ANALYSIS OF SOCIO-ECONOMIC FACTORS AFFECTING PROFITABILITY OF SORGHUM FARMING IN SIAYA COUNTY, KENYA

BY

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DECLARATION

Declaration by the Candidate

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DEDICATION

To my family, especially my wife, and loving Parents, Mr. and Mrs. Charles & Damaris Kula. I wish to dedicate this work to my loving parents for instilling the virtue of hard work and resilience that has propelled me continuously throughout my education to this level. Also, I appreciate my dear wife, Eddah Onyango and my children Blessing and Imani Onyango, for their moral support throughout this academic journey.

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ABSTRACT

The uptake of sorghum farming as a viable enterprise among small holder farmers in Siaya County has been low despite the changing climatic conditions that make sorghum the most suitable cereal crop for the region. Many questions have been raised regarding the low proportion of farmers who plant sorghum despite the desirable attributes of sorghum such as performing well under low input conditions, being drought resistant, less vulnerable to pests and diseases and its high nutritive value. The main purpose of this study was to analyze the gross margin of sorghum and the socioeconomic, institutional, and policy factors that affect profitability of the crop. The study was undertaken in Siaya County where cross-sectional survey research design was utilized in data collection. A combination of multi stage and purposive sampling was used. Alego-Usonga Sub County was purposively selected to represent the entire population because the sub county has high poverty levels, as well as high population of sorghum farmers. The target population included all the sorghum farmers in Siaya County. A total of 310 respondents randomly selected from Alego-Usonga Sub County were used to represent the research population. Gross margin and multiple regression were employed to examine the profitability of sorghum farming, and the effect of socioeconomic, institutional factors, and policy factors on the gross margins from sorghum respectively. The study was based on the theory of the firm Stata and SPSS aided in analyzing data. The results found gross margin from sorghum to be positive with a value of kshs. 4,286 per acre on average. The average revenue per acre was found to be kshs. 14, 175 while average variable cost per acre was ksh. 9, 889. This shows that sorghum farming is profitable in the short run. Socioeconomic, institutional and policy factors found to significantly determine gross margins included age of household head (β = -1.3122, p = 0.016**), household size (β = 3.791, p = 0.000***), education level of household head (β = -3.3826, p = 0.000***), household income (β = 1.7639, p = 0.018**), access to extension (β = 2.2287, p = 0.002**), number of crops intercropped with sorghum (β = -0.09369, p = 0.097*) and Nature of farming (β = 1.5265, p = 0.007**). In conclusion, sorghum farming in Siaya County is profitable in the short run, but in the long run it will depend on variability of all factors. Consequently, the study recommended that extension services should be improved; farmers should be encouraged to embrace sustainable farming practices such as mixed farming, farmers be encouraged to practice objective intercropping, and also to diversify their income sources. Finally, incentives should be provided to lure young people to embrace sorghum farming.

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ACRONYMS AND ABBREVIATIONS

ASARECA – Association for Strengthening Agricultural Research in Eastern and Central Africa.

GM – Gross margin

FAO – Food and Agriculture Organization

KNBS – Kenya National Bureau of Statistics

MAFAP – Monitoring African Food and Agricultural Policies

SPSS – Statistical package for social sciences

TC – Total Cost

TR – Total Revenue

TVC – Total variable cost

FSTS – Food security technical secretariat/Ministry of Agriculture

SIFSIA – Sudan Integrated Food security information for Action.

KGS – Kilograms

KSH – Kenya Shillings

QTLs – Quantitative Trait Locus

KALRO – Kenya Agriculture Livestock Research Organization

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter gives an overview of sorghum production globally, in Kenya, and in Siaya County. It also describes the statement of the problem, the objectives of the study, the hypotheses tested and a justification for the study.

1.1 Background Information

Sorghum is an essential crop in several parts of the world. It is the fifth grain globally in terms of annual production (Mundia et al, 2019). Sorghum provides a range of benefits in three main forms, as fiber, as grain, and as fodder (Frederiksen and Smith, 2000). Sorghum thrives in warm climate, and it is grown in the tropical and sub-tropical regions of Sub Saharan Africa and Asia. The crop matures within a shorter period of time and also produces relatively higher food levels per unit of energy spend compared to other crops (Mundia et al, 2019). Currently, sorghum plantations cover approximately 45 million hectares of land which makes it the second major crop across all ecologies in Africa after maize (ASARECA, 2006). Sorghum has served as an important staple food for the majority of impoverished communities in different parts of the world for several years. Sorghum is mainly grown in areas which experience low rainfall and relatively high temperatures (Okeyo et al, 2020). According to Kange (2014), sorghum's special extensive root system and waxy bloom on leaves reduces water loss and makes it an ideal crop in most arid and semi-arid regions of Africa and Asia. Previous studies have observed that sorghum has capacity to withstand higher average temperatures than most cereal crops (Frederiksen and Smith, 2000). Notably, the distinct features enable sorghum to preserve moisture, which enhances its ability to grow and do well even in semi-arid areas. This explains

why sorghum continues to be a dependable source of energy, proteins, vitamins, and minerals for poor people in most developing countries.

Sorghum does well in hostile climatic conditions where some crops cannot grow. Like cassava, sorghum does well even in areas that are considered to be less fertile and dry for the production of crops like wheat. Most smallholder farmers in different regions grow sorghum without applying fertilizer, pesticides, and other chemicals (Taylor and Duodu, 2019). The crop does well in areas with an altitude of 500 meters to 1700 meters above sea level with an annual rainfall of about 300 mm per year (Taylor and Duodu, 2019). Grain sorghum is ranked as the third most important cereal crop cultivated in the United States. According to Frederiksen & Smith (2000), sorghum is grown in more than 30 states in the United States although the crop is generally more common in the Southern Great Plains in America. Overall, grain sorghum is ranked as the fifth most significant cereal crop in the world. Nigeria, United States, and India were ranked as the largest, second-largest, and third-largest producers of grain sorghum in the world in 2010. Actually Nigeria and Sudan are the leading producers of sorghum in Africa ((Mundia et al, 2019). Frederiksen& Smith (2000) report that the United States has witnessed an increase in sorghum yields to about 4000kg/hectare and the country exports almost 50% of all its sorghum grains. Most developed countries and a few developing countries such as India mainly use sorghum as a fodder crop for cattle and poultry. The United States, Australia, and Argentina are the leading exporters of grain sorghum while Mexico is the world's leading importer of the crop based on 2010 sorghum trade statistics.

Sorghum is used as a staple food in several parts of the world. Sorghum meal is an important component of meals in South Africa. It is usually consumed in the form of

stiff porridge and is usually served with sour milk or any other acceptable supplement. In Ethiopia, sorghum is usually processed to produce a special kind of bread known as injera (Neela and Fanta, 2020). Indians mix sorghum with other grains to produce a special meal known as dosa. Similarly, Arabians use sorghum to make cakes, soups, and porridge. Sorghum grains can also be popped using oil to produce meals similar to popcorns.

Sorghum seeds and stock is a source of important feeds for both poultry and cattle. Some special species of sorghum are often used to make brooms, as roofing materials, for making baskets, for fencing, and also for making roofs. Still, sorghum stocks can be used as fuel. The use of sorghum in the production of homemade and commercial bread has been increasing since 2000.

Sorghum straw can be used to manufacture wall boards for houses. The straws can also be used to make biodegradable packaging materials. Sorghum fiber can also be used to make packaging materials for delicate electronic substances and equipment because it does not accumulate static electricity.

According to Frederiksen and Smith (2000), sorghum kernel has the same features as the maize kernel in that they both contain a lot of carbohydrates and very low proteins. This makes sorghum to be a good source of energy.

1.2 Sorghum Farming in Kenya

Sorghum is an important cereal crop in the medium and low altitude regions of Kenya. According to KALRO (2021), the vital role of sorghum in Kenya and the entire East Africa region is reflected in the fact that research on sorghum in the East African community began in the 1950s when the member states recognized the crop

as a vital component of their food security matrix. In Kenya, sorghum is commonly grown in Siaya, Migori, Homabay, Busia, Makueni, Tharaka Nithi, Meru and Nakuru counties. A report by Njagi et al

(2019) noted that Kenya has an estimated 240, 000 small scale sorghum farmers with land sizes of between 0.4 and 0.6 hectares spread in different parts of the country. The sorghum producing regions, especially Siaya and Makueni usually experience poor yields or total failure of maize crops during seasons of low rainfall. Consequently, the major concern for agricultural stakeholders in the sorghum subsector in Kenya has always revolved around increasing the yields and productivity of the crop, enhancing the ability of sorghum varieties that are more resistant to droughts, pests and diseases, as well as improving the efficiencies along the sorghum value chains.

The arid and semi-arid nature of the counties and regions where sorghum is grown explains why these regions are generally more suited for sorghum production as compared to other cereal crops such as maize. According to Enserink (1995), some of the perceived disadvantages of sorghum include the vulnerability of the crop to damage by birds, lack of organized marketing channels for sorghum as compared to maize, and more input required in the preparation of sorghum compared to maize. Nonetheless, sorghum has attracted considerable interest from research and government development agencies such as KALRO since the 1980s. According to the FAO Report of 1979, the long term goals of Kenya's sorghum was to improve the role played by the crop in Kenya's economy (Enserink, 1995). Surprisingly, most smallholder farmers have shifted their focus to maize and have continued to give sorghum second precedence after maize over the years. However, the communities that grow sorghum are yet to exploit the full potential of this crop despite the ability

of the sorghum to contribute significantly to solving the perennial problem of food and nutrition insecurity.

Table 1.1: Sorghum production Trend in Kenya between 2010 and 2020

Market Year	Production (1000MT)	Growth Rate
2010	164	65.66%
2011	160	-2.44 %
2012	167	4.38 %
2013	169	1.20 %
2014	178	5.33 %
2015	189	6.18 %
2016	117	-38.10 %
2017	149	27.35 %
2018	206	38.26 %
2019	150	-27.18 %
2020	200	33.33 %

Source: United States Department of Agriculture (2020)

Kenya has recorded a slight growth in the production of sorghum between 2010 and 2020 although the country's sorghum yields is still lower compared to what other countries in East Africa, especially Ethiopia. Whereas countries like Ethiopia have recorded tremendous growth in sorghum yields over the last couple of decades, Kenya's sorghum production and productivity has shown little improvement (Njagi et al, 2019). For instance, in 2010, Kenya produced 164, 000 metric tons of sorghum while in 2020, the country produced about 200,000 metric tons of the crop (United States Department of Agriculture, 2020). The slight growth of 36,000 metric tons in the 10 year period was characterized by mixed trends in terms of net annual production growth. Climate change and reducing levels of soil fertility have affected the ability of sorghum growing regions in Kenya to experience sustainable growth of sorghum yields. According to KALRO (2021), most sorghum growing regions in

Kenya have continued to experience low yields because farmers use the local cultivars which are mostly affected during the short rain seasons because they mature slowly. Pests such as birds, aphids and boll worms have also affected yields among farmers. Poor storage facilities and high moisture content during storage have also contributed to post harvest losses and reduced overall yields for most farmers. Njagi et al (2019) reported that almost 15% of the total sorghum produced in Kenya is lost in the field and other aspects of post-harvest losses. These factors have contributed to the fluctuating growth prospects in the sorghum sub sector over the years and Kenya needs to do more to realize a consistent growth prospects for the crop. Despite the stagnated production trend, there is a huge potential for the sorghum subsector in Kenya. For instance, the demand for sorghum in the alcohol industry to make beer has led to a rise in the quantity of the crop used for industrial purposes by more than 20% in the previous five years (Njagi et al, 2019). Moreover, the fact that Kenya still imports about 30% of the total sorghum consumed in the country shows that the country could do more to upscale sorghum yields going forward.

1.3 Sorghum Cultivation in Siaya County

Siaya County is one of the regions that produce sorghum in Kenya. Traditionally, Siaya residents used sorghum to cook porridge and ugali. Farmers have focused more on maize despite the low returns from maize (Otieno, 2014). Fluctuations in rainfall, drought, and the changing climatic conditions have negatively affected maize yields in the County. However, farmers have continued to devote more of their land parcels to maize than sorghum even though the former can do well even in hostile climatic conditions. According to a study carried out by Akuno et al., (2015), only 10% of farmers in Siaya County have fully embraced sorghum with the remaining 90% still focusing on maize as their preferred crop. At the same time, increased demand for

sorghum by the alcohol-based companies such as the Kenya Breweries has increased the market outlets and commercial value of the crop. According to Obiero (2013), Siaya is a food deficit county because the county meets its food requirements for an average of four months only every year. Similarly, Otieno (2014) reported that over-reliance on maize has led to perennial food shortages with 37% of the Siaya population suffering from food insecurity mainly occasioned by the fact that residents have neglected sorghum and other drought-resistant crops in favor of maize. This is quite disturbing considering the county's productivity in maize, which happens to be the main staple food crop, is quite low compared to other parts of the country. There is a need to boost the production of sorghum to improve food security in the county.

Table 1.2: Sorghum Yields in Siaya County between 2012 and 2018

Year	Area under cultivation (Ha)	Yield (MT)
2012	19, 185 ha	19707 MT
2013	11630 ha	14358
2014	15986	11585
2015	10574 ha	17942 MT
2016	14949	12448
2017	20229ha	21, 404 MT
2018	11295	17, 257

Source: MoALF, 2021.

From the table, it is evident that the area of land dedicated to production of sorghum has continued to stagnate with very minimal growth between 2012 and 2018. On the same note, the average output of sorghum produced in the county has been fluctuating from 19, 707 metric tons in 2012, to 17, 257 metric tons in 2018 with minimal variation between the years.

1.4 Statement of the Problem

Over-reliance on maize has contributed to perennial food shortages in Siaya County. This is because the yield for maize in the county has been poor and fluctuating over

the years. Despite the increasing need for farmers to embrace sorghum production to supplement maize, the adoption of the crop has been rather low. According to Pender et al., (2006), only 36.8% of households in Siaya County grow Sorghum, with 35.4% growing the crop for home consumption and only1.4% growing the crop for commercial purposes. The productivity of local maize in Siaya County stands at 632.3 Kg/ha during the long rains and 599.5 kg per acre during the short rains while hybrid maize seeds produce 681.9kg/ha during the short rains and 780.5 kg/ha during the long rains (Obiero, 2013). This is quite low when compared with other regions in Kenya where farmers get up to 8.8 tons/ha (Nyataya, 2014).

Interestingly, sorghum does well even in seasons of low rainfall. Essentially, sorghum is less vulnerable to production risks resulting from fluctuations in rainfall compared to maize. The crop can do significantly well even without the application of fertilizers and pesticides. At the same time, sorghum is less affected by pests and diseases as compared to other crops such as beans and maize. Sorghum is also rich in terms of nutritional value. The sorghum grain contains substantial quantities of vitamin B which supports metabolism, as well as the development of skin and hair. At the same time, sorghum contains magnesium which is vital for the formation of bones and also facilitates numerous biochemical reactions in the body and development of a healthy heart (Davidson, 2019). Additionally, sorghum supplies the body with fiber which helps to stabilize the blood sugar level and body weight. Another important attribute of sorghum is the fact that it is a gluten free protein which makes it a recommended source of protein for people suffering from cardiac diseases. Finally, sorghum supplies the body with proteins, fats, carbohydrates, zinc, copper and iron (Davidson, 2019). Despite the special attributes of sorghum, the uptake of the crop in Siaya County has been rather low. Most farmers continue to grow maize at the expense of

sorghum although sorghum is more adapted to the harsh and unpredictable weather conditions in Siaya County. According to a study carried out by Kange et al., (2014), the low uptake of Sorghum in Siaya County partly explains why the county continues to suffer from perennial food shortages. There is inadequate information explaining why most households in Siaya County shy away from growing sorghum despite the crop's ability to thrive even with low rainfall. Surprisingly, previous studies have done little in examining the economic returns of sorghum in Siaya County. Consequently, this study sought to determine the profitability of sorghum by analyzing the gross margins of the crop. The study also examined the socioeconomic and institutional factors that influence the profitability of the crop.

1.5 Research Objectives

1.5.1 General Objective

The purpose of this study was to analyze the profitability of sorghum farming; and to determine the socioeconomic, institutional, and policy factors that influence the gross margin from sorghum in Siaya County.

1.5.2 Specific Objectives

1. To determine whether sorghum farming in Siaya County is profitable.
2. To assess socioeconomic factors influencing gross margin from sorghum in Siaya County
3. To assess institutional and policy factors influencing gross margins from sorghum in Siaya County

1.6 Hypotheses

H_{01}: Sorghum farming in Siaya County is not profitable

H_{02}: Socio-economic factors do not affect gross margins of sorghum in Siaya County

H_{03}: Institutional and policy factors do not affect gross margins of sorghum in Siaya County.

1.7 Justification of the Study

Information about profitability and gross margins from sorghum in Siaya County has been limited. However, the low and unpredictable rainfall pattern in Siaya County has led to low and irregular harvests for maize. In other words, overreliance on maize has been unable to guarantee food security to the people of Siaya County because of the low productivity of maize in the county. This means that the county must find alternative crops that would make the county food secure. According to Mango (1999), all households grow maize intercropped with beans, although only a small percentage of the farmers grow sorghum. Interestingly, sorghum does well in seasons with low rainfall, and also with limited supply of inputs such as fertilizer and pesticides. Sorghum is generally a hardy crop that is not easily affected by pests and diseases. Consequently, Siaya County residents must exploit the huge potential that sorghum presents and use the crop to supplement other crops such as sweet potatoe, cassava, beans, cow peas, and traditional vegetables in enhancing food security status of Siaya county residents.

Crops such as sorghum and cassava are good alternatives that can do well in Siaya, and assist the county to cope with changing climatic conditions. However, farmers in Siaya County are yet to embrace the crop fully. At the same time, there is limited literature about the economic returns and profitability of sorghum in Siaya County. Therefore, this study sought to add literature on the economic returns and profitability of sorghum in Siaya County, as well as the socioeconomic and institutional factors which influence the profitability of the crop. Having sufficient information about the

gross margins would enable farmers in Siaya County to make a favorable decision in terms of picking sorghum as a preferred crop in the county. On the same note, having information about the socioeconomic and institutional factors that influence gross margins would enable farmers and other stakeholders to understand the farm management practices and institutional variables that could enable them to improve the productivity of sorghum in the county.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter looks at previous studies that have been conducted about sorghum, theoretical literature upon which this study is founded, including key concepts such as gross margin analysis, socio-economic and institutional variables and how they are perceived to influence profitability, as well as previous studies on sorghum in Kenya and Siaya County. Finally, this section outlines the conceptual framework supporting the study.

2.1 Sorghum Production Trend in Kenya

The small sizes of land under sorghum, coupled with low uptake of modern production technologies that could enhance sorghum yields have reduced the yields of sorghum in Kenya. For instance, Kenya accounts for only 0.6% of the total sorghum produced in Africa (ASARECA, 2006). In general, Kenya has potential to enhance the productivity of sorghum even though most of the country's sorghum production has been for consumption purposes (Kilambya and Witwer, 2013). In general, Kenya has over the years been a net importer of sorghum, except in 2010 when the country exported 49, 709 tonnes of the crop to Somalia and Sudan, especially because the two countries experienced severe drought in that year.

The average production of sorghum in Kenya is 0.85 tons per acre based on a study carried out by Kange et al., (2014). Kange's study compares well with a study by Too et al., (2014) reported that the yield of sorghum grain in Sub Saharan Africa has been as low as 2 tons per hectare despite the vital position that sorghum continues to hold in terms of food security and sustainability of livelihoods among rural households in

sub-Saharan Africa. Consequently, increasing the area under sorghum could be a huge step in enhancing the yields and average productivity of the sorghum crop in Kenya. Kenya could emulate a country like Zimbabwe where the large sorghum commercial farms has the yields for sorghum going as high as 2 to 3 tonnes per hectare while the small traditional smallholder farmers still produce low yields of between 400 kg to 600 kg per hectare. The variations in yield among farmers in Zimbabwe show that with proper management and increased economies of scale, it is possible to increase the yields and profitability of sorghum crops even in Kenya.

Another challenge that has continued to affect sorghum farming is the fact that young farmers in Kenya have continued to shy away from sorghum farming. In other words, sorghum has remained relatively more popular among older farmers as compared to young farmers. For example, a study by Amusala et al., (2018) found that sorghum farming in Kenya was dominated by older people, compared to Uganda where farmers who cultivate sorghum were relatively younger. The fact that Kenyan farmers are relatively old could partly explain why Kenyan farmers are slow when it comes to adopting new sorghum farming technologies (Amusala et al, 2018). This is because older people tend to be less receptive to new technologies compared to their younger counterparts who generally tend to embrace new technologies faster.

Additionally, the use of local farm-bred seeds usually reduces the overall yield of sorghum because the quality of such seeds is usually low. According to a report by MoALF (2016), spoilage of seeds which include seeds rotting before they germinate is one of the key challenges that farmers who use local seeds face. The increased spoilage of seeds sometimes emanates from the poor storage methodologies farmers employ to keep the grain. Interestingly, Kange et al (2014) found that about 53% of

farmers in sorghum growing counties in Kenya prefer the use of local seeds as opposed to commercial certified seeds. Apparently, most of these farmers consider the locally produced seeds to be cheaper because they can easily recycle them while the commercial seeds cannot be recycled. At the same time, most farmers believe that certified seeds such as the special white variety are usually preferred by birds. Regrettably, the special varieties such as the white variety are often more preferred for industrial purposes by companies such as the Kenya Breweries.

The acidity of soils has also been a challenge in sorghum farming. Too et al., (2014) mentioned the increasing level of acidity of soils as another factor that has continued to affect sorghum production in several parts of Kenya. Acidity is generally a big problem in Kenya considering the fact that, acid soils cover up to 13% of the entire arable land in the country (Too, Were, Onkware, and Kisinyo et al, 2014).

2.2 Review of Challenges Facing Sorghum Farming in Kenya

Sorghum farming in Kenya has faced several challenges that have affected the success of the sorghum value chains in the last several decades. According to Kange et al., (2014), some of the constraints that affect sorghum farmers include lack of adequate inputs, poor seed quality (use of uncertified seeds), as well as pests and diseases. According to KALRO (2021), local sorghum seeds normally mature late and are sometimes affected during the short rain seasons common in the arid and semi-arid regions such as Siaya County. Although sorghum is generally a hardy, various diseases such as leaf spot, rust, leaf blight, anthracnose, ergot, head smut, and covered kennel smut (KALRO, 2021). The absence of a well-organized marketing system for sorghum seeds, as well as harvested sorghum grain is partly to blame for the sluggish uptake of sorghum among some regions in Kenya. A report done by ASARECA

(2006) also categorized the challenges facing sorghum marketing around ineffective marketing channels, small sizes of land under sorghum both in Kenya and other Eastern African countries, absence of supportive policies which can provoke farmers to increase the land under sorghum, low level of processing and utilization of the crop among Kenyans and other countries in Eastern and Central Africa. Few processing and utilization technologies is also a big challenge that has affected the marketability of sorghum among both the rural and urban populations (KALRO, 2021). Sorghum is mainly consumed as porridge in most households with the demand for the brown and red sorghum varieties considered to be lowest among most household especially because such varieties are believed to be less presentable. Lack of adequate extension services is another factor that has affected the ability of farmers in Siaya County to optimize their potential (Okeyo et al, 2020). Extension services is a critical factor that helps farmers to access, understand and embrace new technologies such as organic farming, improved seed technologies, and best practices for minimizing post-harvest losses. The study done by Okeyo et al (2020) focused on categorizing and investigating lack of access to extension as a challenge that affects the adoption and productivity of the sorghum crop without assessing the effect of lack of access to extension on the profitability and gross margin of sorghum. This study intends to bridge this gap by assessing the effect of extension on the gross margin of sorghum farming among small holder farmers in Siaya County.

Sorghum farmers also face problems associated with poor soils and changing climatic conditions in Siaya county and other parts of Kenya. The declining fertility of the soils is another factor that has negatively affected the yields from sorghum over the years. According to Okeyo et al (2020) the small land sizes and poor farm management by most farmers have contributed to the low productivity of sorghum in

Siaya County. Mango (1999) noted that poor soils and environmental degradation are some of the worse problems that affect sorghum farmers in Siaya County. Aside from low levels of soil fertility in most parts of Siaya County, intense rainfall and heat stress as well as excessive dry spell in some seasons also affect sorghum yields in Siaya County (MoALF, 2016). Unfortunately, the hazards of intense rainfall, and heat stress caused by dry weather spells are usually common in AEZs LM3, LM4 and LM5 ecological regions where most of the sorghum in Siaya County are grown (MoALF, 2016).

Nonetheless, whereas declining soil fertility affects the output in sorghum farming, sorghum still produces better yields than maize in such soils because the latter is hardy and adapts to hard soil and environmental conditions than maize. Apart from the limited supply of improved sorghum seeds within the reach of farmers, financial constraints also affect the ability of farmers to purchase the improved sorghum seeds (Okeyo et al, 2020). The study also reported attack of the sorghum fields by birds to be another challenge that affects the output and productivity of sorghum fields in Siaya County and other parts of the country (Okeyo et al, 2020). However, the study by Mango (1999) as well as other previous studies on the crop has failed to provide adequate literature with regard to the economic returns from sorghum. Consequently, this study seeks to contribute more literature and offer more insight regarding the profitability of sorghum farming in Siaya County. These studies show that sorghum has huge untapped potential, and that farmers could increase the productivity of their farms, increase the overall yields of sorghum by increasing land under sorghum, especially in terms of benefits of economies of scale that come with large scale production if they embrace sorghum farming.

2.3 Why Sorghum is a Critical Cereal Crop

Sorghum is an important crop that can supplement maize to solve the food insecurity challenge in Siaya County and other parts of Kenya. The intensity and persistent droughts brought forth by climate change in recent years have significantly shifted the focus of policymakers and researchers towards drought-tolerant crops such as sorghum (ASARECA, 2006). In this regard, there are several previous studies which have cited the important role that sorghum plays in enhancing food security. For instance, a study done by Ibrahim and Hassan (n.d.) noted that sorghum is a special cereal crop because it can tolerate poor soils, and also because it can do well in harsh weather conditions. The amount of focus, research and effort put to improve the productivity of sorghum confirms the important role of sorghum in enhancing food security in Siaya county and other parts of Kenya (Okeyo et al, 2020). A report by ASARECA (2006) also mentioned sorghum as a vital cereal crop that can assist rural populations to attain food security, especially the rural poor who reside in arid and semi-arid areas. This is because sorghum plants have a very large root to leaf surface area feature that enables the sorghum plants to absorb a lot of moisture even in relatively dry areas (Ibrahim & Hassan, n.d.).The extensive root system enables the sorghum plants to absorb enough moisture from deep down the surface even in seasons of low rainfall. This is one of the core reasons that allow sorghum to be a relevant crop even in arid and semi-arid areas. Okeyo et al (2020) agree that sorghum is a suitable alternative crop that could assist communities in arid and semi-arid areas to deal with problem of food insecurity. The fact that Kenya has 80% of its land mass being arid and semi-arid makes sorghum a critical crop for the country's food security prospects. To this end, Okeyo et al (2020) assessed the factors that affect the adoption of sorghum crop among farmers in Siaya County, and found preference for maize and

limited land sizes as common challenges that have impeded the adoption and increased productivity of sorghum in the County.

The special attributes of sorghum partly explain why sorghum covers the second-largest land area in Sub Saharan Africa - only coming second to maize. According to Zalkuwi et al., (2015), sorghum is important because it can be used for several purposes such as food, feeds for livestock, as well as the industrial application for beer production. A report by ASARECA (2006) affirms that if sorghum could be produced more consistently with top-notch management practices, the most marginalized regions in Eastern Africa would benefit from increased food yields, food security status, as well as enhanced income levels. Sorghum requires less input in terms of fertilizer, pesticides, and other chemicals which make it a good option for resource constrained small holder farmers. Too et al., (2014) agree that sorghum is a vital staple cereal crop in many parts of Kenya, as well as in other parts of Sub Sahara Africa. This is because of the unique attributes of sorghum that makes it survive even in the arid and semi raid areas that are characterized by relatively high temperatures. Kange et al., (2014) pointed out that sorghum is an important cereal crop that has the potential of boosting food security in arid and semi-arid areas where many cereal crops produce little. Similarly, Frederiksen & Smith (2000) asserted that sorghum is a special crop because of its ability to generate and sustain livelihoods for farmers in areas that are quite dry for other rain crops. Similarly, Ibrahim & Hassan (n.d) reported that sorghum is a special cereal crop that can assist several areas, especially the impoverished regions to reduce the level and intensity of food insecurity. At the same time, sorghum competes with grain crops such as maize because of the short season requirement that makes it ideal for a rotational approach to crop husbandry. According to Frederiksen & Smith (2000), aside from grain, sorghum is appropriate

for silage and is commonly grown for forage on a large scale in the United States. Ball and Rothgeb (1915) noted that livestock and poultry of different kinds feed on sorghum grains. Findings from all these studies point to the fact that more studies should be done on sorghum, especially issues about the profitability and the economic returns from sorghum. This is what this study aims to achieve.

2.4 Gross Margins, uses and Returns from Sorghum

There are several uses of sorghum. Apart from food, sorghum can be used to provide fuel and also as animal feed. According to a study carried out by Janssen and Rutz (2012), using sorghum to produce biofuel can significantly increase the gross margins from the crop, especially if a well-organized management regime for the crop is executed. However, Njagi et al (2019) noted that sorghum farming in Kenya has mainly been subsistence in nature. A study on sorghum done in Western Kenya and Eastern Uganda by Amusala et al (2012) found that the yield from sorghum was less than 1 ton/acre, and this was expected to drop even further owing to the present climate change and unpredictable rainfall patterns in the region. The low yields implies that sorghum production and productivity has not reached the optimal levels in Siaya County. Another study by Njagi et al (2019) found that a typical Kenyan sorghum farmer who does not use improved sorghum seeds and fertilizers could make a negative gross margin of Kenya Shillings 17, 440 while a commercial oriented sorghum farmer who uses both fertilizer and improved seeds could make gross margin of up to Kenya shillings 13, 700 per acre. The huge variation in gross margin between farmers who farm their crop without fertilizer and improved seeds vis-à-vis those who use such inputs shows that a lot of study needs to be done to understand the socioeconomic factors which influence the gross margin among small holder sorghum farms. According to a study carried out by Zalkuwi et al. (2015), the gross margins

from sorghum production in Nigeria and India were found to be Rs. 17354.30 (about Ksh. 26, 031.45) and Rs. 20642.10 (about Ksh. 30, 963.15) per acre respectively. The output from sorghum production was found to be 17.68 QTLs and 18.14 QTLs in India and Nigeria respectively. According to Kilambya and Witwer (2013) the average sorghum yield in Kenya has been 0.8 tons per hectare for the last two decades with the peak production being experienced in 2005 when production averaged 1.2 tons per hectare. These yield levels are still very low considering the fact that with proper field management regime certified improved seeds have the capacity to produce between 2 and 5 tons per hectare per season of production (Kilambya and Witwer, 2013). A study done by Karanja et al (2017), on behalf of KALRO found that when growth enhancers were introduced to Katumani sorghum, the gross margin from the crop was KSH. 53, 633 per acre in a season where rainfall averaged more than 300mm, and Ksh. 18, 101 per acre in a season where the rainfall supply was below 300 mm. However, a similar study that focuses on the gross margins has not been carried out in Siaya County.Another study carried out by Rutz (2012) underscored the importance and profitability of sorghum when used to produce ethanol on a large scale. According to Oloo (2014), the use of modern sorghum varieties can significantly improve the returns from the crop because improved sorghum varieties such as the sweet sorghum have immense industrial use. The fact that most sorghum farmers in Kenya do not add value to their produce before selling also makes it difficult for them to make huge profits from the cereal crop (Njagi et al, 2019).

The sweet sorghum has the potential of producing biofuels for motor vehicles apart from other obvious uses such as fodder. Consequently, Faki (2017) asserted that sorghum should no longer be considered as a poor man’s crop because of the changing tastes and the high degree to which Kenyans are embracing beer processed

from sorghum. A report by Njagi et al (2019) found that the emergence of sorghum as a vital component in the manufacture of beer has led to the increase in the industrial demand and use of sorghum for industrial purposes by more than 20% in the past five years. In other words, commercializing sorghum production can significantly increase farmers' incomes while also safeguarding the food security interests of communities and counties that grow sorghum.

Post-harvest losses are another big challenge that has continued to affect sorghum farming in Kenya and other parts of Africa. According to research done by FSTS (2011), post-harvest losses are another serious problem that has continued to affect sorghum farmers and other crop enterprises. Delayed and irregular harvesting is one of the key challenges that contribute to post harvest losses (MoALF, 2016). Post-harvest losses usually affect farmers who do not have proper storage facilities to keep their produce after the harvest. Lack of quality storage facilities implies that farmers have to contend with the pressure to sell their products faster in order to avert losses, or they end up having huge financial losses when their produce goes bad or deteriorates in quality (MoALF, 2016). Farmers can also experience post-harvest losses during winnowing and packaging. For instance, the Food Security Technical Secretariat (2011) report further revealed that uncoordinated research and the lack of adequate extension services have continued to affect the overall yields from sorghum and other crops. To this end, previous studies have done little to investigate gross margins from sorghum in Siaya County and the socioeconomic factors affecting its production. As such, this study sought to bridge this gap by investigating the socioeconomic, institutional, and policy factors which affect the gross margin of the sorghum crop among the small holder farmers in Siaya County.

2.5 Sorghum Farming and Adoption Trends in Kenya

Although sorghum is a distinct and hardy crop that does well even in harsh environmental and climatic conditions, the Kenyan population is yet to fully embrace the crop both as food and as a viable commercial crop. Interestingly, sorghum is regarded as the only cereal crop species indigenous to Kenya, and it can do well in any region with an altitude of 0 to 2500 above sea level and rainfall of at least 250 mm per year and minimum temperature of 10 degrees Celsius (Kilambya and Witwer, 2013). Yet despite these favorable and distinct features, the area under sorghum in Kenya is very minimal, especially when compared to other cereal crops grown in the country. A study conducted by Akuno et al., (2015) found that about 90% of the Kenyan population depends on maize for food and commercial purposes even in areas where sorghum can be a better substitute. It is still not very clear why farmers tend to be attached to maize farming even in areas where sorghum production has a clear comparative advantage in terms of weather conditions, input use, and yield expectations. According to a study carried out by Nyangweso and Amusala (2018) farmers are often not willing to purchase certified sorghum seeds even if such seeds have distinct and special attributes such as being tolerant to drought and unmatched yields. On the same note, Akumo et al., (2015) noted that some of the factors which have affected the production and success of sorghum production in Siaya County and other parts of Kenya include the inadequate supply of seeds appropriate for the socioeconomic and agro-ecological needs of the rural small scale farmers as well as lack of a well-coordinated sorghum market. Amusala et al., (2018) further recommended that farmers should increase the land under sorghum in order to increase their yields by taking advantage of economies of scale in their production

and marketing of the crop. However, the scarcity of land limits the scope of escalating sorghum production through increasing acreage.

Notably, the sorghum studies carried out by both Akuno (2015) and Nyangweso et al., (2018) did not focus on determining the gross margins of sorghum in Siaya County. Still, the studies did not focus on examining the socioeconomic and institutional factors influencing the gross margins from sorghum. Therefore, there is a need to carry out more studies to determine the economic returns of sorghum and whether the crop is profitable. This study provides new insight with regard to the profitability of sorghum by analyzing the gross margins of the crop.

2.6 Sorghum Consumption and Commercialization Dynamics

In Kenya and other parts of Africa, most of the sorghum produced is for home consumption. This is because sorghum is mostly grown by small scale, resource-poor farmers whose main objective is mostly food security for their households. In most cases, the sorghum grain is processed into flour which is then used to make a special porridge commonly referred to as 'ugali' in Kenya. According to ASARECA (2006), at least 70% of the total sorghum produced in the major sorghum production zones in Africa is consumed as food. Kilambya and Witwer (2013) agree that only about 30% of the total sorghum produced by smallholder farmers is marketed. This is because the majority of sorghum growing farm households mainly produce only what is sufficient to satisfy their household food requirements. The small quantities of sorghum which are sold as flour commercially are usually processed by millers who sometimes mix the sorghum with cassava floor, and sell it to consumers as a packaged floor (Kilambya and Witwer, 2013). In such cases, the flour produces a byproduct that could be used as animal feeds. The commercialization of grain sorghum has continued

to face various challenges. The most prevalent one has been the small areas committed to sorghum production relative to other substitute cereal crops such as maize. The small areas underproduction leads to higher prices compared to maize which in turn makes sorghum quite uncompetitive and unattractive (ASARECA, 2006). On the other hand, Chimoita (2017) noted that the low uptake of the latest sorghum seed technologies and the continuous behavior of farmers' sticking to old low productive sorghum varieties have contributed partly to the inability of farmers to embrace commercialization of sorghum production. Interestingly, Chimoita (2017) reported that the poor flow of research information about the latest agricultural technologies between research institutions to farmers was also to blame for the slow uptake of technologies. This is because the inefficiencies in the flow and delivery of information to farmers affect the ultimate consumption of research outputs generated by research institutions. Even the government of Kenya has not been effective in transferring information about sorghum technologies to farmers because of limited human resources as well as other logistical challenges.

Post-harvest losses have also impacted the sorghum production and marketing in a big way. Kilambya and Witwer (2013) reported that up to 11% of the total sorghum produced in Kenya is lost after harvest while 10% is used to make animal feeds, and another 2% is used as seeds in the following season.

Aside from domestic production, Kenya sometimes imports sorghum from countries such as Uganda and Tanzania to supplement what is produced at home. Whereas EAC and COMESA member states are allowed to freely export sorghum into Kenya, Kenya imposes a tariff of 25% on sorghum imports from countries outside these two trading blocs (Kilambya and Witwer, 2013). However, the analyses done by

Kilambya and Witwer (2013) shows that the tariffs imposed on sorghum imports have had little impact on the domestic prices for the crop over the years.

2.7 Summary of Literature

The literature review shows that sorghum is an important crop in Siaya County and other parts of Kenya. The reviewed literature further reveals that sorghum farmers face various challenges. Whereas some farmers realized positive gross margins, others realized negative gross margins. However, there is inadequate literature regarding the nature and extent of influence of socioeconomic factors such as age, household size, and education level of household head on the gross margins of sorghum. Consequently, this study sought to find out the gross margin from sorghum, as well as the socioeconomic factors that affect gross margins from sorghum in Siaya County. As such, this study will provide important findings about the gross margin of sorghum, as well as the socioeconomic, institutional and policy factors on the gross margin of sorghum.

2.8 Theoretical Framework

2.8.1 Theory of the Firm

The theory of the firm posits that firms, including agricultural enterprises are motivated by the need to maximize profits. Consequently, this theory asserts that business owners, including farmers make decisions regarding the allocation of resources, the kind of production methods to employ, and the kind of good and services to produce or the right crops to grow.

Essentially, profit is a function of the total cost incurred in producing a given quantity of commodity and the revenue generated from the sale of the commodity. However, the total cost incurred will depend on the nature, types, and cost of individual inputs

used to produce a commodity. In the case of sorghum, the total cost is the sum of individual input costs used in production such as seeds, land preparation, planting, weeding, harvesting, and fertilizer.

To a great extent the analysis of gross margin in agricultural enterprises links both the production theory and the profit maximization theories. The production theory essentially looks at the economic principle through which firms use the factors of production of capital, labor, and raw materials to produce economic goods or commodities. Fundamentally, the theory of production uses the production function to model the relationship between inputs and output in the production process.

On the other hand, the profit maximization theory asserts that the main objective of farm households is to maximize profits. As such, in profit maximization, the main focus is to minimize production costs and maximize the prices to realize the maximum profits in the presence of various production and marketing constraints. Because this study analyzes the gross margins from sorghum, it combines the concepts of inputs and production costs, as well as returns which are represented by the gross margins.

Therefore, gross margins will be used to analyze the magnitude of production costs that farmers incur and revenues that they accrue from the sorghum production enterprises.

For this study, the gross margin was the dependent variable while the socioeconomic factors such size of the household, gender of the household head, education level of the household head, access to extension, distance to markets, and access to credit were the independent variables in the study.

The relationship between the gross margins was conceptualized using an equation which is closely related to the profit function. In this study, the gross margin was the dependent variable, and the independent variables was presented using the equation below.

$$Y= f(x_1, x_2, x_3, x_4 \ldots\ldots x_n)$$

Where Y = Gross Margin

= Independent variable (household size, age of household head, the gender of household head, size of land under sorghum, number of crops intercropped with sorghum, education level of household head, access to extension, Nature of farming, access to credit, and distance to the market).

2.8.2 Various Methods Used in Economic Returns Analysis

Several economic concepts can be used to analyze the profitability of projects and enterprises. These concepts include gross margin analysis, cost-benefit analysis, partial budgeting analysis, cost-effective analysis, and cost-utility analysis.

The cost benefit analysis is mostly suitable in situations where a business or individual evaluates one or more projects to ascertain the merits and demerits of each project in terms of potential financial benefits and costs respectively (Evenson & Pengali, 2007). On the same note, partial budgeting is also a decision making tool that is often used by agricultural farms and other enterprises to determine to assess the costs and benefits of alternative projects or programs (Belli, 2001). Specifically, partial budgeting looks at the extent of reduction of costs and increase in benefits that a firm would realize after implementing a given alternative (Evenson & Pengali, 2007). Although partial budgeting and cost-benefit analysis are viable for assessing

expenses and revenues, they do not offer the best alternative for assessing the profitability of small holder sorghum farms.

On the other hand, the cost utility analysis and cost effective analysis are more relevant when assessing the projected health outcomes of various management decisions taken by farms and projects. Essentially, the Cost Utility analysis compares one management intervention with another in terms of the extent, quality, or magnitude of health outcomes that such outcomes would generate. Apart from the cost utility analysis, the internal rate of return is an economic tool that measures the financial performance of enterprises, projects, and capital investments over a period of time. In short, the internal rate of return is suitable in analyzing the performance of projects within a particular time period (Evenson & Pengali, 2007). Just like the internal rate of return, the net present value evaluates projects and economic expenditures in terms of the time value of money (Belli, 2001). Normally, the net present value focuses on looking at the future financial cash flows in terms of their present value. Although both the IRR and NPV are effective ways of measuring the viability of projects by incorporating the concept of time value of money, the two methods are not the most effective in measuring the gross margins from small holder agricultural enterprises such as small holder sorghum farms.

Although all these methods analyze returns, gross margin is the best method that can be used to analyze the profitability of a given agricultural enterprise because it is simple and accurate (Firth, 2002). Most of the other methods such as the net present value, Internal rate of return, cost benefit analysis and partial budgeting are effective in analyzing diverse aspects of profitability and cost prospects of various policy interventions, projects and capital expenditure. However, the gross margin analysis

offers a simple and effective way of assessing the profitability of agricultural enterprises such as small holder sorghum farming. The effective nature of gross margin in determining profitability explains why it was used in this study.

2.8.2.1 Gross Margin Analysis

Gross margin refers to the difference between the total revenue generated from the sale of a commodity and the total variable cost incurred in the production of the commodity. In simple terms, gross margin is the revenues generated from sales less the cost of production (Mbah, 2012). Gross margin is the best method that can be used to analyze the profitability of a given agricultural enterprise because it is simple and accurate (Janssen & Rutz, 2012). Moreover, gross margin is generally the most effective method that can be used to analyze the profitability of farming enterprises that have negligible fixed costs. In agricultural economics, analysis of gross margin helps in examining the financial gain or loss, commonly referred to as the profitability or economic returns of a given agricultural enterprise or crop. Behjat & Ostry (2013) used gross margins to analyze the profitability of regional farms in British Columbia health areas. Similarly, a study done by the CIMMYT (2014) used the gross margin analysis to characterize and compare the profitability of seed crops and non-seed crops in Eastern Kenya. Similarly, Janssen and Rutz (2012) used gross margins to determine the profitability of sweet sorghum varieties when grown under varied scenarios such as small scale, improved rain-fed system, single cropping, and double cropping. The study demonstrated how gross margin helps in highlighting both profit-making and loss-making enterprises. It is important to note that the gross margin is not the same as net profit because it does not take into account the overhead costs, fixed costs, and capital costs associated with a particular enterprise (Celik, Semerci & Parlakay, 2014). Nonetheless, gross margin analysis is appropriate for examining the

economic returns of small scale farm enterprises such as sorghum farming in Siaya because the fixed costs of such small holder farm enterprises tend to be negligible. The complex nature of farm enterprises and the difficulty of categorizing fixed costs in agricultural farm enterprises further make gross margins to be the most acceptable method of examining the profitability of crops such as sorghum.

Based on the concept of gross margins, an enterprise with a positive gross margin value (Value more than zero) is considered profitable (Oseni and Aledwale, 2013). On the other hand, a gross margin value less than zero depict an enterprise as unprofitable.

2.8.3 Conceptual Framework

Based on the production theory, the main objective of farmers is usually to generate maximum output from their farms. The nature and efficiency of existing production and marketing systems affect the actual returns that farmers realize from their farms. Socioeconomic attributes of farmers such as age, gender, education, income, family size, group membership, primary economic activity, resource endowments, and risk attitude; institutional factors(farm ownership and management types) and policy factors(access to extension, access to credit) have a direct influence on the returns that farmers realize from their agricultural engagements.

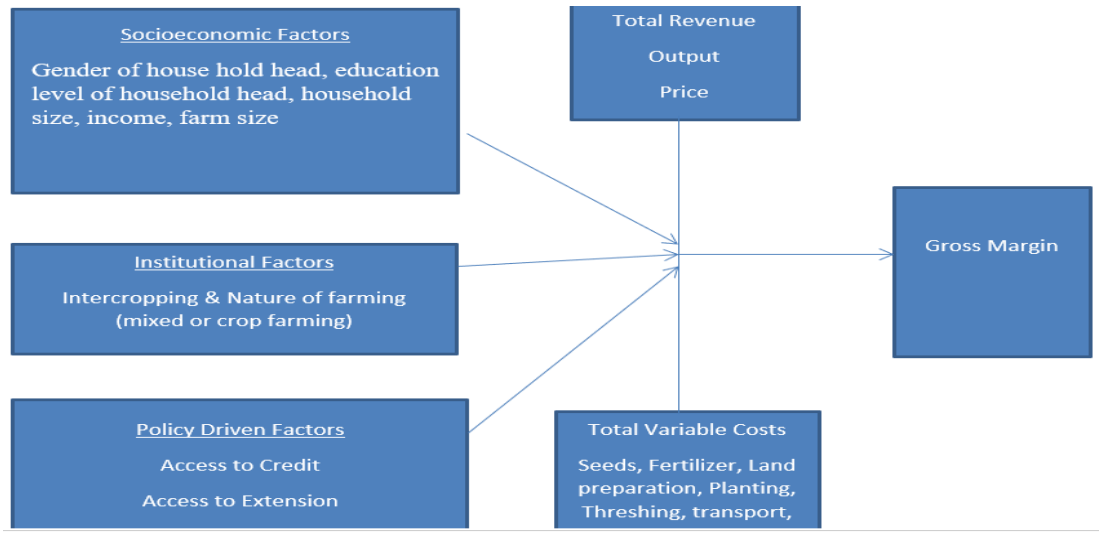


Figure 2.1: Conceptual Framework
Source: Researcher's own compilation, 2019.

In this study, sorghum farmers in Siaya County are conceptualized to be maximizing returns/output to achieve their subsistence/income goals. Consequently, their attributes, i.e. production costs, socio-economic factors, institutional factors, and policy factors influence the practices they use in the production and marketing of their produce. Regression analysis was used to determine the effect of production, socioeconomic, institutional and policy factors on the gross sorghum margins.

2.8.4 Operationalization of Variables and their expected Signs

2.8.4.1 Household size

Household size was measured in terms of number of people who live in the household for at least one full season for the sorghum crop. Household size is expected to have a positive coefficient. This is because more members in a household translate to more labor readily available for use in the farms.

2.8.4.2 The area under sorghum in acres

The area under sorghum will be measured in acres, and is expected to have a positive gross margin. This is because larger farms are more likely to benefit from economies

of scale in terms of purchase and use of inputs, as well as in the sale of sorghum output.

2.8.4.3 Nature of farming

Nature of farming was operationalized in terms of whether the farmer engages in mixed farming or crop farming with no livestock enterprise. It is expected to have a positive coefficient where those who have mixed farms accrue higher gross margins compared to those who do crop farming alone. This is because farmers who do mixed farming are likely to benefit from the symbiotic mutual relationship between crop and animal enterprises.

2.8.4.4 The Education/Literacy level of the household head

The literacy level was operationalized in terms of the years spent in school by the household head. education level is expected to have a positive coefficient. This is because farmers with higher education levels tend to have higher literacy levels. The higher literacy levels help such farmers to make better decisions in terms of farm management. As such, farmers with higher literacy levels tend to have better and more effective farm management skills compared to farmers with less education.

2.8.4.5 Gender of the household head

The gender of the household head is expected to have a positive coefficient. This is because male farmers tend to have more financial and technical resources. It will be operationalized as 1 or 0 variable where 1 represents male and 0 will represent female.

2.8.4.6 Access to credit

Access to credit will be measured as a binary variable where 1 represents affirmation of access and 0 represented non access to credit. Credit enhances the ability of farmers to access inputs. As such, access to credit is expected to have a positive coefficient.

2.8.4.7 Access to extension

Access to extension was considered as a binary variable where 0 reflects access and 0 reflects non access to extension services. Access to extension is expected to have a positive coefficient. This is a credit facility that enhances the ability and capacity of farmers to purchase farm inputs.

2.8.4.8 Number of crops Intercropped with Sorghum

The number of crops intercropped with sorghum is expected to have a negative coefficient. This is because of intercropping results in competition among the crops for nutrients and moisture.

2.8.4.9 Household Income

The total household income was measured in terms of Kenya shillings. Total household income was expected to have a positive coefficient. This is because household income directly reflects the purchasing power of the household. As such, households with higher incomes are more likely to access and purchase the required farm inputs at the right time, and also in the right quantities.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter describes the methodology that the study employed. It comprises of five different sections which include the area of study, data collection procedure, the research design, sampling design, the sources and types of data, data analysis as well as the model that was employed for analysis in the study.

3.1 The Study Area

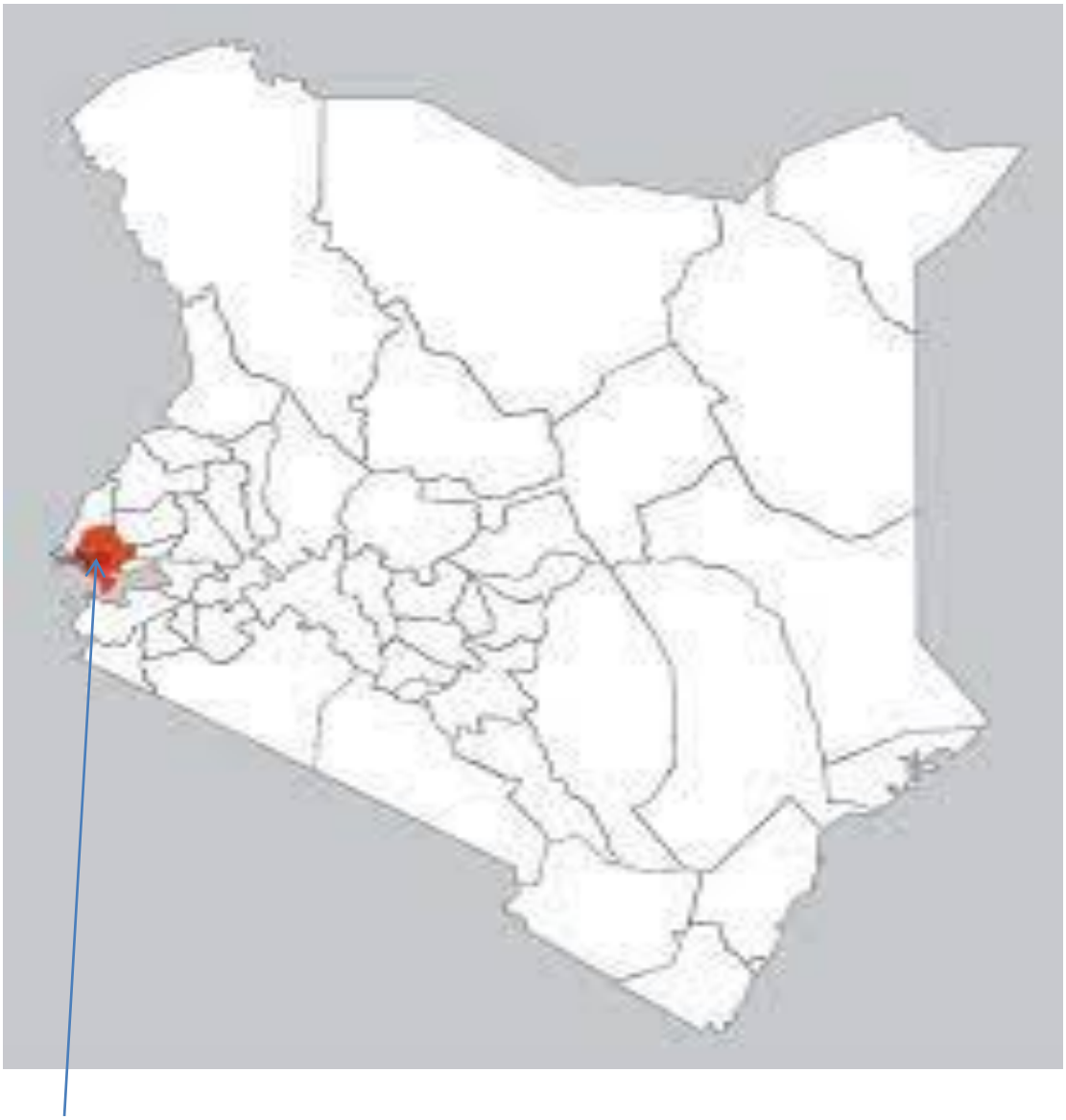
Siaya County is located in the southwestern part of Kenya. The county has a total land size of 2, 530km^2 which comprises of highlands, wetlands, and agricultural lands (County Government of Siaya, 2018). The county borders Busia, Kakamega, Vihiga and Kisumu counties to the north, northeast and southeast respectively. The county is positioned on latitude 0° 26' to 0° 18' north and longitude 33° 58' east and 34° 33' west. The average land in Siaya County is about 1.02 Hactares in Alego and Ugenya, and about 3.0 hectares in Bondo. The soils are diverse which includes the red well drained clay soils mostly referred to as nitisols which are mostly found in Uyoma areas of Bondo sub county. The areas along river Yala have alluvial soils while most parts of Alego, Ugenya and Gem Sub County have loam and clay soils with moderate levels of fertility (County Government of Siaya, 2018). Also, Siaya County covers different ecological zones which ranges from LM1 to LM5. The surrounding regions which are adjacent to Lake Victoria such as Uyoma and Yimbo are semi humid and semi dry Lower midland zones (LM4 and LM5). On the other hand, vast regions of Alego cover the LM3 ecological zones (County Government of Siaya, 2018). These ecological zones can be categorized into agro ecological zones such as the Lower midland sugarcane zone (Subzone LM1 *l^m i*) which is common with crops such as

maize intercropped with beans, maize, sorghum, cassava, sweet potatoes, and ground nuts (County government of Siaya, 2018). The marginal sugarcane zone subzone LM2 *l^ (m/s)i* which covers some parts of Ugenya is also dominant with maize, sorghum and banana, ground nuts, and beans. Both agro ecological zones support two seasons which comprises of the long rains in the first five months of the years and the short season which covers three to four months towards December.

The county comprises of six sub-counties and has its administrative headquarters in Siaya town. The majority of rural households in Siaya County engage in subsistence farming. These ecological zones support sorghum production as well as other crops such as maize, sugar cane, and cassava (County Government of Siaya, 2018). Overall, the county does not have a major cash crop. Although a few households, especially, those around the beaches, earn their livelihood from fishing, most families engage in subsistence farming. In addition, the majority of the Siaya county residents rear livestock such as poultry, sheep, and cattle. Other households also grow and sell vegetables to supplement their income. Apart from agriculture commercial motorcycle transport (*Bodaboda*) has become a significant source of income for several households. The average production of sorghum in Kenya is 0.85 tons per acre.

In terms of indicators of welfare, the proportion of county residents who are able to read and write are 79.75% and those who have no ability to read and write is 18.25%. On average, life expectancy in the county is 40 years which is lower than the national average of 56.6 years (County Government of Siaya, 2018). The low life expectancy could be attributed to the high level of poverty and unemployment in the county. Interestingly, the county has a high fertility rate of about 5.5 children per woman

which is above the national average of 4.6 children per woman (County Government of Siaya, 2018). Malaria, respiratory tract infections and diarrhea are the major causes of mortalities in the county. Wage employment accounts for about 17% of the total employment opportunities in the county with agriculture offering more than 60% of all jobs in the county while those who are self-employed in the urban centers account for 14% of the county's overall labor force.



Siaya County
Figure 3.1: Map of Siaya County
Source: eLimu (2020)

Figure 3.2 Map of Siaya County
Source: eLimu (2020)

3.2 Data Types and Sources

Data about the socioeconomic characteristics of the household such as income in Kenya Shillings, education level of household head in terms of years in school, age and gender of household head, size of the household, institutional factors such as agronomic practices like intercropping and nature of farm ownership, and policy factors such as access to extension, and access to credit were provided by the household head. Also, the various variable costs used in the production process such as cost of seeds, land preparation, planting, weeding, harvesting, and fertilizer as well as information about the quantity and prices of sorghum produced by farmers in terms of Kenya shillings and kilograms were all collected from the respondents.

3.3 Data Collection Tools

3.3.1 Questionnaire

The study used structured questionnaires to collect data. The questionnaire was employed in the study because it is a more efficient, effective and economical tool in

terms of time and cost of collecting data. Additionally, the use of questionnaire enabled respondents to provide sufficient information, especially about confidential information such as number of children and income. Moreover, the use of questionnaires supported the collection of standardized information which eases the categorization and analysis of collected data. Although, questionnaires had a few limitations such as some respondents making incomplete entries, the method was generally successful in helping the researcher to gather all the information required for the study.

3.4 Data Collection Procedure

The study employed a multistage sampling approach. The study respondents were recruited from Alego-Usonga Sub County and used to represent the research population. The researcher purposively picked on Alego-Usonga Sub County because of the high proportion of sorghum farmers in the sub county.

From within the sub-county, the researcher selected the respondents using simple random sampling method. Such an approach is justified because it presented all the farmers with an equal chance of being selected in the study.

3.5 Research Design

The study employed a household survey research design to collect data for the study. The cross sectional survey of households enabled the researcher to gather data about socioeconomic characteristics of the households at that time.

3.6 Population and Sampling Design

3.6.1 Research population and Sample Size

The sorghum farmers in Siaya County formed the study population. The population of rural households in the county was 199, 034 as per the KNBS 2015 data. However,

the study selected a sample of 310 households using scientific criteria demonstrated below to represent the target population. The households were then picked using purposive technique whereby households which engage in sorghum farming were objectively included in the study.

3.6.2 Determination of the Sample Size

The sample size for the study was determined using the formula developed by Krejcie and Morgan (1970) as outlined below. The Krejcie and Morgan (1970) sample estimation method is acceptable in studies where the target population is more than 50,000. According to KNBS data 2015 data, the number of households in Siaya County was 199, 034. With about 36.8% of households in Siaya county growing sorghum, this translates to about 73, 245 households farming sorghum. As such the formula was appropriate for the study

The formula was specified as

$n = (Z^2 \times p\ (1-p))\ /M^2$

Where:

N = Sample Size for infinite population,

Z = Z value (e.g. 1.96 for 95% confidence level)

P = population proportion (expressed as decimal) (assumed to be 0.5 (50%)

M = Margin of Error at 5% (0.05)

Therefore the sample size $n = ((1.96^2 \times 0.5\ (1-0.5))/0.05^2 = 385$

However, because the study had an 81% response rate in terms of questionnaires filled, the study enlisted 310 respondents for the study.

3.7 Empirical Framework

Gross margin was used as a proxy for profits to assess the profitability of small holder sorghum farming in Siaya County. In the short run, sorghum farming comprises of negligible fixed costs. However, in the long run, all the costs are variable. Such observation explains why the gross margin was used to determine profitability of sorghum farming. Gross margin is the difference between total revenue and total variable cost. The algebraic expression of gross margins is represented as: GM = TR - TVC

Where GM = Gross margin, TVC = Total variable cost

TR = Total revenue (which is generated by the product of prices and quantity)

The total revenue was computed by the formula Pi*Qi; where Pi is the price per quantity (kilogram) of sorghum produced, Qi is the quantity of sorghum produced. The quantities used in this study included both the number of products sold, the amount of the produce consumed, and the amount used for other purposes such as donations to churches or relatives. Factoring in all these categories of products helps in determining accurately the quantity of output produced in a farm and hence accurately reflects the gross margin or profitability of a given agricultural enterprises (Behnke, 1985).

TVC = Total variable costs

Variable cost according to Oseni and Aledwale (2013) includes the costs of labor, fertilizer, transport, weeding, land preparation, harvesting, seeds, and pesticides. From common understanding, these are costs that vary as output varies. Upton (1974)

defines variable costs as costs of inputs that can be spared and used in the future. According to Fox et al. (2005), it is possible to calculate labor costs using the opportunity cost of the labor or by determining the market price for the labor. In most cases, small scale farmers usually employ minimal quantities of hired labor because family members are usually engaged to provide work on the farms (Upton, 1974). Based on this observation, the study employs the market cost of labor to determine the estimates of labor costs in scenarios where family members were engaged to provide labor on the farm. This approach assisted the researcher to avoid the underestimation of gross margin from those farmers who employ hired labor instead of using family labor.

Labor was measured in man-days. The use of man-hours considers the total hours the farmer spent in doing the activities of the production of a crop or livestock, in this case, sorghum (Braun, 1991). Ideally, peasant farmers usually employ even women and children on their farms at times to complement the labor offered by adult and male members of the family. Consequently, appropriate labor equivalences should be used to cater for any variance occasioned by the use of women and children (Abdullahi, 1990). The prevailing market rates for labor were used to rate and price the family labor used in the farms.

In terms of the values of the gross margin, a positive gross margin value where $GM>0$ would reflect sorghum farming as a profitable venture. On the other hand, a negative gross margin value, $GM<0$ would imply that sorghum farming in Siaya county is not profitable. In short, it would mean that farming sorghum in Siaya County is a loss making venture. Finally, a gross margin value of zero, $GM=0$, would mean that sorghum farmers in Siaya County merely break – even, and they neither make profits

or losses. It shows that the total variable costs that sorghum farmers in Siaya County use in their sorghum farms is equal to the revenue they generate from their sorghum farms.

3.8 The Multiplicative Regression Analysis

The factors that influence gross margin were examined using the multiplicative regression analysis which was adapted from the Cobb Douglas production model. The linearized Cobb Douglas model was used because gross margin is a function of the cost of inputs employed in producing sorghum and the value of sorghum output produced. As such, a linearized Cobb - Douglas function would fit in this analysis. The Cobb Douglass production function was linearized by applying logs on both sides

$$Y = \beta_0 \prod_1^n X_i^{\beta_i} e^{\lambda_1 z_1 + \lambda_2 z_2 + \lambda_3 z_3 + u}$$

When you log linearize, the equation transforms to:

$$lnY = ln\beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \lambda_1 z_1 + \lambda_2 z_2 + \lambda_3 z_3 + \lambda_4 z_4 + \boldsymbol{\mu}$$

This translates to the final equation enlisted below

$$lnY = A_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \lambda_1 z_1 + \lambda_2 z_2 + \lambda_3 z_3 + \lambda_4 z_4 + \boldsymbol{\mu}$$

Where, $A_0 = ln\beta_0$,

Y = Gross margin and

X_1 =Household size, X_2 = Area under sorghum in acres, X_3= Education level of household head, X_4 = Number of crops grown, X_5 = Household Income, Z_1 = Access to credit, Z_2 = Access to extension, Z3 = Nature of farming, and z_4 = Gender of household head and μi= error Term

3.9 Data Analysis

The researcher coded the data collected from the study using Stata statistical software. The researcher classified the data collected from the field to make analysis easy. The regression analysis was used to determine how the household socioeconomic attributes affect gross margins from sorghum. The categorical variables such as gender of household head, access to extension, access to credit, and nature of farming were considered in the model while the other variables such as size of land under sorghum, age of the household head, income level of the household, number of crops intercropped with sorghum were first log – linearized and then incorporated into the model. SPSS and Stata helped in categorizing and ascertaining the trends of qualitative attributes such as education levels among the respondents

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the findings of the study. This chapter comprises of five sections. The first section provides a brief introduction of the chapter, the second section contains descriptive results for the variables under investigation, the third section discusses the gross margin of sorghum while section four presents the regression results of factors affecting sorghum gross margin in Siaya County. Finally, section five summarizes the findings of this study.

4.1 Descriptive Results

4.1.1 Diagnostic Tests

Various diagnostic tests were carried out to ensure that the selected regression model fitted well with the assumptions of the ordinary least square (OLS). Some of the tests that were done include Ramsey's test for omitted variables, heteroscedasticity, and multicollinearity tests.

Testing for multicollinearity was conducted to ensure that there was no single or more linear relationship between the independent variables used in the model. The table below shows the Variance inflation factor (VIF) results for the independent variable.

Table 4.1: Variance Inflation Factor for the Independent Variable (VIF) Test

Variable	VIF	1/VIF
LnHousehold income	3.38	0.2959
LnHousehold size	3.45	0.2899
Lnsize of sorghum farm	1.43	0.6996
Access to credit	1.13	0.8825
Access to Extension	3.50	0.2858
Gender	2.90	0.3443
lMEducation level	3.91	0.2558
LnNumber intercropped	2.91	0.3437
LnAge	1.12	.8918
Nature of Farming	3.34	.2997
Ln TotalCost	2.13	.4699
Mean VIF	2.6545	

Source: Survey findings.

Normally, the presence of collinearity between two or more variables affects the ability to sufficiently isolate the impact on the explained variable that has been caused by one or more explanatory variables sufficiently. For this study, all the explanatory variables had VIF values of between 1 and 4 with a mean VIF of 2.655. The results confirmed the absence of multicollinearity among the variables. Normally, very high VIF values reflect the presence of multicollinearity in a regression model.

For heteroscedasticity, the Breach Pagan test results had a *P*-value of 0.1852 and a chi-square value of 16.74. These values indicated that the error term had a constant variance.

Ramsey's test for omitted variables had a *p-value* of 0.001 and *an F-value* of 3.15. These results confirm that there were no omitted variables in the model. This is because these values are more than 0.05 which shows that the estimated linear model is sufficient to model the relationship between the explained and explanatory variables

Table 4.2: A summary of Gross margin and key socioeconomic attributes of Farmers

Variable	Obs	Mean	Std. Dev.	Min	Max
Gross margin per acre	310	4286.09	2898.30	-2700	24000
Household size	310	4.17	2.13	1	10
Total land size	310	2.39	1.12	0.13	5
Sorghumland (acres)	310	.70	.4032711	0	3
ageofhhh	310	54.22	14.45153	28	80
Household income	310	5319.52	2363.12	1800	16000
Number intercropped	310	1.60	1.09	0	3
Total cost per acre	310	9600.39	701.05	7500	12000

Source: Survey Findings, 2019.

4.2 Socioeconomic Attributes of the Respondents

4.2.1 Gender of the Household head

Out of the 310 households, 56.77% (176) were male headed while 43.23% (134) were headed by females.

Table 4.3: Gender of Respondents

Gender of HH	Frequency	Percentage
Female	134	43.23
Male	176	56.77
Total	310	100.00

Source: Survey Findings, 2019.

According to Karane (2016) gender of household has been found to be a significant factor that influences the profitability of agricultural enterprises. This is because the head of the household normally makes vital decisions regarding farming practices and adoption of farming technologies and techniques at the farm. In this study, men headed households were the majority at 57% while households headed by women

were 43%. These results are in line with those of the international food policy discussion paper Quisumbing, (1995), that gender differences have an impact on agricultural productivity.

4.2.2 Age of the Household Head

The study found that 35% of farmers were below 40 years while the rest were more than 40 years. This shows that sorghum farming is dominated by older farmers. Younger farmers prefer to grow maize and other crops.

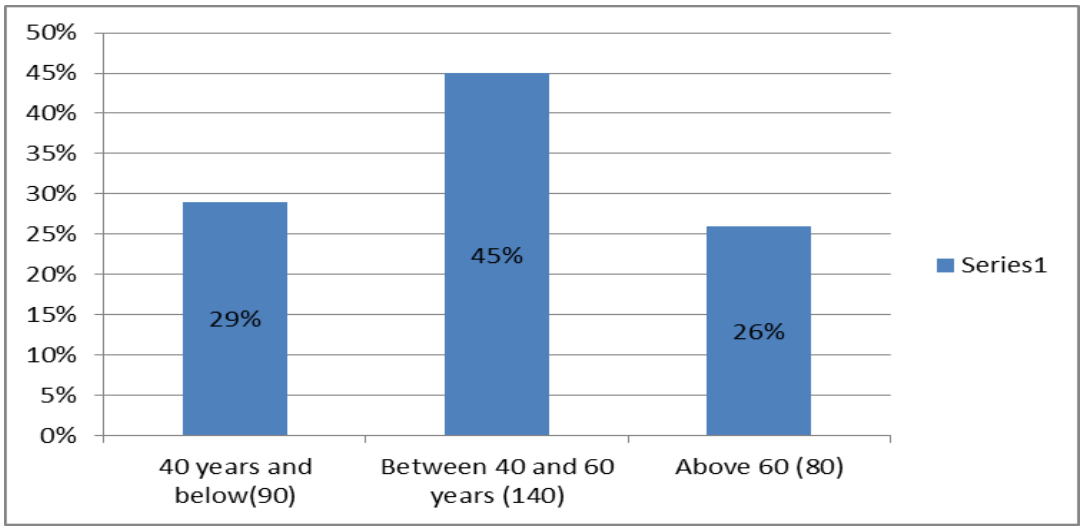


Figure 4.1: Age distribution among respondents.
Source: Survey Findings, 2019

The average age of the farmers was 54.22 years old. This shows that the uptake of sorghum farming among young farmers is still low. Consequently, relevant authorities such as the county government of Siaya, non-governmental organizations, seed companies and other value chain players in the sorghum sub sector should make a deliberate effort to engage and entice young people to farm sorghum. This could be done by coming up with incentives like providing subsidized sorghum seeds to young people and also offering intensive trainings through seminars.

4.2.3 Size of land under sorghum

Most farmers had less than one acre of land under sorghum. The mean land size occupied by sorghum was found to be 0.7 acres. About72% of farmers had less than one acre of land under sorghum while only 27% had at least one care under sorghum. This shows that the Country government, sorghum seed companies, and other relevant authorities need to make deliberate effort to educate farmers on the special attributes or sorghum, especially the fact that sorghum is a hardy crop that can do well even with limited application of fertilizer and limited rains. The county government could, for instance, roll out a sorghum seed subsidy program and vigorous trainings programs to help farmers to give sorghum a priority in land allocation. This is because the total land sizes in Siaya County are generally low. From the study, the average total household land is 2.39 acres while the average land under sorghum is 0.7 acres. This shows that sorghum covers an average of 29.3% of the total land per household. Sorghum competes with other crops such as maize, beans, potatoes, and cassava for space among most households in Siaya County. Consequently, focusing on trainings and relevant incentives could assist lure farmers to increase land under sorghum in the long run.

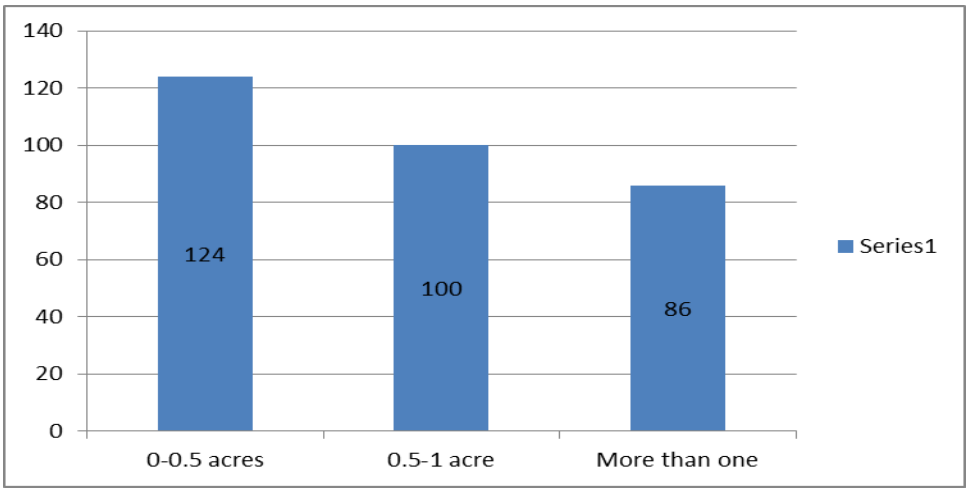


Figure 4.2: Size of land under sorghum
Source: Survey findings, 2019.

4.2.4 Education Level of Household Head

The survey found that 202, that is, 65.16% of the respondents had attained at least primary education. Those that had attained secondary and tertiary education were 142 (45.81%).

Table 4.4: Education level of household head

Education Level	Frequency	Percentage
Primary	108	34.84
Secondary	60	19.35
Tertiary	85	27.42
Total	57	18.39

Source: Researcher's own compilation, 2019.

Overall, a higher percentage of the respondents had some basic education which points to a commendable literacy rating in the county. The high level of literacy in the county shows that with proper policies, farmers could adopt modern farming practices such as organic farming which enhances sustainable soil fertility and use of improved seeds which could help to boost the sorghum yields in the county remarkably.

4.2.5 Access to Extension

Access to extension is another important factor that influences the overall yields of most crops. However, based on the results from the research, 128 respondents (41.29%) sorghum farmers who participated in the study had not received extension services. This shows that the County government of Siaya should review its agricultural extension programs to reach more farmers because the existing County structures regarding agricultural extension have been less effective in reaching farmers. However, stakeholders in the sorghum value chains could also pick up the opportunity to drive a demand driven extension approach to fulfill the extension gaps in sorghum sector in Siaya County.

Table 4.5: Access to Extension

Access to Extension	Frequency	Percentage
Yes	182	58.71
No	128	41.29
Total	310	100.00

Source: Researcher's own compilation, 2019.

Interestingly, most of those who had received extension services had benefitted from the services of non-governmental organizations especially one-acre fund and Momentum. These organizations were found to have done an extensive job in training farmers regarding good farming practices such as organic farming and financial literacy. Although the provision of extension services through the demand-based approach has been drawing considerable attention in recent years, these findings show that the government needs to do much more in terms of the provision of extension services to farmers.

4.2.6 Access to Credit

Access to credit is another important factor that determines the profitability of agricultural enterprises. In this research, access to credit was examined by considering farmers who had received credit facilities in the previous one year.

Table 4.6: Access to Credit

Access to Credit	Frequency	Percentage
Yes	73	23.55
No	237	76.45
Total	310	100.00

Source: Researcher's own compilation, 2019.

Only 73 farmers (23.55%) had accessed credit while the remaining 237 (76.45%) had not accessed credit facilities. The County government should provide more training

and enlighten farmers about the credit facilities available in commercial banks and micro financial institutions as well as government institutions such as the Agricultural Finance Corporation. Such approach would enable more farmers to access credit.

4.3 Analysis of Gross Margin

The below shows the gross margins, revenues and variable costs of sorghum.

Table 4.7: Sorghum Gross Margin per Acre Analysis

VARIABLE	QUANTITY
Revenue (Per Acre)	
Average kilograms/acre/season	405
Average Price per kg	35
Total Revenue	**14, 175**
Variable Costs (Per Acre)	
Land Preparation	2115
Planting	2000
Weeding	2054
Seeds	300
Fertilizer	600
Harvesting	1120
Threshing	1195
Transport	505
Storage	-
Total Variable Cost/acre/season	**9, 889**
Average Gross Margin Per Acre/Season	**4, 286**

Source: Survey Findings, 2019

The average gross margin for sorghum was found to be positive. This shows that sorghum farming in Siaya County is profitable. The study found the average gross margin per acre from sorghum to be 4, 286. The most profitable farm had a gross margin of Kenya shillings 24, 000 per acre while the farmer with the least profit had a negative gross margin (loss) of Kenya Shillings 2700. It is also important to note that

out of the 310 respondents, only 3.2% (10) had negative gross margin while the rest had positive gross margin.

The findings of this study is consistent with that of a previous study by Ibrahim & Musa (n.d) who found the gross margin from sorghum to be positive in a study carried out among farmers in Habila scheme, Ethiopia. Another study carried out by Baiyegunhi & Fraser (2009) in Three Villages of Kaduna State, Nigeria also found sorghum to be a profitable crop. Still, Zalkuwi et al (2014) found sorghum farming in six states in India to be profitable in a study aimed at examining the profitability of sorghum in India. However, the results of positive gross margins in this study contrasts the result of a study done by Kaliba et al (2017) who found some sorghum varieties to generate negative gross margins in a study that was conducted in Tanzania. Similarly, a report by ASARECA (2006) noted commercial sorghum production in Botswana to be unprofitable due to the low yields which averaged 250kg/hectare.

Farmers generally sold their sorghum to local traders and final consumers at an average price of Kenya shillings 35. Farmers reported to sell at as high as 50 Kenya shillings per kilogram during the peak season, and as low as 15 shillings per kilogram during harvesting season. Most farmers harvested between 2 bags and 9 bags (of 90 kilos) of the crop per acre with the average yield being 405 kilograms (4.5 bags per acre). It is also important to note that 248 respondents (about 80%) of farmers reported that they plant sorghum purely for consumption purposes compared with only 5% (16) who plant the crop for commercial interest. About 10% of the respondents planted with the dual objectives of home consumption and commercial purposes.

Land preparation, planting and weeding formed the highest percentage of variable costs that farmers incurred, accounting for an average of 62.38% of the total variable costs associated with production and marketing of sorghum. Most farmers used casual laborers and family members to carry out various production activities such as land preparation, planting and weeding. The average cost of hiring a laborer was between Kenya shillings 150 and Ksh. 250 per man day.

Fertilizer was one of the least variable cost that farmers incurred contributing only 6% on average. This finding is consistent with the result of Kabila et al (2017) who found sorghum farmers in Tanzania prefer to use farm yard manure on their farms, as opposed to commercial fertilizers. In some instances, farmers just planted the sorghum fields without applying any fertilizer partly because of the belief and fact that sorghum does well even when planted without the fertilizer.

Transport cost was also minimal for most sorghum farmers. Most farmers used their means of transport mostly bicycles and family members to transport the harvested crop to their homes. Only 5.1% of farmers used hired means of transport, mainly motor cycles to transport the produce either from the farms to the storage points at home or from their homes to the markets.

None of the respondents incurred storage costs in their production cycles. This is because all the farmers used their own stores in their homes to store the harvested sorghum.

4.4 Regression Results for Factors Affecting Sorghum Gross Margin

Table 4.8 shows the results from Multiple regression analysis of factors affecting Gross Margin of sorghum.

Table 4. 8: Regression Results for factors affecting Sorghum Gross margin

GM/Acre	Coef.	Std. Err.	T	P>t	[95% Conf.	Interval]
Lneducyears	3.382639	0.6814491	4.96	0.000***	4.72371	2.041558
Lnhouseholdsize	3.790559	0.7659913	4.95	0.000***	2.283101	5.298017
Lnsorghumlandsize	0.8105924	0.3086238	2.63	0.009***	0.203225	1.417959
Lnnumberintercroppedwithsor	-0.936851	0.5630131	-1.66	0.097*	-2.04485	-1.711489
Creditaccess	0.1657074	0.3770891	0.44	0.661	-0.57639	0.9078125
Accesstoextension	2.228745	0.7132409	3.12	0.002***	3.632391	0.8250987
Lnageofhhh	-1.312245	0.5405745	-2.43	0.016**	-2.37608	-0.248403
Membershiptofarmergroup	-0.364990	0.5133586	-0.71	0.478	-1.3752	0.6452907
Natureoffarming	1.526543	0.5589462	2.73	0.007***	.4265462	2.62654
Lnhhincome	1.763861	0.7434733	2.37	0.018**	0.300718	3.227004
Lntotalcostperacre	-2.292394	2.080595	-1.10	0.271	-6.38697	1.802182
Genderofhh	-0.021666	0.5158481	-0.04	0.967	-1.03684	0.9935141
_cons	16.54496	19.64841	0.84	0.400	-22.12279	55.2127

Notes: One, Two and three asterisk (s) implies significance at 1%, 5% and 10% level of significance respectively. R^2 41.06 Adjusted R^2 38.68

Source: Survey findings.

4.4.1 Age of the Household Head

Age was found to be a significant factor that influences the gross margin from sorghum (P = 0.016<0.05). However, the parameter estimate was negative (-1.3122). This means that a unit increases in age of the household head will lead to a decrease in gross margin by 1.3126 units. This implies that as a farmer ages, his/her gross margin reduces. These results agree with those of Meijer, Catacutan, Ajayi, Sileshi, & Nieuwenhuis, (2015) on the role of age on agricultural perceptions and adaptation. This could be because age affects the perception of farmers towards good farming practices such as crop rotation and organic farming. Older people are usually less

willing to embrace new ideas that could improve productivity such as use of improved seeds, fertilizers, pesticides, and crop rotation. Also, as farmers get older, their physical energy reduces; this affects their ability to perform some of the physical farm activities. From the study, 35% of farmers were below 40 years while the rest were more than 40 years. This shows that sorghum farming is dominated by older farmers, which may be the reason for the negative relationship between age and gross margin from sorghum. As seen earlier in the descriptive statistics, the average age of the farmers was 54 years old. This shows that the uptake of sorghum farming among young farmers is still low.

This contrasts a previous study by Otieno (2017) which found age to be positively related to gross margin and Ibrahim & Musa (n.d) who found age to be insignificant in determining the gross margin from legumes and sorghum respectively. Younger farmers were found to have conceptualized sorghum as a commercial crop compared to the older farmers. Older farmers viewed sorghum purely as a food crop. As such, the older farmers were less ambitious in terms of having the drive to increase the average productivity of their sorghum farms. On the other hand, younger farmers were more aggressive in terms of looking for professional advice from extension officers, while also embracing fruitful agricultural practices such as organic farming as well as objective intercropping of sorghum with beans and other legumes.

4.4.2 Years Spent In School (Education Level)

In this study, years of schooling was found to be positive and significant (P value of 0.000), with a coefficient of 3.3826. This implies that a unit increase in the years of schooling leads to an increase in gross margin by 3.3826 units. This shows that farmers with higher levels of education were likely to accrue higher gross margins

compared to those who had attained lower education levels. The results obtained from this study is in line with previous findings by Obiero, (2011), Ibrahim & Musa (n.d) and Modeste et al (2018) which found education to have a positive influence on the gross margins and profitability of maize and soya beans respectively.

The positive relationship between education level and gross margins is because higher education level positively influences farmers' worldview towards emerging technologies and farming practices. At the same time, people who have attained higher level of education tend to be more knowledgeable about best farm management practices such as the right time to plough, to weed, and to harvest. For instance, it was found that timely land preparation usually goes a long way in increasing the average yields and gross margins.

4.4.3 Size of household

Size of household was measured in terms of number of people living in a household. The variable was found to be significant with a P value of 0.000. The coefficient was 3.791, implying that an increase in household size by one unit leads to an increase in gross margin by 3.791 units. The result confirms findings by previous studies on profitability such as one carried out by Hoque (2014) as well as Ibrahim & Musa (n.d) who found the size of household to be positively related to the yield and profitability of various crop enterprises. It was found that households with more members were more likely to get adequate labor from family members. Because of the readily available labor supply, such households are more likely to carry out farm activities such as land preparation, planting, and weeding at the right time and more conveniently. On the other hand, most households with fewer members were often forced to carry out farm activities such as planting and weeding at a slower pace,

especially for those households which could not afford to hire labor. Unfortunately, the slow pace of carrying out vital farm activities such as planting and weeding had a direct negative effect on yields and ultimately on the gross margins of these farms.

4.4.4 Number of Crops Intercropped on the Farm

The number of crops a farmer intercropped with sorghum had a negative effect on the gross margins. This variable was significant (P = 0.097) with a coefficient of -0.9369. This implies that increasing the number of intercrops with sorghum on the same farm reduced the gross margin from the crop by 0.94 units. The results show that farmers who had not intercropped sorghum with other crops had higher gross margins compared to those who had intercropped the crop. However, most farmers who had intercropped sorghum with a single crop experienced minimal change in gross margins compared to those who had grown only sorghum on their farms. This could have resulted from the fact that most farmers who had a single crop intercropped with sorghum had either beans or cow peas. The results of this study is consistent with the results of a study done by Osiru et al (2004)among sorghum growing households in Eastern Uganda which showed that intercropping sorghum with both ground nuts and cow peas had positive impact on the gross margins from sorghum. These legume plants are known to enhance nitrogen fixation on the soil, a fact that works positively in raising the fertility and hence yields of the cereal crop. At the same time, legume plants do not compete so much for space, water, and moisture with the sorghum crop compared to crops with extensive root system such as maize and cassava. Crops like beans, soya beans, and cow peas helps to conserve moisture because of their ability to cover the ground with their leaves. On the other hand, when farmers introduced more than two crops such as sorghum intercropped with maize and beans, or sorghum with maize, beans, and cassava, the yields and gross margins reduced dramatically.

Interestingly, most farmers who intercropped sorghum with more than two or more crops perceived such practice as the most optimal in terms of getting higher food yields from their pieces of land. This show why there is need to educate farmers to desist from nonobjective intercropping of sorghum with crops which only compete with the sorghum crop for moisture and nutrients. However, farmers could be encouraged to intercrop sorghum with crops such as beans and cowpeas that supplement soil fertility and ultimately boost the overall yield of the sorghum crop.

4.4.5 Access to Extension

Access to extension had a positive coefficient of 2.287 and was significant with a p - value of 0.002. This shows that farmers who had received services from extension providers generated more profits from their farms. Such farmers are likely to make 2.287 units more of gross margins per acre of sorghum from a unit of extension services received. The study had similar results of a study by Hoque (2014) who found extension and access to valuable agricultural information to have a positive effect on the gross margin of rice in Bangladesh. This could be attributed to the fact that farmers who have interacted with extension officers were found to be more better equipped with good farm management practices such as objective intercropping, use of available and cheap manures, and determining the optimal storage duration for the harvest. This group of farmers was also more knowledgeable on the best methods of reducing post-harvest losses as well as the optimal time to sell their produce to attain maximum profits.

4.4.6 Household Income

Income is a vital factor when it comes to analysis of agricultural enterprises managed at the household level. This is because income reflects the ability of farmers to purchase various inputs used in the production process.

In this study, household income was significant (p=0.018) with a coefficient value of 1.764. This means that an increase in household income by one unit increases the gross margin by 1.764 units per acre. The findings of this study corresponds with the results of a study by Obiero (2011) which found a positive relationship between household income and the yields and profitability of various crops in Siaya County. Higher incomes reflect the ability and capacity of farmers to access inputs required in the production process at the appropriate time. As such, farmers with higher incomes affirmed that they were more empowered to make important production choices, including the type of crop to grow. Aside from their family food security status, farmers with higher incomes also focused on production decisions that could yield optimal financial returns. This is in contrast to farmers with lower incomes who admitted that their main focus when making production decisions was getting maximum yields to safeguard their families from hunger.

4.4.7 Nature of Farming

Nature of farming was conceptualized in terms of whether the farmer engages in mixed farming or not (A value of 1 reflected practicing of mixed farming while a value of 0 represented crop farming alone). In this study, nature of farming had a significant impact on gross margin with a coefficient value of 1.527 and a p- value of 0.007. A coefficient value of 1.527 shows that farmers who engage in mixed farming were likely to make 1.527 times a gross margin per acre of sorghum who do not engage in mixed farming. This could be attributed to the fact that crops and animals

enjoy symbiotic relationship where crops get sufficient supply of organic manure while animals feed from the fiber from the crops. In short, those who practice mixed farming enjoy a cheap supply of ready manure which helps to raise the yield.

4.4.8 Total Cost per Acre

Total variable cost is an important factor which determines the gross margins. Some of the cost components that were summed to reflect total cost include cost of land preparation, seeds, fertilizer, planting, weeding, and harvesting. In this study, the total cost had a gross margin of -2.292394. This means that an increase in total variable cost by one unit leads to a decrease in gross margin by 2.29 units.

4.4.9 Other Variables in the Model

Access to Credit and gender were not significant in explaining gross margin.

In summary, **t**his study hypothesized that sorghum farming in Siaya County is not profitable, and that socio-economic factors and institutional factors do not significantly affect the profitability of sorghum in Siaya County. The first hypothesis was that sorghum was not profitable. The null hypothesis stated that sorghum farming is not profitable which implies that gross margin is zero or negative.

Null hypothesis, H_0: $\boldsymbol{\mu} \leq 0$

Alternative hypothesis, H_1: $\boldsymbol{\mu} \neq 0$

The t - statistics was used to test the results for the gross margin. The gross margin, $\boldsymbol{\mu}$ was found to be positive with a p value of 0.001 and was significant at 1% level of significance hence the null hypothesis was rejected.

From the results, the gross margin was positive with an average value of Ksh. 4, 286 per acre, and therefore the null hypothesis was rejected.

The second hypothesis was that socio-economic factors such as age of the household head, income level of the household, education level of the household head, size of the household, gender of the household head, and distance to the markets do not affect the gross margin of Sorghum. However, the t test confirmed various socioeconomic factors were significant in explaining the dependent variable at 1%, 5% and 10% level of significance. From the results, age of the household head, education level of the household head, income level of the household, and size of the household were found to have a significant effect on gross margin. Therefore, the null hypothesis was rejected.

The third hypothesis stated that institutional and policy driven factors such as access to credit and access to extension do not affect the gross margins from sorghum. However, access to extension was found to significantly affect the gross margin from sorghum. Also, nature of farming and level of intercropping were found to have a significant effect on the gross margin. As such, the null hypothesis was rejected.

4.5 Overall Significance of the Model

This was established using the F-statistic, where hypothesis was tested for all the coefficients in the model. The calculated f-statistic was found to be F (12, 297) = 17.24, which was significant at 1% level of significance.

The regression results had an R^2 value of 0.4187. R^2 value of 0.3868 shows the extent to which explanatory variables influence the dependent variable. Fundamentally, it implies that 41.8% of the variations in the dependent variable, the gross margin from sorghum is explained by changes in the independent variables.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

The objectives of the study were to analyze the gross margins from sorghum farming in Siaya County; to assess socioeconomic factors influencing gross margin from sorghum such as age, gender, and education level of household head, total cost, size of sorghum farm, household income; and to assess institutional factors such as nature of farming, membership to farmer groups, and number of crops intercropped with sorghum and policy factors such as access to extension and access to credit that influence gross margins from sorghum. The study was undertaken in Siaya County and a survey research design was utilized to collect data. Siaya Sub County was purposively selected to represent the entire population because the sub county has high population of sorghum farmers. The target population included all the sorghum farmers in Siaya County. A total of 310 respondents randomly selected from Siaya Sub County were used to represent the research population. A mix of multistage and purposive sampling techniques were used to collect data. The study employed both primary and secondary data. Questionnaires were the instrument of data collection.

The first objective of this study was to determine whether sorghum farming in Siaya County is profitable. The gross margin analysis of sorghum farming was used to accomplish this objective. The study found the average gross margin per acre from sorghum to be Kenya shillings 4,286. The most profitable farm had a gross margin of Kenya shillings 24, 000 per acre while the least profitable farm had a negative gross margin value of Kenya Shillings.2, 700.

The high variance between the most profitable farm and the least profitable farms shows that with improved production methods and farm management approach, farmers could significantly increase their production yields. Consequently, sorghum could provide vital alternative option that could assist Siaya County to solve the perennial problem of food shortages. Being a profitable crop in the region, Siaya county residents could focus more on producing the crop for commercial purposes.

The second objective was to determine the socioeconomic factors which affect gross margin. The study found education level of household head, size of sorghum land, household size, and household income to have a positive influence on gross margin. On the other hand age of sorghum farmers and household size, had a negative relationship with gross margin.

In terms of institutional factors, access to extension was significant and was found to have a positive relationship with gross margin. Finally, the number of crops intercropped with sorghum also had a negative relationship with the gross margin.

5.2 Conclusion

Sorghum is a profitable crop based on the positive gross margins that was reported in this study. The study also found that education level of household head, household size, household income, age of sorghum farmers, nature of farming, size of sorghum farm, intercropping and access to extension have significant impact on the gross margins of sorghum.

Therefore, the county government of Siaya, the national government, research institutions, seed companies, non-governmental organizations, and all other stakeholders should educate sorghum farmers, especially on the best farming practices

that would improve yields and profitability of the crop. Farmers should be encouraged to practice mixed farming, and where possible, to increase size of farms under sorghum to enable them benefit from economies of scale. Also, objective intercropping where farmers intercrop sorghum with legumes such as beans would help to maximize yields and profitability by preserving the fertility and carrying capacity of the soil. Improving and expanding the scale of extension services availed to farmers would go a long way to improve sorghum production in the county. Expanding the production and promoting the consumption of sorghum within Siaya County could not only help farmers to increase their incomes but could also improve the food security status of Siaya County. Because household incomes has a direct impact on gross margins from sorghum, farmers should be encouraged to diversify their income sources by engaging in enterprises such as poultry and dairy farming, as well as businesses to boost their incomes levels. Having diversified income sources would help farmers to build capacity to carry out land preparation, planting, weeding, and other farm activities on time and in the process boost the income levels from sorghum.

5.3 Recommendations

Having found sorghum to be a profitable agricultural enterprise, the government should begin to objectively encourage famers to improve yields by using improved sorghum seeds and fertilizers, especially organic fertilizers that would guarantee sustainable yields in the long run. Because most farmers have less than 3 acres of land available for expansion of sorghum farms with the average land size of only 0.7 acres dedicated to sorghum farming currently, using best farming practices such as objective application of organic fertilizers and improved seed varieties could assist farmers in Siaya County to achieve sustainable growth in yields and sorghum

productivity. This could be done by providing free or subsidized certified sorghum seeds and fertilizers to act as an incentive to entice more farmers to farm sorghum, while also encourage existing farmers to increase their land under sorghum.

Because the average age of farmers who engage in sorghum farming was found to be relatively high at 54 years of age, the county government and other relevant organizations should come up with programs that focus on enticing young people to embrace sorghum as a substance as well as a commercial crop. Such strategy would assist the county government to make significant progress in improving sorghum yields.

Additionally, farmers should be encouraged to engage in mixed farming. mixed farming was found to be a cheap and effective source of organic manure for sorghum farmers. Actually, mixed farming were found to have a positive impact on gross margin. Farmers who engage in mixed farming were likely to make 1.527 units of gross margin per acre more than farmers who do crop farming. The positive results from mixed farming may be due to the fact that mixed farms have a consistent supply of organic manure. The use of organic manure would not only help in conserving soil moisture and structure, but would also be a cheaper soil fertility agent for sorghum farmers Therefore, farmers should be encouraged to keep livestock such as cows, goats, and sheep and also poultry in their farms.

It is also recommended that farmers be facilitated to access extension services. This will assist farmers to be more knowledgeable regarding best farm management. As part of the concerted campaign to promote sorghum faming, the county government should encourage the Siaya county populace to gradually shift from considering maize as the only staple food to embracing sorghum, and even other traditional

‘orphaned’ food crops such as cassava and sweet potato. Such strategy would enable the county to reduce over relying on maize, and hence to solve the overall problem of perennial food shortages in the county. To achieve this, the county government could organize for multiple trainings and farmers field days to engage and communicate to farmers, with a view of shaping the general perception and view of the people of Siaya regarding sorghum.

Finally, the county government should link with other players, the county government of Siaya, as well as the national government, should support and partner with agricultural research centers, companies which produce and distribute seeds and institutions of higher learning to continue doing more research, and to make available sorghum seeds, which are more adaptable to the changing weather and climatic conditions in Siaya County, and other parts of the country.

5.4 Contributions to Knowledge

This study sought to determine whether sorghum farming in Siaya County is profitable or not. Additionally, the study aimed at examining the socioeconomic and institutional factors which affect the gross margins from sorghum farming in Siaya County. Consequently, this study provides significant contribution regarding sorghum, sorghum profitability, and the socioeconomic and institutional factors which influence the gross margins, and hence the profitability of sorghum farming in Siaya County. Furthermore, the study has revealed how socioeconomic and institutional factors affect gross margins, with notable inclusion of intercropping and its influence on gross margins of sorghum. Finally, this study adds to the existing literature and pool of knowledge regarding gross margins of the sorghum crop.

5.5 Suggestions for Further Research

This study focused on assessing the gross margins from sorghum at the farm level. However, more research should be conducted on the entire sorghum marketing system and value chain in Siaya County to reveal the margins at different levels along the chain. Finally, more research should be conducted on adoption rate for new sorghum varieties in Siaya County, and the factors that influence adoption trends for these new varieties.

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APPENDICES

Appendix I: Questionnaire

I am a postgraduate student at Moi University, in the Department of Agricultural Economics And Resource Management. I am carrying out a research on the impact of livelihood diversification on food security in Siaya County. Am therefore kindly requesting for your cooperation in answering questions in this questionnaire to help me attain the objectives of this study. The information collected using the questionnaire will be treated with utmost confidentiality, and will be used sorely for academic purposes. Thank you.

Questionnaire Code ……

1. Household characteristics

Kindly provide information about the following elements.

Name of household head	
Gender of Household head (HH)	1=Male, 0=Female
Age of Household head (in years)	
Number of years in school (in years)	
Size of the household	
The main occupation of the household head	1= Formal employment, 2= Casual employment 3= Business 4= Fully in farming

2. Farm Characteristics

What is the size of your land in acres?

What is the area of land under sorghum?

Do you lease any land for sorghum production. If yes, what is the size and cost of the leased land per acre?

Apart from sorghum, what other crops/ livestock do you engage in?

Do you consider increasing land under sorghum? Kindly Explain

1=Yes	0= No

3. Production System/Level of Intercropping

What is the mode of production you use for your sorghum farming and which crop do you intercrop sorghum with?

0= No intercrop	1= one intercrop	2= Two intercrops	3= More than 2 (specify)

What is the quantity and cost of the following inputs you used in the last season (per acre)?

Input	Quantity	Cost per unit	Total Cost
Seeds			
Labour i) ploughing ii) Planting			

iii) Weeding iv) Harvesting v) Threshing vi)transport vi) storage			
Fertilizer			
Other Marketing costs			

How many bags (90kg) did you realize from your harvest?

At what price did you sell per kilogram?

Do you always use certified seeds?

1=Yes	0= No

If No, what seeds do you use and why. Kindly clarify

To whom did you sell your sorghum to (Tick the appropriate response)…

1=Final Consumers	2= retailers	3= whole salers	4= Kenya Breweries/ Others (please specify)

Have you ever accessed extension services?

1=Yes	0= No

If Yes, How many times and from which organizations or government agencies did you receive the extension services?

1. Have you ever accessed credit facilities

1=Yes	0= No

If Yes, from which institutions

1= Banks	2= Micro financial institutions	3= AFC and other governmental agencies	4. Shylocks	5. Others. Specify

What is the distance between your farm and the nearest sorghum market

Appendix II: Sorghum Trade and Production in Kenya

Market Year	Production	Unit of Measure	Growth Rate
1975	219	(1000 MT)	NA
1976	223	(1000 MT)	1.83 %
1977	220	(1000 MT)	-1.35 %
1978	221	(1000 MT)	0.45 %
1979	186	(1000 MT)	-15.84 %
1980	220	(1000 MT)	18.28 %
1981	200	(1000 MT)	-9.09 %
1982	131	(1000 MT)	-34.50 %
1983	180	(1000 MT)	37.40 %
1984	120	(1000 MT)	-33.33 %
1985	170	(1000 MT)	41.67 %
1986	165	(1000 MT)	-2.94 %
1987	145	(1000 MT)	-12.12 %
1988	165	(1000 MT)	13.79 %
1989	143	(1000 MT)	-13.33 %
1990	140	(1000 MT)	-2.10 %
1991	130	(1000 MT)	-7.14 %
1992	135	(1000 MT)	3.85 %
1993	135	(1000 MT)	0.00 %
1994	150	(1000 MT)	11.11 %
1995	140	(1000 MT)	-6.67 %
1996	150	(1000 MT)	7.14 %
1997	140	(1000 MT)	-6.67 %
1998	140	(1000 MT)	0.00 %
1999	130	(1000 MT)	-7.14 %
2000	82	(1000 MT)	-36.92 %
2001	117	(1000 MT)	42.68 %
2002	116	(1000 MT)	-0.85 %
2003	130	(1000 MT)	12.07 %
2004	70	(1000 MT)	-46.15 %
2005	150	(1000 MT)	114.29 %

2006	131	(1000 MT)	-12.67 %
2007	147	(1000 MT)	12.21 %
2008	54	(1000 MT)	-63.27 %
2009	99	(1000 MT)	83.33 %
2010	164	(1000 MT)	65.66 %
2011	160	(1000 MT)	-2.44 %
2012	167	(1000 MT)	4.38 %
2013	169	(1000 MT)	1.20 %
2014	178	(1000 MT)	5.33 %
2015	189	(1000 MT)	6.18 %
2016	117	(1000 MT)	-38.10 %
2017	149	(1000 MT)	27.35 %
2018	206	(1000 MT)	38.26 %
2019	150	(1000 MT)	-27.18 %
2020	200	(1000 MT)	33.33 %

Source: United States Department of Agriculture (2020).