Constant	-0.407**	0.192	-2.12	0.034
Usigma	-1.028***	0.0781	-13.16	0.000
Vsigma	-6.154***	0.419	-14.70	0.000
Diagnostic tests				
Sigma u	0.5979837	0.0233585	25.60	0.000
Sigma v	0.0460944	0.0096507	4.78	0.000
Lambda (λ)	12.97302	0.0269179	481.95	0.000
Sigma2	0.3597092			
Gamma (Υ)	0.99409331			
Log likelihood	-101.1355			
Prob > chi2 = 0.0000				

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

The parameters of fertilizer, labour, seed cane and farm size were significant at 1% level. The estimated β-coefficients were 0.267, 0.626, 0.155 and 0.146 respectively. These coefficients are also the production elasticities. The results imply that a one percent increase in the quantity of fertilizer applied increases sugarcane yield by 0.267% and a one percent increase in labour use increases sugarcane output by 0.626%. In addition, a one percent increase in improved seed-cane increases output by 0.155% and an increase in farm size by one percent increases sugarcane yield by 0.146%.

The results in Table 4.10 also indicates the value of lambda (λ) which is 12.973 with gamma (γ) value of 0.994 which is very close to one. This implies that much of the variation in production of sugarcane was being accounted for by the technical inefficiency and thereby justifying the use stochastic frontier as the most appropriate model. Additionally, the estimated value of sigma squared (σ^2) is 0.3597, which is significantly different from zero, indicating the appropriateness of the model. The log likelihood statistic also shows that the model is appropriate given it is significant at 1% level and the large absolute value of Log Likelihood ratio of -101.1355.

4.3.5 Technical efficiency among sugarcane farmers

The results of the frequency of the technical estimates are presented in Table 4.11 where none of the respondents was fully efficient with 1 level of technical efficiency.

Table 4.11. Frequency distribution of technical efficiency estimates

Technical efficiency range		**Frequency**	**Percentage**
0.0 – 0.20		12	3.13
0.21 – 0.40		30	7.81
0.41 – 0.60		54	14.06
0.61 – 0.80		142	36.98
0.81 -0.99		146	38.02
Mean	0.7069		
Minimum	0.000465		
Maximum	0.9829		

From the results shown in Table 4.11, only 38.02% of the respondents recorded a technical efficiency of between 0.81 and 0.99 with majority recording below 0.81 level of technical efficiency. This imply that most of the small scale sugarcane farmers are technically inefficient. The results also indicated that farmers are operating at an average technical efficiency of 0.7069 ranging from a minimum of 0.000465 to a maximum of 0.9829. 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 yield by increasing technical efficiency.

4.3.6 Factors affecting technical efficiency among sugarcane farmers

Table 4.12 shows the relationship between socioeconomic factors and technical efficiency. In the assessment of factors affecting technical efficiency (TE), age, gender, education, family size, farming experience and credit access were considered. Other factors considered were farm distance from home, access to extension services, contract engagement, soil testing before planting and farm record keeping. These factors were regressed against the technical efficiency using Tobit regression model since efficiency has a lower limit of zero and an upper limit of one. The results of Tobit regression analysis are given in Table 4.12. The log likelihood statistic which measures the fit of the model shows that the model is appropriate given its significant chi-square ($p<0.000$) and the large absolute value of Log Likelihood ratio of 155.53.

The results presented in Table 4.12 reveal that the level of education, farming experience and soil test before planting are positive and significant at 5% level. Family size, access to extension services and access to credit are positive and significant at 1% level. However, age of the farmer and contract engagement were found to be negative and significant at 1% level. Farm record keeping was positive but insignificant at all levels. The negative sign on age, farm distance from home and contract engagement indicate that an increase in age or distance or participation of contract services decrease technical efficiency which means that as these factors increase the level of technical inefficiency increases. However, other factors such as education, family size, farming experience, credit access, extension services and soil testing before planting are positive implying that farm technical efficiency increases with an increase in either of these factors.

Table 4.12. Tobit regression model results for effects of factors affecting efficiency

Variables	Coef.	Std. Err.	t-value	P value
Age	-0.0726***	0.0155	-4.70	0.000
Gender	0.0109	0.0190	0.58	0.564
Education	0.0213**	0.0108	1.98	0.049
Family size	0.0240***	0.00403	5.95	0.000
Farming experience	0.00429**	0.00177	2.41	0.016
Credit access	0.0596***	0.0203	2.94	0.003
Farm distance from home	-0.0982***	0.0140	-7.02	0.000
Extension services	0.105***	0.0192	5.46	0.000
Contract engagement	-0.0938***	0.0213	-4.41	0.000
Soil test before planting	0.0476**	0.0241	1.97	0.049
Farm record keeping	0.0153	0.0199	0.77	0.442
Constant	0.797***	0.0572	13.95	0.000
Sigma	0.161***	0.00582		
Log likelihood	155.53			
Prob > chi2 = 0.0000				

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

4.3.7 Effect of factory contracted services on profitability

This section show the results of gross margin analysis of sugarcane production and the effect of factory contracted services on profitability.

4.3.7.1 Gross margin analysis of sugarcane production.

Gross margin was used as proxy for profitability and was estimated using total variable costs and total revenues of farmers. Table 4.13 shows the results of the variable costs, revenues and the gross margin analysis.

Table 4.13. Analysis of the variable costs, revenues and gross margin

Variable	Obs	Mean	Std. Dev.	Min	Max
Total variable costs per acre (KES)	384	42848.64	22472.16	7660	166500
Total revenue earned per acre (KES)	384	73841.15	39271.65	5700	258300
Gross margin (KES)	384	30992.51	30561.31	-69403	174900

Total variable costs were derived from farmers' payment statements, farmers' handbooks or records as well as direct estimation from households. These costs included; survey charges, furrowing costs, cost of fertilizer, seed-cane charges, transportation, labour cost and harvesting charges. The kind and amount of costs incurred depended on whether the farmer is contracted or non-contracted among other factors. The revenue was determined by the product of the selling price and the total yield. There were two sugarcane milling factories in the study area which are West Kenya and Butali Factory. These factories however buy sugarcane at different prices which are KES. 4100 and KES. 3800 per tonne of sugarcane respectively. Selling price therefore varied depending on which factory was chosen by the farmer. The findings indicated that on average the total revenue earned and cost incurred by a farmer are KES. 73841.15 and KES. 42848.64 per acre per season respectively.

Gross margin (GM) was computed as the difference between gross revenue and total cost incurred per acre per season. From Table 4.13, it is indicated that, on average the gross margin is 30992.51 ranging from a minimum of KES. -69403 to a maximum of KES. 174900 per acre per season. This implies that farmers had a potential of earning a revenue of KES. 174900 per acre of sugarcane farm in every 14 to 18 months season.

4.3.7.2 Comparison of profitability of contracted and non-contracted sugarcane farmers

The mean gross margin were determined for the contracted and non-contracted farmers. A summary of the mean gross margin for the two groups is as indicated in Table 4.14. The results show that non-contracted farmers are more profitable than contracted farmers. Contracted farmers have a mean profit of KES. 21291.56 per acre while non-contracted farmers have a mean of KES. 36015.53 per acre as gross margin. Contracted farmers indicated that they were exorbitantly paying for cane transportation, ploughing, furrowing, seed-cane, harvesting, and fertilizer supply among other costs. On average, contracted famers were incurring a total cost of KES 51, 424 per acre per season while non-contracted farmers were incurring a total cost of KES 33, 770 per acre per season.

Table 4.14. Summary of Gross margin

Group	Mean	Standard deviation	Frequency
Contracted	21291.56	32422.61	131
Non-contracted	36015.53	28336.75	253

This study applied one way ANOVA which is a statistical technique for testing differences among means by analyzing variance to understand whether variations in gross margins were dependent on contract engagement among smallholder sugarcane farmers in Malava Sub-county. The results of ANOVA are as shown in Table 4.15.

The results show that the relationship between contract engagement and gross margin at farm level in the study area was significant with P value of 0.0000. This implies that participation in factory contracted services was critical in explaining the variation of farmers' profitability in the study area.

Table 4.15. One way ANOVA on contract engagement and profitability

Source	SS	Df	MS	F	Prob > F
Between groups	1.8712e+10	1	1.8712e+10	21.08	0.0000
Within groups	3.3901e+11	382	887455562		
Total	3.5772e+11	383	933993709		

4.3.7.3 Effect of selected contracted services on sugarcane profitability

Seven contracted services offered by factories were used in assessing the effect of contracted services on the gross margin using multiple linear regression analysis. The results of the multiple regression analysis are given in Table 4.16. From the results, the effect of provision of extension and cash credit services were significant at 1%. The effect of provision of labour was also significant at 5%. The negative sign on provision of labour and cash credit services imply that participation in these services negatively affect the gross margin. On the other hand, provision of extension services was positive implying that provision of these services increase gross margin of smallholder sugarcane farmers. However, provision of seed-cane, fertilizer, agrochemicals and transport services were found to be insignificant implying that provision of these services might have no effect on farmers' gross margin. There was an R^2 of 0.4764 implying that 47.64% of variation in profitability was accounted for by farmers' participation in contracted services. The mean Variance inflation Factor (VIF) of 1.18 indicated that there was no problem of multicollinearity among the explanatory variables in the model.

Table 4.16. Empirical results for effect of contracted services on profitability

Contracted provision	**Coef.**	**Std. Err.**	**t-value**	**P value**	**VIF**
Labour	-11,554**	4946.114	-2.34	0.021	1.33
Seeds	11,111	5853.517	1.90	0.060	1.28
Fertilizer	9,089	5332.855	1.70	0.091	1.23
Agrochemical	27127	14447.43	1.88	0.063	1.17
Extension services	24714***	5100.625	4.85	0.000	1.11
Transportation services	-3181.823	4865.566	-0.65	0.514	1.06
Cash credit services	-21779***	4853.258	-4.49	0.000	1.05
Constant	14766	7808.763	1.89	0.061	
Prob > F = 0.0000					
R-squared = 0.4764					
Mean VIF = 1.18					

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

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the results, discussion, conclusion and the recommendations of the study. The results of the study are discussed as per the objective of the study. The chapter also looks at the findings in view of what has been described in literature in order to assess the underlying factors that possibly explain the observed trends and outcomes. This chapter illustrates the existing gaps and sets a basis for recommending the necessary policies to address the identified gaps.

5.2 Summary of the results

Descriptive results indicated that on average the size of the family is 5.8 people per household with an average years of experience of 16 years. Both the youth and elderly are engaged in sugarcane farming where majority lie between 21 and 50 years of age. Similarly, both male and female gender were involved in sugarcane production, however male gender were the majority. Majority of the respondents had attained formal education with only 12.50% of respondents who had not attained formal education at all. Results demonstrated that only 42.19% of the respondents required credit in their production, however, only 64.81% of those required credit were able to access. Most of the respondents have their farms located nearer home where majority are farm owners. Most feeder roads (77.60%) have murram making them accessible. The results however showed that majority of farmers have no access to extension services where most (65.89%) of farmers are non-contracted farmers.

In addition, the results showed that majority of the farmers had adopted improved sugarcane varieties with the D8484 being highly adopted (32.29%). The results on agronomic practices revealed that most farmers were not carrying out soil testing with majority applying a combination of Urea and DAP fertilizer which may not be effective. It is indicated that most farmers do not keep farm records and 94.27% of respondents do not carry out pest and disease control in their farms. Majority of respondents manually weed their farms and that they are below the recommended number of weeding times (at least 4 times). Farmers in the study area prefer selling their cane to Butali Sugar Mill as it pays slightly higher price per tonne than West Kenya Factory. Majority of the contracted farmers were provided with labour, seed-cane, fertilizer, extension services, transport services and cash credit.

Econometric results on the other hand, indicated that use of improved seed variety, soil testing before planting, type of fertilizer applied and frequency of weeding per season and harvesting at the recommended time positively and significantly affect sugarcane production. Stochastic frontier results showed that fertilizer, labour, seed-cane and farm size which were important inputs in sugarcane production were significant at 1% level. Majority of the respondents in the study area were operating below their production potential recording an average technical efficiency of 0.7069 with wide variation from a minimum of 0.000465 to a maximum of 0.9829 level of efficiency. An analysis of the effect of socioeconomic factors on technical efficiency showed that the level of education, farming experience, soil testing before planting, family size, access to extension services and access to credit have positive and a significant effect on technical efficiency. However, age of the farmer and contract engagement were found to be negative and significant at 1% level. Additionally, the study assessed the effect of contracted services on profitability and found that provision of extension services, cash credit services and labour significantly affect profitability.

5.3 Discussion

5.3.1 Effect of best agronomic practices on production of sugarcane

The study assessed the effect of the best agronomic practices on production of sugarcane among smallholder farmers. Four key sugarcane production inputs were used which are fertilizer, labour, seed cane and farm size. Eight best agronomic practices were considered in the production function as dummy variables to estimate their effect on sugarcane production.

From the results, the amount of fertilizer and farm size were found to be positive and significantly affecting sugarcane yield. An increase in the amount of fertilizer by 1% would increase sugarcane yield by 0.235% while 1% increase in the size of the farm would increase sugarcane yield by 0.0817%. These results concur with those of Ahmad *et al.* (2005), Baruwa & Oke (2012) and Wawire & Ouma (2013).

Adoption of improved varieties in the study area showed a positive and significant effect on production where adopters could increase their output by 18.3%. Improved varieties are attributed among other factors to high yielding, high sucrose content and early maturing capacity. These results concur with those of Jamoza (2005). Descriptively, the results showed that majority of the respondents had adopted new varieties with only 9.11% who were still planting traditional varieties. This indicated that adoption of new varieties in the study area by farmers was not a major issue and that low sugarcane production could be caused by other factors other than adoption of improved varieties. This contradicted with the results by Odenya *et al.* (2010) who showed that the adoption rate of these varieties was lower than expected. The low adoption had been attributed to lack of seed-cane and awareness by farmers (Jamoza *et al.*, 2013).

The best agronomic practice regarding the efficient use of fertilizer nutrients include soil testing among other practices. Soil testing before planting was therefore included in the model to determine its effect on sugarcane production. The positive and statistically significant value of the coefficient for this variable was found to be 0.00597, showing that soil testing practice positively influence sugarcane yield. This practice helps the farmer to determine the type and amount of nutrients required in the soil. Similar results were found by Amolo *et al*. (2017) and Jamoza *et al*. (2013).

Accordingly, the results revealed a positive and significant effect of the type of fertilizer applied on sugarcane production. Combination of CAN and DAP was coded with the highest number (4), followed by CAN only (3), Combination of Urea and DAP (2) and use of Urea only was coded with the lowest (1). This means that the more the farmer reduce the use of Urea and increase use of CAN fertilizer the higher the yield. Similar results were found by Beth & Cher (2007). However, descriptive statistics showed that only 28.91% of respondents had adopted a combination of DAP and CAN. The majority (60.68%) apply Urea and DAP implying that majority of the farms are likely to be acidic due to long term use of Urea fertilizer which result to low sugarcane production. High acidity in the soils were also confirmed by Amolo *et al.* (2017) who recommended the need for appropriete nutrient replenishment for soils in western part of Kenya.

Harvesting of sugarcane at the recommended time showed positive and significant relationship with the production. This means that farmers who harvest their sugarcane at the right time are likely to get higher yield than those who harvest pre-mature sugarcane or over-mature cane. The recommended time for sugarcane harvesting depends on the variety of sugarcane planted. However, most of the improved varieties mature at the age of 14 to 16 months. Harvesting of fully matured canes reduces the production losses. Karaye *et al*. (2017) showed in his study that timely harvesting is very important in crop production since pre-mature or delay in harvesting leads to reduction in crop yield and quality.

Adoption of the recommended frequency of weeding per season revealed that adopters could increase their sugarcane production by 32.6%. The results implied that an increase in the number of times of weeding sugarcane farm, increases sugarcane yield per acre. However, descriptive statistics showed that majority of the farmers (55.21) had not adopted the recommended number of times in weeding their farm. The number of times that the crop was weeded ranged from once (13.80%) to 4 times (2.86%). The results indicated that majority of farmers were either not aware of the recommended number of times (at least 4 times) to weed the crop, lacked labour or machinery to carry out this practice. Weeds in sugarcane production were estimated to cause 12 percent to 72 percent reduction in cane output which depend on the severity of infestation (Odilla *et al*., 2013). The results revealed that majority of the respondents (93.23%) were using manual methods to control weeds which may not be effective method for some weeds. Failure to adopt the recommended number of weeding times (At least four times) and use of integrated method of weeding is most probably among the major causes for low sugarcane productivity in the area of study.

On the other hand, pest and disease control, and farm record keeping were insignificant in the study area. This contradict with the study by Odilla *et al*. (2013) who showed that pests such as termites and ratoon stunting disease were common among farmers in Kakamega County. However this may not be the current situation since most farmers have adopted improved varieties that are attributed to high diseases resistance.

5.3.2 Effect of selected socioeconomic factors on technical efficiency

5.3.2.1 Estimation of parameters of the frontier production function

The study considered four key inputs used in sugarcane production which included amount of fertilizer, labour, seed cane and farm size. Moreover, the study hypothesized that all of those factors were significant in the production of sugarcane among smallholder farmers. Results in Table 4.10 confirm this hypothesis. Based on the signs of coefficients, all the four inputs were found positive and significant in the study area. These findings also revealed that farmers are currently operating below the optimal level of input use as increase in either of these inputs lead to a higher output quantity. The results are in line with the economic theory of production and concur with the findings by Wawire and Ouma (2013) who found out that sugarcane farmers were not maximizing their production.

The findings on the effect of farm size on sugarcane production in the current study were in line with those of Khan *et al*. (2010) and Baruwa & Oke (2012) in Bangladesh and Nigeria respectively. However, these results were in contradiction with the results by Tchale (2009) which showed a negative influence of farm size on technical efficiency in Malawi. The latter study however associated the negative effect with operating beyond the optimal scale of the land where production was carried out on larger farms than what a farmer could manage. Thus, in Kenya the size of sugarcane farms can still be managed and increase in sugarcane farm area would increase production. However, farm expansion should be carried out with care as Anyaegbunam *et al*. (2012) found out in their study that farm size may inversely increase with technical efficiency. Since all the four key inputs used in sugarcane production were positive and significant, it is deduced that these factors significantly determine sugarcane output in the study area.

The findings in Table 4.9 indicated that the value of lambda (λ) is 12.973 implying that in total deviation of 12.973% difference between observed and potential yield is due to the inefficiency among the sampled respondents. The parameter gamma (γ) value is 0.994 which is very close to one. This parameter is usually associated with the two error terms of the stochastic frontier function (Batesse and Coelli, 1995). This parameter measures the deviation of the output from the frontier caused by the effect of inefficiency and it equals to $\sigma^2\mu/ (\sigma^2 v + \sigma^2\mu)$ whereby $\sigma^2\mu$ and $\sigma^2 v$ represent the variances related to technical inefficiency and statistical noise respectively. The values therefore indicated that 99.4% variations in the composite error terms was caused by inefficiency effects. Additionally, the estimated value of sigma squared (σ^2) is 0.3597, which is significantly greater than zero, indicating the appropriateness of the model.

5.3.2.2 Technical efficiency levels

The findings in Table 4.11 indicate that majority of respondents recorded below 0.81 level of technical efficiency. This shows that most of the smallholder sugarcane farmers are technically inefficient. The results also showed that farmers are operating at an average technical efficiency of 0.7069 ranging from a minimum of 0.000465 to a maximum of 0.9829. This wide variation in technical efficiency estimates indicates that majority of the farmers are inefficiently utilizing their resources in the production process and there are opportunities for increasing their current yield by improving technical efficiency. An average farmer is operating at 70.69% below the production frontier due to inefficiency effects. This 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 or wastage of inputs. Similar results were reported by Kassa *et al*. (2019) and Nyagaka *et al*. (2010).

5.3.2.3 Factors influencing technical efficiency among sugarcane farmers

The findings presented in Table 4.12 showed that, the level of education, farming experience and soil testing before planting are positive and significant at 5% level. Family size, access to extension services and access to credit are positive and significant at 1% level. However, age of the farmer and contract engagement were found to be negative and significant at 1% level. Gender and farm record keeping were positive but insignificant at all levels.

Age variable depicted a negative effect on technical efficiency where an increase of age by one percent would reduce technical efficiency by 0.0726%. This showed that the older a farmer become, the higher the technical inefficiency in sugarcane production. Age of the farmer can take a positive sign when older farmers are willing to adopt improved methods thus increasing technical efficiency effects or when knowledge, skills and the experience gained during their years of farming contribute in reducing inefficiency. This variable can take a negative sign like in the current study, indirectly showing that older farmers are resistant to adopt improved technologies and that they lack mental and physical capacity to efficiently participate in sugarcane production. Similar results were found by Khan and Saeed (2011) who argued that older farmers are less technically efficient than younger farmers, showing that the more the younger farmers get educated the more efficient they become. On the contrary, Getahun and Geta (2017) and Binam *et al*. (2004) assumed that when farmers get old, they become more experienced and efficient. Then again, higher technical efficiency is attained by the age group which have more interest in the type of crop being cultivated. (Thabethe & Mungatana, 2014).

The level of education is positive and significant indicating that 1% increase in the level of education would increase technical efficiency by 0.0213%. This relationship is significant at 1% level. This means that when farmers are educated on the suitable techniques of farming as well as resource use, they become more efficient. This finding concur with those of Weir and Knight (2007) who found out that there was a positive relationship between the level of education and efficiency among small scale farmers. A study by Sulaiman *et al.* (2015) on resource use efficiency among sugarcane farmers in Nigeria indicated that farmers who are more educated quickly acquire new technologies and produce more output which is closer to the production frontier.

Family size indicated a positive relationship with the technical efficiency as expected. From Table 4.12, it is shown that 1% increase in family size increases the technical efficiency by 0.024%. Large family size is associated among other factors with availability of cheap family labour. Sugarcane production is a labour intensive activity and hence a large family size is assumed to provide cheap labour. This results concur with those of Mailena *et al*. (2014), Sulaiman *et al*. (2015) and Ahmad *et al*.(2018). However, the results by Kadiri *et al*.(2014) showed a negative relationship between family size and technical efficiency of paddy rice production in Nigeria. On the other hand, Ali & Jan, (2017) and Getahun & Geta (2017) showed that there was insignificant effect of this variable on technical efficiency. This variable therefore needs more research on its effect on technical efficiency in order to make a reliable conclusion.

The findings on farming experience revealed a positive relationhip with technical efficiency. An increase in the level of experience by 1% increases sugarcane yield by 0.00429%. High farming experience is associated with increased proficiency in the processes of farm production and hence inreased productivity. Similar results were found by Nyagaka *et al*. (2010) in their analysis of economic efficiency in Irish potato production in Kenya. Mulwa *et al*. (2014) and Mburu *et al*. (2014) showed the same relationship between farming experience and efficiency among smallholder maize farmers in Western Kenya and Nakuru District in Kenya respectively.

Credit access showed a positive relationship with technical efficiency whereby access to credit services would increase sugarcane yield by 5.96%. Access to credit is an important source of capital which enables smallholder sugarcane producers to purchase production inputs on time thereby increasing farm productivity. It enables the farmer to adopt new technologies and practices through easing farmers liquidity constraints (Ike & Inoni, 2006). This variable was hypothesed to have a positive effect on technical efficiency which was confirmed by findings. The findings were similar to those by Kibaara (2005) and Sulaiman (2015) who found a positive relationship between access to credit and technical efficiency.

Extension services revealed a positive and significant relationship with technical efficiency among sugarcane farmers. This implied that access to extension services by sugarcane farmers would increase technical efficiency by 10.5%. The positive effect of extension services on technical efficiency could be linked to the information and knowledge received by sugarcane farmers which complement the trainings. These findings were consistent with those of Nchare (2007) and Simonyan *et al*. (2011). In contrast, Dube *et al*. (2018) found out that extension services had a negative effect on technical efficiency which was not expected and they recommended further research to be conducted on the same.

Farm distance from home showed a negative relationship with technical efficiency implying that nearer farms can be efficiently managed as compared to farther farms. The more the distance of sugarcane farm from home, the more the difficulty in farm management and hence low productivity. The findings were in line with those of Mamo, *et al*. (2018). Contract engagement also showed a negative relationship with technical efficiency. These findings on the contract engagement concur with those of Waswa *et al*. (

2012), Sopheak (2015) and Musungu & Sorre, (2017). The negative effect on technical efficiency may be attributed among other factors to increased input prices and harvesting of canes before maturity. On the contrary, the results by Hu (2013) and Igweoscar (2014) showed a positve and significant effect of contract engagement on technical efficiency. This variable therefore needs more investigation since farmers enter into contract engagement with the aim of increasing their productivity which the current study has revealed otherwise.

Soil testing before planting is an important practice which helps farmers to identify the type of nutrients needed in the soils as well as the type of crops appropriate in the area. The study showed a positive relationship of this variable with technical efficiency as expected. It showed that adoption of this practice increases technical efficiency by 4.76%. The results are consistent with the findings by Jamoza *et al*. (2013) and (Amolo *et al*., 2017).

5.3.3 Effect of farmers' participation in factory contracted services on profitability.

The study analyzed the relationship between provisions of selected factory contracted services on profitability in order to provide an inference on third hypothesis that farmers' participation in factory contracted services have no significant effect on profitability of smallholder sugarcane production in Malava Sub-county.

The results indicated that minority of respondents (34.11%) are contracted farmers with majority failing to participate into contract where some had withdrawn from contract engagement. This may be associated to situation where critical aspects of the contract, such as the pricing and grading mechanisms, benefits of engagement among others are not fully shared with the farmers. Literature had revealed that contracts are less likely to succeed under conditions of mistrust resulting from information asymmetry (Porter & Phillips-Howard, 1997; Kirsten & Sartorious, 2002 and Kottila & Rönni, 2008).

Non-contracted farmers were found to be more profitable whereby they could earn KES 14723.97 more than contracted farmers per acre of sugarcane. This is attributed to high cost of inputs offered by contracting factories. This concur with the results by Musungu and Sorre (2017) and Waswa *et al.* (2012). However, the findings contradict with those of Igweoscar (2014) who found out that contracted farmers could earn more income than non contracted ones. Supprisingly, the later study noted that there was no significant difference in welafare status between the two categories of farmers in Nigeria. Azumah *et al.* (2016) also showed that participation in contracted farmers were earning more income than non-contracted ones though in their study some of the contracted services had negative influence on income and others were insignificant.

Participation of farmers in factory contracted labour provision negatively affect the gross margin. Farmers' participation in this service decreases their income by about KES 11, 554 per acre of sugarcane. Sugarcane production in Kenya is a labour intensive activity. High labour is required during harvesting which drive farmers to seek contracted labour services. Comparatively, contracted farmers were found to be incurring higher labour cost than non-contracted farmers. On average the total labour cost incurred by a contracted farmer is approximately KES 23,050 per acre per season, while a non-contracted is approximately KES 17,500 per acre per season. Contract service providers charge higher labour costs and interest resulting to a reduction of farmers' profitability. Similar results were found by Musungu and Sorre (2017) who argued that Mumias Sugar Company had negatively impacted on farmers income due to high interest rates on their inputs including labour. However, the results contradict with those of Azumah *et al.* (2016) who found a positive influence on contracted labour on income in Ghana. However, though the later study found a positive influence the impact was too small where 1% increase in contracted labour could only increase income by 0.1% in Ghana.

Similarly, provision of credit services negatively affect farmers income. Results showed that participation of this service decreases farmers income by KES 21,779 per acre per season. With credit, farmers are expected to have access to productivity enhancing inputs such as fertilizer and seed-cane which are needed for the production of sugarcane that meet quality requirements set by the contracting factories. The negative influence revealed in the study is associated with the high cost of credit levied by contract service provider. Comparatively, the study revealed that non-contracted farmers get credit at lower costs as some obtain credit from informal sectors with low costs. This findings concur with the Sugar Industry Stakeholders Taskforce Report by the Republic of Kenya in 2020 which postulated that high cost of inputs and credit were negatively affecting farmers' gross margin. Rendering of extension services to farmers by sugar factories was however found to have a positive effect on the gross margin. Farmers who received contracted extension services were likely to increase their income by KES 24,714 per acre. This relationship could be attributed to new technological knowhow received by farmers to improve their sugarcane production. Similar results were found by Nchare (2007) and Mwololo *et al.* (2019).

The results showed that participation in most contracted services have no impact on gross margin of smallholder farmers. Contracts have been confirmed to be beneficial to both farmers and contracting factories if they are managed effectively and both parties are in a long-term relationship (Azumah *et al.*, 2016; Da-Silva, 2005; Eaton and Shepherd, 2001; Pradhan *et al*., 2016). Therefore, the contracting factory need to assume part of the production and price risks and transfers some of the rights in decision making to contracted farmers (Mwambi *et al*., 2016) which is likely to impact positively on farmers' profitability. Ideally, the type of contracted services investigated in this study appears to have failed to serve the intended objective of contracting where only extension service that positively impact farmers' profitability.

5.4 CONCLUSION

Agriculture plays an important role in improving household income and livelihoods of the rural population and it is clear that improving the resource use efficiency in agricultural production is important. Inefficient use of farm inputs in sugarcane production result to many adverse effects on farmers and environment because farmers using inputs inefficiently incur higher costs and sometimes low productivity, although they are able to produce the same or higher level of crop production by using farm inputs more efficiently and adopting best agronomic practices.

Adoption of the best agronomic practices by the farmers is expected to minimize their costs and impact on environment while maintaining or increasing crop returns. Determination of the effect of these practices on production is very important to provide empirical information to research institutions and policy makers. The results on the first objective of this study revealed that agronomic practices such as use of improved seed varieties, soil testing before planting, type of fertilizer applied, harvesting at the recommended time and frequency of weeding are significantly affecting sugarcane production. The first null hypothesis is therefore rejected in favor of the alternative. However, other recommended practices were found to be insignificant in the study area. As such, there is need for more empirical evaluation on these practices in order to make a reliable conclusion.

The second objective of the study was to determine the effect of selected socioeconomic factors on technical efficiency of smallholder sugarcane farmers in Malava Sub-county. In order to achieve this objective, technical efficiency levels among sugarcane farmers were determined using stochastic frontier model. Selected socioeconomic factors were then regressed on efficiency using tobit regression analysis to determine their effect on technical efficiency. The results showed that smallholder sugarcane farmers are inefficient with a mean technical efficiency of 0.7069 and indicated a high variation of technical efficiency among smallholder sugarcane farmers in the study area. The maximum likelihood estimates indicated that fertilizer, labour, seed-cane and farm size make significant contribution in improving the productivity of sugarcane among smallholder farmers. The study tested a null hypothesis that socioeconomic factors have no effect on technical efficiency among smallholder sugarcane farmers. The findings revealed that age, education, farming experience, family size, access to extension services, access to credit, contract engagement and soil testing before planting were significantly affecting technical efficiency. Therefore, the second null hypothesis is rejected in favor of the alternative that socioeconomic factors have a significant effect on technical efficiency among smallholder sugarcane farmers.

Finally, the study assessed the effect of farmers' participation in factory contracted services on profitability of smallholder sugarcane farmers in Malava Sub-county of Kakamega County. Profit function was used to determine the gross margin among smallholder sugarcane farmers. The analysis of variance (ANOVA) was applied to test whether the differences in profitability were statistically significant. The results showed that contracted farmers were less profitable as compared to non-contracted farmers and that there is a statistically significant difference between the two groups of farmers. Multiple linear regression analysis showed that participation in labour, extension, cash credit services have a significant effect on gross margin. However, participation in other services offered such as provision of seed-cane, fertilizer, agrochemicals and transport services have no effect on gross margin. The combined effect of participation in these services therefore provides enough evidence to reject the null hypothesis in favor of the alternative that farmers' participation in factory contracted services have a significant effect on profitability of smallholder sugarcane production.

5.5 RECOMMENDATIONS

The findings of the study revealed that there exist an opportunity to increase sugarcane production at the existing level of inputs use and level of technology. The study therefore came up with recommendations to guide farmers, policy makers as well as researchers for further investigations.

First, soil testing before planting, type of fertilizer applied and the number of times to weed the sugarcane farm per season were revealed to be very important practices yet most farmers had not adopted them. Therefore there is need for the Kenyan government to increase awareness on these practices through provision of quality extension services to smallholder farmers for increased sugarcane productivity. Furthermore, evaluation by research institutions is needed on some practices such as integrated weeding, pest and disease control and record keeping among sugarcane farmers since this study found these practices to be insignificant among sugarcane farmers.

Sugarcane farmers should establish a formal and active association to represent their interests so as to help them to acquire new and current information about sugarcane cultivation, access to credit, technical support and rights on contract engagement from the Agriculture and Food Authority- Sugar Directorate (AFA-SD), KESREF and Sugar factories. Moreover, some of the farmers in the area of study achieved high yield and obtained high technical efficiency and hence such farmers can be used as model farmers to illustrate the usefulness of good farming practices in order to reduce the gap that exists between the most technically efficient and the most inefficient farmers.

Furthermore, farmers engage in contract farming in order to improve their productivity. However, this study has revealed that contract engagement is negatively affecting technical efficiency. Most of the contracted services offered revealed a negative influence on profitability with only extension services indicating positive effect on profitability. As such, the Kenyan government should review farmer-miller contract policies and develop input cost mechanism that guarantees low cost of production and high returns to smallholder sugarcane farmers.

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APPENDICES

APPENDIX 1: SURVEY QUESTIONNAIRE

CONFIDENTIALITY: This survey questionnaire is being administered for the academic purpose. The information will be used to determine the effect of socioeconomic factors on economic efficiency of smallholder sugarcane production in Malava Constituency. All the collected data will be treated with utmost confidentiality and will only be used for the purpose of this study.

Name ____ (Optional)

SECTION A: DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

1. Indicate your age in years
   a) Less than 20 [ ]
   b) 20-30 [ ]
   c) 30-40 [ ]
   d) 40-50 [ ]
   e) Above 50 [ ]
2. State your gender
   a) Male [ ]
   b) Female [ ]
3. State your level of education
   a) No formal education [ ]
   b) Primary [ ]
   c) Secondary [ ]
   d) Tertiary [ ]
   e) Other (specify)……………………………………………………………………
4. In which category of sugarcane farming project are you involved?
   a) Farming [ ]
   b) Marketing [ ]
   c) Agency [ ]
   d) Extension [ ]

e) Other (specify)……………………………………………

5. What is the size of your family?

a) Below 5 members [ ]

b) 6-10 members [ ]

c) Over 10 members [ ]

d) Other (Specify) ……………………………………………

6. For how long have you been in the sugarcane farming industry?

a) Below one year [ ]

b) 1-5 years [ ]

c) 6-10 years [ ]

d) 11-15 years [ ]

e) 15-20 years [ ]

f) Over 20 years [ ]

SECTION B: INSTITUTIONAL FACTORS

i. Access to credit facilities

Please indicate **Yes** or **No** appropriately in the table below

Purposes for borrowing	Needed credit: Yes or No	Credit type: Money or Input	If Yes did you get it? Yes or No	If Yes, did you get the amount needed at market rate of interest?
1. Buying seeds				
2. Buying fertilizer				
3. Buy other agricultural inputs				
4. Farm equipment/implements				
5. Buying oxen for traction				
6. Buy other livestock				
7. Invest in irrigation				
8. Non-farm business				
9. Buying food				
10. Children's education				
11. Family Health/medical				
12. Rent in (fixed) land				
13. Social obligations				

ii. Infrastructural services

1. What is the distance of your farm from your home?
   a. Less than 1 Km [ ]
   b. 2 - 4 Km [ ]
   c. Over 4 Km [ ]
2. How is the status of the route towards your farm?
   a. Muddy road [ ]
   b. Murram road [ ]
   c. Tarmacked [ ]
   d. Any other (Specify) ………………………………………………………………………
3. After how long is the route maintained?
   a. Yearly [ ]
   b. After 1- 2 years [ ]
   c. After 3 – 5 years [ ]
   d. Over 5 years [ ]
4. Does the status of the route affect your productivity?

   Yes [ ] No [ ]

   If YES, how?

………………………………………………………………………………………………

iii. Extension services

1. Have you attended any farmer training about sugarcane activities / Farmer Field School?

   Yes [ ] No [ ]

   If YES, how many trainings have you attended in the last 3 years?

   …………………………………………………………………………..
2. Do you get agricultural extension services?

   Yes [ ] No [ ]

   If YES, how many times in the past one year did you receive extension services?

   …………………………………………………………………………..
3. Does these extension services have any impact in your farming activities?

   Yes [ ] No [ ]

   If YES, how does this affect your sugarcane production?

   a) Increase production [ ]

   b) Have no effect [ ]

   c) Reduce production [ ]

4. Do you listen to agricultural programs on Radio or TV?

   Yes [ ]   No [ ]

5. Is there any farmers' association where you belong?

   Yes [ ]   No [ ]

   If YES, in the last one year, how many times did you attend farmer's association?

   ……………………………………………………………………………………

SECTION C: PRODUCTION FACTORS

1. State ownership of sugarcane land
   a) Owned [ ]
   b) Rented [ ]
   c) Borrowed [ ]
   d) Other, specify ………………………………………………………………………….
2. What is the size of your land under sugarcane production?
   a) Below 2 acre [ ]
   b) 2 – 5 acres [ ]
   c) 6 – 10 acres [ ]
   d) Over 10 acres [ ]
3. Approximately what amount of cane seeds in tonnes did you plant?
   a. Less than 5 tonnes [ ]
   b. 5 – 10 tonnes [ ]
   c. 10 – 15 tonnes [ ]
   d. 15 - 20 tonnes [ ]
   e. Over 20 tonnes [ ]
   f. Other (Specify) ……………………………………………………………….

4. Which type and amount of labour do you employ in your sugarcane production activities?

Activity	**Type of labour**	**Number of laborers**	**Number of days taken**
First ploughing	Family labour [ ] Hired labour [ ] Traction [ ]	1-5 people [ ] 6-10 people [ ] 11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 - 2 days [ ] 3 – 5 days [ ] 1 week [ ]
Second ploughing	Family labour [ ] Hired labour [ ] Traction [ ]	1-5 people [ ] 6-10 people [ ] 11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 - 2 days [ ] 3 – 5 days [ ] 1 week [ ]
Planting	Family labour [ ] Hired labour [ ]	1-5 people [ ] 6-10 people [ ]	1 - 2 days [ ] 3 – 5 days [ ]

	Traction [ ]	11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 week [ ]
First weeding	Family labour [ ] Hired labour [ ]	1-5 people [ ] 6-10 people [ ] 11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 - 2 days [ ] 3 – 5 days [ ] 1 week [ ]
Second weeding	Family labour [ ] Hired labour [ ]	1-5 people [ ] 6-10 people [ ] 11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 - 2 days [ ] 3 – 5 days [ ] 1 week [ ]
Fertilizer application	Family labour [ ] Hired labour [ ]	1-5 people [ ] 6-10 people [ ] 11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 - 2 days [ ] 3 – 5 days [ ] 1 week [ ]
Harvesting	Family labour [ ] Hired labour [ ] Traction [ ]	1-5 people [ ] 6-10 people [ ] 11- 15 people [ ] 15 – 20 people [ ] Over 20 people [ ]	1 - 2 days [ ] 3 – 5 days [ ] 1 week [ ]
Others (Specify)			

5. Which production asset do you own?

Asset	Size / Number	Date acquired	Source of income
Tractor			
Plough			
Disc			
Irrigation pump			
Lorry			
Others (Specify)			

SECTION D: FACTORY CONTRACTED SERVICES

1. Which factory do you sell your cane?
   a. Butali Sugar Mill [ ]
   b. West Kenya factory [ ]

2. Do you engage in contract farming?
   a. Yes [ ]

b. No [ ]

If yes, which type of contract are you engaged in?

a. Resource-providing contract [ ]
b. Production management contract [ ]
c. Both [ ]

3. The services listed below are some the contracted services provided by the factory. Which ones do you participate in? **(For contract farmers only, tick Yes or No)**
   a. Provision of labour [YES] [NO]
   b. Provision of sugarcane cutting [YES] [NO]
   c. Provision of fertilizer [YES] [NO]
   d. Provision agrochemicals [YES] [NO]
   e. Extension services [YES] [NO]
   f. Transport services [YES] [NO]
   g. Credit services [YES] [NO]
4. Does the participation in these services (indicated in 3 above) beneficial to you?
   a. Yes [ ]
   b. No [ ]

5. If **yes in 4 above**, how is the contract engagement beneficial? (**Tick YES or NO**)
   a. Offer credit at low interest rates [YES] [NO]
   b. Offers farm inputs on time [YES] [NO]
   c. Inputs offered are of low cost [YES] [NO]
   d. Supply good quality sugarcane seeds/setts [YES] [NO]
   e. Good payment per tonne of sugarcane [YES] [NO]
   f. Offer infrastructural services [YES] [NO]
   g. Other (specify)_______________________

SECTION E: BEST AGRONOMIC PRACTICES

1. Below are various sugarcane varieties. Indicate appropriately which variety you planted;

a) KEN 00-13 [ ] b) KEN 00-3548 [ ] c) KEN 00-3811 [ ]

d)KEN 00-5873 [ ] e) KEN 98-530 [ ] f) KEN 98-533 [ ]

g) KEN 98-551 [ ] h) KEN 98-367 [ ] i) KEN 82-62 [ ]

j) KEN 82-121 [ ] k) EAK 73-335 [ ] l) D 8484 [ ]

m) KEN 83-737 [ ] n) KEN 82-601 [ ] o) KEN 82-472 [ ]

p) KEN 82-216 [ ] q) KEN 82-808 [ ] l) KEN 82-401 [ ]

m) KEN 82-493 [ ] l) Others _______________________

2. Did you carry out soil test in your sugarcane farm before planting?
   a. Yes [ ]
   b. No [ ]
3. Which kind of fertilizer do you apply in your farm?
   a. DAP [ ]
   b. Urea [ ]
   c. CAN [ ]
   d. Both DAP and Urea [ ]
   e. Both DAP and CAN [ ]
4. On average what amount of fertilizer / Manure do you apply on your farm per year?

Fertilizer	**Amount (Kgs)**
DAP	• 50 - 100 Kgs [ ] • 101 – 150 Kgs [ ] • 151 - 200 Kgs [ ] • 201 – 250 Kgs [ ] • Over 251 Kgs [ ]
Urea	• 50 - 100 Kgs [ ] • 101 – 150 Kgs [ ] • 151 - 200 Kgs [ ] • 201 – 250 Kgs [ ] • Over 251 Kgs [ ]
Any other (Specify)	
Manure	**Amount (Kgs)**
Farmyard	
Compost	
Any other (Specify)	

5. After how long did you harvest your cane (In months)?

____

6. Do you have farmer's handbook where you keep records on production?

Yes [ ] No [ ]

7. Do you have any mechanism to control pests and diseases in your farm?

Yes [ ] No [ ]

If yes how do you control____

8. How many times do you apply fertilizer on your sugarcane farm?
   a. Four times [ ]
   b. Three times [ ]
   c. Two times [ ]
   d. Once [ ]
9. Which method of weeding do you use in your farm?

a. Manual weeding [ ]
b. Chemical weeding [ ]
c. Biological weeding [ ]
d. Integrated weeding [ ]

10. At what interval do you weed your sugarcane farm per season?
    a. 4 – 5 weeks [ ]
    b. 2 – 3 weeks [ ]
    c. 1 – 2 weeks [ ]
    d. Any other…………………………..

11. How many times do you weed your sugarcane farm per season?
    a. Four times [ ]
    b. Three times [ ]
    c. Two times [ ]
    d. Once [ ]

SECTION F: EFFICIENCY OF SMALLHOLDER SUGARCANE PRODUCTION

1. **Variable resources/inputs used in sugarcane production.**

For each of the resources itemized in the table below indicate whether or not it was used in your sugarcane production last year and if it was used, indicate the quantity used, unit cost and the total cost per acre.

S/No	Variable input	Whether used or not		Quantity used	Unit cost per acre (kshs.)	Total cost per acre (Kshs.)
		Yes	No			
1.	**Fertilizer (Kilogramme**)					
	Urea					
	DAP					
	Manure					
2.	**Labour (Man-days)**					
	Land clearing					
	Burning					
	Fertilizer application					
	Herbicide application (If any)					
	Fungicide application (If any)					
	First weeding					
	Second weeding					

3.	**Fungicide (Litres)**					
4.	**Herbicides**					
5.	**Cuttings**					
6.	**Ploughing**					
7.	**Ridging**					
8.	**Fuel**					
9.	Others, please specify					

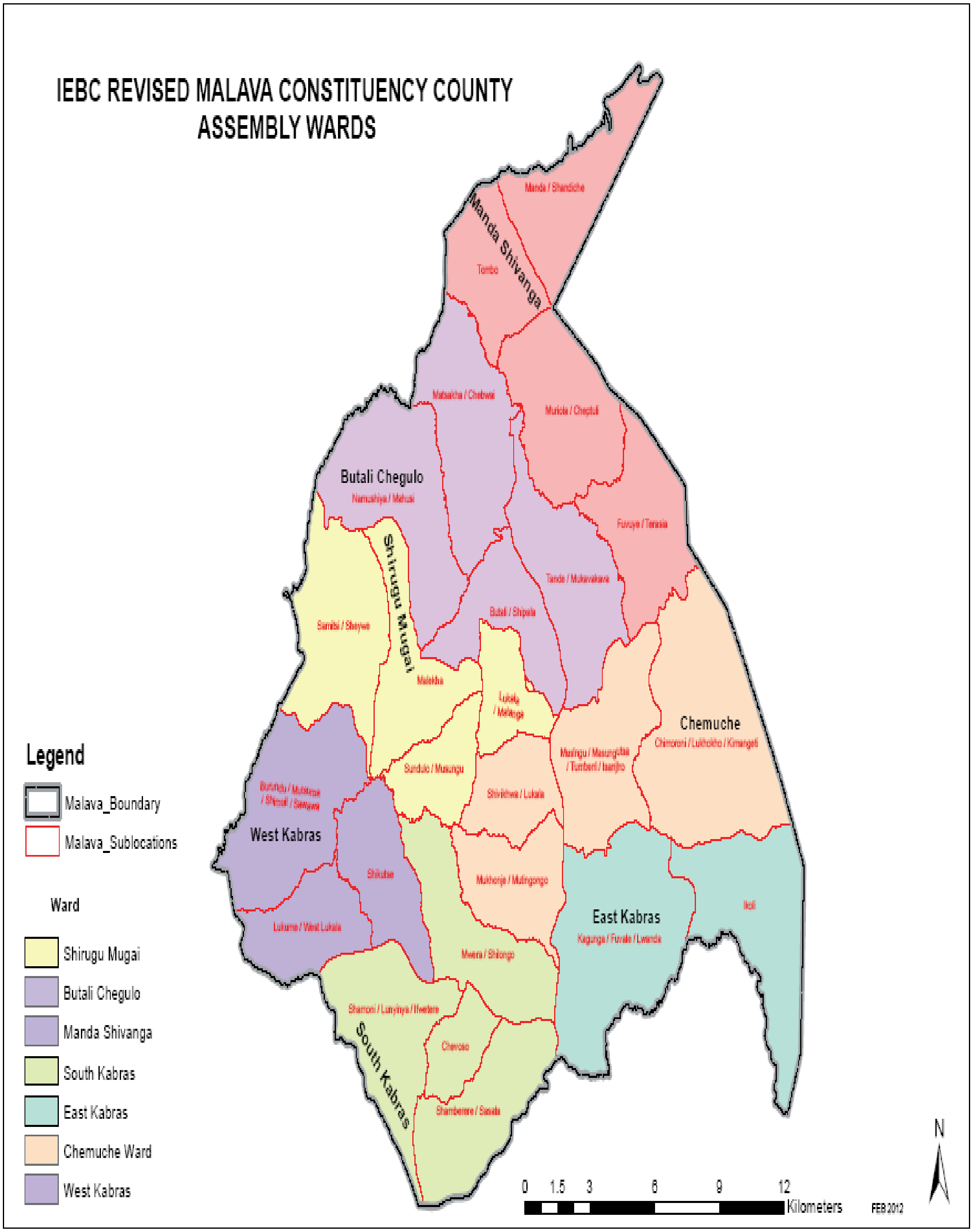
2. Output of sugarcane production

Total acres of land	**Output**			
	Number of trucks of sugarcane	**Weight (Tonnes) per truck**	**Selling price per tonne**	**Total**

END

THANK YOU

APPENDIX 2: MAP OF MALAVA SUBCOUNTY



Source: Independent Electoral and Boundary Commission (2017)

APPENDIX 3: WORK PLAN

	2018/2019								
ACTIVITY	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**
Proposal writing and presentation									
Correction of presented proposal									
Data collection									
Data analysis									
Publication and Thesis writing									

APPENDIX 4: BUDGET

Activity	Item	Quantity	Unit cost in Kshs.	Total cost in Kshs.
Proposal development	Printing papers Printing Photocopying Binding	2 reams 1copy (30 pages) 6 copies 6 copies	500 300 60 50	1000 300 360 300
Subtotal				**1,960**
Data collection	Printing papers Questionnaire preparation Questionnaire pretesting Transport Training enumerators Payment of enumerators Data collection Subsistence	2 reams 450 copies*4 50*4 For 15 days 3 3 15 days 15 days	500 2 2 5,000 1,000 6,000 4,000 3,000	1,000 3,600 400 75,000 3,000 18,000 60,000 45,000
Subtotal				**206,000**
Thesis preparation and report writing	Photocopying Loose binding Hardbound copies	7 copies * 60 pages 7 copies 7 copies	2 per page 50	840 350 700
Subtotal				**6890**
Contingency				**6000**
Total				**220850**

APPENDIX 5: RESEARCH LICENSE

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