

**EFFECT OF MARKET INTEGRATION AND ACCESS ON FOOD
SECURITY AMONG SMALLHOLDER SORGHUM FARMERS IN
MACHAKOS COUNTY**

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DECLARATION AND APPROVAL

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I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, this dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

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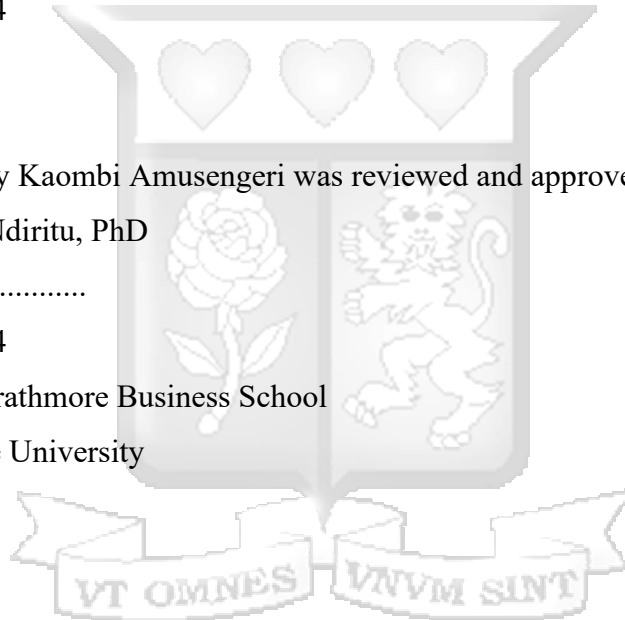
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ABSTRACT

Smallholder farmers are critical to developing countries food security. The aim of this study was to investigate the effects of market integration (horizontal and vertical) and access on food security among smallholder sorghum farmers in Machakos county, Kenya. This study was guided by two theories: the Transaction Cost Economics Theory (TCE) and Entitlement Approach (EA) to food security. Data was collected using structured questionnaire from 240 smallholder sorghum farmers which was representative of the target population. Descriptive statistics was used to analyse data collected from the participants. Farmers contracts and farmers cooperatives were used as proxy for vertical and horizontal integration. Farmers Access to Market Index (FAMI) which considered proportion of households reporting sorghum sales, total quantity of sorghum sales per household, and the proportion of sorghum quantity sold to input suppliers was employed as a proxy for market access. The Food Insecurity Experience Scale (FIES) survey and subjective measures were used to analyse household food security. Probit regression model was applied to analyse the determinant variables. This study found a high prevalence of food security among highly educated households. Further, this study revealed that farmers contracts, cooperative membership and sorghum sales had a significant inverse relationship with food security, due to structural constraints, lack of institutional support and insufficient productive resources experienced by the smallholder sorghum farmers. Therefore, this paper recommends that the county and national government launch initiatives to raise awareness about the importance of drought-resistant sorghum crop in improving household food security. To fully realise the potential benefits of farmers contracts and cooperative memberships the government ought to first focus on addressing the challenges the smallholder farmers face in sorghum production and marketing. Second, establish contractual frameworks and cooperative management structures aimed to support smallholder farmers to produce more efficiently and access more reliable markets, through their contractual and cooperative membership arrangements. The government and policy makers to establish and implement policies that effectively organise the sorghum market to make the crop more competitive for farmers to produce and market, and ultimately improve their household food security.

KEY WORDS: *Vertical Integration. Horizontal Integration. Market Access. Food Security. Markets. Smallholder Sorghum Farmers.*

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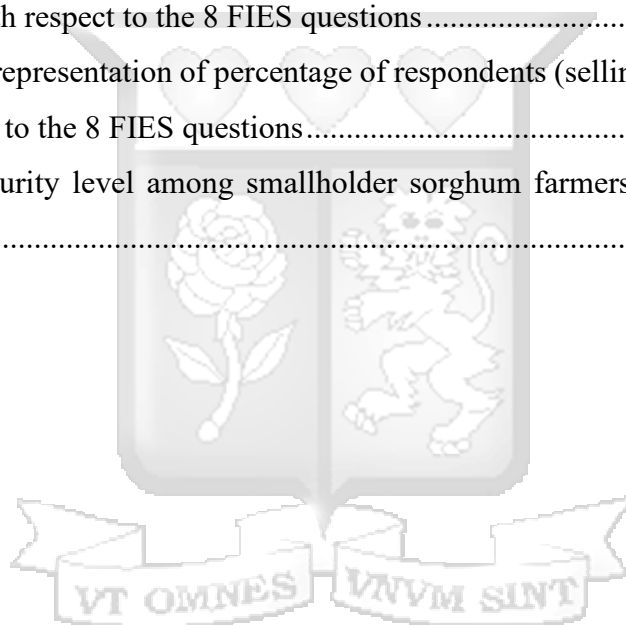
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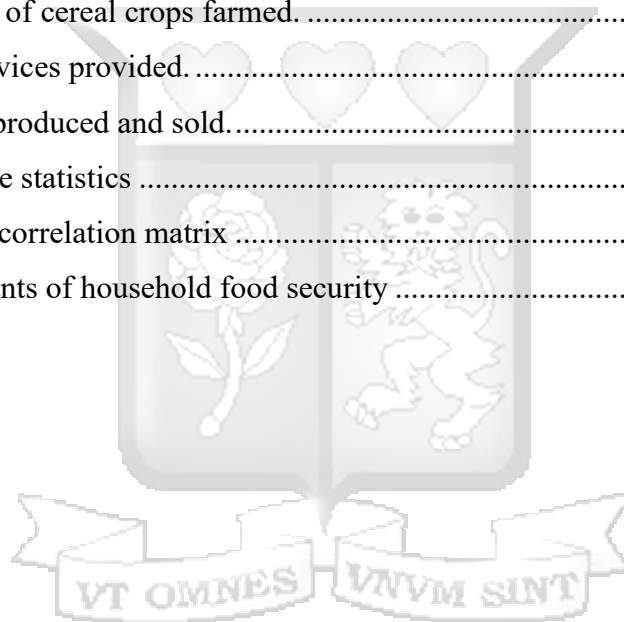
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LIST OF ABBREVIATION

ABP	: Anchor Borrowers Program
COMESA	: Common Market for Eastern and Southern Africa
EABL	: East African Breweries Limited
EAC	: East African Community
EA	: Entitlement Approach
FAMI	: Farmers Access to Market Index
FAO	: Food and Agriculture Organisation
FAO-VoH	: FAO-Voice of Hunger
FEWS NET	: Famine Early Warning Systems Network
FIES	: Food Insecurity Experience Scale
GDP	: Gross Domestic Product
KNBS	: Kenya National Bureau of Statistics
NACOSTI	: National Commission for Science, Technology, and Innovation
SSA	: Sub Sahara Africa
TCE	: Transaction Cost Economics
UN	: United Nation
USA	: United States of America
USAID	: United State Agency for International Development



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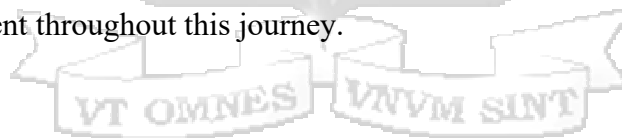
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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Agriculture is an important economic activity in sub-Saharan Africa (SSA). Agriculture contributes 23% of SSA's Gross Domestic Product (GDP) Goedde, et.al. (2019), with smallholder farmers accounting for more than 60% of the farming population. In Kenya, agriculture employs approximately 40% of the total population and more than 70% of the population living in the rural area, contributing 26% of the GDP directly and an additional 27% indirectly through its linkage with other sectors (FAO, 2021). A vast majority of households consider staple crops which dominate agricultural production as the most important source of food and income generation (USAID, 2010). Recently, there has been a global shift towards the adoption of more climate resilient, underdeveloped and underutilised crops anchored towards the development of sustainable farming aimed at enhancing food security and the general well-being of the current and future generations (Robertson, 2015; Teferra and Awika, 2019). This study focused on sorghum, a staple crop consumed by majority of people who live in the dry climates (Teferra and Awika, 2019). Sorghum, unlike other major cereal crops such as, rice and maize, has been identified as a socio-economically and geographically underutilised crop that performs well in water scarce and elevated temperature conditions (Hadebe, et al., 2016; Teferra and Awika, 2019). Sorghum is also well known for its diverse use for both human food and animal feed, biofuel, low cost of production and high returns, and more resilience to harsh environmental conditions (Khalifa and Eltahir, 2023). Therefore, due to these aspects there has been renewed interest to promote sorghum as most suitable cereal crop for rescuing households from being deprived of basic food needs and destitution (Muui, et al., 2013; Chepng'etich, et al., 2015; Okeyo, et al., 2020).

1.1.1 Global outlook

Globally, sorghum is the fifth most produced cereal (Mundia et al., 2019). The top ten largest sorghum producing countries, accounting for 78.6% (46.1 million t) of total global sorghum production are the USA (10.1 M t.), Nigeria (7.3 M t.), India (6.2 M t.), Mexico (5.9 M t.), Sudan (4.2 M t.), Ethiopia (3.4 M t.), Argentina (2.8 M t.), China (2.6 M t.), Brazil (1.9 M t.), and Australia (1.8 M t.) (Khalifa and Eltahir, 2023). Sorghum is produced primarily for both food and feed with a focus on domestic and export markets (Hansen, et al., 2018). The largest

sorghum consumers are typically the largest sorghum producers (Hansen, et al., 2018). In Mexico, sorghum is less expensive to produce, has high yields and was originally used as animal feed; however, due to growing demand for food-quality sorghum varieties to make food such as tortillas there has been an increase in the cereal's import into Mexico (Mundia, et al., 2019).

In the USA sorghum is cultivated in the dry areas of Texas, Missouri, Nebraska and Kansas (Mundia, et al., 2019), primarily for livestock feed and industrial uses such as bioethanol production (Teferra and Awika, 2019). In Kansas, for example, sorghum was grown on 1,054,000 hectares of land from 2007 to 2016, yielding 4,800 million kgs and worth nearly US\$ 800 million (Dille, et al., 2020). The USA is the largest sorghum exporter primarily for livestock feed, hence dictates the global market prices (Mundia, et al., 2019). As of 2016, China was the dominant importer and driver of the USA sorghum production (Li, et al., 2018). Sorghum consumption in China being mainly attributed to the brewing of sorghum-based alcohol, and livestock and poultry feed use (Liu, et al., 2020). However, following changes in China's corn policy and the implementation of anti-dumping policies, these imports have declined (Hansen, et al., 2018).

In Asia, India is the largest producer of sorghum, with smallholder farmers in the arid regions dominating production (Anbazhagan, et al., 2022; Chapke and Tonapi, 2019). Sorghum is cultivated either solely or intercropped with pulses and oilseeds due to unpredictable weather (Chadavalada, et al., 2022). Sorghum-based intercropping is regarded as the most suitable solution for ensuring continuous agricultural productivity, sustainability and livelihood security for smallholder farmers (Maitra and Duvvada, 2020). It is primarily used for animal and poultry feed or as subsistence crop where market linkages are poor or limited (Anbazhagan, et al., 2022). Households use it as flour to make products such as unleavened flat bread (Roti), thin and stiff porridge (Sangati), pancakes (Dosa), including alcoholic beverages (Ejeta, et al., 1990; Mundia, et al., 2019).

In SSA, Nigeria is the largest grower accounting for 34% of sorghum production in the continent, Sudan 21%, Ethiopia, Tanzania, Uganda, Rwanda and Kenya accounting for 7%, 4%, 2%, 0.8% and 0.6% respectively (Mitaru, et al., 2012; Dube, et al., 2014; Okeyo, et al., 2020). In comparison to other grains, sorghum grows very well in a wide range of ecological conditions in SSA (Ejeta, et al., 1990; Yahaya, et al., 2022). Smallholder farmers are critical to sorghum production and significantly contribute to SSA's overall food supply (Chiaka, et al., 2022). Most SSA countries, produce sorghum primarily for domestic consumption and use it in various forms such as pancake-like bread (*Injera*) and thin porridge (*Uji/Aceda/Ogi*), with

commercial use limited to flour and beer brewing (Dicko, et al., 2006; Mundia, et al., 2019; Orr, et al., 2020). There is limited value addition activities with sorghum in most parts of Africa since farmers experience a number of bottlenecks such as, farmer-market connectedness, lack of guaranteed markets, consumer preferences, and subsistence use (Mundia, et al., 2019; Musara, et al., 2019) In East and Southern Africa, sorghum consumption has decreased over time due to urbanisation; however, demand, driven by population growth, is expected to increase by 29.9 metric tonnes by 2050 (Orr, et al., 2020). Furthermore, SSA countries are yet to tap into the global sorghum market, despite growing demand for gluten-free flour, livestock feed and biofuels (Njagi, et.al., 2019; Teferra and Awika, 2019).

1.1.2 Kenya outlook

In Kenya, sorghum is grown in drought-prone agricultural regions including the Eastern, Nyanza, and Coast regions (Muui, et al., 2013). Smallholder farmers primarily grow the crop under subsistence production system (Njagi, et.al., 2019). According to, Kazungu, et al., (2023), the majority of smallholder farmers with farm sizes ranging from 1 to 1.5 acres grow sorghum and intercrop it with maize and pulses. Unlike other crops such as maize, the crop is grown on small acreage of land (Okeyo, et al., 2020; Kilambaya and Witwer, 2013). Similarly, production is lower than consumption demand (Okeyo, et al., 2020; Recha, 2018). Commercial demand for sorghum is high, particularly for brewing (Muui, et al., 2013). The beer market in Kenya has grown, encouraging commercialization of sorghum as a primary ingredient in production thereby stimulating vertical and horizontal integrations through partnerships with local brewers such as EABL and the government of Kenya (Nyamamba, et al., 2022; Njagi, et.al., 2019). Further, sorghum is viewed to have the a potential to improve food security in Kenya, particularly in dry areas, such as Eastern region where maize crop failure is common (Mwadalu and Mwangi, 2013; Muui, et. al., 2013). Therefore, with increased demand for sorghum food and commercial purposes, smallholder farmers have numerous opportunities both locally and globally such as, market-oriented sorghum production, collective marketing through groups and contract farming (Njagi, et.al., 2019).

1.1.3 Food security, market integration and access concepts

Food security is a broad concept that encompasses the dimensions of ‘food availability’, ‘food accessibility’, ‘food utilisation’ and ‘food systems stability’ (Iram and Butt 2004; FAO 2008; Ndiritu and Muricho 2021). The concept has evolved since mid-1970 where initial focus of

attention was primarily on the volume and stability of food supplies (Clay, 2002), to the wider construct of social security. The 1996 World Food Summit in Rome adopted a more complex definition which declared that “food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996).

In line with Food Agriculture Organizations’ (FAO’s) ‘twin-track approach’, food security can be attained by integrating sustainable agriculture and rural development (FAO 2006). This demonstrates how important agriculture is to enhancing food security and serves as the cornerstone for many rural households. In addition, the aspect of promoting drought-tolerant crop farming and boosting yields on smallholder farms are a central pillar to sustainable agriculture and rural development (Larson, 2014).

According to Pinstrup-Andersen (2009), factors such as price of food, total income of a household, and household and consumer behaviour determine food security. However, objective measures for food security at the household level, such as food expenditure data and caloric consumption may not adequately assess food security (Mallick and Rafi, 2010; Ndiritu and Muricho, 2021). Therefore, subjective measures can be used to assess food security vulnerability and sustainability for households (Pinstrup-Andersen, 2009; Ndiritu and Muricho, 2021).

Market access is frequently defined through a single indicator; physical dimensions such as distance to market or transport costs. However, a number of studies (Chamberlin and Jayne, 2013; Satyasai and Pereira, 2019) recommend an elaborate definition of market access as it involves multiple dimensions and cannot be easily reduced to a single indicator. Satyasai and Pereira, 2019 proposed a functional definition of market access to encompass market orientation of commodities, market channels and market information. Hlatshwayo, et al., (2022) defined market access as an approach to ensuring the food needs of smallholder farmers are facilitated.

Integration is the process of combining two or more parts into one or creating a whole part. The term vertical integration is commonly used interchangeably with vertical coordination and contract production (Cramer and Jensen 1988; Paarlberg 1995; Cramer, et al., 1997; Rehber, 2000). Vertical integration occurs when a firm combines activities, that are not currently performed by the firm such as marketing and production (Rehber, 2000). It is control over the entire production or distribution process as opposed to control over a specific input into a process.

Horizontal integration occurs when a firm acquires control of other companies that perform similar tasks whose production and marketing chains are at par (Rehber, 2000). Horizontal integration in agriculture is a process in which multiple groups of producers are involved in production and economic relationships are established between farms producing the same category of agricultural products (Pawlewicz, 2014). According to The World Bank Group (2020), horizontal integration through producer organisations can spur agricultural transformation for smallholder farmers and facilitate positive outcomes such as socio-inclusion, socio-economic benefits, efficiency and sustainability.

1.2 Problem statement

This study identified sorghum as a crop with the potential to improve food security in Kenya (Mwadalu and Mwangi, 2013). The crop is drought tolerant and requires relatively less water to grow (Hadebe, et al., 2017), resistant to pests and diseases, and has a high nutritional value which helps to reduce malnutrition in households (Muui, et al., 2013; Okeyo, et al., 2020). Furthermore, smallholder sorghum farmers have been identified as key contributors to addressing the food security situation in Kenya (Okeyo, et al., 2020). However, these farmers, including smallholder farmers in Machakos county, are known to face multiple challenges (Mwadalu and Mwangi, 2013; Bosire, et al., 2019), which contribute to sorghum's underutilisation as a cereal crop capable of improving food security (Mwadalu and Mwangi, 2013; Okeyo, et al., 2020). These challenges include but are not limited to lack of access to proper production systems (seeds, fertiliser, machinery), unreliable markets (low market prices, high transaction costs that reduce net margins, poor market infrastructure, inaccessible transport systems), and limited access to finance or credit due to their perceived high risk (Odame, et al., 2014; Kagwiria, et al., 2019; Musara, et al., 2019; Kazungu, et al., 2023). Furthermore, government policies and agricultural priorities have prioritised maize farming over farming of drought tolerant crops like sorghum, even in drought prone areas with erratic rains (Okeyo, et al., 2020). These constraints have manifested themselves as high transaction costs preventing sorghum farmers from market integration through contracts or cooperative associations, and market access Marangu, et al., (2014); Kilambaya and Witwer, (2013); Musara, et al., (2019) thereby contributing less to food security.

Despite renewed interest in sorghum as a cereal crop with the capability to improve food security Mwadalu and Mwangi, (2013), previous studies have primarily examined factors that influence sorghum production (Muui, et al., 2013; Chepng'etich, et. al., 2015; Kagwiria, et al., 2019; Mundia, et al., 2019; Njagi et al., 2019; Okeyo, et al., 2020). There is limited empirical

knowledge linking the effect of market integration and access on food security among the smallholder sorghum farmers. Therefore, this study aimed to fill this knowledge gap.

Second, this study used the Farmers Access to Market Index (FAMI) as a proxy for market access. Several past studies have identified market access as a key pathway to improving household food security, emphasising geographical distance to market and road infrastructure as indicators of market access (Dorosh, et al., (2012); Usman and Haile (2019); Usman and Callo-Concha, (2021)). However, this study used FAMI a different indicator employed and recommend by Satyasai and Pereira, (2019) as a comprehensive indicator for market access. The rationale for using FAMI was that it took market orientation, market agency choice and market information as proxies for market access (Satyasai and Pereira, 2019). FAMI addresses the methodological gap in assessing market access by road infrastructure.

Finally, this study used Food Insecurity Experience Scale (FIES) (FAO, 2023), a global reference scale and indicator for monitoring food insecurity Cafiero, et al., (2018) to measure the prevalence of food insecurity among the smallholder sorghum farmers. Additionally, subjective measures for food security Mallick and Rafi, (2010); Kassie, et al., (2014); Ndiritu and Muricho, (2021) were employed as proxies for behavioural and psychological aspects of food insecurity for households. Various past studies Abebaw, et al., (2010); Mucbe, et al., (2014) have used objective metrics, such as consumption-based estimates, to assess household food insecurity. However, this study used subjective measures to overcome the limitations of consumption-based estimates, which do not address food security vulnerability and sustainability (Ndiritu and Muricho, 2021).

1.3 Research objectives

1.3.1 General objective

The broad aim of this study was to investigate the effect of market integration and access on food security among smallholder sorghum farmers in Machakos county and recommend policies.

1.3.2 Specific objectives

To address the general objective, the study attempted to answer the following specific objectives:

- i. To determine the effect of market access on food security among the smallholder sorghum farmers in Machakos county.
- ii. To investigate the effect of sorghum vertical integration on food security among the smallholder sorghum farmers in Machakos county.
- iii. To examine the effect of sorghum horizontal integration on food security among the smallholder sorghum farmers in Machakos county.
- iv. To determine the effect of household characteristics on food security among the smallholder sorghum farmers in Machakos county.

1.4 Research questions

The study answered the following questions:

- i. What is the effect of market access on food security among the smallholder sorghum farmers in Machakos county?

The rationale for market access stemmed from various studies Usman and Haile (2019); Islam, et al., (2018); Sibhatu, et al., (2015) that used distance to market as a proxy for market access to determine food security. This study used FAMI Satyasai and Pereira, (2019) as a proxy for market access, rather than the conventional distance to markets.

- ii. What is the effect of sorghum vertical integration on food security among the smallholder sorghum farmers in Machakos county?

The rationale for vertical integration stemmed from various studies Adebisi, et al., (2019); Nazifi, et al., (2021) that used contract farming as a proxy for vertical integration to determine food security. This study used contract farming as a proxy for vertical integration.

- iii. What is the effect of sorghum horizontal integration on food security among the smallholder sorghum farmers in Machakos county?

The rationale for horizontal integration emanated from various studies Mende, et.al, (2015); Mchopa, et al., (2020) that used cooperative membership and farmers groups as a proxy for horizontal integration to determine food security. This study used cooperative membership or farmers' group as a proxy for horizontal integration.

- iv. What is the effect of household characteristics on food security among the smallholder sorghum farmers in Machakos county?

The rationale for household characteristics stemmed from various studies Ogeto, et al., (2013); Ndiritu and Muricho, (2021) that have used factors such as gender of household head and education level as proxies for household characteristics to determine food security. This study used age, gender, year of schooling, gender of household head, household size and farm size under sorghum as proxies for household characteristics.

1.5 Scope of the study

Initiatives to promote sorghum production to achieve food security in Kenya have mostly concentrated on dry climates, for example, Eastern region (Chepng'etich, et al., 2015). This study focused on Machakos county, located in Eastern Kenya (S 01°34.56, E 037°14.43), with a population of 1.4 million people as of 2019 (KNBS, 2019; Huho, 2017; Mwadalu, et al., 2022). Machakos county has a semi-arid climate, and it is hilly with altitudes ranging from 400 to 2,100 meters above sea level (Huho, 2017).

Agriculture is the primary economic activity in Machakos county with cereals, pulses, and root crops accounting for majority of production (Bosire, et al., 2019). The sector is important for food security, employment, and income generation (Bosire, et al., 2019). Sorghum, one of the cereals grown in Machakos county, has a high potential to accelerate the county's development and improve household food security (Mwadalu and Mwangi, 2013). However, in addition to unfavourable climatic conditions, farmers in the county face structural challenges such as lack of inputs and markets, which have prevented them from contributing to food security (Mwadalu and Mwangi, 2013; Muui, et al., 2013; Bosire, et al., 2019).

This study was conducted in a duration of six months following the approval of the research proposal.

1.6 Significance of the study

This study would benefit the following:

1.6.1 Policymakers and regulators

The outcomes of this work were aimed to inspire the government, both at county and national levels, to improve sorghum's position to provide food security at the national economy by

supporting smallholder farmers, from sorghum production through to consumption. The goal was to inspire policymakers and regulators to support farmers by enacting regulations and policies that encourage sorghum production, ensure the provision of inputs to farmers at subsidised prices and a ready market at both the local and regional (EAC, COMESA) levels. This would increase market access and participation while ensuring that sorghum is sold at competitive prices, as in the case with other cereal crops, thus providing competitive returns to smallholder sorghum farmers and, ultimately, food security.

1.6.2 Potential investors and existing stakeholders in the sorghum industry

Given the potential for private sector sorghum investment to grow through public-private partnerships, this study aimed to assist potential investors and existing stakeholders in evaluating their roles and contributions in the sorghum value chain in terms of food consumption. Its goal was to assist existing stakeholders identify the challenges they face in their current roles, their participation in the industry, and how they can make it more inclusive and focused on improving Kenya's food security.

1.6.3 Academicians and researchers

The study's aim was to enlighten academics and researchers on how to rethink the concept of market access, vertical integration, and horizontal integration analysis in the agricultural sector for smallholder farmers as well as its broader impact on national food security. Its purpose was to allow researchers to create value by investigating options that promote inclusivity for the smallholder farmers. Thus, academics and researchers could focus on the "ancient and lost crops" which can contribute significantly to providing food security and nutrition to the population in hunger-stricken regions, particularly in developing countries.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter identifies and informs the relevant components of a vertical integration, horizontal integration and market access and their contribution to household food security and inform their operationalization. This was accomplished by reviewing theoretical and empirical literature. Section 2.2. examined the transaction cost economics (TCE) theory and entitlement approach (EA) to food security. Section 2.3 examined empirical studies on the influence of vertical, horizontal and market access on food security. Section 2.4 highlights the summary of the literature and research gaps identified. Section 2.5 aimed at contributing to the conceptualisation of the independent variables and dependent variable. Section 2.6 informed the operationalisation of all the variables considered in this study.

2.2 Theoretical review

This study was guided by the transaction cost economics (TCE) theory pioneered by Ronald Coase in 1937 and expounded on by Olivier Williamson in 1981 and the Entitlement Approach (EA) to Food Security by Amartya Sen (Sen, 1981).

2.2.1 Transaction cost economics theory

TCE theory is based on Coase (1937) paper 'The Nature of the Firm', which pioneered the concept of transaction costs. Coase proposed that transactions should be organised within a firm when the costs of doing so are lower than that of the market, and that the cost of signing long-term contracts is relatively low compared to the cost of constantly recontracting with external firms (Grossman and Hart, 1986). Williamson (1979) further developed the transaction cost economics theory, where his work on vertical integration focused on the type of contracts, asset specificity – both human and physical capital, the incentives for opportunistic behaviour, information imperfections and the governance structures for commercial transactions and costs and benefits of internal organisations.

According to Williamson (1979), when considering governance structures, the critical dimensions of a contract are not always expressly identified. The author observed that where transactions were idiosyncratic (specific/distinct to the parties involved), recurrent, and characterised by uncertainty, a transaction-specific governance (commonly vertical integration)

structure was more fully developed. The optimisation of these commercial transactions required paying attention to both production and transaction-cost economies which dominate the theoretical analysis of vertical integration.

However, various studies including Alchian and Demsetz (1972), criticized the Transaction Economies Costs theory, giving rise to the concept of incomplete contracts. According to Hamdaoui and Bouayad (2019) the concerns raised included (I) it is not often possible to specify the type of transaction costs and (II) that there is a weakness in the separation of the role of authority within the firm and that of the market's price mechanism. Alchian and Demsetz (1972) observe that almost every contract is open-ended, in the sense that many contingencies are left unaddressed. Recently, Hamdaoui and Bouayad (2019) noted that the concept of an incomplete contract emphasised how the contract and the firm represent different governance models and that contracts are inherently incomplete because certain events are numerous or unpredictable to be fully documented in writing.

Therefore, residual rights are used to define the firm because contracts are often incomplete and transaction costs are high (Hamdaoui and Bouayad, 2019). These are rights to make decisions regarding asset's use and the rights are not explicitly transferred or granted to other parties in a contract. According to Grossman and Hart (1986), ownership is defined as the purchase of all rights that are not fully documented in a contract. Furthermore, Grossman and Hart (1986) describe vertical integration as the purchase of assets from a buyer or seller with the purpose of acquiring the residual rights of control. Therefore, to address the concept of incomplete contracts and the distribution of residual rights to a party in a contract-contractee relationship, the contractee is perceived to have the residual rights of control over the non-specified deeds (Grossman and Hart, 1986). Hence, in the incompleteness of a contract, the efficiency of property rights consequences is determined by the allocation of the residual rights of control (Chaddad and Iliopoulos, 2012).

2.2.2 Rationale for transaction cost economics theory

This study selected to be guided by this theory because it identified the measures of integration and viewed integration as a remedy for incompleteness of contracts. Furthermore, due to the idiosyncratic, recurrent and uncertain nature of smallholder farmers' transactions, the farmers are likely to benefit from integration. For example, through contractual relationships and having in place institutions to govern their formal exchanges, such benefits would include, lower transaction costs, higher net margins and ease of markets access. Additionally, transactions costs are also identified as a barrier to market access in the theory. Therefore, the smallholder

sorghum farmers are likely to be motivated to integrate and access markets where the benefits of integration and access to markets significantly outweighs the costs of integration and access to the markets. In previous studies, Yao and Shanoyan, (2018) used this theory to assess market participation of smallholder farmers in developing countries, in response to growing food security concerns.

2.2.3 Entitlement approach to food security

“The entitlement approach concentrates on each person’s entitlements to commodity bundles including food, and views starvation as resulting from a failure to be entitled to any bundle with enough food” (Sen, 1983). Amartya Sens’ EA challenges the Neo-Malthusian view of food availability which argues that the world’s capacity to produce enough food to meet its feeding needs could be surpassed by population growth (Aliyu et al., 2021). Amartya Sens prioritises food access over food availability.

The entitlement approach based on two components:- (I) the personal endowment, which refers to the resources a person legally owns, and (II) the exchange entitlement mapping, which refers to the commodities that a person can access through trade and production (Sen, 1981; Osmani, 1995; Burchi and De Muro, 2012). The approach argues that when an individual has sufficient means to survive, a decline of the endowment can lead to starvation, and even with the same endowment, if the exchange entitlement mapping declines, a person can still fall into a starvation trap (Burchi and De Muro, 2012).

Various studies including Devereux (2001), have criticised the EA. According to Devereux (2001) famine is a political issue with conflict, civil war, and natural factors such as drought and floods being significant causes of famine (Kurniawan, 2016). Furthermore, Devereux (2001) characterises the entitlement approach limitations into four categories; (I) ‘choosing to starve’ (II) ‘starvation or epidemics’ (III) ‘fuzzy entitlements’ and (IV) ‘extra-entitlement transfers’. These limitations have two common underlying themes: first, individuals are not recognised as socially integrated members of a family unit, a community, and a nation, and second, famines are political crises as they are economic crises and natural catastrophes (Devereux, 2001).

This theory outlines how food security has evolved from the concept of food availability which focuses on food supply, to food accessibility which relies on economics and the individual as a unit of analysis, to more complex issues such as political regimes, civil wars, natural disasters, governance, climate and environmental changes.

2.2.4 Rationale for entitlement approach to food security

This theory was used in this study because it improved the assessment of food security by emphasising on the significance of considering non-food resources such as politically stable governments, that have a direct impact on hunger and food security. Therefore, a complete set of assets was considered, providing additional details on the long-term well-being and susceptibility to hunger, as few resources or assets suggested that an individual would have more difficulties being food secure in the future. Finally, the theory identified individuals as well as households as a unit when analysing the means to access food and other resources linked to food security. Previous studies, used this theory to assess household food security in terms of available household resources such as farmers' group membership Mende, et al., (2015), cash spent on buying food Kayunze, et al., (2007) and livestock (Mende, et al., 2015; Kayunze, et al., 2007).

2.3 Empirical review

2.3.1 The influence of vertical integration on food security

Contract farming, according to Erkan (1998), is the first step towards vertical integration in agriculture and it offers numerous benefits to both the primary producers and integrators. Minot (2011) categorises farmers contracts into three types (1) market-specifying contracts – these contracts describe the sales transaction in terms of price, quantity, timing and product attributes. When a farmer requires inputs, for example, the contract leaves production decisions to farmer (2) resource-providing contracts – this is appropriate when a farmer requires specialised production inputs, better access to credit and sometimes production advice; (3) production management contract – this is appropriate when the buyer wants to ensure a level of quality and food safety. According to Minot (2011), many contracts combine elements from all three categories.

Binpori, et al., (2021) highlights that the main factor influencing smallholder farmers to contract is access to resources such as guaranteed adequate supply of raw materials and better market access. Issa and Chrysostome (2015) found that socio-economic factors such as lack of credit, off-farm income, farm contract agreements, farm under other crop cultivation, experience, and farm size influence coffee farmers' willingness to engage in cooperatives in Rwanda's Huye district. Contrary to common literature findings, Ba, et al., (2019) showed that various transaction costs for instance, information costs (market access, education), negotiation

costs (association membership, age, farming experience), and monitoring costs (trust), determined the decision of households in the Vietnamese rice industry to engage in contract farming.

According to Chang, et.al., (2022), access to healthy seeds and seedlings, access to knowledge on pesticide use, access to harvesting and transportation modes, an increase in revenue, and good reputation influence Taiwan's potato farmers' willingness to engage in contract farming. In smallholder farmer's households in Lin'an, China, Ao, et al., (2021) observed that increasing the degree of vertical integration (a shift from "production oriented farmer", "production and processing-oriented" to "production processing and sales oriented") improved production efficiency, reduced production risks and distributed farmers' income across the different production processes and increased the family income from other sources and the income from their farming operation. Accordingly, Koller (1950) observed that vertical integration provides numerous opportunities to improve agricultural marketing and purchasing.

Bellemare and Lim (2018), reviewed contract farming varieties in six regions of Madagascar and observed that growers with contract farming agreements covering dozens of crops had high incomes, experienced less fluctuations in income and had better access to food (Bellamere and Novak, 2016). Adebisi, et al., 2019 compared the state of hunger of contract and non-contract poultry farming households in Osun state, Nigeria, using a Propensity Score Matching (PSM) method, and found that contract farmers had increased household food security. Therefore, it is a strategy that can be used to increase farmers welfare gains from their production, while taking into account agreements that factor in risk sharing in cases where there are production failures and protect farmers from becoming overly vulnerable. According to Nazifi, et al., (2021), maize contract farming increased productivity and reduced their food insecurity for the Kano and Kaduna smallholder maize farmers and therefore, recommend contract farming as a tool that can be used to reduce rural farming households' hunger and poverty.

Binpori, et al., (2021) observed that taking part in contract farming could significantly increase food security in their study to determine whether contract farming can improve Ghana's rice farmers' food security. However, it is not obvious that participating in contract farming leads to improved food security. Banerjee and Mullainathan, (2010) and Bellamere and Novak, (2016) note that first, self control is a problem common among the poor and those who live 'at the margins' and second, it is unclear whether contracted or uncontracted farming households that receive cash during the harvest period of their crops spend it on necessities like food or on other gains. Olounlade, et al., 2020 in a study carried out on rice farmers in Benin, found that,

contract farming is not a viable policy tool for increasing household food security, in marginal areas with limited markets and other infrastructure.

2.3.2 The influence of horizontal integration on food security

Cooperatives, according to Emelianoff (1942) and Iliopoulos (2003), are a type of vertical integration. While Sexton (1984) and Iliopoulos (2003) argue that cooperation's are "horizontal coordination to achieve mutual vertical integration". Kohler (1950) observes that cooperatives are key to improving the economic position of farmers. Kohler (1950) views integration as establishing a monopoly in firms, integration by farmers is quite different due to the sector's unique characteristics such as, no barrier to entry, abundance of substitutes, and divergent interests of farmers and cooperatives. Farmers must be organized into groups to meet the demands of increasingly competitive markets, because active participation in these groups not only provides production technology, financial support and marketing of products, but also technical assistance such as agricultural education and counselling Pawlak, et al., (2019). According to Vroegindewey, et al., (2018) both horizontal integration and vertical integration are capable structures that effectively coordinate activities that promote the welfare of farmers. Kissoly, Faße and Grote (2017), emphasised the need for policies that promote effective vertical and horizontal integration of smallholder farmers in order to enhance food security and livelihoods. Sorghum for example, was excluded from the governments Anchor Borrowers Program (ABP) which requires smallholder farmers to be organised in groups, cooperatives or associations in order to get low-interest loans. Policymakers, according to Yahaya, et al., (2022) should address this constraint that prevents sorghum farmers from accessing production inputs. Furthermore, exclusion acts as a disincentive for smallholder sorghum farmers to join cooperatives. Musara, et al., found that strengthening cooperative based marketing reduced the risks of transacting with external traders who exploit farmers in terms of price, payment time and quality.

According to, Mende, et.al, (2015), households whose heads were members of a farmers group or association were more likely to be food secure. Mchopa, et al., (2020) found that households of cooperative members had better food security than non-members in a cross-sectional study conducted in rural Tanzania. Cooperative smallholder farmers increased their productivity and incomes by negotiating better input prices and infrastructure, contributing to increased food production, better market prices and distribution, all of which contributed to long-term food security Dyalvane, (2015); Mchopa, et al., (2020). According to Gebremichael, (2014)

agricultural cooperatives play important roles in improving members' income and access to services, potentially improving agricultural production and food security.

Contrary to common finding, Ndlovu and Masuku, (2021) found that due to a lack of institutional support and insufficient productive resources, agricultural cooperatives do not completely alleviate the susceptibility of households to hunger. Furthermore, Bizikova, et al., (2020) found that farmers who are already marginalised due to factors such as market access may require additional support systems to improve their capacities and resources before benefiting from farmers group membership. As a result, in order for more rural households to join agricultural cooperatives and benefit from sustainable food security, governments must increase awareness through training, public meetings and discussions, workshops and expanded information infrastructure in rural areas in collaboration with other concerned bodies (Nugussie, 2010).

2.3.3 The influence of market access on food security

According to Usman and Haile (2019), market access can boost smallholder farmers' income by lowering transaction costs, increasing food consumption, reducing poverty and household food insecurity. Various studies, (Mwadalu and Mwangi, 2013; Kagwiria, et al., 2019; Musara, et al., 2019) show that the lack of markets access associated with poor market infrastructure (road connectivity), lack of inputs (like seeds and subsidised fertilisers), and a lack of technologies reduces sorghum productivity. Mundia, et al., (2019); Musara, et al., (2019); Okeyo, et al., (2020) demonstrate that smallholder sorghum farmers are poorly linked to markets due to lack of information, low production, and both low producer and global market prices. Usman and Haile (2019) notes that in sub-Saharan Africa the household food security can be improved by developing markets, rural facilities and infrastructure that connects the smallholder farmers to markets.

Markets can provide households with a wider range of foods (Bellon, et al., 2016; Usman and Callo-Concha, 2021), determine the produce prices, influence the farmers revenues and household consumption (Stifel and Minten, 2017; Usman and Callo-Concha, 2021). Therefore, it is critical to connect smallholder farmers to markets, particularly women and the elderly in order to boost agriculture, food security and access to wider variety of foods (Hlatshwayo, et al., 2022). The income received from market sales can be used to purchase production inputs thereby increasing the outputs and food availability (Govereh and Jayne, 2003; Ntakyo and Berg, 2019). According to Usman and Callo-Concha, (2021) market access can boost the household food dietary and consumption needs in diverse ways and this includes but not limited

to, agricultural productivity, food availability and diversity, food prices, and increased household income that be used to purchase a wider range of foods for domestic consumption. Therefore, market participation is critical in determining increased revenues and sustainable livelihoods for the smallholder farmers (Kyaw, et al., 2018; Salami, et al., 2020). Despite these potential benefits, smallholder farmers continue to face challenges in interacting with markets directly (Hlatshwayo, et al., 2022).

Linderhof, et al., (2019) found that the commercialisation of agriculture had an effect on food security and this varied significantly depending on the region, the commercialisation indicator, and the ability to transfer relationships from one region to another. Ntakyo and Berg, (2019) using the case of commercial rice production, found that households producing rice with a market orientation consumed fewer calories because rice for own consumption were replaced by marketable crops and cash earned from crop sales was less likely to be spent to food purchases. Chege et al., (2015), Fischer and Qaim, (2012), and Usman and Haile (2019), noted the outcome of higher returns on increasing the susceptibility of being food secure is contingent upon several factors such as allocation of income linked to market access and the accessibility of diverse foods in the local markets. Therefore, because market access is context-dependent, it may not always result in increased household food security Usman and Callo-Concha, (2021). Various studies, have considered distance to market centre, road infrastructure, off-farm income and market participation as proxies for a measure of market access (Usman and Haile 2019; Islam, et al., 2018; Sibhatu, et al., 2015). However, Satyasai and Pereira, (2019) developed a multi-dimensional market access model that takes into account market orientation of commodities, market channels and market information and demonstrated that improved market access improves farm returns.

2.4 Summary of literature and research gaps

Contract farming is a first step towards vertical integration in agriculture. Agricultural cooperation's are examples of 'horizontal coordination' that can be used to achieve mutual vertical integration. Contract farming can increase a farmer's household food security and thus serve as a strategy for increasing farmers' welfare gains. Contrary to popular belief, contract farming does not always result in increased household food security due to factors such as self-control and farmers spending harvest proceeds on other gains other than food (Banerjee and Mullainathan, 2010; Bellamere and Novak, 2016). The review Gebremichael, (2014); Dyalvane, (2015); Mchopa, et al., (2020) also noted that agricultural cooperatives played

important roles in improving members' income and access to services and thus can be viewed as potential source of increased agricultural production and food security.

Market access, has previously been demonstrated to imply increase in household food security for smallholder farmers (Govere and Jayne, 2003; Ntakyo and Berg, 2019; Usman and Haile, 2019; Usman and Callo-Concha, 2021; Hlatshwayo, et al., 2022). Some of the potential benefits of market access include reduced transaction costs, access to information and prices, increased household income and access to more diverse foods (Bellon, et al., 2016; Mundia, et al., 2019; Musara, et al., 2019; Okeyo, et al., 2020; Usman and Callo-Concha, 2021). In contrast, access to markets does not always imply household food security as evidenced by factors like climate change Ndiritu and Muricho, (2021) and the substitution of domestic food crops for own consumption for marketable crops (Ntakyo and Berg, 2019)

According to the empirical review, less effort has been made to fully realise the potential of sorghum such as, through research, publication of research findings, and promotion of sorghum commercialisation in Kenya and abroad (Mwadalu and Mwangi, 2013). There is limited empirical knowledge linking the effect of market integration and access on the food security among the smallholder sorghum farmers, since past have focused on factors influencing sorghum production (Muui, et al., 2013; Chepng'etich, et. al., 2015; Kagwiria, et al., 2019; Okeyo, et al., 2020). This study sought to address this knowledge gap.

Second, previous studies Usman and Haile (2019); Islam, et al., (2018); Sibhatu, et al., (2015) have primarily focused on market proxies such as distance to market and road infrastructure. Therefore, future research should investigate other proxies for market access including the transaction costs associated with each different marketing channel and market strategies. This study aimed to fill this methodological gap and employed FAMI as a proxy to market access.

Finally, household food security has previously been measured using consumption-based estimates such as food expenditure data Abebaw, et al., (2010); Muche, et al., (2014). These measures have been shown to be insufficient for addressing the vulnerability and sustainability of households to food security (Pinstrup-Andersen, 2009; Ndiritu and Muricho, 2021). To address the limitations of consumption-based estimates, this study employed subjective measures as a proxy to food security.

Table 2.1 The key empirical studies

Study	Author(s)	Jurisdiction	Methodology	Findings	Gaps	How the gaps were addressed by this study
The potential role of sorghum in enhancing food security in semi-arid Eastern Kenya: A review	Mwadalu and Mwangi, (2013)	Eastern, Kenya	A review	Sorghum has the capacity to increase food security in dry climates where maize grows poorly.	In Kenya and abroad, limited research and promotion of the sorghum markets has been done to fully tap into its capacity as a crop that be used to increase food security.	This study investigated sorghum integration and market access and its effect on food security among smallholder sorghum farmers in Machakos county, Kenya.

Study	Author(s)	Jurisdiction	Methodology	Findings	Gaps	How the gaps were addressed by this study
Determinants of sorghum productivity among small-scale farmers in Siaya County, Kenya	Okeyo, et al., (2020)	Siaya County, Kenya	Cross-sectional survey design	The overall productivity of sorghum was determined by significant factors such as sorghum land size, farm gate process, sorghum seed varieties, and labour.	Futures research should consider incurred transaction costs and market strategies used by sorghum farmers with the goal of designing policies that can make the sorghum enterprise more profitable.	This study's review identified transaction costs as a main barrier to smallholder farmers participating in markets. As a result, it aimed to evaluate the integration approaches identified as strategies by the review and their effect on food security.

Study	Author(s)	Jurisdiction	Methodology	Findings	Gaps	How the gaps were addressed by this study
The effect of Market Participation on Food Security Among Smallholder Sorghum Farmers in Kwara State, Nigeria	Salami, et al., (2020)	Kwara State, Nigeria	Logistic regression model was used to analyse the data and variables.	Engaging in markets was positively correlated with household food security for smallholder farmers in Kwara State Nigeria.	Distance to market was a variable in determining crop market participation.	This study employed Satyasai and Pereira, (2019) recommendation and considered the Farmers Access to Market Index (FAMI) which considers
Market access, food security and nutrition: evidence from selected sub-Saharan African countries	Usman and Haile, (2019)	Ethiopia and Tanzania	The relationship between market access and household consumption expenditures was analysed by the random-effect regression model	Food security and household consumption were positively and significantly linked to market access.	Market access was evaluated using off-farm income, distance to market center. However, it viewed distance to market center as a limitation as this metric	market orientation, market agency choice and market information as proxies of market access.

Study	Author(s)	Jurisdiction	Methodology	Findings	Gaps	How the gaps were addressed by this study
					may obscure the quality of the market access.	
The efficacy of Agricultural Cooperatives Towards Enhancing Food Security in Rural Areas: Mbombela Local Municipality, Mpumalanga Province	Ndlovu and Masuku, (2021)	Mbombela Local Municipality, Mpumalanga Province, South Africa	To predict the improvement of food security through cooperatives, thematic analysis was used to analyse data from focus group discussions and face-to-face interviews.	Cooperatives are a supplementary intervention to food security especially when the government intervenes to provide institutional support with the goal of increasing productivity.	There is a need for funding to enable farmers invest in farming equipment and buy agricultural inputs.	The effect of vertical and horizontal integration on food security was assessed and the study highlighted recommendations and policy directions that can be implemented to improve access to inputs, market and other resources.

2.5 Conceptual framework

A conceptual framework is an illustration that shows how variables interact with one another (Kothari, 2004). The relationship between the independent variables – vertical integration, horizontal integration, access to markets and selected household characteristics, and the dependent variable – food security were investigated in this study. Other factors including, smallholder farmers’ off-farm income, climate change, and other cereal crops planted by the households that could have an effect on food security that this study were considered as control variables. Figure 2.1 illustrates this.

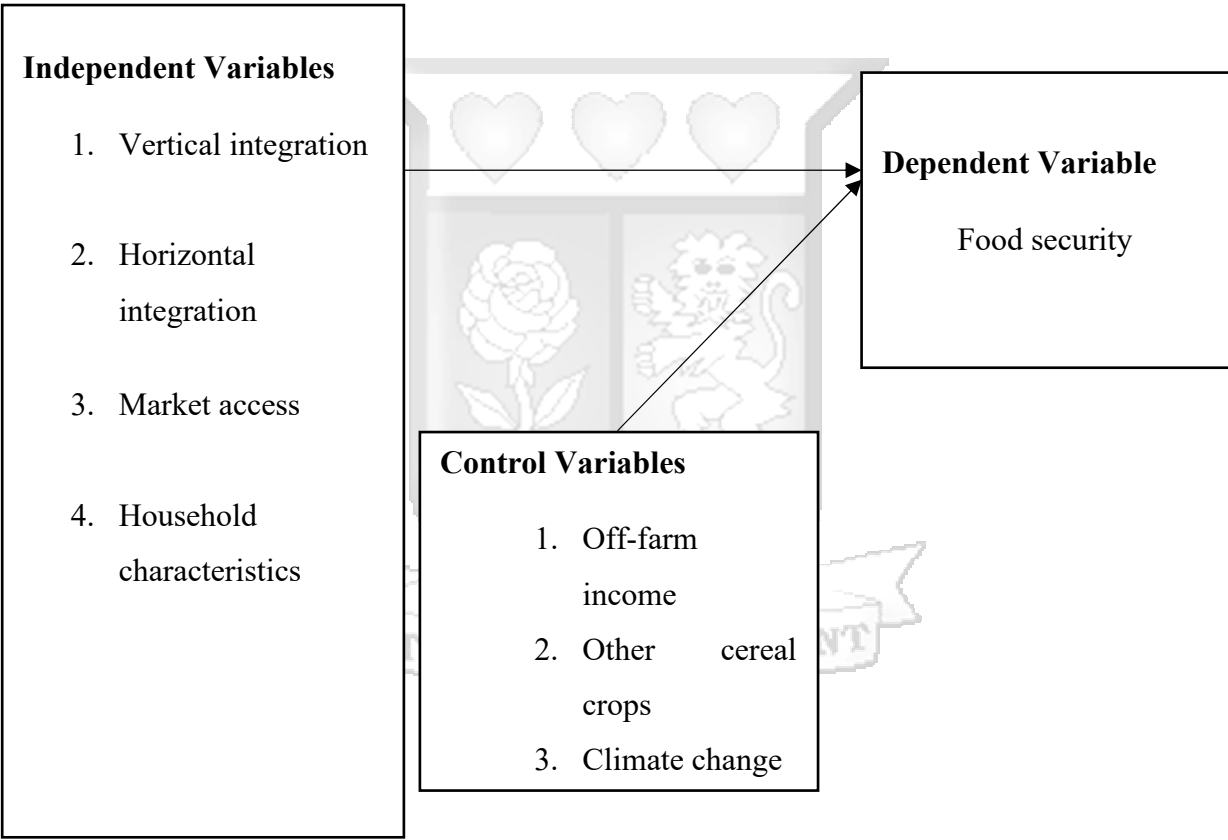


Figure 2.1: Conceptual framework adopted from literature review.

2.7 Operationalisation of study variables

Based on the conceptual framework outlined in section 2.5 the variables were measured as indicated in the below table 2.2

Table 2.2 Operationalisation of study variables

Variable	Type of variable	Metrics	Source	Data collection instrument
Independent Vertical integration	Binary	Farmer's contracts	Erkan, (1998) Kvaloy, (2007)	Questionnaires
	Binary	Degree of integration - Integration of production - Integration of production and processing - Integration of production, processing, and sales	(Ao, et al., 2021)	Questionnaires
Independent Horizontal integration	Binary	Farmer's groups/ cooperatives	Iliopoulos, (2003) Pawlewicz, (2014)	Questionnaires
Independent Market access	Discrete	1. Proportion of households (HH) reporting sorghum sales	Satyasai and Pereira, (2019)	Questionnaires
	Discrete	2. Total quantity sold per HH reporting sorghum sales.		Questionnaires

Variable	Type of variable	Metrics	Source	Data collection instrument
	Discrete	3. Proportion of quantity sold to their input suppliers.		Questionnaires
Independent Household characteristics	Binary	1. Gender of sorghum farmer	(Ao, et al., 2021)	Questionnaires
	Discrete	2. Gender of household head (HHH)		Questionnaires
	Continuous	3. Age of sorghum farmer		Questionnaires
	Discrete	4. Education level of sorghum farmer		Questionnaires
	Discrete	5. Household size		Questionnaires
	Continuous	6. Operating land area of household allocated to sorghum		Questionnaires
Dependent	Binary	1. FIES Survey Model	FAO, (2023)	Questionnaires
	Binary	2. Qualitative assessment of food security.	(Ndiritu and Muricho, 2021)	Questionnaires
Control	Discrete	1. Off-farm income	(Ao, et al., 2021)	Questionnaires
	Discrete	2. Other cereal crops		
	Continuous	3. Climate change		

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methods used in this study. It describes the research philosophy, the research design, and the criteria used to select respondents to ensure that the sample chosen was representative. It focuses on the types of respondents who were sampled, the instruments used to collect data, how the data collected was analysed, how the study ensured the validity of, and reliability of the data collected and the ethical methods that were considered.

3.2 Research philosophy

This research employed a subjective ontological philosophy. The research objectives were addressed using an interpretivism approach combined with deductive approach. The justification for using a deductive approach was that this study examined existing empirical studies and theories, hypotheses were developed based on the existing theories, data was collected to test the hypotheses, and results were analysed to determine whether the data supported the hypotheses that had been developed.

3.3 Research design

The research design was descriptive, and the study used quantitative data analysis approach. Structured questionnaires were used as a tool to collect data. The data was collected from smallholder sorghum farmers using closed ended questionnaires. The author of this study was fully involved in the data collection interpretation and analysis process.

3.4 Population and sampling

This study was carried out in Eastern Kenya, Machakos county. The county had a population of approximately 1.4 million people in 2019 (KNBS, 2019; Mwadalu, et al., 2022). Machakos county had a total of 402,466 farming households, with 217,073 engaged in crop production. The total number sorghum-producing households was 22,077 (KNBS, 2019). Subsistence farming is the predominant mode of food production.

A sample size representative of the target population was selected. Data was collected from 240 smallholder sorghum farmers. The equation below illustrates how the sample size estimate was calculated.

$$n = \frac{z^2 \times p^{\wedge} (1-p^{\wedge})}{\varepsilon^2}$$

$$n = \frac{2.576^2 \times 0.1 (1-0.1)}{0.01^2}$$

$n = 238.89$ Therefore, at least as 240 was considered as the appropriate sample size.

Where;

n is the sample size

z is the z score

p^{\wedge} is the population proportion (sorghum farming population)

ε is the margin of error

Sub-counties, constituencies, wards and households of smallholder sorghum farmers were sampled using stratified sampling.

3.5 Data collection methods

Primary data was provided by smallholder sorghum farmers in the study area. Structured questionnaires with closed ended questions were used to collect data. Refer to Appendix II, where Section A and B collected demographic, household, and operational information from the respondents. Sections C, D and E collected data from respondents on vertical integration, horizontal integration, and market access, respectively. Finally, section F collected data on food security and included both FIES questions refer to question 1-8 and subjective measures refer to question 9. FIES questions ranged from 'being worried about having enough to eat' to 'going the whole day without eating' with questions 1, 2 and 3 assuming mild severity, questions 4, 5, and 6 assuming moderate severity and questions 7 and 8 assuming severe severity to food insecurity.

3.6 Pilot study

To ensure the designs' feasibility, a pilot study with 30 participants was carried out to pre-test and validated the questionnaire and interview guide. The pre-test conducted on smallholder sorghum farmers from Matuu ward, Yatta sub-county, Machakos county. The pilot study results were used to validate the participants' responses to the study's objectives and ensure that they understood the questions while addressing the objectives. Additionally, the results influenced the modification of the questionnaire, in a way that the respondents could easily understand.

The findings also influenced the development of the timelines and budgets for data collection from participants.

3.7 Validity and reliability of the research instrument

The validity of the research instrument was assessed in two ways. First, the questions in the questionnaire were discussed with the supervisor. Second, a pilot test of the questionnaire was conducted to ensure that it asked the right questions, was understandable, and acceptable to the target audience. Reliability was achieved by designing the research instrument's questions so that participant responses remained consistent throughout the questionnaire. The questionnaire had a leading question which checked the next question.

3.8 Data analysis

Descriptive statistics were used to analyse data collected from the participants. The information gathered was edited, coded, and classified according to common characteristics and attributes. The food security situation of smallholder sorghum farmers who were integrated and had market access was compared to those who were not integrated and did not have market access. The FIES survey and subjective measures were used to assess the availability, accessibility, vulnerability, and sustainability of the household food security among smallholder sorghum farmers in Machakos county. The STATA statistical software package 17.0 was used to carry out statistical analysis of the data.

Since research questionnaires were used to assess the household food security, the dependent variable was designed to be binary in nature (food-secure or food-insecure). As a result, the probit regression model was used to analyse the variable.

$$\Pr (Y = 1|X_1, X_2, X_3) = f(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4) + \varepsilon \quad (1)$$

Where:

Y= food security

X₁= vertical integration

X₂ = horizontal integration

X₃ = access to markets

X₄ = household characteristics

β₀ = coefficient of the intercept

β₁ = coefficient for vertical integration

β₂ = coefficient for horizontal integration

β_3 = coefficient for access to markets

β_4 = coefficient for household characteristics

f = cumulative normal distribution function

$f(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4) = z$ -value

ε = error term

The following hypotheses were developed to determine the relationship between the dependent and the independent variables.

H₀ – Vertical integration has no significant influence on food security.

H₁ – Vertical integration has a significant influence on food security.

H₀ – Horizontal integration has no significant influence on food security.

H₁ – Horizontal integration has a significant influence on food security.

H₀ – Market access has no significant influence on food security.

H₁ – Market access has a significant influence on food security.

H₀ – Household characteristics has no significant influence on food security.

H₁ – Household characteristics has a significant influence on food security.

3.9 Ethical considerations

This work adhered to the Strathmore Business School, Strathmore University's ethical guidelines. To facilitate the start of the research, a research licence was obtained from the National Commission for Science, Technology, and Innovation (NACOSTI) (Appendix V). This study and its author ensured participant anonymity, confidentiality, voluntary participation, and informed consent from all respondents. The respondents were provided with a participants and consent form which informed the participants about this study, the respondents eligibility to participate in this study, the risks and benefits of participation, and the confidentiality of the information provided during this study.

CHAPTER FOUR

PRESENTATION OF RESEARCH FINDINGS

4.1 Introduction

This chapter presents the actual findings from the respondents' feedback with respect to the objectives of the study. The objectives of this study were (i) to determine the effect of market access on food security, (ii) to investigate the effect of sorghum vertical integration on food security, (iii) to investigate the effect of sorghum horizontal integration on food security, (iv) to determine the effect of household characteristics on food security, among the smallholder sorghum farmers in Machakos county. The results are tabulated and graphically illustrated to aid comparison and statistical analysis.

4.2 Analysis of response rate

Questionnaires were used to collect views from Machakos county's smallholder sorghum farmers. 240 questionnaires were equally distributed evenly in each sub-county, with 210 received and three rejected due to incorrect completion. In total, 207 were accepted as properly filled, representing an 86.3% response rate. According to Mugenda (2009), a 50% response rate is adequate, 60% is good and 70% or higher is excellent. While (Sekaran and Bougie, 2013) suggest that a response rate of approximately 60% is adequate. Therefore, these claims imply that the response rate for this study was adequate. The level of response rate is depicted in Figure 4.1 and 4.2. More urban areas, such as Mavoko had a lower representation when compared to its counterparts.

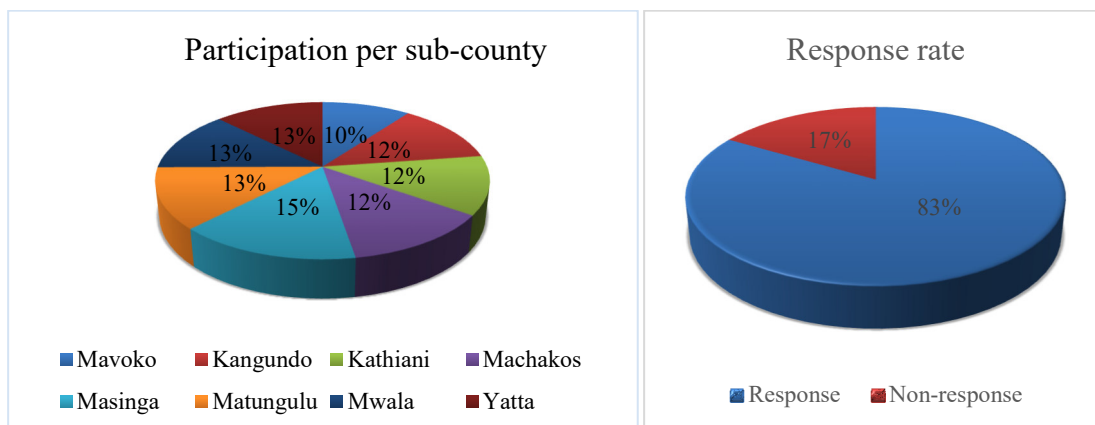


Figure 4.1: Participation per sub-county
Survey Data (2023)

Figure 4.2: Response rate

4.3 Demographic characteristics

This section provides information on the distribution of the smallholder sorghum farmers in terms of gender, age, and year of schooling.

4.3.1 Gender

The gender distribution of participants in this study was 47.3% male and 52.7% female (Table 4.1).

Table 4.1: Respondents' gender

Gender	Frequency	Percentage
Male	98	47.3
Female	109	52.7
Total	207	100

4.3.2 Age

Table 4.2 shows that 0.5% of the participants were aged between 18 and 28 years, 17.4% between 29 and 39 years, 28.5% between 40 and 49 years, 23.2% between 50 and 59 years, and 30.4% were over the age of 60.

Table 4.2: Respondents' age group

Age	Frequency	Percentage
18 – 28 years	1	0.5%
29 – 39 years	36	17.4%
40 – 49 years	59	28.5%
50 – 59 years	48	23.2%
Above 60 years	63	30.4%
Total	207	100

4.3.3 Years of education

Majority (88.4%) of the respondents had 7 and more years of schooling (Table 4.3). The average number of years of schooling was ten (Table 4.11).

Table 4.3: Respondents' years of schooling

Years of education	Frequency	Percentage
0 – 2 years	10	4.8%
3 – 4 years	6	2.9%
5 – 6 years	8	3.9%
7 – 8 years	52	25.1%
9 – 10 years	21	10.1%
11 – 12 years	58	28.0%
13 – 14 years	19	9.2%
15 – 16 years	33	15.9%
Total	207	100

4.4 Household and operational characteristics

This section contains information on the smallholder sorghum farmers' household and operational characteristics such as household composition, farmland size owned by farmers, farmland size under sorghum production, and other types of cereals produced by the smallholder sorghum farmers.

4.4.1 Household composition

This study registered 90.3% of the respondents as household heads, while 9.7% were not. The results also show that 32.9% of the households were female-led, while 67.1% were male-led (Table 4.4).

Table 4.4: Head of the household

Head of the household	Frequency	Percentage	Frequency	Percentage
Yes	187	90.3%	-	-
No	20	9.7%	-	-
Female-headed	-	-	68	32.9%
Male-headed	-	-	139	67.1%
Total	207	100	207	100

84.5% of the households had between 1 and 5 people, while 15.5% had between 6 and 10 people (Table 4.5). The average household had 4 members (Table 4.11).

Table 4.5: Number of members in the household

People per household	Frequency	Percentage
1 – 5	175	84.5%
6 – 10	32	15.5%
Total	207	100

4.4.2 Smallholder sorghum farmer farmland

58% of the respondent's owned farmland size ranging between 0 and 2.9 acres, while 42% owned farmland larger than 3 acres (Table 4.6). In addition, it was quite apparent that majority of the respondents grew sorghum on farmland smaller than 0.5 acres, accounting for 61.8% of the total farmland dedicated to sorghum farming (Table 4.7).

Table 4.6: Size of farmland

Acres	0 – 0.5	0.6 - 1.1	1.2 - 1.7	1.8 - 2.3	2.4 - 2.9	Above 3	Total
Frequency	13	31	20	42	14	87	207
Percentage	6.3%	15.0%	9.7%	20.3%	6.8%	42.0%	100%

Table 4.7: Size of farmland allocated to sorghum.

Acres	0 – 0.5	0.6 - 1.1	1.2 - 1.7	1.8 - 2.3	2.4 - 2.9	Above 3	Total
Frequency	128	52	12	8	1	6	207
Percentage	61.8%	25.1%	5.8%	3.9%	0.5%	2.9%	100%

4.4.3 Other cereals crops

In addition to sorghum, 97.1% of respondent's grew maize, while 9.2% grew millet (Table 4.8). This suggests that maize is a popular cereal crop in Machakos county.

Table 4.8: Other types of cereal crops farmed.

Cereal crop	Maize	Millet	Wheat	Rice	Barley	Oats	Rye
Frequency	200	19	-	-	-	-	-
Percentage	97.1%	9.2%	0%	0%	0%	0%	0%

4.4.4 Farm services

The types of farm services received by respondents were considered because of their contractual relationship and membership in cooperative societies. The results indicate that majority (47.3%) of the respondent's received farm inputs primarily seeds by being integrated (Table 4.9).

Table 4.9: Type of services provided.

Services	Farm inputs	Transportation	Storage	Credit/ Financing	Marketing	Training
Frequency	52	10	3	24	21	22
Percentage	47.3%	9.1%	2.7%	21.8%	19.1%	20%

4.5 Market characteristics

The quantity of sorghum produced and sold per harvest by the respondents was determined. Table 4.10 indicates that majority of the respondents produced (44.9%) and sold (15.9%) sorghum in quantities ranging between 0 and 90 Kgs on average.

Table 4.10: Sorghum produced and sold.

Sorghum produced per harvest					
Quantity	0 – 90 Kgs	91 – 180 Kgs	181 -270 Kgs	271 – 360 Kgs	Above 360 Kgs
Frequency	93	19	20	21	34
Percentage	44.9%	18.8%	9.7%	10.1%	16.4%
Sorghum sold per harvest					
Quantity	0 – 90 Kgs	91 – 180 Kgs	181 -270 Kgs	271 – 360 Kgs	Above 360 Kgs
Frequency	33	26	19	13	18
Percentage	15.9%	12.6%	9.2%	6.3%	8.7%
Sorghum sold to formal agencies per harvest					
Quantity	0 – 90 Kgs	91 – 180 Kgs	181 -270 Kgs	271 – 360 Kgs	Above 360 Kgs
Frequency	15	14	12	10	11
Percentage	7.2%	6.8%	5.8%	4.8%	5.3%
Sorghum sold in open market					
Quantity	0 – 90 Kgs	91 – 180 Kgs	181 -270 Kgs	271 – 360 Kgs	Above 360 Kgs
Frequency	11	10	2	-	-
Percentage	5.3%	4.8%	1.0%	0%	0%
Sorghum sold to input suppliers per harvest					

Quantity	0 – 90 Kgs	91 – 180 Kgs	181 -270 Kgs	271 – 360 Kgs	Above 360 Kgs
Frequency	7	7	5	3	2
Percentage	3.4%	3.4%	2.4%	1.4%	1%

4.6 Descriptive analysis of the results

The average sorghum yield per harvest was 223.7 kilograms, with the highest production amounting to 4,000 kilograms. Similarly, the highest kilogram sold was 4,000 kilograms, and the average quantity sold per harvest was of 154.1 kilograms with an average of 106.33 kilograms sold per contractual agreement or to farmers cooperatives / groups, and an average of 28.9 kilograms sold to input suppliers (see Table 4.11).

Table 4.11 indicate that 42.5% of the respondents had contracts and 53.1% were members of a cooperative society or farmers group. 64.8% of the contractual agreements were formal, while 35.2% were informal. Furthermore, the majority of respondents who had contracts or were members of a cooperative society, participated in the contractual agreements and cooperative societies at producer level (71.6% and 77.3% respectively). 37.2% of the respondents with or without contracts or memberships in cooperative society, participated in open market.

Table 4.11: Descriptive statistics

Variable description	Mean	Median	Std. Dev	Min	Max
Age of respondents	52.1	52.0	12.2	28.0	83.0
Years of schooling	10.3	11.0	3.9	0	16.0
Household size	4.0	4.0	1.6	1.0	9.0
Size of farmland owned (acres)	3.5	2.0	3.7	0.3	30.0
Size of farmland allocated to sorghum farming (acres)	0.9	0.5	1.5	0	20.0
Average sorghum produced per harvest (kgs)	223.7	130	350.5	0	4,000.0
Average sorghum sold per harvest (kgs)	154.1	30.0	348.7	0	4,000.0
Average sorghum sold per contractual agreement or to farmers group/ cooperative society	106.3	0	331.2	0	4,000.0
Average sorghum sold to input suppliers (kilograms)	28.9	0	93.8	0	900.0

Variable description	Measure	Frequency	Percentage
Farmer sold produced sorghum	Yes = 1 ;	112 ;	54.1% ;
	Otherwise = 0	95	45.9%
Farmer sold produced sorghum to input suppliers	Yes = 1 ;	39 ;	18.8% ;
	Otherwise = 0	168	81.2%
Gender of household head:	Male = 1 ;	139 ;	67.1% ;
	Otherwise = 0	68	32.9%
Contractual agreement in place	Contract = 1 ;	88 ;	42.5% ;
	Otherwise = 0	119	57.5%
Type of contractual agreement in place:	Formal = 1 ;	57 ;	64.8% ;
	Otherwise = 0	31	35.2%
Variable description	Measure	Frequency	Percentage
Degree of participation in contractual Agreement	As producer = 1;	63 ;	71.6% ;
	As producer and processor = 2;	0 ;	0% ;
	As producer, processor, and marketer = 3	25	28.4%
Member of farmers group / cooperative society	Member = 1 ;	110 ;	53.1% ;
	Otherwise = 0	97	46.9%
Degree of participation in farmers group /cooperative society	As producer =1;	85 ;	77.3% ;
	As producer and processor = 2;	0 ;	0% ;
	As producer, processor, and marketer = 3	25	22.7% ;
Participates in open market	Yes = 1;	77 ;	37.2% ;
	Otherwise = 0	130	62.8%

4.6.1 Food insecurity occurrence by integration and market access characteristics based on FIES categories.

FIES developed by FAO-VoH, was used to collect food security data. FIES consists of 8 questions with dichotomous answers of “Yes”/ “No”. At the time of data collection, respondents were asked if they had experienced different levels of food insecurity in the previous twelve months (Sheikomar et al., 2021).

FIES results revealed that the overall trend of the number of respondents experiencing food insecurity decreased from mild (contract = 18%, without contract = 48%) to severe (contracts = 8%, without contracts = 28%) (see Figure 4.3). In addition, respondents without contracts reported a higher proportion of the population experiencing food insecurity than those with contracts.

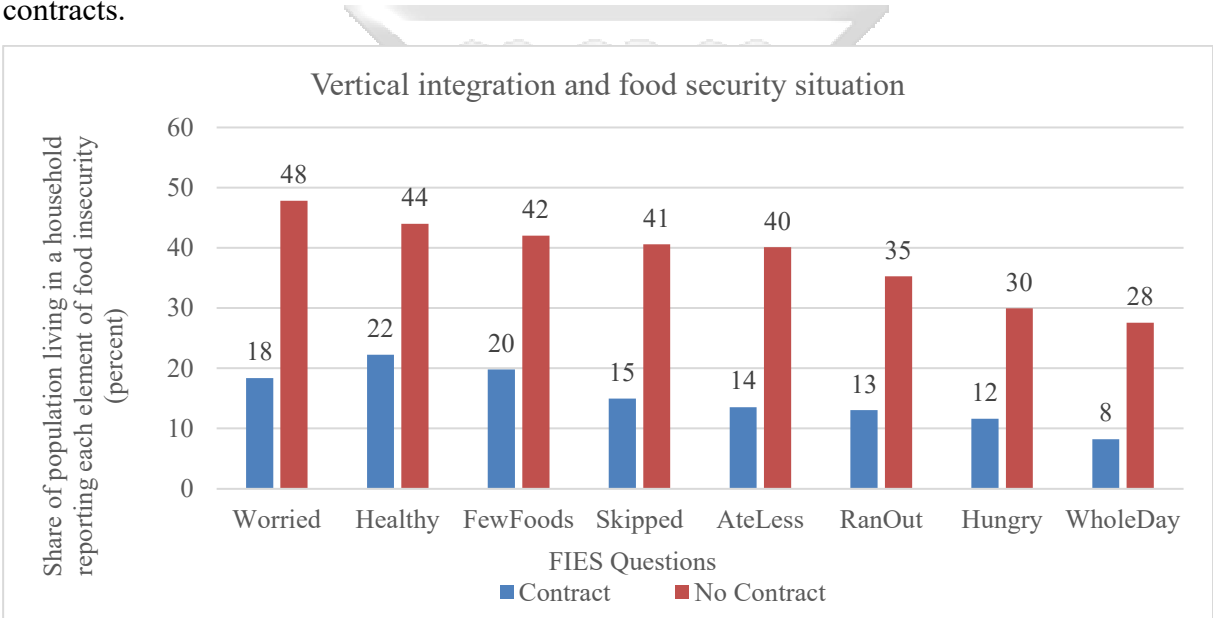


Figure 4.3. Graphical representation of the distribution of percentage of respondents (contract and without contract) with respect to the 8 FIES questions. Source: Own analysis Respondents with contracts and who participated solely as producers had a higher proportion (11%) experiencing food insecurity than those who participated in the contracts as producers, processors, and marketers (1%) (Figure 4.4).

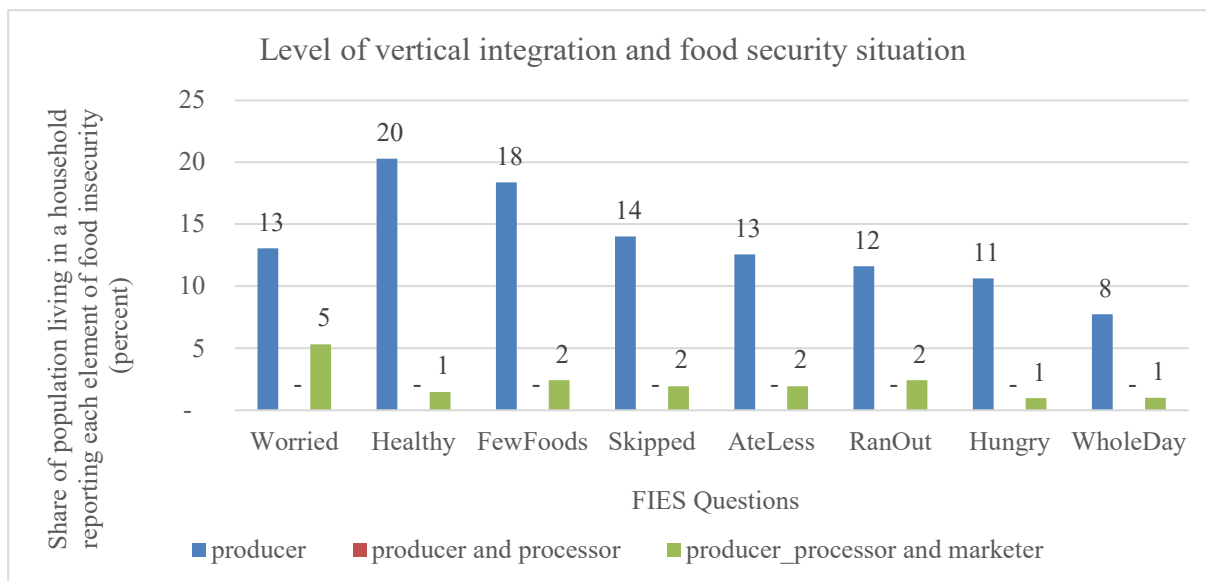


Figure 4.4. Graphical representation of the percentage distribution of respondents with contracts – i) producers only, ii) producers and processors, iii) producers, processor, and marketer – with respect to the 8 FIES questions. Source: Own analysis

Further, the results indicated that non-members had a higher level of food insecurity 27% compared to members 9%, as the trend of the food insecurity across the scale decreases from mild (members = 29%, non-members = 38%) to severe (members = 9%, non-members = 27%) (Figure 4.5).

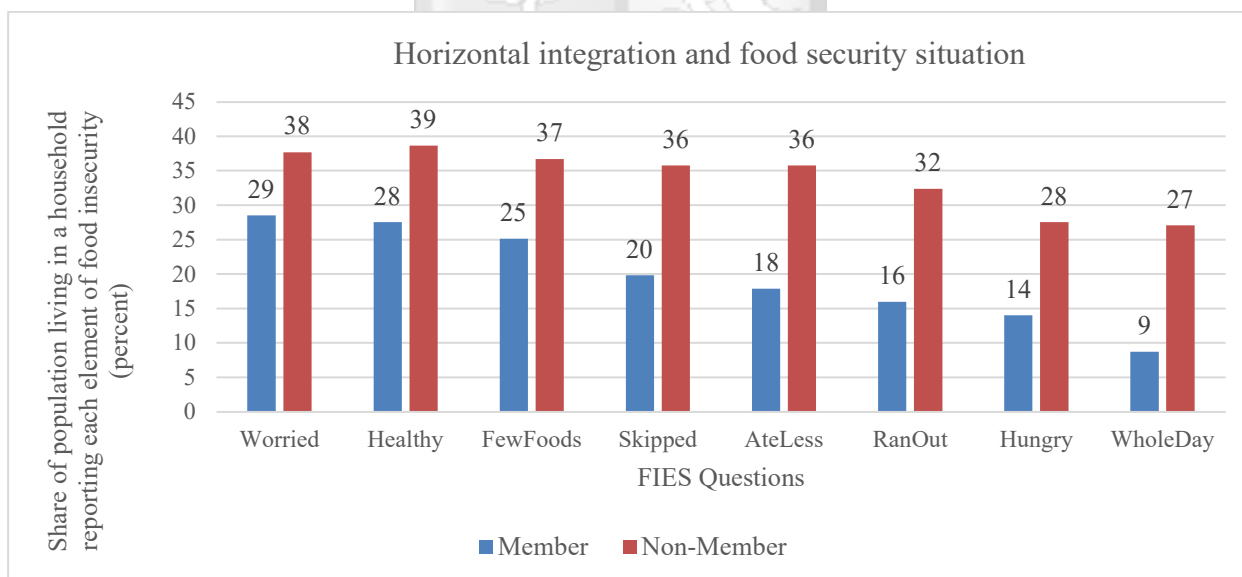


Figure 4.5. Graphical representation of the distribution of percentage of respondents (members and non-members) with respect to the 8 FIES questions. Source: Own analysis

Respondent households that did not sell their sorghum produce had a higher proportion of the population experiencing food insecurity than those who sold their sorghum produce (Figure 4.6).

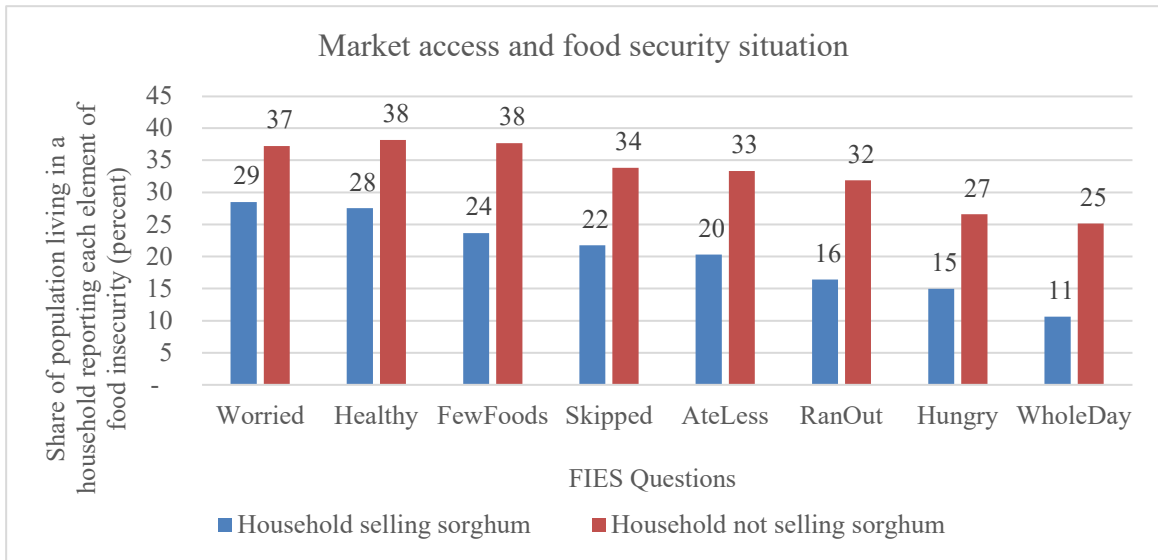


Figure 4.6. Graphical representation of percentage of respondents (selling and those not selling sorghum) with respect to the 8 FIES questions. Source: Own analysis

4.7 Regression analysis

Prior to performing the inferential analysis, Pearson correlation was used to test for the presence of multicollinearity in the variables.

4.7.1 Multicollinearity test.

The Pearson's correlation coefficient was used to test the relationships among all variables; both independent (age, gender, household size, years of schooling, farm size under sorghum, contract, open market participation, cooperative membership and sorghum sold) variables and the dependent (food security) variable.

The intercorrelation matrix (Pearson correlation results) tabulated in Table 4.12 revealed that based on the study objectives, contracts a proxy of vertical integration, cooperative membership a proxy of horizontal integration, and sorghum sold a proxy of market access, had a strong and negative correlation with food security.

Table 4.12. Pearson's correlation matrix

	Food security	Age	Gender	Household Size	Years of schooling	Farm size under sorghum	Contract	Open Market participation	Cooperative membership	Sorghum sold
Food security	1.00									
Age	0.07	1.00								
Gender	0.03	-0.09	1.00							
Household Size	-0.10	0.13	0.03	1.00						
Years of schooling	0.04	-0.43	-0.13	-0.02	1.00					
Farm size under sorghum	0.25	0.19	0.04	0.04	-0.16	1.00				
Contract	-0.52	-0.03	0.01	-0.01	-0.02	-0.14	1.00			
Open market participation	0.17	0.04	0.06	-0.05	-0.10	0.21	-0.22	1.00		
Cooperative membership	-0.54	-0.21	-0.03	0.03	0.02	-0.31	0.64	-0.15	1.00	
Sorghum sold	-0.39	-0.08	-0.03	0.01	-0.03	-0.29	0.39	0.08	0.42	1.00

4.8 Model empirical results

The empirical results were obtained by analysing data collected from respondents using subjective measures of food security (Table 4.13). Respondents were asked to select from four mutually exclusive options, an option that would best assess their own level of food security in the previous 12 months prior to the survey. Among the options were, ‘there is food security along with food shortage throughout the year’ (categorised as *chronic*), ‘there is food shortage occasionally in the year’ (categorised as *transitory*), ‘there is no food shortage nor food surplus in the year’ (categorised as *break-even*) and ‘there is food surplus throughout the year’ (categorised as *surplus*) (Ndiritu and Muricho, 2021; Kassie, et al., 2014). In our analysis the categories *chronic* and *transitory* were merged to form a *food-insecure* group because of the relatively small number of observations in the categories, and for similar reasons, *break-even* was merged with the *surplus* group to form a *food-secure* group. As a result, the predicted variable was binary in nature and was coded 0 if a respondent’s household was *food-insecure* and 1 if it was *food-secure*. The distribution of food security status among the sorghum farmers in Machakos is presented in figure 4.7. The overall result reveals that majority of the respondents were food secure (67%) and nearly 33% were food insecure.

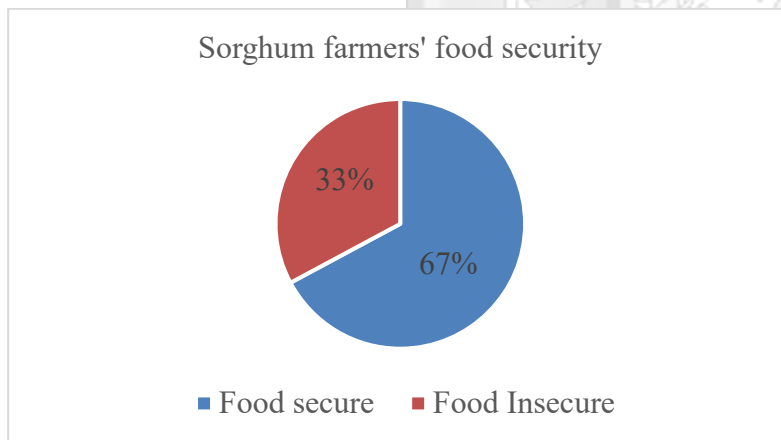


Figure 4.7. Food security level among smallholder sorghum farmers in Machakos county, Kenya. Source: Own analysis

The explanatory variables used were expressed as follows:

- *Age* represents the age of the respondent (1 = (18 – 28 years) , 2 = (29 – 39 years), 3 = (40 – 49 years), 4 = (50 – 59 years) and 5 = (60 and above)).
- *Gender* represents gender of respondent (1 = male and 2 = female).
- *Household_head* represents gender of household head (1 = male and 2 = female).

- *Household_size* represents the number of people living in a household (1 = (1- 5 people) and 2 = (6 - 10 people)).
- *Years of schooling* represents the level of education of the household head (1 = (0 – 8 years) and 2 = (9 – 16 years)).
- *Farm size under sorghum* represents the size of farmland allocated to sorghum production by each household (1 = (0 – 0.5 acres) 2= (0.6 – 1.1 acres) 3 = (1.2 – 1.7 acres) 4 = (1.8 -2.3 acres) 5 = (2.4 – 2.9 acres) and 6 = (3 and above acres)).
- *Sub_county* represents the sub-county in which the respondent had the farmland allocated to sorghum (1 = (Mavoko), 2= (Kangundo) 3= (Kathiani) 4 = (Machakos), 5= (Masinga), 6 = (Matungulu), 7 = (Mwala) and 8 = (Yatta)).
- *Contract* represents whether the respondent’s household had a contractual agreement (1 = Yes and 2 = No).
- *Open market participation* represents whether the household freely sold their sorghum produce in the market based on the demand expressed by the buyers (1 = Yes and 2 = No)
- *Cooperative membership* represents whether the respondent’s household belonged to an agricultural cooperative society (1 = Yes and 2 = No).
- *Sorghum sold* represents whether the respondent’s household sold their sorghum produce after harvest (1 = Yes and 2 = No).
- *Sorghum sold to input supplier* represents whether the respondents sold a proportion of their harvest sorghum to their input supplier (1 = Yes and 2 = No).

This study tested the following hypotheses at 1%, 5% and 10% significance threshold levels to determine the relationship between independent (vertical integration, horizontal integration, and market access), and the dependent variable: food security.

H₀ – Vertical integration has no significant influence on food security.

H₁ – Vertical integration has a significant influence on food security.

The probit model results (Table 4.13) revealed that contracts had a significance value ($p=0.001$), below the 1% p -value significance threshold, therefore, the null hypothesis was rejected and the alternative accepted: implying that contracts had a high significant impact on food security among households.

H₀ – Horizontal integration has no significant influence on food security.

H₁ – Horizontal integration has a significant influence on food security.

Cooperative membership registered a significance value ($p=0.005$) below the 1% p -value significance threshold; therefore, the null hypothesis was rejected and the alternative accepted: meaning cooperative membership had a high significant impact on food security among households.

H_0 – Market access has no significant influence on food security.

H_1 – Market access has a significant influence on food security.

The probit model results (Table 4.13) revealed that sorghum sold recorded a significance value ($p=0.044$) below 5% p -value significance threshold, thus the null hypothesis was rejected and the alternative accepted. This suggested sorghum sold had a significant impact on food security among the households.

H_0 – Household characteristics has no significant influence on food security.

H_1 – Household characteristics has a significant influence on food security.

The probit model results (Table 4.13) revealed that year of schooling recorded a significance value ($p=0.001$) below 1% p -value significance threshold, thus the null hypothesis was rejected and the alternative accepted. This suggested that year of schooling had a high significant impact on food security among the households.

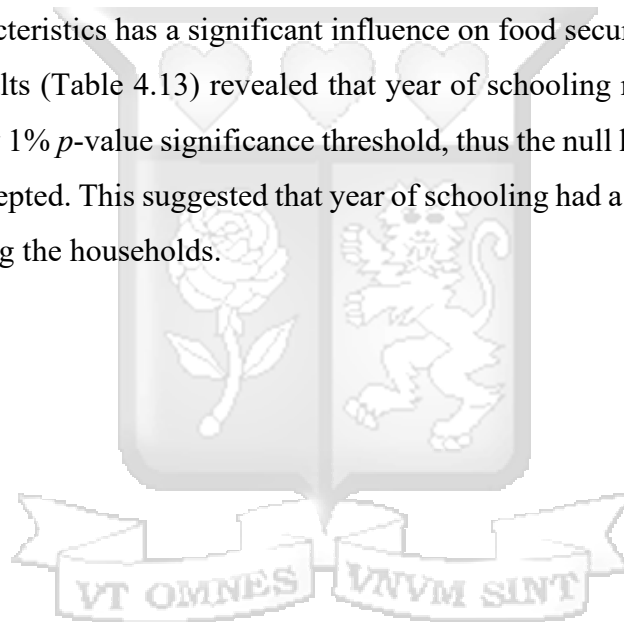


Table 4.13 Determinants of household food security

			No. Observations:	207
			LR chi2 (12):	110.92
			Prob > chi2:	0.0000
			Pseudo R-squ.:	0.4232
			Log-Likelihood:	-75.595
			Model:	Probit Regression
Food Security	Probit		Marginal Effect	
	Coef.	St. Err.	<i>p</i> -Value	dy/dx
Age	-0.168	0.131	0.198	0.047
Gender	-0.148	0.313	0.636	-0.041
Household head	0.451	0.361	0.211	0.125
Household size	-0.562	0.321	0.080*	-0.156
Years of schooling	0.962	0.297	0.001***	0.267
Farm size under sorghum	0.110	0.079	0.166	0.031
Sub county	-0.086	0.054	0.108	-0.024
Contract	-1.211	0.352	0.001***	-0.337
Open market participation	0.307	0.166	0.065*	0.085
Cooperative membership	-0.860	0.307	0.005***	-0.239
Sorghum sold	-0.541	0.268	0.044**	-0.150
Sorghum sold to input supplier	-0.405	0.392	0.302	-0.113
constant	3.164	1.252	0.012**	

*Notes: Dependent variable is food security, ***, **, * indicate significance at 1%, 5% and 10% level, respectively. Source: Own analysis*

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the discussion of findings, conclusions, recommendations, and suggestions for future research.

5.2 Discussion of findings

Smallholder farmers in Machakos county can grow sorghum for a living. However, structural constraints Odame, et al., (2014); Kagwiria, et al., (2019); Musara, et al., (2019) and prioritisation of maize over sorghum Okeyo, et al., (2020) prevent them from producing and accessing markets, despite the prospects that sorghum pose to increase food security (Mwadalu and Mwangi, 2013). This study examined the determinants of integration and market access and their effect on household food security. The probit regression model was employed to predict likelihood that each sample household would become food secure, with subjective measures of 0 for food-insecure and 1 for food-secure applied. Both coefficients and marginal effects were examined. The estimated coefficients on the probit regression model indicate the direction and influence of independent variables on food security. On the other hand, marginal effects were used to estimate the effect of a unit change in each independent variable on the likelihood of being food secure, holding all other variables constant (Habyarimana, 2015).

5.2.1 The effect of sorghum farmers household characteristics on food security

First, in terms of demographic characteristics, the study found that number of female respondents nearly equalled that of the male, demonstrating that gender diversity was achieved. In this study, gender was not a significant factor (p -value, 0.636) in influencing food security. Second, most of the respondents were middle-aged, with an average of 10 years of education suggesting that they understood the research questions posed to them (Table 4.1, 4.2 and 4.3). Household heads were mostly men with 1-5 dependants on average (Table 4.4 and 4.5). Despite most respondents owning a farmland size of 0-2 acres, only 0.5 acres or less was dedicated to sorghum farming, indicating low preference for sorghum as a staple food (Table 4.6 and 4.7). Notably, the level of education for the household head acquired a positive probit coefficient value (0.962) and exhibited a high significance (p -value, 0.001) on food security. This indicates that food security predominant among educated households and implies that households with

higher education have access to information that can help them improve their household food security. The results are consistent with previous studies (Muche, et al., 2014; Ndiritu and Muricho, 2021; Hlatshwayo, et al., 2022). The marginal effect is that an increase in the education level by one unit – which corresponds to one year – would increase the average probability of becoming food secure by 0.267 everything else held constant.

5.2.2 The effect of sorghum vertical and horizontal integration on food security

Nearly half of the respondents had contracts and membership in cooperative society or farmers group (Table 4.11). These agreements and memberships allowed them to receive farm services (Table 4.9). Remarkably, a majority of the respondents only participated in the contractual agreements and cooperative societies at producer level with very few respondents participating as ‘producer-processors-marketers’ farmers (Table 4.11 and Figure 4.4). These findings suggest that the level of integration among the smallholder sorghum farmers in Machakos county was low. Additionally, the farmers still reported challenges such as grain storage, access to credit, birds, and pesticide infestation. This implies that the smallholder farmers continue to face structural constraints in their contractual relationships, which result in limited access to productive assets that can facilitate production and marketing of sorghum. Therefore, the farmers are unable to obtain high yields and premium prices for the sorghum which would increase their income to cover household expenditure.

Both farmers contracts and cooperative membership integration metrics depicted a high significance on food security (p -value, 0.001, and p -value, 0.005) at 1% threshold, respectively. However, both contractual agreements and cooperative membership recorded a negative probit coefficient (-1.211 and -0.860 respectively) indicating inverse relationships with food security. With respect to contractual agreements, this result contradicts past studies by Nazifi, et. al., (2021); Binpori, et al., (2021); Bellemare and Novak, (2017) which indicate that participation in contract farming would increase the food security status of smallholder farmers. This result is in line with Olounlade, et al., (2020) who found that contract farming does not always improve household food security, particularly in areas where necessary resources and economic environment are not yet fully established to reap the potential benefits of contract farming.

Regarding cooperative membership, this result is consistent with Bizikova, et al., (2020) who found that farmers facing structural constraints may need additional support systems to improve their capacities and resources before benefiting from farmers’ group membership. Furthermore, Ndlovu and Masuku, (2021) found that agricultural cooperatives do not fully alleviate the susceptibility of households to food insecurity due to the lack of institutional support and

adequate productive resources. The marginal effect is that a unit change in contractual agreements or cooperative membership would lead to a decrease in the probability of a household being food secure by 0.337 and 0.239 respectively, all other factors held constant.

5.2.3 The effect of market access on food security

Most households produced sorghum for consumption and made few sales (Table 4.10). Households with large farmland sizes under sorghum committed a larger portion of their harvest for sale (Table 4.11). Overall, the average quantity of sorghum sold per harvest was quite low, including the average quantity sold in open markets and to the input suppliers (Table 4.11). This indicates that despite the popularity of sorghum crop in dry climates (due to its high tolerance for heat and drought), its uptake in these areas is still quite low. In line with previous studies, Usman and Callo-Concha, (2021); Abay and Hirvonen, (2017); Hirvonen, et al., (2016) suggest that households rely heavily on their harvested produce, therefore the impact of market access on household consumption might be low. Furthermore, most of the smallholder sorghum farmers believe that that sorghum is not economically rewarding because of the limited support they receive to grow and sell the crop. In this work, households that sold sorghum significantly influenced food security (p -value, 0.044) at 5% significance threshold. However, this metric registered a negative probit coefficient value (-0.541) suggesting an inverse relationship with food security. The marginal effect is that a unit change in sorghum sold would result in a decrease in the probability of a household becoming food secure by 0.150.

5.3 Summary of findings

In summary, the results show that, the level of education, farmer contracts, cooperative membership, and sorghum sales, possess a significant effect on household food security. While the level of education of the household head linearly influenced food security, contractual agreements, cooperative membership, and household that sold sorghum inversely influenced food security. Accordingly, a unit change in the level of education would increase the probability of a household becoming food secure whereas, a unit change in contractual agreements, cooperative membership and households that sold sorghum would decrease the probability of a household becoming food secure.

Generally, the level of sorghum uptake, production, and crop output market participation were quite low. Moreover, both farmers contracts and cooperatives which are viewed as mechanisms

for addressing challenges such as market access and livelihood strategies, have yet to be fully implemented in the study area.

5.4 Conclusion and recommendations

This body of work contributes to the limited published literature on the effect of market integration and market access on the food security among the smallholder sorghum farmers. The study used original household data survey to examine the effect of integration and market access among smallholder sorghum farmers in Machakos county, Kenya. Using FIES metrics the study revealed the occurrence of food insecurity among households that were neither integrated nor had access to markets. In addition, the study used subjective measures and a probit regression model to predict whether each household in the sample would become food secure. The study concludes that the level of education, farmers contracts, cooperative membership and sorghum sales are essential and statistically significant in explaining household food security.

Therefore, considering the findings from this study, it recommends that; to fully realise the potential benefit of household characteristics influencing household food security, the county and national government should pursue efforts through trainings, programmes and initiatives aimed at raising awareness on the importance of sorghum crop as an alternative livelihood option.

To fully realise the potential benefits of sorghum vertical and horizontal integration influencing household food security, the government at local and national level, as well as other stakeholders should first establish frameworks that address challenges that smallholder farmers face when producing and marketing sorghum. Second, once appropriate resources and markets are in place, establish contractual frameworks and cooperative management structures to help smallholder farmers produce more efficiently through contractual and cooperative membership arrangements. The frameworks should aim to improve the smallholder farmers degree of integration by allowing them to participate in the arrangements as both producers and marketers. This will provide farmers with better and reliable market opportunities, resulting in higher income from their produce and increased food security.

To fully realise the potential of market access influencing household food security, the government at local and national levels, as well as, other stakeholders, should incentivize the smallholder sorghum farmers to sell their produce through cooperatives, given the relatively low volumes of sorghum produced per individual farmer. This will enable the farmers secure better prices and markets through collective marketing and bargaining. Furthermore, the

government and policy makers should establish policies that effectively organize the sorghum market to make the crop more competitive for farmers to produce and market.

5.5 Limitations to the study

This study did not consider qualitative data; therefore, it may not have fully explored the food security experiences of the smallholder sorghum farmers. This study did not consider consumption-based estimates for food security, such as caloric consumption, and may have underestimated the importance of diet and nutrition. This study focused solely on Machakos county in Kenya.

5.6 Suggestions for future research

The study focused on Machakos county, Kenya. Therefore, the generalizability of this study's conclusion is limited and insufficient. Other counties such as Kitui county, for example, enacted the Kitui County Sorghum Act which governs all aspects of the sorghum industry in the county, including registration of smallholder farmers with cooperatives. Therefore, in the future, the sample can be expanded to include other Kenyan counties, and a global comparative study can be carried out to comprehensively validate the research findings, making them more widely applicable and valuable.

Second, future research could broaden the scope to examine smallholder farmers' willingness to pay for a contract or membership to a cooperative society and its effect on food security. Finally, qualitative data can be used in the future to deepen the understanding of the experiences of smallholder farmers on food security. Food security, dietary and nutrition, and diet diversification are also important concerns for smallholder farmers.

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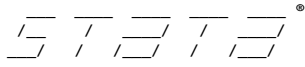
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APPENDICES

Appendix I: Supplementary information



17.0
SE-Standard Edition

Statistics and Data Science

Copyright 1985-2021 StataCorp LLC
StataCorp
4905 Lakeway Drive
College Station, Texas 77845 USA
800-STATA-PC <https://www.stata.com>
979-696-4600 stata@stata.com

Stata license: Unlimited-user network, expiring 15 May 2024
Serial number: 401809309501
Licensed to: Ray Amusengeri
Strathmore University

Notes:

1. Unicode is supported; see [help unicode advice](#).
2. Maximum number of variables is set to 5,000; see [help set maxvar](#).
3. New update available; type `-update all-`

```
. import excel "C:\Users\User\Desktop\Reica_STATA\New folder\STATA_Input_output_data_imported_v2.xlsx", sheet("Sheet1") firstrow
> et1") firstrow
(13 vars, 207 obs)
```

```
. probit Food_security Age Gender Household_head Household_Size Schooling_Years S_FarmSize Sub_county Contract O_m
> arket_participation coop_membership sorghum_sold sorghum_sold_to_input_supplier
```

```
Iteration 0: log likelihood = -131.05439
Iteration 1: log likelihood = -78.456611
Iteration 2: log likelihood = -75.6347
Iteration 3: log likelihood = -75.595179
Iteration 4: log likelihood = -75.595141
Iteration 5: log likelihood = -75.595141
```

Probit regression

Number of obs = 207
LR chi2(12) = 110.92
Prob > chi2 = 0.0000
Pseudo R2 = 0.4232

Log likelihood = -75.595141

Food_security	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
Age	.1683029	.1307187	1.29	0.198	-.0879011	.4245068
Gender	-.1479382	.312657	-0.47	0.636	-.7607347	.4648583
Household_head	.4507824	.3607698	1.25	0.211	-.2563135	1.157878
Household_Size	-.5623538	.3214527	-1.75	0.080	-1.192389	.0676819
Schooling_Years	.9616863	.2969093	3.24	0.001	.3797547	1.543618
S_FarmSize	.1099584	.0793796	1.39	0.166	-.0456229	.2655396
Sub_county	-.0860059	.0535116	-1.61	0.108	-.1908867	.0188748
Contract	-1.210916	.3524267	-3.44	0.001	-1.901659	-.5201719
O_market_participation	.307235	.1663636	1.85	0.065	-.0188316	.6333017
coop_membership	-.8603976	.3065403	-2.81	0.005	-1.461205	-.2595897
sorghum_sold	-.5410486	.2679963	-2.02	0.044	-1.066312	-.0157856
sorghum_sold_to_input_supplier	-.404631	.3923504	-1.03	0.302	-1.173624	.3643617
_cons	3.163571	1.251941	2.53	0.012	.7098128	5.617329

```
. mfx
```

Marginal effects after probit
y = Pr(Food_security) (predict)
= .80213746

variable	dy/dx	Std. err.	z	P> z	[95% C.I.]	X
Age	.0468142	.03673	1.27	0.203	-.025185	.118813		3.657
Gender	-.0411497	.08684	-0.47	0.636	-.211354	.129054		1.52174
Househ~d	.1253873	.10057	1.25	0.212	-.071718	.322492		1.3285
Househ~e	-.1564214	.08976	-1.74	0.081	-.332352	.01951		1.15459
School~s	.2674977	.08034	3.33	0.001	.110039	.424956		1.62802
S_Farm~e	.0305855	.0222	1.38	0.168	-.012928	.074099		4.38164
Sub_co~y	-.023923	.01501	-1.59	0.111	-.053339	.005494		4.60386
Contract	-.336822	.09009	-3.74	0.000	-.513389	-.160255		1.57005
O_mark~n	.0854589	.04611	1.85	0.064	-.004916	.175834		1.24155
coop_m~p	-.2393237	.08565	-2.79	0.005	-.407191	-.071457		1.4686
sorghu~d	-.1504953	.07531	-2.00	0.046	-.298092	-.002898		1.45894
sorghu~r	-.1125501	.10853	-1.04	0.300	-.325259	.100158		1.81159

Appendix II: Research questionnaire

A STUDY ON EFFECT OF MARKET INTEGRATION AND ACCESS ON FOOD SECURITY AMONG SMALLHOLDER SORGHUM FARMERS IN MACHAKOS.

Questionnaire No:			
-------------------	--	--	--

Dear Participant,

This questionnaire is based on a study on effect of market integration and access on food security among smallholder sorghum farmers in Machakos county. The aim is to establish the appropriate market and integration strategies that can tackle the challenges faced by smallholder sorghum farmers, ensure sustainable farming, and promote food security in households in Kenya. Your response will help contribute towards achieving this objective. All information provided by you will be solely utilised for this study and will be treated with utmost confidentiality without any reference to you. The contacts of the principal researcher are kaombi.amusengeri@strathmore.edu . Thank you for your cooperation.

PART A: DEMOGRAPHIC INFORMATION

Please fill in the information below

1. What is your gender?

Male Female

2. How old are you?

|_|_|year(s)

3. Are you the head of the household?

Yes No

4. How many people are currently living in your household?

_____people

5. What are your years of schooling?

_____year(s)

PART B: HOUSEHOLD AND OPERATIONAL INFORMATION

1. In which sub-county is your sorghum farm located?

Athi River Kalama Kangundo Kathiani

Machakos Masinga Matungulu Mwala

Yatta

2. What is the size of your farmland?

_____ Acre(s)

3. What size of your farmland have you allocated to sorghum farming?

_____ Acre(s)

4. How many people in your household are involved in the sorghum farming?

_____ people

5. How old are they? Please record the age of each of them.

__|__ year(s) __|__ year(s) __|__ year(s) __|__ year(s) __|__ year(s)
 __|__ year(s) __|__ year(s) __|__ year(s) __|__ year(s) __|__ year(s)

6. What are their years of schooling? Please record the years of schooling for each of them.

_____ year(s) _____ year(s) _____ year(s) _____ year(s) _____ year(s)
 _____ year(s) _____ year(s) _____ year(s) _____ year(s) _____ year(s)

7. Do you farm any cereal crops in the other portion not allocated to sorghum farming?

Yes No

8. What cereal crop(s) do you farm on the other portion of the farmland?

Maize Millet Rice Wheat

Barley Oats Rye None

PART C: VERTICAL INTEGRATION

1. Do you have a contractual arrangement to produce sorghum?

Yes No

2. If yes, what type of the contractual arrangement do you have in place?

Formal Informal

3. How do you participate in this contractual arrangement?

As producer only As a producer and processor

As a producer, processor, and marketer

4. Do you also participate in an open market sale in addition to your contractual arrangement?

Yes No

5. Does your contractual arrangement entail receipt of other farm services?

Yes No

6. If yes, select a service(s)?

Farm inputs (i.e., seeds & fertiliser) Transportation

Credit /financing Marketing All

Other _____

Storage

None

PART D: HORIZONTAL INTEGRATION

1. Are there sorghum farmers' cooperative societies or groups in your sub-county?

Yes No

2. If yes, are you a member of a sorghum farmer cooperative society or group?

Yes No

3. If yes, how do you participate in the sorghum farmer's cooperative society or group?

As producer only As a producer and processor

As a producer, processor, and marketer

4. Do you also participate in an open market sale in addition to your cooperative society/
group arrangement?

Yes No

5. Does the membership to the cooperative society entail receipt of other farm services?

Yes No

6. If yes, select the service(s)?

Farm inputs (i.e., seeds & fertiliser) Transportation Storage

Credit /financing Marketing All None

Other _____

PART E: MARKET ACCESS

1. How many times in a year do you harvest sorghum?

_____ time(s)

2. On average how many kilograms of sorghum do you produce per harvest?

_____ Kgs

3. Do you make any sorghum sales from the harvest?

Yes No

4. On average how many kilograms of the harvested sorghum do you sell?

_____ Kgs

5. On average how many kilograms of the harvested sorghum do you sell per your contractual or cooperative/group arrangement?

_____ Kgs

6. Do you sell your harvested sorghum to your input suppliers?

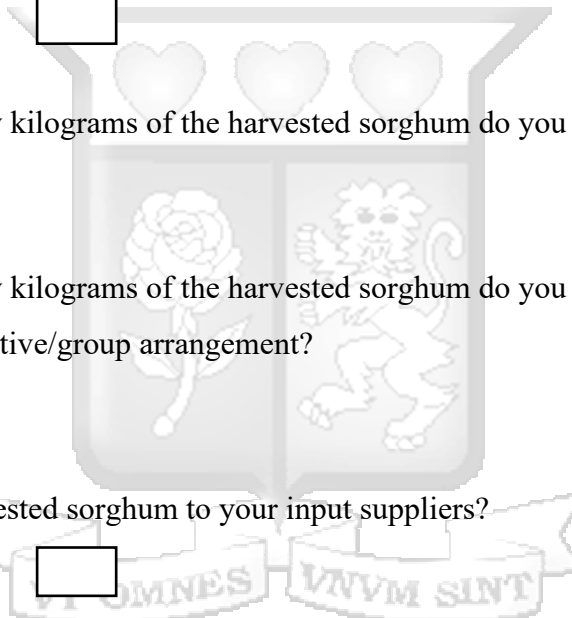
Yes No

7. On average how many kilograms of the harvested sorghum do you sell to your input suppliers?

_____ Kgs

8. I am satisfied with the contractual or cooperative/ group arrangement that I have.

1.Strongly disagree 2. Disagree 3. Neutral 2. Agree
5.Strongly Agree



PART F: FOOD SECURITY

1. During the last 12 months, was there a time when you were worried that you or your household would not have enough food to eat because of a lack of money or other resources?
Yes No
2. During the last 12 months, was there a time when you or any household member were unable to eat healthy and nutritious food because of a lack of money or other resources?
Yes No
3. During the last 12 months, was there a time when you or any household members ate only a few kinds of food because of a lack of money or other resources?
Yes No
4. During the last 12 months, was there a time when you or any household member had to skip a meal because there was not enough money or other resources to get the food?
Yes No
5. During the last 12 months, was there a time when you or any household member ate less than you thought you should because of a lack of money or other resources?
Yes No
6. During the last 12 months, was there a time when your household ran out of food because of a lack of money or other resources?
Yes No
7. During the last 12 months, was there a time when you or any household member were hungry but did not eat because of a lack of money or other resources for food?
Yes No
8. During the last 12 months, was there a time when you or any household member went without eating for a whole day because of a lack of money or other resources for food?

Yes No

9. How would you assess the status of your household food security in the last 12 months?

Please select one.

There is food security along with food shortage all through the year (chronic)

Occasional food insecurity

Break-even (food shortage is non-existent but there is no surplus)

Food surplus (food security)

THANK YOU



Appendix III: Budget plan

Item/Services	Quantity	Unit cost	Total (Kshs.)
1. PILOT STUDY			
i) Transport of the principal researcher	1	5,000	5,000
ii) Subsistence allowance	1	2,000	3,000
Sub total			8,000
3. DATA COLLECTION			
i) Translation of questionnaire	1	10,000	10,000
ii) Printing of questionnaires	240	5	9,600
iii) Subsistence & transport for the principal researcher	1	20,000	20,000
iv) Airtime, transport, for the data collection assistants	4	2,000	8,000
v) Allowance for data collection assistants	4	10,000	40,000
Sub total			87,600
4. PREPARATION OF DISSERTATION			
i) Stationery			
a) To print dissertation		3,000	3,000
c) To bind dissertation drafts		500	500
d) To bind final dissertation		500	500
Sub total			4,000
Total			99,600
Contingencies (10% of the total)			9,960
GRAND TOTAL			109,560

Appendix IV: SU-ISERC approval



28th March 2023

Ms Amusengeri Ray Kaombi,
kaombi.amusengeri@strathmore.edu

Dear Ms Amusengeri,

RE: The Effect of Integration and Market Access on Food Security among Smallholder Sorghum Farmers in Machakos County, Kenya

This is to inform you that SU-ISERC has reviewed and approved your above SU- master's research proposal. Your application reference number is SU-ISERC1661/23. The approval period is from 28th March 2023 to 27th March 2024.

This approval is subject to compliance with the following requirements:

- i. Only approved documents including (informed consents, study instruments, and MTA) will be used
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-ISERC.
- iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-ISERC within 48 hours of notification
- iv. Any changes, anticipated or otherwise, that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-ISERC within 48 hours
- v. Clearance for the export of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days of completion of the study to SU-ISERC.

Before commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology, and Innovation (NACOSTI) <https://research-portal.nacosti.go.ke/> and obtain other clearances needed.





Yours sincerely,

for: **Dr Ben Ngoye,**
Secretary; SU-ISERC

Cc: Mr Ambrose Rachier,
Chairperson; SU-ISERC



Appendix V: NACOSTI permit

 <p>REPUBLIC OF KENYA</p>	 <p>NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION</p>
<p>RefNo: 120536</p>	<p>Date of Issue: 25/April/2023</p>
<p>RESEARCH LICENSE</p>	
	
<p>This is to Certify that Ms. Ray Kaombi Amusengeri of Strathmore University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Machakos on the topic: The Effect of Integration and Market Access on Food Security among Smallholder Sorghum Farmers in Machakos County, Kenya for the period ending : 25/April/2024.</p>	
<p>License No: NACOSTI/P/23/25406</p>	
<p>Applicant Identification Number 120536</p>	
<p>Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION</p>	
<p>Verification QR Code</p> 	
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END