DETERMINANTS OF SMALLHOLDER FARMERS' PARTICIPATION IN CONTRACT FARMING AND ITS EFFECTS ON SORGHUM PRODUCTIVITY IN SIAYA COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This research thesis is wholly my original work and to the best of my knowledge has not been presented for the award of any degree in any other University.

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Recommendation

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DEDICATION

This thesis is dedicated to my parents Tom Onyango and Monica Atieno, my sisters: Doris, Perez, Suzan, Serfine, and Mary, my bothers Joseph and Maurice, my fiancé Mildred for their love, support, and encouragement.

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ABSTRACT

Sorghum production in Siaya County is inherently low. To mitigate this, the East Africa Breweries Company has entered into a public-private partnership arrangement with the County Government of Siaya to increase sorghum production through contract farming. Contract farming is regarded as among the viable solutions for addressing farmers' problems by providing quality inputs such as seeds and fertilizers, improving access to markets, promoting new agricultural innovations and consequently raising household incomes. Since farmers enroll themselves in sorghum contract farming, the factors influencing their participation and its effect on productivity in Siaya county is not clearly understood. The objectives of this study were to: determine factors influencing smallholder farmers' decision to participate in contract farming; determine smallholder farmers' preferences for various sorghum contract design attributes; and determine the effect of contract farming participation on smallholder farmers' sorghum productivity. A multistage sampling procedure was used to select 240 smallholder sorghum farmers (105 contracted and 135 non-contracted). A semi-structured questionnaire was administered through face-to-face interviews to smallholder sorghum farmers. Logistic regression was used to estimate determinants of smallholder sorghum farmers' participation in contract farming. Their preference for farming contract design attributes was estimated by conjoint analysis. The effect of participation in contract farming on sorghum productivity was estimated using endogenous switching regression model.

Results indicate that age, gender, education of the household head, number of active household members, farmer group membership, distance to the nearest main road, and asset ownership positively influenced participation in contract farming. Distance to extension agent office negatively affected participation in the contract farming. Smallholder sorghum farmers preferred farming contract offering high prices, deferred payments, and financial services. Participation in sorghum contract farming was associated with 104% gain in sorghum productivity. Counterfactual results indicate that had non-contracted smallholder farmers participated in contract farming, they would have sorghum yield gain of 116%. These sorghum yield impacts of contract farming highlight the potential of achieving significant growth in sorghum production in Kenya through promoting contract farming among a broad base of smallholder farmers. Designing of such contracts should be cognizant of farmers' socio-economic characteristics, as they influence their decisions to participate in the contracts, and the need for contract terms that are responsive to farmers' preferences. Public investments to improve access to agricultural information and extension services and rural access roads would play important facilitative role for farmers' effective engagement in contract farming.

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LIST OF ABBREVIATIONS AND ACRONYMS

AHT	Average Heterogeneity effect for the Treated
AHU	Average Heterogeneity effect for the Untreated
ASALs	Arid and Semi-Arid Lands (ASAL)
ASTGS	Agricultural Sector Transformation and Growth Strategies
ATT	Average Treatment effect on the Treated
ATU	Average Treatment effect on the Untreated
CBK	Central Bank of Kenya
CC	Contingency Coefficient
CDF	Cumulative Distribution Function
EABL	East African Breweries Limited
ESR	Endogenous Switching Regression
EUCORD	European Cooperation for Rural Development
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FIML	Full Information Maximum Likelihood
GDP	Gross Domestic Product
IIA	Independence of Irrelevant Alternatives
KALRO	Kenya Agriculture and Livestock Research organization
KASAL	Kenya Arid and Semi-Arid Lands
KCSAP	Kenya Climate Smart Agriculture Project
KES	Kenyan Shilling
LPM	Linear probability model
MoALF & I	Ministry of Agriculture, Livestock, Fisheries and Irrigation
NIE	New Institutional Economics
PSM	Propensity Score Matching
SD	Standard Deviation
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
STATA	Statistics and Data
TCT	Transaction Cost Theory
TLU	Tropical Livestock Unit
VIF	Variance Inflating Factor

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Sorghum is a drought-resistant crop commonly grown in arid and semi-arid (ASAL) of Kenya. The ASAL counties in Coastal, Eastern, parts of Western and Nyanza regions constitute about 80 percent of Kenya's total land area. The ASAL regions in Kenya, are prone to droughts and adverse weather conditions (Power *et al.,* 2019). In these regions, farmers perceive sorghum as a "traditional poor man grain crop", leading to many smallholder farmers to prefer growing maize despite its low productivity. However, sorghum is recognized for its potential to reduce food insecurity for households in ASAL (Njinju *et al.,* 2019). Sorghum is also a useful raw material in beer malt industry (Ratnavathi *et al.,* 2019).

Production of sorghum grain in Kenya has fluctuated for the last decade, with a notable decline from 164066 tonnes in 2010 to 117000 tonnes in 2016, a period during which the country experienced severe droughts (Njagi *et al.,* 2019). However, there was a steady increase in production from 144000 tonnes in 2017 to 315000 tonnes 2020, attributed to the emergence of alcoholic beverages industry as a market for sorghum and implementation of targeted strategies and policy interventions aimed at positioning sorghum as a high-value crop (Njagi *et al.,* 2019). Despite these incentives, the quantity of sorghum imported and exported followed a consistent trend from 2011 to 2016, after which the imported quantities increased significantly compared to exports (FAOSTAT, 2022). This indicates that in Kenya, an intervention aimed at increasing sorghum productivity is necessary to achieve a reduction in imports. One such intervention is promoting sorghum production under contract farming.

Kenya produces suboptimal sorghum yields of approximately 1000kg/ha, against a potential of 2800kg/ha. Western is one of the leading sorghum producing regions in Kenya yet productivity estimated at 700kg/ha is lower than the national productivity level and a regional potential of between 2000 and 5000kg/ha (Musafiri *et al.,* 2022). Low sorghum productivity in the country is attributed to climatic changes resulting from intense rainfall, high temperatures, salinity, droughts, low adoption of agricultural technologies, and outbreaks of pests and diseases (Omoyo, 2020). Other contributing factors to low sorghum productivity are low input use, striga weeds, soil infertility, and water scarcity (Kagiwiria *et al.,* 2019).

Sorghum is a source of livelihood to more than 3 million people in Kenya. Additionally, it is projected that the demand for sorghum will rise due to the increasing domestic consumption and industrial demand. The ASAL regions have the potential to produce higher quantities of sorghum. However, these farmers in ASAL regions are constrained, resulting in low yield and poor quality of sorghum (Muui *et al.,* 2019). Most smallholder farmers in these regions practice subsistence sorghum production and have low access to quality certified sorghum seed varieties, resulting in low productivity (Kagiwiria *et al.,* 2019).

Sorghum has been identified as one of the priority value chains by several projects, including the Kenya Climate Smart Agriculture Project (KCSAP) in Siaya County (Njinju *et al.,* 2022). Increasing farmers access to improved high quality seed has therefore been identified as essential for upgrading the sorghum value chain and attaining high yields and food security Sorghum production trends in ASAL areas have stagnated over the last few years as most farmers need access to drought-tolerant sorghum varieties that can adapt to constant climate changes (FAOSTAT, 2022). There is a need to explore the effect of new agricultural interventions, such as contract farming, on sorghum productivity.

Contract farming is among institutional arrangements with a potential of upgrading and revitalizing the sorghum value chain. It has been widely adopted as an essential agricultural intervention for enhancing food security, improving livelihood, increasing yield, income, and mitigating climate change (Malak-Rawlikowska *et al.,* 2019). Contract farming is essential for smallholder farmers to overcome market failures, production and marketing risks (Soullier & Moustier, 2018). Contractual arrangements address transactions costs arising from risks, market failures, and managerial inadequacies. Firms and farmers rely on contract farming to facilitate market transformation, mitigate competition for inputs, and ensure a consistent supply of raw materials (Marwa & Manda, 2022). Contracting firms also provide farmers with quality inputs, technical training, and access to markets (Ncube, 2020). Despite the significant economic benefits of contract farming, smallholder farmers adopt few contracts, and many contract farming projects have failed as farmers often opt out of the arrangements (Ochieng *et al.,* 2017). Smallholder farmers also prefer numerous attributes of the traditional spot market, including sales at the farm gate, cash payments, and individual selling of farm produce (Ruml *et al.,* 2022). Differences between farmers and contracting firms arise from issues such as produce quality, side-selling, deferred payment, delayed delivery, and sales price (Muller *et al.,* 2021). These issues often cause

most contracts to fail. Therefore, it is necessary to determine factors influencing smallholder farmers' participation in contract farming.

The EABL and several county governments in Kenya have collaborated to improve sorghum production under contract farming (Manyasa, 2016). The EABL mobilizes and sensitizes farmers on the importance of contract farming. The company conducts farmer training, provides inputs on credit to farmers, and buys sorghum from contracted farmers. It does these in collaboration with the Ministry of Agriculture, Livestock, Fisheries and Irrigation (MoALF & I), Equity Bank, Kenya Arid and Semi-Arid Lands (KASAL) project, Kenya Agriculture and Livestock Research Organization (KALRO), Smart Logistics Ltd, and European Cooperation for Rural Development (EUCORD). The main objective of this project is to improve sorghum productivity and farmers' income (Wawire *et al*., 2016). Despite the economic importance of sorghum contract, EABL has not reached a critical mass of farmers to satisfy its current demand of 22,000 MT per annum of sorghum nor to guarantee the anticipated surge in demand over the next decade (EABL, 2018). The EABL Company anticipated to contract 45,000 sorghum producers, but only 30,000 farmers have been contracted.

In Kenya, more research needs to be done on factors influencing smallholder farmers' participation in sorghum contract farming. Design contract attributes for sorghum contract farming have yet to be thoroughly evaluated to determine whether they maximized utility to smallholder farmers. In addition, the effect of contract farming by EABL Company on sorghum productivity needs more attention. Recent studies done on sorghum are: determinants of sorghum small-scale, productivity, effect of zaipits or minimum tillage on productivity and economic efficiency analysis (Kimaru-Muchai *et al.,* 2021; Musafiri *et al.,* 2022; Mwangi *et al.,* 2020; Okeyo *et al.,* 2020). This study aimed to fill these gaps by analyzing the determinants of smallholder farmers' participation in contract farming and its effect on sorghum productivity in Siaya county.

1.2 Statement of the Problem

Sorghum is an essential crop in arid and semi-arid regions of Kenya. Despite the importance of sorghum crop, the yields attained by smallholder farmers are low and it is reflected in the national productivity per hectare which is still below the potential. This is largely because smallholder sorghum farmers practice subsistence farming confined to low input intensity, low productivity, inadequate market access, and low incomes. To mitigate this, the East Africa Breweries Company has entered a public-private partnership arrangement with the County

Government of Siaya to increase sorghum production through contract farming. Contract farming is regarded among the viable solutions for addressing farmers' problems by providing quality inputs such as seeds and fertilizers, improving access to markets, promoting new agricultural innovations and consequently raising household incomes. Since farmers enroll themselves in sorghum contract farming, the factors that influence their participation and its effect on productivity in Siaya County is not clearly understood. The purpose of this study is to fill this knowledge gap.

1.3 Objectives of the study

The general objective of this study is to contribute to improved efficiency, productivity and competitiveness of sorghum value chain in Siaya county, Kenya

The specific objectives were:

i. To determine the factors influencing smallholder farmers' decision to participate in sorghum contract farming in Siaya county, Kenya.
ii. To determine smallholder farmers' preferences for sorghum contract design attributes in Siaya county, Kenya.
iii. To determine the effect of contract farming on sorghum productivity among smallholder farmers in Siaya county, Kenya.

1.4 Research questions

i. What are the factors that influence smallholder sorghum farmers' decision to participate in sorghum contract farming in Siaya county, Kenya?
ii. What are the smallholder farmers' preferences in sorghum contract design attributes in Siaya county, Kenya?
iii. What is the effect of contract farming on sorghum productivity among smallholder farmers in Siaya county, Kenya?

1.5 Justification of the study

Determinants of factors influencing smallholder farmers' decision to participate in sorghum contract farming would be crucial for informing interventions and policies that encourage smallholder farmers' participation in contract farming. The findings from this study would inform development of targeted policies and programs that address the concerns of smallholder farmers. Besides, the findings will provide alternative strategies of engaging and supporting smallholder farmers to encourage them to participate in contract farming.

However, understanding of smallholder farmers' preferences for various contract design attributes would allow customization of contracts that are attractive and acceptable to smallholder sorghum farmers. This will enhance their participation in sorghum contract farming as they will comply with contract terms and conditions. It will also, enable smallholder farmers to negotiate for fair and equitable contracts. Inclusive participation and addressing of the power dynamics will ensure that their needs, interests, and rights are protected by contracting entities. This will contribute to achieving Agricultural Sector Transformation and Growth Strategy (ASTGS) goals, which aims at developing and transforming agriculture sector by increasing smallholder farmers' crop productivity, transforming from subsistence to commercialized agriculture, and building resilience (GOK, 2019).

Determining the effect of contract farming on sorghum productivity would provide evidence of the effect of contract at smallholder farm level, justify scaling of the institutional arrangements and provide a basis of policy advocacy for a favorable environment for contractual arrangements. It will also guide public and private investments in the sorghum value chain, resulting in value chain upgrading. Overall, enhanced sorghum productivity and assured competitive markets would result in higher incomes that empowers smallholder farmers. Thus, increasing smallholder farmers' access to better market information and technical support through participating in contractual agreement. These will contribute towards attainment of multiple Sustainable Development Goals (SDGs), including SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 8 (Decent work and economic growth), SDG 10 (Reduced inequalities), and SDG 17 (Partnerships for the goals). It will also contribute to African Union Agenda 2063 goals of increasing agricultural production and productivity.

1.6 Scope and limitation of the study

The study was conducted in Bondo sub-county in Siaya County Kenya. Contracted and non-contracted smallholder sorghum farmers who produced sorghum in the 2020 cropping calendar were considered. Contracted smallholder sorghum farmers considered were those under EABL contracts during the 2020 production cycle. The limitation was the reliance on recall data because most non contracted farmers did not keep records. This limitation was addressed through thorough probing during face-to-face interviews. Additionally, data were collected for the most recent production period that the farmers could easily remember.

1.7 Operational definition of terms

Contract attributes are the key features of sorghum farming contract that influence farmers' attitudes towards the agreement.

Contract farming is an agreement between sorghum farmers and EABL Company on the production and sale of sorghum under agreed terms and conditions.

Participation: This refers to being contracted by EABL Company during the period under review.

Productivity: Total sorghum yield in kilograms per acre of land planted with sorghum.

Smallholder farmers: Sorghum farmers characterized by planting sorghum in farm field between 0.2 to 3 hectares.

Stated preference is a situation where sorghum farmers' preferences for contract is based on using hypothetical contract attributes to reveal their decision to participate in the contract.

Transaction cost: Cost incurred while designing and enforcing sorghum farming contract by EABL Company. The costs include information search, negotiation and enforcement of sorghum contract.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter provides a literature review of past similar studies on the general overview of contract farming, factors influencing smallholder farmers' decision to participate in contract farming, preferences for various contract design attributes, and the effect of contract farming on smallholder farmers' crop productivity. The chapter also presents a theoretical and conceptual framework adopted by the study. The literature review underscores the research gaps that this study sought to address.

2.2 General overview of contract farming

Contract farming is a binding oral or written agreement between contracting firm and farmers with a well-defined obligation and remuneration for tasks done, often with specifications on production and product properties (Lee & Kiml, 2020). Contract farming is a form of vertical coordination that promotes production and marketing in the agricultural sector (Pham *et al.*, 2021). Contract farming is perceived to be beneficial to smallholder farmers, processors, traders, and consumers. Contract farming is a common approach for enhancing sustainable development, improving social welfare, incapacitating market failures, and a form of horizontal integration (Bijman *et al.*, 2020; Hoang, 2021). It has also been perceived as a measure for reducing transaction costs, achieving economies of scale in agricultural production, improving social welfare, limiting farm challenges, minimizing production and marketing risks (Hoang, 2021). In addition, contract farming improves access to credit, market access, increases crop productivity, produce quality, and improves income of smallholder farmers in developing countries (Hoang, 2021; Meemken & Bellemare, 2020).

However, various contractual arrangements have faced criticisms in the economy as they failed to benefit and inspire smallholder farmers to participate in the arrangements. Firms use contracts to exploit farmers by transferring production and marketing risks, but in return contracting firm benefits from cheap labor (Mishra *et al.*, 2018). Contracting companies prefer working with larger producers, resulting in discrimination and marginalization of poor smallholder farmers. Contractors provide farmers with inputs, technical training, and credit at an agreed price at harvest, thus limiting smallholder farmers from accessing market information on inputs and credit. Low fixed output prices, high input prices, high produce quality, delayed and default

payments are witnessed by smallholder farmers in contracts that lower their participation rate in contract schemes (Hoang *et al.,* 2021). These make farmers loose benefits from market changes such as high prices, loss of autonomy, abandonment of traditional production methods, and reduced crop diversification, as most of them will rely on the contracted crop. Firms are challenged by high transaction costs for engaging several smallholder farmers, side-selling, and crop failure negatively affect supply of produce to contracting company (Hoang & Nguyen, 2023).

Contractual arrangements are categorized into five models. These models are the nucleus, centralized, informal, multipartite, and intermediary. The centralized model (out-growers scheme) involves a centralized processor collecting products from farmers. It is common for crops such as coffee, sugarcane, tea, and dairy products such as milk (Machimu, 2020). A multipartite model is a situation where the contractor collaborates with an agent when introducing a new crop to the farmers. An informal arrangement is an oral contract created through trust resulting from a repeated transaction between buyers and sellers (Sok *et al.,* 2022). The intermediary model involves contractual companies using intermediaries such as brokers to act on their behalf to offer service to the contracted farmers. Contracting firm representatives provide production inputs, extension services, transport services, and payments on behalf of the contracting company (Chen & Zhou, 2023). Lastly, the nucleus model differs from the centralized model in that the contracting company owns and monitors an estate plantation near a processing plant.

The nature and the structure of contracts varies in Kenya. Marketing and production contracts are the most common contractual arrangements in Kenya. Marketing contracts are formal agreements between buyers and sellers on the specification on product quantity, quality, price, payment and delivery terms. Production contracts constitute a more detailed specification that relates to inputs use, management terms, and quality attributes. Besides, the production contract involves offering technical training and credit facilities to contracted farmers (Ruml & Qaim, 2020). Most past studies conducted on contract farming in Kenya mainly focus on industrial cash crops for export, horticultural, dairy, and poultry. Hence, creating an evidence gap on the effect of contract farming on traditional food crops productivity for staple food crops such as sorghum and millet (Maertens & Velde, 2017).

In Kenya, different forms of vertical coordination and collective action in the past did not incorporate traditional staple food non-perishable crops, but most of the economic actors preferred spot markets for staple food crops (Ruml *et al.,* 2022). Predictions showed that transaction costs

associated with market access to such traditional crops were relatively low; thus, contracts would have little influence on price. Traditional food crops were of low-value addition requirements thus making spot market to be more favorable compared to contracts. Staples food crops such as cereals, if stored, increase the chances for opportunistic behavior by producers. Thus, contract enforcement for staple food crops such as sorghum is difficult, due to high chances of side-selling (Kangile *et al.,* 2020). Therefore, there is a need for more research contract farming on traditional food crops as there exists limited research done in Kenya concerning the effect of contract farming on food crops productivity.

2.3 Factors Influencing Smallholder Farmers' Decision to Participate in Contract Farming

Smallholder farmers' decision to participate in contract farming is influenced by demographic, socioeconomic, institutional, and geographical factors. These factors could influence smallholder farmers' decision either positively or negatively. Institutional factors that influence smallholder farmers' decision to participate in contract farming include asset specificity, access to agricultural training, group membership, access to market information, access to credits, and extension service. These factors usually influence farmers' decisions to either take or reject new agricultural intervention. Household and farm characteristics such as gender, age, education level, occupation, off-farm income, experience, household size, farm size, and assets owned by the household head influenced major decision made by the farmer. Lastly, geographical factors, which include distance to local administration, extension officer, distance to the main road, distance to the input market and output, influence farmers' decisions to engage in contracts (Hoang & Nguyen, 2023).

Age of the household head significantly influence smallholder farmers' decision to participate in contract farming (Kar *et al.*, 2020). Research conducted by Miassi and Dossa (2018) and Muroiwa *et al.* (2018), found age of the household head to inversely influence smallholder farmers' decision to engage in contract farming. The findings deduced that younger farmers are more likely to enter contract farming than older farmers. Results of their findings implies that youths have more capacity and inclination to innovate than older people. Thus, as the age of the farmer increases, farmers abandon contracts for a low-demanding agricultural system with few transactional costs. Also, aged farmers tend to be more risk-averse and always prefers to avoid contractual arrangements to evade associated risks. On the contrary, studies done by Hoang and Nguyen (2023) and Masangano *et al.* (2017), found age of the household head had a positive

influence on smallholder farmers' decision to participate in contract farming. They concluded that as age of the household head increase the likelihood to engage in contract farming increases. This finding is because most youths need more appreciation for the significance of agricultural activities in rural areas compared to older people. Older, experienced farmers usually make maximum efforts to improve agricultural productivity compared to youths.

Number of active household members positively influences the decision to participate in contract farming. Soullier and Moustier (2018) found that the number of active members in the household positively influenced contract farming participation. The results were ascertaining the availability of labor needed for contracted crop. Similarly, Muroiwa *et al.* (2018), found that the availability of family labor positively influences participation in tobacco contract farming due to the labor-intensive nature of the tobacco production system. The results disagree with the findings of Sharma (2016), who found the proportion of adults in the household to have an inverse relationship to contract farming participation.

Gender of the household head influences farmers' decision to participate in contract farming. Studies conducted by Dubbert (2019), Muroiwa *et al.* (2018) and Pandey (2016), found male-headed households to directly influence decision to participate in contract farming. Results from the study reported that male-headed households were more likely to engage in contract farming than female-headed households. This is because men made more farming decisions than women. Women mainly engage in domestic activities and responsibilities that take much of their time. In addition, males have control of production assets such as capital and land required in contract production. Female farmers lack adequate control of resources to enable them to participate in contract farming. Gender inequity in access and control of agricultural production resources leads to less participation by females in contract farming. The findings contradict those of Hoang and Nguyen (2023), who found that female-headed households were more likely to participate in contracts than their counterparts. The results revealed that females are vital in promoting contract farming in rural areas.

The education level of the household head is another crucial factor that determines farmers' decision to participate in contract farming. Research conducted by Kiwanuka and Machethe (2016), Kutawa (2017), Miassi and Dossa (2018), Muroiwa *et al.* (2018) and Mwambi *et al.* (2016), revealed that years of schooling of the household head positively correlated to farmers' decision to participate in contract farming. Additional years of schooling increase the chances of

participation in contract farming. Education builds a supportive mental attitude toward innovative practices, mainly information and management-intensive practices. The education puts farmers in a position to acknowledge the benefits and advantages of contract farming. On the contrary, Abdulai and Al-Hassan (2016), Wainaina *et al.* (2016) asserted that the household head's years of schooling negatively influence farmers' decision to participate in contract farming. Educated farmers tend to seek better market opportunities for selling their produce at a higher price rather than contracts.

Land size owned by the household is another significant factor determining farmers' decision to participate in contract farming. Kutawa (2017) conclude that household land size positively influences farmers' decision to participate in contract farming. The reason behind this argument is that farmers with large land sizes can expand their production capacity to accommodate the contracted crop. In contrast, Abdulai and Al-hassan (2016) and Azumah *et al*. (2016) found a negative relationship between total land size and farmers' decision to participate in contract farming.

The household's Off-farm income earnings are another factor contributing to farmers' decision to engage in contract farming. A higher level of off-farm income reduces the likelihood of farmers to participate in contract farming. If a farmer has more than one sources of income besides earnings from the farm, they tend to refrain from engaging in contractual arrangements (Akhtar *et al.,* 2021). On the contrary, off-farm income positively influences the farmers' decision to participate in contract farming (Wainaina *et al.,* 2016). This finding suggested that financially sTable farmers had a high probability of participating in contract farming. With off-farm income farmers are capable of acquiring quality inputs required by the contracting company such as certified seeds.

Membership in farm groups influences farmers' participation in contracts. Bellemare and Lim (2018), Mounirou (2020), Mulatu *et al*. (2017) and Odunze *et al*. (2015) found a positive relation between group membership and contract farming participation. Farmers in groups are more likely to participate in contract farming than their counterparts. Farmers in groups could easily sign the contract than individual farmers. Group membership strengthens networks of farmers to exchange new farming ideas with other actors. Lastly, group membership improves farmers' economic status that attracts contracting firms. Alulu (2020) research found an inverse relationship between group membership and contract participation. Group members usually pool

resources to search for high-paying markets rather than contractors who offer lower prices for the produce. Also, group members could easily influence each other to refrain from joining contract farming based on past bad experiences of default and delayed payments by contractors.

Furthermore, access to extension services by the farmers contributes to farmer' decisions to engage in new farming methods such as contract farming. Access to extension services increases the probability of farmers participating in contract farming (Rondhi *et al.*, 2020). Farmers with access to extension services are more likely to participate in contract farming than those without similarly, the location of the farmers' home to the nearest extension agent office influences farmers' decision to engage in contract farming. According to Mwambi *et al.* (2016) and Kutawa (2017), proximity to extension officials increases the households' probability of engaging in contract farming. Farmers' home located nearer to extension agent office positively relates to contract farming participation. Those nearer the extension agent's office easily access new information about contract farming compared to those far away from the extension office. It implies that farmers in contact with extension agents tend to increase their level of participation in contract farming. Research by Wainaina *et al.* (2016) contradicts the above findings and found an inverse relationship between access to extension services and contract participation. Farmers with access to extension services are less likely to engage in contract farming since they have information on alternative marketing channels and other production methods other that contract.

Farmers' home location to the nearest main road informed the decision on whether to join contract farming or not. Mulatu *et al*. (2017), Muroiwa *et al*. (2018), and Ton *et al.* (2017) concluded that the distance from the farmers' homes to the main road negatively influences farmers' decision to participate in contract farming. This implies an extra mile from the main road to farmers' residential homes reduces the probability of participation in contract farming. This is because farmers far from the main road lacks more information about contract farming, thus reducing their chances of participation. Furthest farmers' homes from the main road result in inadequate information about new agricultural practices that inversely influence farmers' capability to make rational decisions. Also, contracting companies usually prefer working with farmers nearer to main road for easy access.

Ownership of farm stores by the household influences a decision to participate in contract farming. Soullier and Moustier (2018) found ownership of farm storage facilities positively influenced the uptake of contract farming. Farmers with storage facilities were more likely to

participate in contract farming than those without. Storage facilities allow farmers to reduce pre-harvest and post-harvest losses on the farm produce. Cattle ownership by the household contributes to the decision to join a contractual arrangement. Muroiwa *et al*. (2018) reported a positive correlation between cattle ownership and contract farming participation. The reason was that cattle provided labor for cultivation, transportation, and manure for improving soil fertility. Besides, livestock in the Tropical Livestock unit (TLU) influences major decisions made on the farm. Bezabeh *et al.* (2020) and Mulatu *et al*. (2017) studies found Tropical Livestock Unit (TLU) positively influences farmers' decision to participate in contract farming. The findings may be because livestock has many economic and social roles that enhance farmers' ability to engage in new farm interventions. Furthermore, the accumulation of livestock is an indication of prestige and wealth that hastens contract participation.

Distance to the nearest input market from the farmers' homestead influences participation in contract farming. Behera (2019) and Bezabeh *et al.* (2020) reported a positive relationship between farmer home location to the nearest input market and contract farming participation. Farmers far from the input market are more likely to participate in contract farming than those near the input market. The possible reason is to reduce the transaction costs of acquiring farm inputs, such as transport costs, as contractors deliver inputs to farmers. Contract farming usually lowers transaction costs associated with input and output market access, which is common when the distance to the market increases.

2.4 Smallholder farmers' preferences for contract design attributes

Revealed and stated preferences are commonly adopted in studying farmers' preference for contract design attributes. Revealed preferences are applicable when the farmer is faced with real choices of contract design attributes. The farmer will state what they did when faced with actual conditions based on their memory and past experiences. The stated preferences are situations where the farmer is faced with a hypothetical situation (Craig *et al.*, 2017). The farmer will reveal the choice when confronted with the real situation. The data used in this study was mainly based on stated preference. A choice experiment was applied to investigate the revealed preference for the sorghum contract attributes. The stated preference estimated the real demand for contract farming based on the contract attributes. Farmers' preferences for sorghum contract attributes are heterogenic since farmers' choices are unobservable (Craig *et al.*, 2017).

Smallholder farmers' participation in contract farming could be higher, and there is always a high rate of dropouts from the contractual agreements (Ochieng *et al.*, 2017). Contract design attributes may influence farmers' decision to participate in contract farming. Price, payment mode, contract duration, and quality requirements are some of the contract attributes that may affect farmers' attitudes toward a given contract (Otsuka *et al*., 2016). Farmers usually prefer to engage in contracts if the design attributes satisfy their needs and reject the contract if the design attributes do not fit their needs. For example, delayed and default payments, unfavorable shifts of risks to farmers, and low prices in the contract compared to market price discouraged farmers from taking contract farming (Andersson *et al.*, 2017). Therefore, before designing contract for farmers, the contracting company should consider the likes and dislikes of the farmer. This will increase the level of uptake of the contracts by the farmers. Thus, for a viable contract, there is a need to adjust contract design attributes to fit farmers' particular wants and eliminate constraints.

However, the product output price offered by the contracting firm usually affects smallholder farmers' decision to participate in contract farming. Contracting firms usually offer a lower price on the product than the market price. This makes farmers instead to prefer spot markets rather than contracts. Conversely, farmers prefer adjustable prices in contracts compared to fixed product prices. Ola and Menapace (2020) conclude that smallholder farmers prefer flexible incentive-based pricing compared to fixed pricing. The result contradicts the assumption that smallholder farmers in developing countries are risk-averse. Lastly, the study suggested that a pricing strategy contingent on specific performance criteria is preferred over a fixed price.

Similar to the findings of Liao *et al.* (2020), who reported smallholder farmers preferred floating prices in contracts compared to fixed prices. Farmers perceive prices as volatile. Fixed prices by the contracting firm will gain less profit if prices shift upwards depending on economic factors such as shortage. Thus, farmers would rather store the produce awaiting higher future prices than sell it at contract fixed prices. Furthermore, farmers consider engaging in contracts if they offer higher prices than the going market price. According to Ochieng *et al.* (2017), Rao *et al.* (2017), the price coefficient is positive and significant, meaning farmers prefer marketing arrangements that offer high prices. Farm earnings and profits increase if the produce prices are higher.

Another contract attribute influencing farmers' decision to participate in contract farming is the contract duration. Contract duration is the length of period taken by the contract. Duration

in terms of contract farming could be per season, yearly, or more than one year, depending on the nature of the crop farmed. Smallholder farmers usually prefer short-term contracts such as per season rather than long-term contracts for season crops (Ann *et al.*, 2019; Arouna *et al.*, 2017). Farmers generally prefer long-term contracts for perennial crops such as coffee, sugarcane, and tea. However, long-term contracts are preferred over short-term agreements if the contracting firm offers incentives to farmers, such as higher payments and other benefits. Most farmers prefer flexible contracts over fixed ones. Olaand and Menapace (2020) found farmers to prefer long term contractual arrangements with their buyers to compared to short term contracts.

Terms of payment is another important contract design attribute that influences smallholder farmers' decision to participate in contract farming. According to Rao *et al.* (2017) research on dairy farmers' preference for dairy farming contracts, contracting firms in dairy sectors offer payment for farmers in two terms. Farmers receive payment when they deliver the milk to the vendor, or payments are made after a duration specified in the contract. The results reveal that farmers prefer delayed payment. Still, the duration should not be longer; farmers derive positive utilities from payments made fortnightly, compared to a cash payment or monthly payment. The finding contradicts results found by Arouna *et al.* (2017), Ochieng *et al.* (2017), Olaand and Menapace (2020) whose studies showed that smallholder farmers preferred payment on delivery at the current market price rather than payment afterward. Most smallholder farmers have a negative attitude toward delayed payments, which is common in contractual arrangement schemes. Deferred payments can worsen liquidity constraints and increase the probability of default payments.

Broeck *et al.* (2017) conducted a study in Benin to determine farmers' preferences for domestic and organic free tree rice contracts. The tenets of the contract under consideration were the type of herbicide used, chemical fertilizer to apply, child labor, premium, input provisions, and selling price. Attributes of more than six will lead to cognitive overload during the choice process. Results showed that farmers preferred domestic contracts over free trade contracts. Hence, with fewer requirements, contract benefits will be higher than the costs. Thus, adding organic requirements standards will reduce the adoption and expansion of free trade. Experienced and resource-constrained farmers' have a higher preference for contracts. Besides, the results showed that input and extension services provisions significantly increase farmer's likelihood of accepting

the contract. Farmers preferred arrangements with significant monetary compensation, no fertilizer use, and child labor restrictions.

Moreover, Ochieng *et al.* (2017) conducted a survey in Kenya to determine farmers' preference for supermarket contract designed attributes. The study considers five attributes of supermarket contracts: place of sales, selling price, the form of sales, time of sales, and payment mode. A lower transaction cost, output premiums, quality controls, and risk-sharing were contract attributes that encouraged farmers' participation in contract farming. Similarly, Anh *et al.* (2019) found pricing methods, delivery time, technical assistance, inputs provision, monitoring, and supervision to be significant attributes influencing farmers' decision to participate in contract farming. To encourage farmers' participation in contract farming, contractors should facilitate written agreement and enforcement of the preceding contract attributes.

2.5 Effect of contract farming on farm productivity

The productivity of farmers could be measured in terms of crop, land, and input productivity. Crop or land productivity refers to the quantity of output a farmer obtains for an area of land used (Heady, 1965). In the context of this study, sorghum productivity means the kilograms of sorghum obtained from an acreage planted. The study looks at the average kilograms of sorghum per acre.

$$Sorghum\ productivity = [Quantity\ of\ sorghum\ harvested\ in\ Kilograms \div area\ planted\ with\ sorgum\ (Acreas)]$$

Contract farming had various impacts on crop productivity; some showed an increase, others a decrease, and no change in crop productivity. Contract farming was attributed to high crop productivity for farmers who participated compared to the non-participants. Contracted farmers had received a higher crop productivity than their counterparts. The increased crop productivity was due to services offered by the contracted company, such as the provision of quality production inputs such as certified seeds (High yielding seeds) and fertilizers to farmers. Furthermore, the contracting company offers contracted farmers technical advice (Extension services) on the best agricultural practices for propagation, agronomy, soil fertility, and control for post-harvest losses. Research conducted by Bidzakin *et al.* (2020), Dubbert (2019), Khan *et al.* (2019) and Meemken and Bellemare (2020) established that contracted farmers had a higher crop productivity compared to non-contracted farmers. Improved crop productivity resulted from improved inputs, better farming practices, and modern marketing methods. Furthermore, access to timely inputs, improved

production technologies, credit access, technical support, and advisory services from contractors to farmers contribute to high yields (Kutawa 2017; Ragasa *et al.*, 2018, Seba, 2016).

Contrary to the above findings, non-contract farmers were found to experience high crop productivity compared to contracted farmers. Reasons behind high crop productivity by non-contracted farmers in the study areas were attributed to high technical skills, knowledge, and training received by farmers outside contractual arrangements. Besides, a decline in crop productivity by contracted farmers was attached to higher production costs under contract farming than in non-contract farming (Kumar *et al.*, 2018; Mishra *et al.*, 2018; Sharma *et al.*, 2016). According to Ren *et al.* (2021), contract farming increases the costs of production. On the other hand, Kumar *et al.* (2018) disagree and concludes that production costs are lower amongst contracted tomato farmers compared to the non-contracted.

However, the literature reviewed above concludes that contract farming could increase or decrease crop productivity. This finding leaves a gap in the literature that showed that no clear, conclusive report could be attached to the effect of sorghum contract farming on sorghum productivity in Siaya County, Kenya. The gap was filled by determining the effect of contract farming on smallholder farmers' sorghum productivity in Siaya County, Kenya.

2.6 Theoretical framework

The theoretical framework section entails the theory that the study adopted. The possible theories for analyzing the preference for contract attributes and the effect of contract farming on smallholder sorghum productivity were Random utility theory, Principal Agent theory, and transaction cost theory. The transaction cost theory was used in this study because random utility theory only addresses the maximum benefits farmers get if they participate in a contract, but eliminates the contribution of the contracting company in the contract undisclosed. Principal agent theory has been adopted in other studies on contract farming. Still, it only explains the existence of information asymmetry between the agent (farmer) and the principal (contracting company) (Mitchael *et al.*, 1976). Principle agent theory does not explore in detail the impact of a contract in agricultural farming but more on the behavior of the contracting parties. Consequently, transaction cost theory was the most preferred as it explored contract farming in detail, including the benefits, behavior of actors, and transactions that entail contract farming (Williamson, 1979).

2.6.1 Transaction cost and contract farming

Transaction Cost Theory (TCT) was developed by Ronald Coase in 1937 to explain the existence of transaction costs in the production and marketing of a given product by the firm in the economy. In 1990 Williamson and North modified the theory and incorporated TCT in learning New Institutional Economics (NIE). Transaction cost theory assumes that actors in the market suffer two main problems; opportunistic behavior and bounded rationality. Due to the two constraints on behavior, the actors in the market can steal and cheat in a transaction (Prowse, 2012; Williamson, 1985). Market participation involves transaction costs, such as cost of information, negotiation terms, and finding a trusted partner in an exchange. Other costs include monitoring performance and covering transaction losses (Williamson, 1979). Transaction costs are affected by the product, the characteristics of the transaction, and the environment in which the transaction is initiated.

Williamson (1979) revealed that transaction costs in an exchange is influenced by uncertainty, asset specificity, and transaction frequency. A specific investment is a situation where an investment loses part of its value when it is used for a purpose outside the firm-specific relationship intended. Uncertainty is a condition where there is incomplete market information between buyers and sellers on current and future situations. Environmental and human behavior causes uncertainty. Environmental uncertainty arises due to asymmetric information in the market, while behavioral uncertainty relates to individual characteristics to predict future contingencies (Lyons, 1996). Human behaviors and environmental factors result in market failure, thus calling for institutions support to enhance the market operation. Institutional laws are essential to reduce opportunistic behavior among parties in a transaction through enforcement and motoring contracts. An incomplete contract exists in the market caused by bounded rationality (Lack of perfect market knowledge of the market) that raises transaction costs, leading to market failure (Williamson, 1979).

Agricultural producers of high-value commodities face difficulties operating in high-value markets due to high transaction costs resulting from weak institutions and market failure. New institutions such as contract farming have been identified to eliminate market failures by providing farmers with inputs and output markets (Williamson, 1979). There is a need to determine how TCT is linked with contract farming. The processor accumulates transaction costs in the market while exchanging goods and services. Costs are incurred when buyers and sellers explore marker prices,

bargain, design contracts, verify contract terms, and search for market information (Williamson, 1985). If contractual arrangements are well-designed, market operation will be done at least transaction cost. Equilibrium price in the market is influenced by transaction costs that result in inefficient utilization of resources.

However, if the transaction cost is high, buyers receive high prices and sellers' low prices, resulting in losses to both parties. Smallholder farmers are constrained in production as they cannot reap commercialization benefits due to high transaction costs in the market. A contract farming scheme is an intervention to encourage smallholder farmers to engage in commercial agriculture to overcome high market transaction costs. Contract farming assured smallholder farmers of the produce market and price-limiting imperfection in spot market dealings (Kumat *et al.,* 2019). Besides, contract farming connects smallholder farmers to the global market for more profits. Contracting companies such as EABL provide sorghum farmers with quality input, technical training, credit, and favorable output prices that enable them to achieve high yields. The EABL benefits from a regular supply of quality sorghum as a raw material that reduces uncertainties in the spot market (EABL, 2018).

Contract farming eliminates brokers/intermediaries that exploit smallholder farmers by acquiring farm produce at a lower price. It controls price distortions, usually shared in informal market value chains where intermediaries benefit on behalf of smallholder farmers. Contract farming offers the best prices for farmers and consumers as there is a reduced impact of market intermediaries. Challenges to contract farming arise as most smallholder farmers are disorganized, lowering their bargaining power with large contracting companies. Thus, contracting firms have more bargaining power than smallholder farmers; they tend to design contract terms and conditions that favor them most at the expense of the farmers. This market power imbalance might result in unfavorable contracts for farmers. Thus, producers maximizing all the benefits from contract farming at the expense of the smallholder farmers (Maertens & Ved, 2017). Contracting companies prefer contracting large-scale farmers to smallholders as such contracts are easy to manage, the risks of dealing with many smallholder farmers are reduced, and it is cost-effective. Firms typically contract with smallholder farmers through farmer groups, which link them to producers and processing firms (Kumar *et al.,* 2019). This study tends to identify determinants of sorghum contract farming participation by smallholder farming to ensure the contract design provides equal

benefits to EABL Company and farmers. This will lower transaction costs in sorghum contract farming and ensure a regular supply of raw materials for the EABL company.

2.7 Conceptual framework

Household, farm characteristics, institutional factors, and contract design attributes influenced the decision to participate in sorghum contract farming in this study. The study assumed that these factors might influence the decision of smallholder farmers to either participate in sorghum contract farming or not. Institution factors such as group membership and access to extension services inform smallholder farmers on new interventions or new farming technologies such as contract farming for improving crop yield. This positively motivates farmers to engage in contract farming to reap maximum benefits. Household characteristics such as age, farm size, education level, and number of active members were assumed to positively influence participation in contract farming. Tropical Livestock Units, ownership of bicycle, distance to the nearest main road, and off-farm income enhance easy access to farm inputs for quality output as required by the contracting company. The farmer who owns larger tracks of land, oxen, and farm stores will be willing to engage in contracts. Contract-design attributes interact with household and farm characteristics, influencing farmers' decisions to engage in contract farming.

Contract farming attributes such as the price offered by the contracting company. If it exceeds the spot market price, the contract will attract more farmers to produce sorghum under the scheme. If a contracting company provides inputs, ensures an output market, offers technical assistance, and offers farmers credit, the scheme will draw more farmers to participate. Most farmers prefer a contract per season, such as sorghum, compared to perennial crops, such as sugarcane and tea, which require long-term contracts. Farmers prefer instant payments if they don't trust the contracting company. Thus, payment at the farm gate motivates farmers to engage in contract farming. Farmers who participated in contract farming were expected to benefit from quality inputs such as certified seeds, access to credit, and training on new farming methods that improved their sorghum productivity. The interaction of the variables from contract participation to crop productivity is represented conceptually in Figure 1.

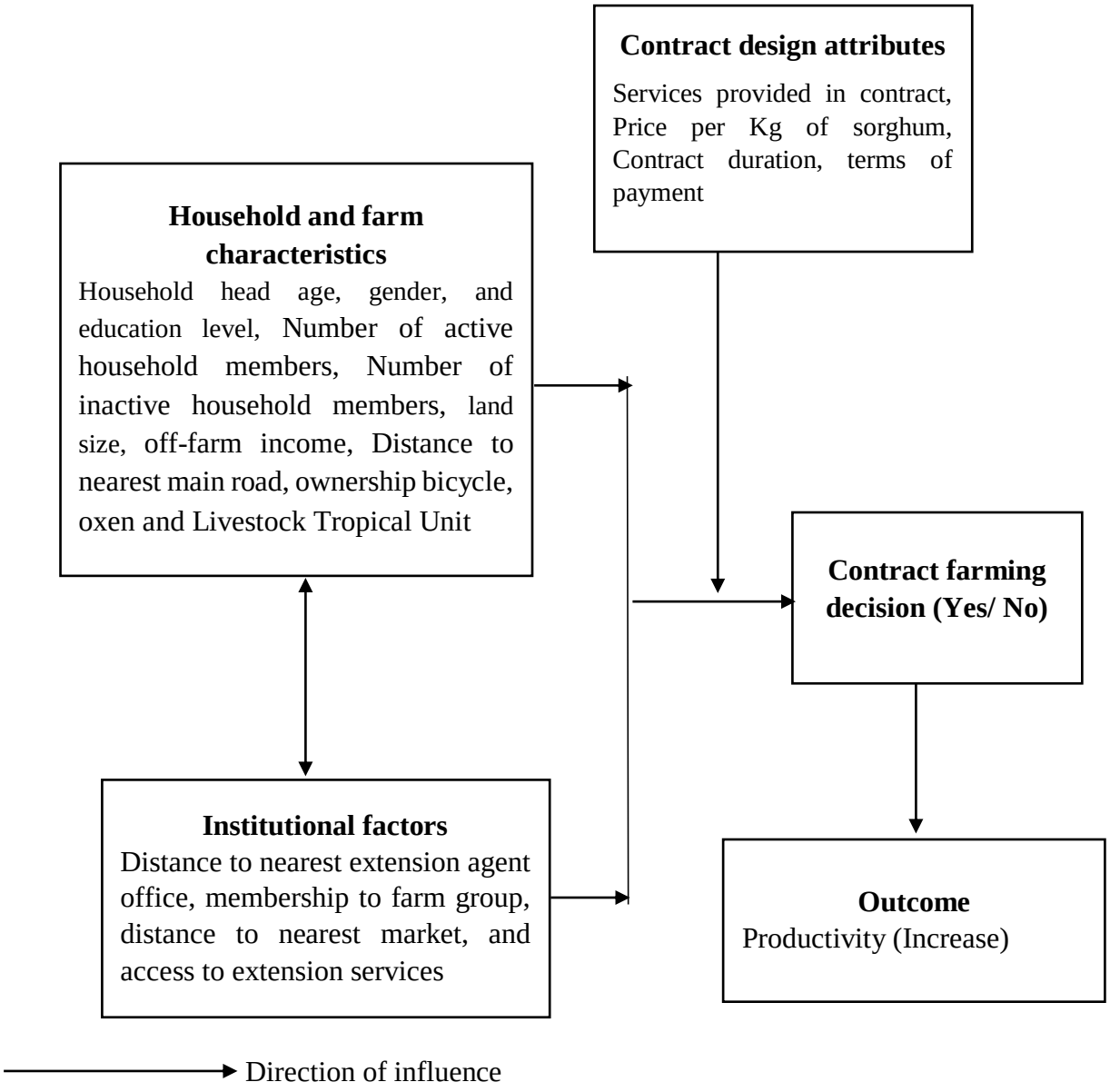

Figure 1 Conceptual framework

CHAPTER THREE
METHODOLOGY

3.1 The study area

This study was conducted in Siaya county, which is located to the Northwest of Busia county, Northeast of Vihiga and Kakamega counties, Southeast of Kisumu county and South of Homa Bay county. The county has six sub-countries: Alego, Bondo, Rarieda, Gem, Ugenya, and Ugunja. Siaya county is between latitude 0º 26´ South and 0º 18´ North and longitude 33º 58´ and 34º 33´ east. Siaya County lies at an altitude of 1,1140m below and 1,140m above sea level. Siaya county has a land size of 2,496.1 Km^2 with a population of 993,181 (KNBS, 2019). Bondo and Rarieda sub-counties are in the drier parts, while Alego, Gem, Ugunja, and Ugenya sub-counties are in the wetter part of the County. The County experiences an average annual temperature range of between 16.3° C and 29.1° C and an average annual rainfall range of 1,800mm to 2,200mm.

Agriculture is the primary source of livelihood in Siaya County, supporting about 80 percent of the population for food and income. Among the key development goals of the Siaya County government is the promotion of food self-sufficiency and food security in the county through the promotion of food crops (mainly sorghum, maize, cassava, and beans). Siaya County was chosen because of the extensive sorghum production in the region under contract farming by EABL Company. Besides, Siaya County is one of the drought prone areas targeted by the Kenya Climate Smart Agriculture Project (KCSAP) to achieve adaptive resilient capacity to climate change impacts by smallholder farmers. Sorghum is one of the vital cereals identified by KCSAP in Siaya County as a climate-smart crop (CIDP, 2018).

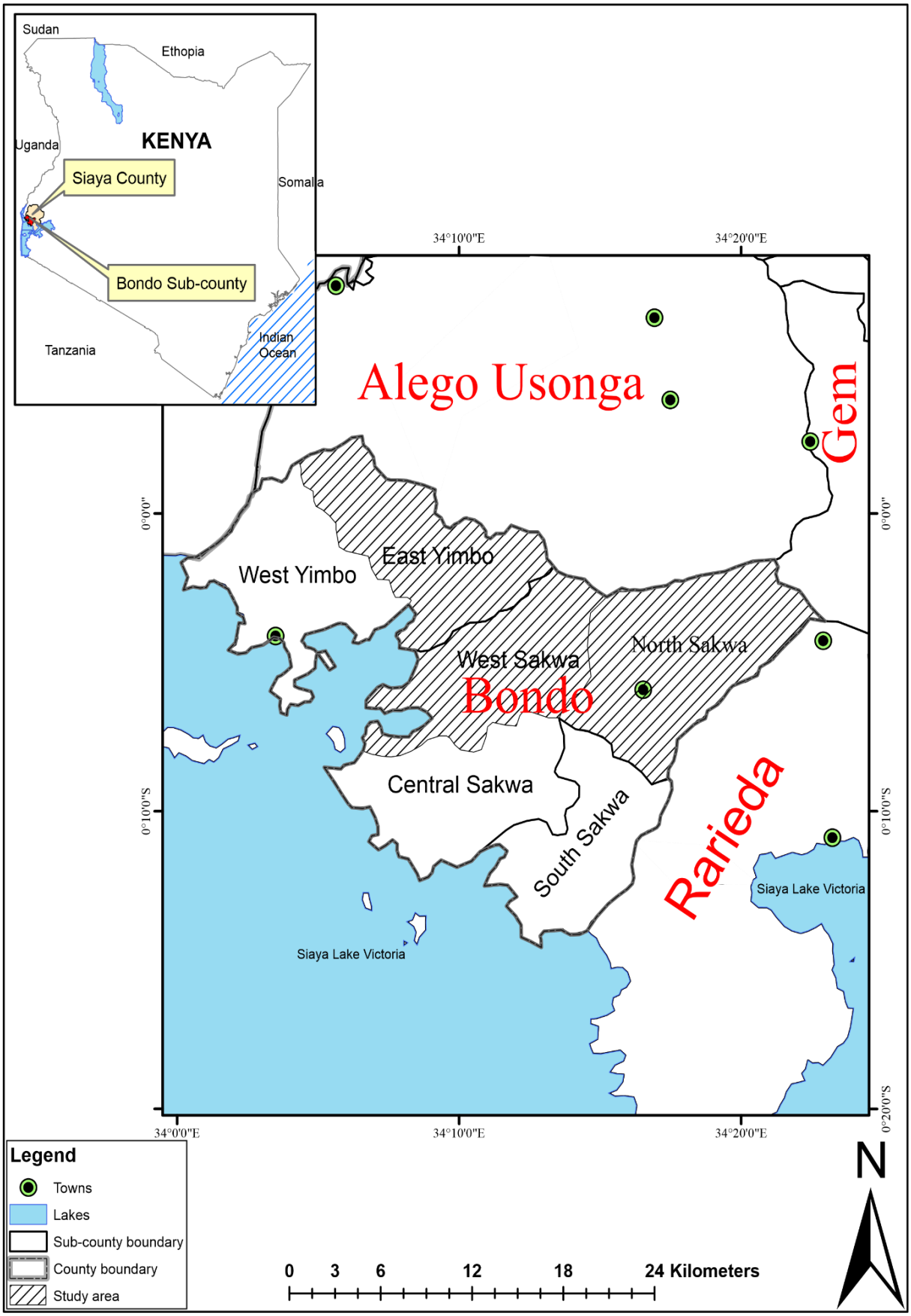

Figure 2 Map of the study area

Source: ESRI, USGS, GEBCO, NPS and other contributors

3.2 Research design

This study used a survey research design because it can be applied in descriptive, explanatory and exploratory research. Therefore, this design was the most suitable to meet the objectives of the study.

3.3 Sample size determination

Sampling is a selection of a sub-set of the population of interest in a research study, while the sample size is a subset to represent the entire population of interest. The sampling unit for this study constitutes smallholder sorghum farmers who plant sorghum either under contract farming by EABL or not. The required sample size for the study was determined proportionately to the size sampling methodology as per the formula by Anderson *et al.* (2007), as shown in the equation below.

$$n = \frac{Z^2 pq}{e^2}$$

Where n is the required sample size, p is the proportion of sorghum farmers in Bondo sub-county. Proportion of sorghum farmers was not known with certainty, and thus $\mathrm{p} = 0.5$. q is a variable computed as $\mathrm{q} = 1 - \mathrm{p} = 1 - 0.5 = 0.5$, Z represents critical value, which is 1.96 at 95 percent confidence interval, and e indicates allowable error term. According to Anderson *et al.* (2007), an error of less than 10% is usually acceptable hence the study used an error of 6.33%. The computation of sample size for the study was expressed as shown in equation (1) below.

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.0633^2} = 239.69 = 240 \qquad (1)$$

Therefore, 240 smallholder sorghum farmers were sampled for the study. Proportionate to size was used to distribute the total sample size between contracted (105) and non-contracted (135) sorghum farmers.

Table 3.1: Sample distribution of contracted and non-contracted farmers per ward

Ward	Sample	Contracted	Non-contracted
East Yimbo	144	54	90
North Sakwa	44	29	15
West Sakwa	52	22	30
Total	**240**	**105**	**135**

Source: Authors Computation

3.4 Sampling procedure

The population of interest was smallholder sorghum farmers in Siaya County, specifically Bondo Sub-county that produces sorghum under contract by EABL Company and non-contracted farmers. Multistage and stratified sampling techniques were used to generate the sample. In the first stage, the Bondo sub-county was purposively selected based on the prominence of sorghum production relative to other sub-counties in Siaya County. In the second stage, East Yimbo, North Sakwa, and West Sakwa wards were purposively selected based on the high number of sorghum farmers compared to West Yimbo, Central Sakwa, and South Sakwa wards. In the third stage, two villages with extensive sorghum production were selected in each ward. In each selected village, sorghum farmers were stratified into two groups: EABL contracted and non-contracted. From the strata, 105 contracted and 135 non-contracted sorghum farmers were randomly selected. A proportionate-to-size approach was applied to determine the number of contracted and non-contracted farmers to sample from each village.

3.6 Data collection

Primary data was collected from 240 smallholder sorghum farmers using a semi-structured pretested questionnaire administered in face-to-face interviews by a team of 8 trained enumerators for eight days. The team used the Kobo collect mobile App to collect the data. A pilot survey was conducted in the Central Sakwa ward in the Bondo sub-county to test the validity and reliability of the questionnaire. Central Sakwa ward was selected purposively based on sorghum production under contract farming and non-contract. The reliability test was conducted using Cronbach's alpha test in SPSS. A Cronbach's alpha of 0.667 was obtained, which indicated that the questionnaire met the internal consistency requirement. The validity of the questionnaire was tested in SPSS using Pearson Product Momentum Correlation. It was done by correlating the scores of questionnaire items (Conjoint questions) with the overall score. The Pearson Momentum correlation of the ten question items selected was significant, indicating that the questions were valid.

3.7 Analytical framework

Data was downloaded from Kobo server in SPSS format and coded to ensure consistency, uniformity, and accuracy. The data was cleaned using SPSS version 26 and analyzed using STATA Version 17. To determine factors influencing farmers' decision to participate in the contract farming, logistic regression (Logit) was used. Conjoint analysis was used to analyze farmers' preferences for sorghum contract attributes while endogenous

switching regression was applied to evaluate the effect of contract farming on smallholder farmers' sorghum productivity. These analytical methods are discussed in the sub-sections that follows.

3.7.1 Determinants of smallholder farmers' decision to participate in sorghum contract farming in Siaya County, Kenya

Decision to participate in sorghum contract farming is a binary variable, taking the value of 1 for contracted and 0 for non-contracted farmers. Modelling such a binary response variable is often through the linear probability model (LPM), Logit model or probit model. Ordinal Least Square (OLS) model was not applicable since dependent variables was categorical not continuous, if used for the analysis will result to biased estimates of the results. The LPM has weaknesses that the resulting probability predictions are not necessarily bounded in the unit interval as it can be less than zero or greater than one. Also, LMP implies there is a constant marginal effect for all the explanatory variables used in the model. Logit and probit models overcome the above drawbacks of LMP. Logit model was chosen over probit model as it is easier to interpret than probit model. Logistic regression is interpreted as the marginal effects (Wooldridge, 2010). Logistic regression model can be expressed as follows;

$$A_i^* = \beta_i X_i + \mu_i \tag{2}$$

Where A_i^* a latent response variable, β_i is the coefficient of the parameter estimate, X_i is a vector for explanatory variables which influence participation decision and u_i is the error term. In practice, A_i^* is unobserved. We observe only a dummy variable A_i which is defined in this case as; A_i = { 1 if $A^*_i > 0$ contract farming and 0 if $A^*_i < 0$ otherwise}. Probability of participation in contract farming is denoted as;

$$prob(A_i = 1) = prob(A_i^* > 0) = prob(\mu_i > \beta X_i) = 1 - F(-\beta X_i) = F(\beta X_i) \tag{3}$$

In this case F represents cumulative distribution function (CDF) for a continuous random variable with a probability density function. The expression for the probability of a farmer participating in sorghum contract farming is as follows:

$$\text{prob}\left(\text{A}_\text{i} = 1/\text{X}_\text{i}\right) = \frac{1}{1+\text{e}^{-\text{BX}_\text{i}}} = \frac{\text{e}^{\text{BX}_\text{i}}}{1+\text{e}^{\text{BX}_\text{i}}} \tag{4}$$

Under a random sampling technique where all the observations of interest are sampled, the contribution of the i^{th} observation is written as,

$$\text{P}_\text{i}^{\text{A}_\text{i}}\left(1-\text{P}_\text{i}\right)^{1-\text{A}_\text{i}} \tag{5}$$

Therefore, the probability function is represented as;

$$L = \prod_{i}^{n} P_i^{A_i} (1 - P_i)^{1-A_i} \quad (6)$$

By taking logarithms of both sides and letting P_i to be $\frac{e^{BX_i}}{1+e^{BX_i}}$, the log- likelihood function will be

$$\log L = \sum_{i}^{n} A_i \beta X_i - \sum_{i}^{n} \log\left(1 + e^{BX_i}\right) \quad (7)$$

In this model with binary dependent variable, the parameter estimates of βs was be interpreted as the probability scale expressed as; dp_j / dX_j which gives the rate of change in the probability as a result of a small change in the dependent variable and given as; $B_j P_i (1 - P_i)$ (Greene, 1994).

Empirical model specification

Participation in contract farming is denoted by;

$$\begin{aligned} A_i = {} & \beta_0 + \beta_1 \text{Education} + \beta_2 \text{Gender} + \beta_4 \text{Age} + \beta_4 \text{Age15to64} + \beta_5 \text{Ageless15great64} + \\ & + \beta_6 \text{LandAcreage} + \beta_7 \text{OffarmIncome} + \beta_8 \text{GroupMembership} + \beta_9 \text{DistExtent AgentMins} + \\ & + \beta_{10} \text{DistMainRo adMins} + \beta_{11} \text{DistInputMarket} + \beta_{12} \text{FarmStoreOwnership} + \\ & + \beta_{13} \text{BicycleOwnership} + \beta_{14} \text{OxenOnwership} + \beta_{15} \text{AnimalAsset} + \varepsilon_i \end{aligned} \quad (8)$$

Where $A = 1$ for contracted farmer and 0 otherwise, β_1 to β_{15} are the parameter estimates of the variables and ε_i is the error term.

Table 3.2: Description of variable and the expected sign in the Logit model

Variable symbol	Variable name	Variable type	Unit of measurement	Expected sign
Participation	Dependent Contract participation	Dichotomous	(0=No 1=Yes)	
	Independent Variables			
Education	Education level of the household head	Categorical	Categorical	+/-
Gender	Gender of the household head	Dichotomous	0=Female 1=Male	+/-

Age	Age of the household head	Continuous	Years	+
Age15 to64	Active household members	Continuous	Numbers	+
Ageless15<64	Household members Age <15 and >64 years	Continuous	Numbers	_
LandAcrage	Land Acres owned	Continuous	Acreage	+
Offarm	Off-farm Income	Continuous	KES	+/-
Group	Group Membership	Dichotomous	0=No 1=Yes	+/-
ExtAgentMins	Distance to nearest Extension Agent office	Continuous	walking minutes	-
MainRoadMins	Distance to nearest Main Road	Continuous	walking minutes	-
InputMarketMin	Distance to nearest farm input market	Continuous	walking minutes	-
Farmstore	Farm Store ownership (0=No 1=Yes)	Dichotomous	0=No 1=Yes	+
Bicyle	Bicycle Ownership (0=No 1=Yes)	Dichotomous	0=No 1=Yes	+
Oxen	Oxen Ownership (0=No 1=Yes)	Discrete	0=No 1=Yes	+
LivestockTLU	Livestock TLU	Continuous	TLU	+

3.7.2 Analysis of smallholder sorghum farmers' preferences for sorghum farming contract design attributes in Siaya County, Kenya

The attributes and levels applied in the choice experiment were identified from literature and discussions made with various stakeholders before the actual survey. The main sorghum contract attributes found were services offered in contracts, contract duration, output price, and terms of payment, which influence farmers' decision to enter contracts. From literature, prices are set above and below market price, contract duration per season, and more than a season. Primary services found to be offered by contracting firms were market and financial assistance. The last attribute was payment terms, in which most studies adopted cash on delivery or deferred payment (Anh *et al.,* 2019; Ochieng *et al.,* 2017; Rao *et al.,* 2017).

The possible profile combination was derived to be $\left(4^3\right)= 64$. When the profiles are too many the true choice of the farmer is distorted. A fractional factorial design was used to reduce the number of profiles to suitable ones by using orthogonal design. A full factorial experimental design was used for the combination of all the four attribute levels to come up with the best alternatives (Ranasingha *et al.,* 2019). The experiment was developed with four attributes (n= services, price, terms of payment and contract duration). Each attribute had three levels (L=3) as indicated in Table 3.2.

Table 3.3: Sorghum contract attributes and levels in Siaya county

Symbol	**Contract attributes**	**Level 1**	**Level 2**	**Level 3**
Price	Prices	KES. 33 per Kilogram	KES. 35 per Kilogram	KES. 37 per Kilogram
Terms	Payment Terms	At farm gate	After 14days	After 30days
Duration	Contract duration	Per season	Yearly	More than 1 year
Service	Services provided	Financial assistance	Inputs provision	Output market

However, the number of profile (np) generated for a full factorial design was Ln=9 profiles (Table 3.3). A conjoint analysis technique was applied for estimating partial utilities on each attribute level and the total attribute utilities were calculated by summing up all the total partial utilities.

Table 3.4: Conjoint plan of sorghum production in Siaya county

Profiles	**Services Provided**	**Contract Duration**	**Price per kg of Sorghum**	**Terms of Payment**
1	Financial services	More than 1 year	37	After 30 days
2	Produce market	Yearly	33	After 30 days
3	Input provision	Yearly	37	Cash at farm gate
4	Financial services	Per season	33	Cash at farm gate
5	Input provision	More than 1 year	33	After 14 days
6	Financial services	Yearly	35	After 14 days
7	Produce market	Per season	37	After 14 days
8	Produce market	More than 1 year	35	Cash at farm gate

9	Input provision	Per season	35	After 30 days

The study was a natural choice experiment, where farmers chose from various sorghum contract attributes. Choice experiments are of two types: discrete and ranked choice experiments. In a discrete choice experiment, the farmers are given two options, and the best option is chosen. In contrast, in a ranked-choice experiment, the farmer is given various alternatives to organize from the most to the least preferred. The study adopted a ranked-choice experiment as farmers were given profiles to rank from the most to the least preferred. The possible models for analyzing rank choice experiments are ranked-ordered logit (Conjoint analysis) and ranked-ordered probit choice model (Adegbola *et al.*, 2019). However, ranked-ordered probit model was not preferred as there were no case-specific and alternative-specific predictors. In addition, the ranked-ordered probit model works best with few alternatives. There were nine alternatives to be ranked, making ranked-ordered probit unsuitable. Ranked-ordered logit was the most preferred model, as the alternatives were not explicitly identified. Besides, the alternatives had no identifying variable (Marden, 1995). Each alternative was recognized by its features as specified by a set of alternative-specific variables. All the predictors were alternative-specific variables. The ranked-ordered logit model assumes the independence of irrelevant alternatives (IIA) (Beggs *et al*., 1981).

The assumption was that farmers were rational in making farm production decisions. Thus, farmers prefer production activity that maximizes utility. Farmers decide to join sorghum contract farming only if the expected utility derived from participating exceeds that of not participating. Conjoint analysis (Ranked ordered logit) is based on the random utility theory, which states that the farmer's main objective is to maximize utility. The farmer faces two scenarios: whether to produce sorghum under contract farming or not. The study assumed that smallholder sorghum farmers could rank their preferences systematically and consistently within their knowledge and budget constraints ((Adegbola *et al.*, 2019). The decision-making process by the farmer on utility maximization was expressed as follows;

$$U_i . > U_j \rightarrow irj \forall j \in B \tag{9}$$

The equation (9) implies alternative i is chosen over alternative j if it yields the highest utility. Therefore, if the utility of alternative i is greater than that of all alternatives j, thus alternative i will be preferred and chosen from a set of alternative B.

Whereas, $i + j$ implies that the alternatives to the left-hand side are more preferred than those on the right hand side. While $\forall j \in B$; represent all the cases j, in the set B. The probability that a farmer choose alternative j can be represented by equation (10) as follows;

$$\Pr = \Pr\left(V_j + \varepsilon_j\right) > V_i + \varepsilon_i \forall i \neq j \quad (10)$$

Moreover, the Random Utility Maximization allows the survey to incorporate uncertainty in the model. The Utility is dived into stochastic, (ε) and deterministic, (V) utilities. Random utility assumed that individual utility (U) is anonymous but can be disintegrated into observed constituent (V) and stochastic constituent(ε). Therefore, an individual smallholder sorghum farmer j in scenario i, maximum utility was expressed as;

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (11)$$

In the conjoint analysis model, the importance of each of the four attributes were computed in the approximation. The relative importance of each attribute (i) was determined. Each of the four attributes, the lowest and the highest part-worth for the attribute was calculated. Besides, the attribute part-worth variation between the highest and the lowest part-worth was determined. The relative importance of each attribute (i) to the farmer was delivered as follows;

$$\text{Relative importance} = \frac{100 \times range(i)}{\sum_i^T range(i)} \quad (12)$$

However, Kim *et al.* (2020) concludes that the part-worth utility model had been numerously applied in making decisions on various preference with different attribute levels. Part-worth utility model results are easier to interpret compared to ideal-point and vector model.

3.7.3 Evaluation of the effect of contract farming on smallholder farmers' sorghum productivity in Siaya County, Kenya

Participation in sorghum contract farming by smallholder farmers in Siaya County is non-random because farmers were not randomly recruited into the contracts. This non-random selection implies potential for selection bias in participation in the sorghum contract farming, which needs to be addressed in evaluation the impact of the contracts.

The average effect on the treated (ATT), or the average effect of participating in the contract farming on sorghum productivity, which can be expressed as $\left[E\left(Y_{i1} - Y_{i0} \middle| A_i = 1\right)\right]$,

where $A_i = 1$ indicates i^{th} household if they participated in sorghum contract farming and 0 otherwise. One can only observe sorghum productivity of the i^{th} household (Y_{i1}) in one state, that is, if they participated in sorghum contract farming or if they did not but not both. This means that to estimate the impact of contract farming on sorghum productivity among the participants, there is need for a counterfactual group that is similar in characteristics to the contract participants for comparison of sorghum productivity.

Farmers do have systematic variations that might influence their participation in sorghum contract farming. Such systematic variations, if they exist, would lead to selection bias when estimating the effect of contract participation on sorghum productivity. In this case, selection bias results from non-random selection of participants in sorghum contract farming. The selection bias can be caused by both observable and non-observable characteristics of the farmer. Observable characteristics that may influence a farmer's decision to participate in sorghum contract farming include household characteristics such as land size, ownership of farm assets and education level of the household head. Unobservable characteristics can be unmeasured attributes such as ability and entrepreneurial skills.

Propensity score matching (PSM) has been widely applied to evaluate the impact of agricultural development interventions. The PSM is a quasi-experimental method which statistically constructs a matching counterfactual group for the treatment group based on observable characteristics (Hu *et al*., 2021; Webster-Clark *et al*., 2021; Wonde *et al*., 2022; Wordofa *et al*., 2021). For this reason, the PSM controls for selection bias caused by observable characteristics but not unobservable characteristics. The method works under the assumption that observable attributes of an individual influence the individual's decision to participate in an intervention, in this case sorghum contract farming. However, the decision to engage in sorghum contract farming may also be influenced by unobservable attributes of the farmer. For this reason, the PSM is not capable of correcting for selection bias due to unobserved attributes. The limitation of PSM is overcome using the endogenous switching regression (ESR).

The ERS takes into account both observable and unobservable characteristics to address the potential selection bias (Lokshin & Sajaia, 2004). Besides, the ESR allows simultaneous estimation of decision to participate in sorghum contract farming and the outcome equation for sorghum productivity for both contracted and non-contracted. Lastly, with ESR it is possible to calculate the actual and counterfactual expected values for sorghum productivity of the contract participants and non-participants. The ESR technique has been applied in numerous studies to evaluate the impact of agricultural innovations on smallholder farmers' income,

productivity and welfare (Danso-Abbeam *et al*., 2022; Marwa *et al.,* 2022; Musafiri *et al*., 2022).

The model is expressed in three equations form. The first equation (13) of ESR entails estimation of the selection equation. This equation constitutes the estimation factors that influence farmers' decision to participate or not to participate in sorghum contract farming. Decision to participate in contract farming is a dummy variable taking the value of 1 if the farmer participated and 0 for non-participants in sorghum contract farming.

$A^{x}_{i} = \beta\chi_i + u_i$ with $A_i = 1$ for contracted and 0 otherwise (13)

where A_i^* is the latent variable for contract farming and A_i is observable variable which is represent decision to participate or not to participate in sorghum contract farming. While β indicates the vector for parameters to be estimated, while χ_i represents independent variables that influences farmers' decision to participate in contract farming. The independent variables are demographic, socio-economic and institution factors influencing smallholder farmers' decision to enter sorghum contract farming (Age, gender, education level, farm size, access to extension services). The vector μ_i denote the disturbance term that accounts for other factors influencing famers' decision into contract farming that are not included in the model.

Equations (14) and (15) represent outcome estimation equations for both participants and non-participants respectively. The equations involve determination of the effect of sorghum contract farming on smallholder farmers' sorghum productivity. At this stage, the actual effect of contract farming was determined for both contracted and non-contracted sorghum farmers.

The ESR model output showed whether there is a significant difference in productivity amongst the two groups (Maddala, 1991).

Contracted $A_{i1} = \alpha_1 X_{i1} + \varepsilon_1$ if $A = 1$ (14)

Non-contracted $A_{i2} = \alpha_2 X_{i2} + \varepsilon_2$ if $A = 0$ (15)

Therefore, A_{i1} and A_{i2} represents sorghum productivity levels for participants and non-participants respectively; where X_{i1} and X_{i2} are independent variables that affects sorghum productivity, α_{i1} and α_{i2} are parameters estimates for independent variables; ε_1 and ε_2 are random error terms for the two scenarios. The ESR model usually works under a joint normality of the error terms in the decision participation equation and the outcome effect estimation

equation. The disturbance terms in the first and second equations are normalized in ESR model. Thus, the error term in decision equation μ_i and the error terms in the outcome equations, α_1 and α_2 are assumed to be normally distributed with a mean of zero. A matrix form to express the relationship of the error terms can be expressed as shown below;

$$Cov(\mu_i, \varepsilon_{1i}, \varepsilon_{2i}) = \Omega = \begin{pmatrix} \sigma^2_{\varepsilon_1} & \sigma_{\varepsilon_1\mu} & \sigma_{\varepsilon_2\mu} \\ \sigma_{\varepsilon_1\mu} & \sigma^2_{\varepsilon_2} & \sigma_{\varepsilon_2} \\ \sigma_{\varepsilon_2\mu} & \sigma_{\varepsilon_1\varepsilon_2} & \sigma^2_{\mu} \end{pmatrix} \quad (16)$$

Where Ω represent covariate matrix, while σ^2_μ represent the variance of the error terms in the selection equation, $\sigma^2_{\varepsilon_1}$ and $\sigma^2_{\varepsilon_2}$ represents the variances in the outcome sorghum productivity equations for participants and non-participants, respectively. The covariates for the error terms in the selection and outcome equations are denoted by $\sigma_{\varepsilon_1\mu}$ and $\sigma_{\varepsilon_2\mu}$. The covariance $\sigma_{\varepsilon_1\varepsilon_2}$ of the error terms in the outcome equation cannot be determine since an individual cannot be contracted and non-contracted farmer at the same time.

The above trivariate error terms for participation and outcome equations with zero mean can be estimated as follows;

$$E(\varepsilon_1 / A_i = 1) = \sigma_{\varepsilon_1\mu} \frac{\phi(X_i\beta)}{\Phi(X_i\beta)} = \sigma_{\varepsilon_1\mu}\lambda_{1\varepsilon_1} \quad (17)$$

$$E(\varepsilon_2 / A_i = 0) = \sigma_{\varepsilon_2\mu} \frac{-\phi(X_i\beta)}{1-\Phi(X_i\beta)} = \sigma_{\varepsilon_2\mu}\lambda_{2\varepsilon_2} \quad (18)$$

where ϕ represents density function of the standard normal distribution, while Φ denotes cumulative distribution function, $\lambda_1 = \frac{\phi(X_i\beta)}{\Phi(X_i\beta)}$ and $\lambda_2 = \frac{-\phi(X_i\beta)}{1-\Phi(X_i\beta)}$. Including this form in equation above can be expressed as shown below;

$$A_{i1} = \alpha_1 X_1 + V_1; \text{ if } A = 1 \quad (19)$$

$$A_2 = \alpha_2 X_2 + V_2; \text{if } A = 0 \quad (20)$$

Where $V_1 = \varepsilon_1 + \sigma_{\varepsilon_1\mu}\lambda_{1i}$ and $V_2 = \varepsilon_0 + \sigma_{\varepsilon_2\mu}\lambda_2$, are the new error terms with normal distribution and zero mean condition. The equation (19) and (20) were estimated by full

information maximum likelihood (FIML) other than OLS which lead to bias estimates of the parameters of the coefficient in the equations. The FIML equation for the estimation can be represented as;

$$\ln L_i = \sum_{i=1}^{n}\left(A_i\left[\ln\phi\left(\varepsilon_{1i} \Big/ \sigma_{\varepsilon_1} \right) - \ln\Phi\left(\psi_{1i}\right) \right] + \left(1-A_i\right)\left[\ln\phi\left(\varepsilon_{0i} \Big/ \sigma_{\varepsilon_0} \right) - \ln\sigma_{\varepsilon_0} + \ln\left(1-\Phi\left(\psi_{01}\right)\right) \right] \right) \quad (21)$$

whereas; $\psi_{1i} = \left(X_i\beta + \rho_j\varepsilon_j / \sigma_{\varepsilon_j}\right) \Big/ \sqrt{1-\rho_j^2} \quad j = 0,1$ ρ is the correlation coefficient of the error terms selection equation and the output equation for both participants and non-participants. Restriction was imposed in the equation for prediction of the coefficient.

To achieve execution of restriction in equation system, two independent variables were included in the selection equation which were not correlated with the outcome (Lokshin & Sajaia, 2004). The instrumental variables selected were distance to the nearest main road in walking minutes and ownership of bicycle. The variables were selected since they influence participation in sorghum contract farming but does not directly influence sorghum productivity (Wooldridge, 2010).

Diagnostic test was conducted on the two instrumental variables and was found to be valid. The test was conducted to determine whether the instruments were significant in the selection equation for participation and insignificant in the outcome equation for non-participants (Di Falco *et al.,* 2013). After additional of two independent variables, it leads to formation of unconditional and conditional equation for predicting the effect of contract farming on sorghum productivity as shown below.

$$E\left(A_1 / A_i = 1\right) = X_1\alpha_1 + \sigma_{\varepsilon_1\mu}\lambda_1 \quad (22)$$

$$E\left(A_2 / A_i = 0\right) = X_2\alpha_0 + \sigma_{\varepsilon_2\mu}\lambda_2 \quad (23)$$

$$E\left(A_2 / A_i = 1\right) = X_1\alpha_0 + \sigma_{\varepsilon_2\mu}\lambda_1 \quad (24)$$

$$E\left(A_1 / A_i = 0\right) = X_2\alpha_1 + \sigma_{\varepsilon_1\mu}\lambda_2 \quad (25)$$

Equations (22) and (23) constitutes the actual predicted values for sorghum productivity effect on both contracted sorghum farmers and non-contracted. Moreover, equation (24) and (25) are the predicted value of effect of sorghum productivity for the counterfactual groups for contracted and non-contracted sorghum farmers (Di Falco *et al.,* 2011). The sorghum productivity effect on the contracted farmer was given by the difference between treated group and non-treated sorghum farmers. This is expressed in equation (26)

$$ATT = E\left(A_1 / A_i = 1\right) - E\left(A_2 / A_i = 1\right) = X_1\left(\alpha_1 - \alpha_0\right) + \left(\sigma_{\varepsilon_1\mu} - \sigma_{\varepsilon_2\mu}\right)\lambda_1 \quad (26)$$

While the average treatment effect on the untreated (ATU) is derived as the different between the untreated and treated group as shown in equation (27) below.

$$ATU = E(Y_{1i} / A_i = 0) - E(Y_{0i} / A_i = 1) = X_{0i}(\alpha_1 - \alpha_0) + (\sigma_{\varepsilon_1 \mu} - \sigma_{\varepsilon_{0\mu}})\lambda_{0i} \quad (27)$$

Similarly, heterogeneity effects on both treated and untreated groups can be calculated. Where, heterogeneity of the treated is determined as the differences between treated and non-treated while the heterogeneity of the untreated is the difference between untreated groups given by equation (28) and equation (29).

$$AHT = E(A_1 / A_i = 1) - E(A_2 / A_i = 0) = (X_1 - X_2)\alpha_1 + \sigma_{\varepsilon_1 \mu}(\lambda_1 - \lambda_2) \quad (28)$$

$$AHU = E(A_2 / A_i = 1) - E(A_2 / A_i = 0) = (X_1 - X_2)\alpha_2 + \sigma_{\varepsilon_0 \mu}(\lambda_1 - \lambda_2) \quad (29)$$

In case the average heterogeneity effect on the treated will be positive and a negative value on the untreated, it will mean that the sorghum contract participants are performing better than their counterparts even if non-participants are given chance to participate in contract. These measures are significant in finding out whether there is existence of some heterogeneity between participants and non-participants that will make them different irrespective of their sorghum contract participation status. The treatments and heterogeneity effects could be presented as shown in Table 3.4.

Table 3.5: Treatment, heterogeneity, and transitional heterogeneity effects

Outcome variable	**Category**	**Decision Stage**		**Treatment effects**
		Contracted	**Non-contracted**	
Sorghum yield (Kg/Acre)	Contracted	(22) $E(A_1 / A_i = 1)$	(24) $E(A_2 / A_i = 1)$	ATT
	Non-contracted	(25) $E(A_2 / A_i = 0)$	(23) $E(A_1 / A_i = 0)$	ATU
	Heterogeneity effects	**BH_1**	**BH_2**	**TH**

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the research findings and discussions. The first section gives a brief overview of the chapter contents and structure followed by summary statistics of the variables used in the study. Subsequently, the econometric model results and discussions are presented. Logistic regression results and discussions of factors significantly influencing smallholder sorghum farmers' participation in sorghum contract farming are presented in section 4.3. Results and discussions of conjoint analysis of farmer preferences for various contract design attributes are presented in section 4.4. Finally, section 4.5 presents results and discussions of Endogenous Switching Regression for the effect of smallholder farmers' participation in contract farming on sorghum productivity.

4.2 Socioeconomic characteristics sampled sorghum farmers

Group comparisons for contract participants and non-participants were conducted using a t-test for continuous variables and a chi-square for categorical variables. The t-test results are presented in Table 4.1. The mean age of household heads was 54 years with contracted farmers being older than the non-contracted 56 and 52 years, respectively. There was a significant difference in mean age between the two groups at 5% significance level. This indicates that older farmers were likely to participate in sorghum contract farming than the younger ones. This result could be attributed to older farmers having more experience in sorghum farming regarding production skills and technology that motivated them to participate in sorghum contract farming. Older farmers have experience in sorghum production and can analyze contract farming intervention regarding its benefits. Similar results were reported by Bidzakin *et al.* (2018), Hirpesa *et al.* (2021) and Hoang and Nguyen (2023), who reported that, on average, contracted farmers are older than non-contracted farmers.

Active household members had a mean of 4 members with 4 and 3 for the contracted and non-contacted smallholder sorghum farmers respectively. There was a significant statistical difference in the number of active household members between contracted and non-contracted smallholder sorghum farmers at a 1% significance level. This finding shows that as the number of active adult members in the household increases, the likelihood of engaging in sorghum contract farming also increases. Probably the active members assist in labour provision and preforming some of the technical activities required in contract farming (Soullier & Moustier, 2018).

Table 4.1: Differences in selected socio-economic characteristics of contracted and non-contracted sorghum-producing farmers in Siaya County, Kenya (continuous variables)

Variables	Non-contracted n=135 Mean	contracted n=105 Mean	Pooled n=240 Mean	t-test
Age of the household head	52.06 (15.78)	56.23 (12.52)	53.88 (14.57)	-2.22**
Number of active household members	2.66 (1.60)	3.86 (2.52)	3.18 (2.13)	-4.48***
Number of inactive household members	2.47 (1.75)	2.8 (1.77)	2.61 (1.76)	1.41*
Land Acres owned	2.54 (3.00)	4.06 (3.58)	3.78 (2.81)	-1.47*
Off-farm income	20,803 (52,664)	41,295 (70,092)	28,768 (61,617)	-2.59***
Distance to the nearest extension agent in walking minutes	175.52 (96.37)	140.86 (80.15)	160.35 (91.10)	2.97***
Distance to the nearest main road in walking minutes	23.96 (30.32)	22.81 (34.76)	23.46 (32.27)	0.27
Distance to the nearest input market in walking minutes	95.15 (82.66)	100.38 (87.59)	97.44 (84.71)	-0.47
Livestock (TLU	2.92 (4.14)	4.31 (3.51)	3.53 (3.93)	-2.74***

Note: Figures in parenthesis represent standard deviations, *, **, *** represent significant at 10%, 5% and 1% level, respectively.

The mean land acreage owned was 3.78 acres with contracted farmers owning more land 4.06 acres, than non-contracted farmers 3.54 acres. There was a significant difference between the two groups at 10%. Farmers with larger land sizes were more likely to participate in contract farming than those with smaller land sizes. Probably, farmers with larger land sizes needed technical support that could allow them use land efficiently to allocate more land for sorghum contract farming. This finding is in line with studies by Ganewo *et al.* (2022), Jagri *et al.* (2021), Marwa and Manda (2022), Rondhi *et al.* (2019), which reported that contracted farmers have a larger land size compared to the non-contracted farmers.

Mean off-farm income was KES 28,768. There was a significant statistical difference at 1% between mean household off-farm income of contracted and non-contracted farmers. The mean off-farm income for the contracted farmers (KES 41295) was greater than that of the non-contracted group (KES 20804). Farmers with less off-farm income were unlikely to participate in sorghum contract farming compared to their counterparts. Probably, the design of sorghum farming contracts required farmers to fund most of the activities making it difficult for those with less off-farm income to participate. A higher level of off-farm income encourages farmers to participate in sorghum contracts as they can purchase certified seeds and quality inputs required to produce the crop under contract. This result is in agreement with that of Ruml *et al.* (2022) deduced that contracted farmers received higher off-farm income than the non-contracted.

The mean distance in walking minutes from the farmers' residence to the nearest extension agent office was 160.35. On average, it took contracted farmers a shorter time 140.86 minutes than non-contracted farmers 175.52 minutes to walk to the nearest extension agent's office. This was significant at 1% and implied that farmers near the extension agent's office were likely to participate in sorghum contract farming than those far away. Probably, farmers were physically contacting extension officers for guidance on contract farming practices making it difficult for those far away from the office to participate.

Mean distance to the nearest main road in walking minutes was 22.46 minutes with 23.96 and 22.81minutes for non-contracted and contracted smallholder sorghum farmers respectively. Mean distance in walking minutes to the nearest input market was 97.44 minutes. On average it took non contracted farmers a shorter time walking to the nearest input market 95.15 than the contracted 100.38minutes respectively.

Mean of tropical livestock units owned by non-contracted and contracted sorghum farmers was 35.53 units. Contracted sorghum farmers owned more tropical livestock units (4.31 TLU) than their non-contracted counterparts (2.92 TLU). There was a significant statistical difference in terms of TLU owned between non-contracted and contracted smallholder sorghum farmers at 1%. Farmers who owned more livestock TLU were more likely to participate in contract farming compared to their counterparts. Probably, farmers in used livestock for cultivation purposes easing land preparation for sorghum production under contract. Livestock is a vital productive asset, a sign of wealth, a source of manure and food to the households. Findings were in agreement with Ganewo *et al.* (2022) who found significant differences in terms of TLU amongst contracted and non-contracted farmers, with

the contracted holding more TLU than non-contracted. Descriptive statistics on categorical variables are presented in Table 4.2.

Table 4.2: Differences in selected socio-economic characteristics of contracted and non-contracted sorghum-producing households in Siaya County, Kenya (categorical variables)

Variables		**Contracted n=105**	**Non-contracted n=135**	**Pooled n=240**	
Gender of the household head **(%)**	Female	28.95	71.05	31.67	
	Male	50.61	49.39	68.33	9.90***
Education level of the household head **(%)**	No formal	13.64	86.36	9.17	
	Primary	45.1	54.9	63.75	
	Post-Primary	50.77	49.23	27.08	9.52***
Group membership **(%)**	No	24.42	75.58	35.83	
	Yes	54.55	45.45	64.17	20.35***
Oxen ownership **(%)**	No	38.05	61.95	85.42	
	Yes	77.14	22.86	14.58	18.57***
Farm store ownership **(%)**	No	33.95	66.05	67.5	
	Yes	64.1	35.9	32.5	19.45***
Bicycle ownership **(%)**	No	23.76	76.24	42.08	
	Yes	58.27	41.73	57.92	28.31***

Note: *, **, *** represent significant at 10%, 5%, 1% level, respectively.

A larger proportion of sorghum farmers were male-headed households, constituting 68.33%, while female-headed households were 31.67%. There was a 1% significant statistical difference between contracted and non-contracted farmers in terms of gender. Amongst the male-headed households, 49.39% were non-contracted, and 50.61% were contracted. In contrast, amongst the female-headed farm households, 71.05% were non-contracted, and 28.95% were contracted, indicating that participation in contract farming among female-headed households was much lower compared to their male-headed counterparts. The low level

of participation by female-headed households in sorghum contract farming could be attributed to limited access to farming resources and engagement in domestic activities. This finding is similar to Adejo and Ndukuba (2022), Jagri *et al.* (2021), Koshuma *et al.* (2023), which reported that contract farming was dominated by male-headed households.

Education level was statistically significant at 1%. Majority of the sorghum farmers (63.75%) had attained a primary level of education, with 27.08% post-primary level and 9.17% having no formal education. Of the farmers who reached the primary level, 54.90% were non-contracted, while 45.10% were contracted. Of farmers with post-primary education levels, 49.23% were non-contracted, while 50.77% were contracted. Moreover, 86.36% without formal education were non-contracted, while 13.64% were contracted. This indicates a low level of participation in sorghum contract farming by farmers who have no formal education compared to farmers who had acquired formal education. Farmers with no formal education are illiterate and unable to understand the terms of the contract. Thus, their participation in sorghum contract farming is limited. This result conforms researches by Adejo and Ndukuba (2022) and Koshuma *et al.* (2023) concluding that most contracted farmers had formal education, with a few without formal education.

Group membership was statistically significant at 1%. Most smallholder sorghum farmers (64.17%) belonged to farmer groups, while few 35.83% were not members of farmer groups. Out of the farmers who belonged to farmer groups, 45.45% were non-contracted, while 54.55% were contracted. Out of the farmers not in farm groups, 75.58% were non-contracted, while 24.42% were contracted. This indicates a high level of participation in contract farming by farmers belonging to farmer groups compared to those not in farmer groups. In groups, farmers acquire more information about innovations such as contract farming and its benefits to farmers. Contracting firms always target farmers organized in groups for easy accessibility. This finding was supported by Ganewo *et al.* (2022), Hoang and Nguyen (2023), Rondhi *et al.* (2019), who found that the majority of contracted farmers were members of cooperatives.

There was a 1% significant statistical difference between non contracted and contracted sorghum farmers in terms of oxen ownership. Majority of sorghum farmers (85.42%) did not own oxen, while 14.58% owned. Thus, out of the farmers who did not own oxen 61.95% of them did not participate in sorghum contract farming, while 38.05% participated. Further, 22.86% of the farmers owning oxen were non-contracted, while 77.14% were contracted sorghum farmers. This shows a high level of participation in sorghum contract farming by farmers who own oxen compared to their counterparts who did not. Oxen could be the main form of land cultivation in the study area, and farmers who own it could cultivate in good time

as required by the contracting company making them adopt contract farming. Contrary to Dagnew *et al.* (2024), who found that contracted farmers have more oxen power than non-contracted farmers.

Regarding ownership of farm stores there was statistical difference between non-contracted and contracted farmers at 1% significance level. Most farmers (67.50%) did not own farm stores, while 32.50% owned them. Of the farmers who did not own farm stores, 66.05% were non-contracted, while 33.95% were contracted sorghum farmers. Of farmers who owned farm stores, 35.90% were non-contracted, while 64.10% were contracted. The results revealed a higher likelihood of farmers with farm stores participating in contract farming compared to those without. Ownership of farm stores motivates farmers to participate in sorghum contract farming as it is easier for farmers with stores to bulk sorghum produce awaiting collection by contracting companies. Findings were in line with the results of Oppong-Kyeremeh *et al.* (2022), Veldwisch and Woodhouse (2022) that found ownership of farm stores encouraging farmers to engage in contract farming.

Bicycle ownership was significant at 1%. Most sorghum farmers (57.92%) owned a bicycle, while 42.08% did not. Of the farmers who owned bicycles, 41.73% did not participate in contract farming, while 58.27% participated in sorghum contract farming. Out of farmers who did not own a bicycle, 76.24% were non-contracted, while 23.76% were contracted. The result indicates a low level of participation in sorghum contract farming by farmers who did not own bicycles compared to those with bicycles. Probably, contracting firms had collection centers where sorghum farmers were required to take their output and collect inputs making it easier for bicycle owners to participate in contract farming. Ownership of a bicycle reduces the transportation cost of sorghum produce to the collection centers and makes it easier to access farm inputs. Veldwisch and Woodhouse (2022) support the above findings and conclude that farmers owning transport facilities are more likely to participate in contract farming.

4.3 Determinants of smallholder sorghum farmers Participation in Contract Farming

Multicollinearity and heteroscedasticity were done before running a logistic regression model on variables influencing participation in sorghum contract farming for consistency and reliability of the results. The continuous explanatory variables were tested for multicollinearity using the variance inflating factor (VIF) while contingency coefficient (CC) method was applied to categorical variables. Multicollinearity test results are presented in Table 4.3, and Table 4.4 for VIF and CC respectively. The mean VIF was 1.18, below the threshold level of

10 (Table 4.3). The mean VIF of 1.18 indicates no serious multicollinearity amongst the continuous explanatory variables in the model.

Table 4.3: Multicollinearity test for continuous explanatory variables (Variance Inflation Factor)

Variable	VIF	1/VIF
Distance to nearest farm input market in walking minutes	1.42	0.70
Distance to nearest Extension Agent office in walking minutes	1.25	0.80
Livestock (TLU)	1.22	0.82
Age of the household head	1.19	0.84
Distance to nearest Main Road in walking minutes	1.18	0.84
Log Land Acres owned	1.13	0.89
Log Off-farm Income (KES)	1.11	0.90
Number of active household members	1.09	0.92
Number of inactive household members	1.06	0.94
Mean VIF	**1.18**	

The contingency coefficient (CC) values from Table 4.4 are not above 0.5, indicating no serious level of multicollinearity amongst the categorical explanatory variables. In addition, the heteroscedasticity test was conducted using the Breush-Pagan test. The chi-square value of 21.24 and p-value 0.8151 indicate the absence of heteroscedasticity.

Table 4.4: **Contingency coefficient test for categorical explanatory variables**

Variables	Education level of the household head	Gender of the household head	Group Membership	Farm Store ownership	Bicycle Ownership	Oxen Ownership
Education level of the household head	1.00					
Gender of the household head (0=Female 1=Male)	0.35	1.00				

Group Membership (0=No 1=Yes)	0.13	0.05	1.00			
Farm Store ownership (0=No 1=Yes)	0.16	0.09	0.37	1.00		
Bicycle Ownership (0=No 1=Yes)	0.10	0.20	0.03	0.11	1.00	
Oxen Ownership (0=No 1=Yes)	0.14	0.05	0.21	0.27	0.18	1.00

A binary logistic regression model fitness test was conducted based on the Log-likelihood, pseudo-R squared, and p-values results. For a good logistic model fit, a p-value should be less than 10 percent and a pseudo-R square between 20 to 40 percent ranges. This study had a p-value of 0.000, Log-likelihood of -111.12, and pseudo-R squared of 32.44 percent, showing logistic regression was suitable for the analysis.

Logistic regression was run to determine factors significantly influencing smallholder farmers' participation in sorghum contract farming in Siaya County Kenya. Marginal effect results of the logistic regression model are presented in Table 4.5. Primary education level, gender, age of the household head, number of active household members, membership to farm group, distance to the main road in walking minutes, and bicycle and oxen ownership positively influenced participation in sorghum contract farming. On the other hand, distance to the nearest extension agent office in walking minutes negatively influenced participation in sorghum contract farming.

Table 4.5: Marginal effects for decision to participate in contract farming by smallholder sorghum farmers in Siaya County, Kenya

Dependent			
Contract participation (0=No 1=Yes)	**Delta-method**		
Independent Variables	**dy/dx**	**Std. err.**	**P>z**
Education level of the household head (Base No Formal)			
Primary	0.22**	0.10	0.04
Post-Primary	0.12	0.11	0.30

Gender of the household head (0=Female 1=Male)	0.14**	0.06	0.02
Age of the household head	0.01***	0.00	0.01
Number of active household members	0.03**	0.01	0.03
Number of inactive household members	0.01	0.02	0.54
Log Land Acres owned	0.00	0.06	0.99
Log Off-farm Income (KES)	0.01	0.01	0.28
Group Membership (0=No 1=Yes)	0.19***	0.06	0.00
Distance to nearest Extension Agent office in walking minutes	-0.00*	0.00	0.10
Distance to nearest Main Road in walking minutes	0.00***	0.00	0.00
Distance to nearest farm input market in walking minutes	0.00	0.00	0.49
Farm Store ownership (0=No 1=Yes)	0.09	0.06	0.12
Bicycle Ownership (0=No 1=Yes)	0.21***	0.05	0.00
Oxen Ownership (0=No 1=Yes)	0.24***	0.08	0.00
Livestock (TLU)	-0.01	0.01	0.28
Wards (East Yimbo base level)			
North Sakwa	0.27***	0.07	0.00
West Sakwa	0.06	0.07	0.39

Note: Standard errors have been calculated using the Delta method, *, **, *** represent significant level at 10%, 5%, 1% respectively

Having acquired primary education had a positive significant influence on smallholder sorghum farmers' participation in contract farming at 5%. Household heads having acquired at least primary education increases their likelihood of participating in contract farming by 22%. Formal Education equips farmers with technical skills and knowledge to better understand contract farming. Formally educated farmers could comprehensively understand the terms and benefits of contract farming compared to those with no formal education. Formal education enables farmers to read and understand contracts to make a rational decision to participate in contract farming. These results are similar to the findings by Gebiso *et al.* (2023), Luh (2020), Melissa *et al*. (2022), Nazifi *et al.* (2021), Yakubu *et al.* (2022), which found out that literacy level positively influences participation in contract farming.

The gender of the household head had a significant positive influence on smallholder sorghum farmers' participation in contract farming at 5%. A farm household head being male-headed increases the likelihood of participation in sorghum contract farming by 14%. A plausible explanation for this result could be that male-headed household make major farm decisions relating to terms and implementation of the contract compared to female-headed

household. Female-headed household are likely to consult widely before signing a contract, contributing to their low participation level. In addition, institutional and cultural factors that are unresponsive to women's needs prevent women from participating in contract farming. Males are more likely to own productive resources such as land and livestock, which favors their participation in contract farming. The results are similar to Meemken and Bellemare, 2020, Hirpesa *et al.* (2020), and Pangapanga-Phiri *et al.* (2024), which found out that female-headed households were less likely to participate in contract farming.

Age of the household head had a significant positive influence on the smallholder sorghum farmers' decision to participate in contract farming at 1% significance level. An increase in the household head's age by one year increases the likelihood of participating in sorghum contract farming by 1%. This is because older farmers had more knowledge and experience in sorghum production. Elderly farmers could analyze and understand the technicalities of contracts and the possible benefits compared to younger farmers. Furthermore, older farmers are risk averse and are willing to engage in contract farming to reduce production and marketing risks. These results are in agreement with Akumu *et al.* (2020), Johnny *et al.* (2019), and Pangapanga-Phiri *et al.* (2024) which found out that age has a positive influence on contract farming participation.

The number of active household members had a significant positive influence on smallholder sorghum farmers' participation in contract farming at 5% significance level. This implies that households with many active family members were more likely to engage in contract farming than those with fewer active members. The active members could be providing labor for planting, weeding, and harvesting sorghum, thus increasing the chance of participating in sorghum contract farming. Family labor reduces the cost of hired labor and raises the farm's profitability. These findings agreed with Soullier and Moustier (2018) concluded that number of active members directly influences participation in contract farming.

Membership to farmer groups significantly and positively influenced smallholder sorghum farmers' participation in contract farming at 1%. Households belonging to farmer groups increases the likelihood of participating in sorghum contract farming. Farmers belonging to groups could easily acquire information about innovative farming methods, such as contract farming, compared to their counterparts. Besides, farmer groups act as a channel for distributing new agricultural training programs by government and non-governmental organizations. Thus, farmers in groups understand the benefits of contract farming better than those not in groups. Farmer groups strengthen social networks and social capital. Farmers in groups also have a higher bargaining power and could enter into contracts to negotiate with

contractors on better prices for their produce. Moreover, contracting companies prefer dealing with farmers in groups to individual farmers for easy management and accessibility. Lastly, group membership is a guarantee to contracts for members to comply with the terms of the contract. The results are consistent with the findings of Bezabeh *et al.* (2020), Dagnew *et al.* (2024), Danso-Abbeam *et al.* (2022), Rondhi *et al.* (2020), Pangapanga-Phiri *et al.* (2024), Yakubu *et al.* (2022) established that cooperative membership positively and significantly influence participation in contract farming.

Farmers' residential home location to the nearest extension agent office in walking minutes was significant but negatively associated with contract farming participation. An extra walking minute from the Farmer's homestead to the nearest extension agent office reduces the likelihood of participation in contract farming by 0.1%. Smallholder sorghum farmers residing closer to the extension office are likely to participate in sorghum contract farming than those residing far away. Probably, farmers in the study area were physically seeking agricultural advisory services on contract farming from extension offices close to them. Farmers depend on extension agents for information on new agricultural practices. Furthermore, access to extension services improves farmers' understanding and efficacy, thus increasing their willingness to engage in contractual arrangements. Access to extension services improves farmers' trust and confidence in the contract terms. The farmers near the extension office could acquire information about contracts by seeking technical advisors on the benefits of contract farming compared to their counterparts. Similar results were obtained by Dagnew *et al.* (2024), Marwa and Manda (2022), Mounirou (2020), and Yakubu *et al.* (2022) found a positive association between extension service access and contract participation.

Farmers' residential home location to the nearest main road in walking minutes was significant and positively associated with contract farming participation at a 1% significance level. Additional walking minutes from the farmer's homestead to the main road increases the likelihood of participation in contract farming by 0.2%. Farmers far from the main road had higher chances of participating in contract farming than those near the main road. The results were contrary to the hypothesized sign. Longer distances from the main road motivate farmers to participate in contract farming to reduce the transportation costs of acquiring inputs and accessing the output market. This is plausible because sorghum contractors facilitate farmers by delivering inputs and collecting sorghum produce near farmers' homesteads. The findings disagree with that of Ziyadhume (2020), who found distance to the main road is negatively associated with contract participation.

Furthermore, ownership of bicycles by the farmer was significant and positively associated with sorghum contract farming participation at a 1% level. Bicycle ownership by the farmer increased the likelihood of participation in contract farming by about 21%. Farmers with bicycles are more likely to participate in contract farming than farmers without. Probably, bicycle is used for transportation during planting, weeding, and harvesting. Besides, bicycle farmers could easily monitor their farms far from the homestead. The farmers also use bicycles to transport sorghum to collection centers, increasing their probability of participating in contract farming. Lastly, bicycles enable farmers to access farm inputs and agricultural information. The results obtained are in line with the findings of Abdul-Rahaman and Abdulai (2020) and Maganga (2021), which found out that bicycle ownership positively influences participation in contract farming.

Ownership of oxen by smallholder sorghum farmers has a significant positive influence contract farming participation at a 1% significance level. Oxen ownership increases the likelihood of participating in sorghum contract farming by 24%. Oxen are the main means of land preparation in the study area. For this reason, farmers who own oxen would not need to hire cultivation services from other farmers, thus reducing the cost of land preparation, and can cultivate on time for early planting. These results were in line with studies by Addis and Mengesha, (2020), Aliyi *et al.* (2024), Dagnew *et al.* (2024), Maganga (2021), Okeyo *et al.* (2020), who concluded oxen ownership positively influences the decision to participate in contract farming.

The location of the farmers' homestead positively influenced contract farming participation. Farmers in the North Sakwa Ward were more likely to participate in contract farming than those in the East Yimbo Ward. The reason is that farmers in East Yimbo practiced watermelon production as an alternative enterprise due to their proximity to Lake Victoria.

4.4 Farmers' Preferences for Sorghum Contract Design Attributes in Siaya County, Kenya

Table 4.6 presents conjoint analysis results of how farmers rank attribute levels and how they influence farmers' preferences for sorghum contract design. The estimation results were based on Random Utility theory to interpret the smallholder farmers' preferences for contract farming attributes depending on the sign of the utility estimates. A positive utility sign indicates the farmer prefers the attribute, and a negative utility sign indicates the farmer does not like the attribute.

Table 4.6: Utility estimates of contract attributes by sorghum farmers in Siaya County, Kenya

Attributes	Levels	Utility Estimate	Std. Error	Relative importance (%)
Services offered by the contractor	Financial services	0.54	0.28	
	Input provision	-0.39	0.28	
	Produce market	-0.15	0.28	48.69
Duration of the contract	Per season	-0.13	0.24	
	Yearly	-0.25	0.48	
	More than 1 year	-0.38	0.73	13.23
Price per Kg of sorghum	KES 33	0.21	0.24	
	KES 35	0.43	0.49	
	KES 37	0.64	0.73	22.38
Terms of Payment	Cash at farm gate	0.15	0.24	
	After 14 days	0.30	0.49	
	After 30 days	0.45	0.73	15.70
(Constant)		4.52	0.87	
Pearson's R	=0.80***			
Kendall's tau	= 0.67***			

Note: *** represent significant level at 1%.

The conjoint analysis model was tested for validity to determine whether the model was fit for data analysis. According to Rao (2014), the Pearson's correlation coefficient shows the correlation of observed preference scores versus the conjoint model estimated preference score. On the other hand, Kendall's tau correlation coefficient indicates the discrepancy in the ranks between the predicted and actual profiles. Pearson's R (0.80) and Kendall's tau (0.67) correlation coefficients were significant at 1%. The respective values were high and moderate. This implies that the model's logical judgment was appropriate. The Pearson's and Kendall's tau being significant shows that the model was well fitted to predict the farmers' preferences for different sorghum contract attributes. The result for model fitness was similar to the findings by Mussa *et al.* (2012), Ogola and Ouko (2021).

In Table 4.6, the highest utility value (0.64) was derived from the price per kilogram of sorghum at KES 37, followed by financial services (0.54). Payment after 30 days had a utility of 0.45; the price per Kg at KES 35 was 0.43; payment after 14 days was 0.30; price of 33 per

Kg was 0.21, while cash at the farm gate received the lowest utility of 0.15. The higher the positive utility value of the attribute, the higher the farmer's preference. The results imply that the three priority attributes for farmers were high prices, provision of financial services, and monthly payments for them to join contract farming. The results were supported by the findings of Anh *et al.* (2019) and Ochieng *et al.* (2017).

On the other hand, the three attributes most disliked by farmers were input provision by the contractor, contracts of more than one year, and annual contracts with a negative utility values of (-0.39), (-0.38), and (-0.25), respectively. The other attributes were produce market and contract per season with negative utility values of -0.18 and -0.13, respectively. The results agreed with Arouna *et al.* (2017) and Raimondo *et al.* (2021). The attribute level that receives a negative utility value does not mean that the factor level was unattractive to the farmer but that the attribute levels that received positive utility values were better (Ogola & Ouko, 2021).

In terms of services offered by the contracting company, financial assistance positively influenced participation in contract farming. Financial assistance in terms of loan provision by the contracting company attracts more farmers to contract farming. Smallholder farmers need more access to capital for acquiring farm inputs, cultivation, weeding, and harvesting labor. Financial availability regarding loans from the contracting firm enables them to improve their farming practice. A loan provision is an incentive for acquiring quality inputs to deliver quality produce required by the contracting company. In addition, financial assistance provision by the contracting company enables farmers to obtain inputs and reduce price uncertainty. The provision of financial assistance enables farmers to acquire production inputs on time for timely planting for increased yield. Similar results were reported by Arouna *et al.* (2021), Mishra *et al.* (2022), Ruml *et al.* (2022) and Tuyen *et al.* (2022) which concluded that the provision of finance by contracting firms positively influence the uptake of contract farming by smallholder farmers. Input provision had a negative influence on contract farming participation by smallholder farmers. Farmers who had access to finance from contracting companies had the flexibility to acquire inputs from different sources. The output market had a negative influence on contract farming uptake. Most farmers viewed the sorghum market as being available in the locality preferred financial assistance to solve all of their problems rather than market provision.

Contract duration at all levels was found to influence contract farming uptake negatively. Most farmers do not prefer a contract whose duration is beyond one year. Since sorghum is a seasonal crop, most farmers prefer seasonal contracts. Long term contracts are more suitable for perennial crops such as tea and coffee. Long-term contracts allow the farmers

to cover the costs incurred in the previous season compared to short-term contracts (Bijman *et al.*, 2022).

Price per kilogram of sorghum benefitted the sorghum farmers positively. Farmers were more likely to take sorghum contracts as the price per kilogram increased. This means most farmers prefer contracts with the highest prices per kilogram. When the prices are high, farmers maximize profits and can cover all costs incurred on the farm. These results conform to the findings by Ochieng (2020), Toiba *et al.* (2023), Veldwisch and Woodhouse (2022), which found that price positively influenced the uptake of contract farming.

The payment terms for sorghum contract farming yielded positive utility at all levels. The utility derived doubles as payment duration increases from cash at the farm gate to 14 to 30 days. This means most farmers prefer to join sorghum contracts that offer payments at a later date than an instant payment. Most farmers prefer deferred payment as it allows them to properly plan the best activity to invest in the funds received from the contracted crops. Most smallholder farmers prefer deferred payment to cash at the farm gate as it can be easily used for unintended purposes and in non-profitable activities. The findings were similar to those of Kramer and Kunst (2020), which reported that smallholder farmers prefer deferred payments in contracts over instant payment at the farm gate. This result contradicts those by Ochieng (2020), Pham *et al.* (2021), and Tuyen *et al.* (2022), that revealed that majority of farmers prefer spot payments for meeting daily expenditures.

4.5 Determination of effect of contract farming participation on sorghum productivity of smallholder farmers in Siaya County Kenya

4.5.1 Descriptive results of sorghum productivity on contract farming participation

A t-test result for sorghum productivity (Table 4.7) was significant at a 1% level indicating variation in sorghum productivity between contracted and non-contracted farmers. Contracted farmers reported a higher mean sorghum productivity of 561.14 kg/acre than non-contracted sorghum farmers, with a mean of 237.34 kg/acre. The results revealed that non-contracted farmers were less productive by 323.80 kg/acre.

Table 4.7: Differences in sorghum productivity for contracted and non-contracted smallholder sorghum farmers (continuous variables) in Siaya County, Kenya

	Non-contracted n=135	**contracted n=105**	**Total n=240**	
Variables	**Mean**	**Mean**	**Mean**	**t-value**
Sorghum productivity	237.34	561.14	379	-16.54***

(Kg/Acre)	(161.74)	(134.47)	(220.10)	
Log sorghum productivity	5.22	6.30	5.69	
(Log Kg/Acre)	(0.78)	(0.82)	(0.05)	-13.49***

Note: Figures in parenthesis represent standard deviations, *** represent significant level 1%.

4.5.2 Estimation of effect of contract farming participation on sorghum productivity of smallholder farmers in Siaya County

An endogenous switching regression model was applied to estimate the effect of sorghum contract farming participation on sorghum productivity. Outcome equations for sorghum productivity (kg/acre) for contracted and non-contracted were jointly estimated with the selection equation for the decision to participate in sorghum contract farming. The instrumental variables used were tested for validity to determine their suitability for the model.

A diagnostic test showed that the coefficient of the two instruments' distance to the nearest main road in walking minutes and ownership of a bicycle are jointly insignificant (F2, 116, p-value= 0.99) in the productivity equation for the non-contracted farmers. Both instruments were significant in the participation decision equation. The instruments were suitable for identifying the outcome equation since they did not directly influence sorghum productivity. The Wald test $\left\lfloor \chi^2(16) = 67.04; p \prec 0.00 \right\rfloor$ showed a joint significance of the instruments rejecting the null hypothesis of weak instruments.

Table 4.8 presents results of the Endogenous Switching Regression Model of effect of smallholder sorghum farmers' participation in contract farming on sorghum productivity. The first column, shows the estimations of the selection equation on determinants of participation in sorghum contract farming. Age of the household head, log of sorghum seed planted (Kg/acre), group membership, and distance to the nearest extension agent office in walking minutes positively influenced participation in contract farming. Contrary, the log of sorghum acres planted negatively influenced the decision to participate in contract farming. The last two columns, 2 and 3, present the results for the outcome equations for sorghum productivity for contracted and non-contracted smallholder farmers, respectively. To explicitly identify the model, the instrumental variables in the (participation equation) Probit model (Distance to the nearest main road in walking minutes and bicycle ownership) are excluded from the productivity function. From the diagnostic test, the two variables did not directly influence sorghum productivity.

The age of household head had a significant negative effect on sorghum productivity at 5% for contracted farmers. For non-contracted sorghum farmers, age had a significant positive

effect on sorghum productivity at 10%. An increase in the age of the household head by one year lowers the sorghum productivity of contracted farmers by 0.6 percent and increases that of non-contracted farmers by 0.8 percent. As contracted farmers' age increases they concentrated more on actualizing other parts of the contract that could otherwise attract legal action against them and thus compromising productivity. Non-contracted farmers on the other hand concentrated on producing more leading to the increase in their productivity. This result agrees with the finding of Deng *et al.* (2020), Dubbert (2019), who found an inverse relationship between age and productivity.

Access to off-farm income was found to significantly and negatively influence the sorghum productivity of contracted farmers at 5%. This finding could be attributed to households with off-farm income spending more time working on other income generating activities and less time on sorghum. This leads to poor management of sorghum crops, resulting in low productivity. Engagement in off-farm income-generating activity reduces the labor force for agricultural activities, resulting in low farm productivity. The result corroborates with that of Almeida and Bravo-Ureta (2019), Kinuthia *et al.* (2019) revealing that off-farm income had an inverse relationship with agricultural productivity.

Table 4.8: Full information maximum likelihood estimation for endogenous switching regression for sorghum contract participation

		Endogenous switching regression	
Dependent variables	**Selection equation**	**Contracted=1 log sorghum productivity per acre**	**Non-contracted=0 log sorghum productivity per acre**
Primary (Base No formal education)	-0.065	-0.141	-0.113
	(0.209)	(0.148)	(0.197)
Post-Primary (Base No formal education)	-0.232	-0.130	-0.263
	(0.261)	(0.153)	(0.243)
Gender of the household head (0=Female 1=Male)	0.114	0.092	0.072
	(0.139)	(0.069)	(0.135)
Age of the household head (Years)	0.009**	-0.006**	0.008*
	(0.004)	(0.002)	(0.004)
Number of active household members (Numbers)	-0.020	-0.010	-0.032
	(0.039)	(0.011)	(0.037)

Log land acres owned	-0.119	-0.088	-0.136
	(0.137)	(0.064)	(0.129)
Off-farm income (0=No 1=Yes)	0.163	-0.121**	0.142
	(0.165)	(0.056)	(0.155)
Sorghum intercrop (0= No 1=Yes)	0.218	-0.070	0.274*
	(0.147)	(0.114)	(0.148)
Log sorghum seed used (Kg/acre)	0.372***	0.042	0.372***
	(0.111)	(0.069)	(0.104)
Log Sorghum acres Planted	-0.754***	-0.443***	-0.783***
	(0.246)	(0.115)	(0.229)
Group Membership (0= No	0.454***	-0.172**	0.418***
1=Yes)	(0.128)	(0.071)	(0.122)
Distance to the nearest main road	0.000	0.001*	0.002***
in walking minutes	(0.002)	(0.000)	(0.001)
Distance to the nearest extension	0.002***	-0.001*	0.001
agent office in walking minutes	(0.001)	(0.000)	(0.001)
Distance to the nearest input	0.001		
market in walking minutes	(0.001)		
Bicycle Ownership (0= No 1=Yes)	-0.008		
	(0.135)		
Oxen Ownership (0= No 1=Yes)	0.028	-0.121	-0.011
	(0.257)	(0.075)	(0.241)
Farm Store Ownership (0= No	-0.074	-0.030	-0.088
1=Yes)	(0.172)	(0.059)	(0.156)
Livestock (TLU)	-0.003	0.008	-0.003
	(0.016)	(0.008)	(0.015)
Constant	4.161***	7.459***	4.248***
	(0.464)	(0.282)	(0.439)
σ		-1.228***	0.077
		(0.113)	(0.000)
ρ		-1.584***	0.328
		(0.504)	(0.292)
LR Test for independence. Eqtns: Rho 1= rho 0 Chi2=8.70 Prob >chi2=0.992***			

Log quantity of sorghum seed (Kg/Acre) increases sorghum productivity for non-contracted sorghum farmers. Intercropping sorghum with legumes was found to influence sorghum productivity positively. Sorghum intercrop with legumes increased sorghum productivity for non-contracted farmers. Intercropping with legumes fixes nitrogen in the soil thus increasing sorghum productivity. The findings were similar to Feng *et al.* (2021), Li *et al.* (2021), Raza *et al.* (2023), who concluded that intercropping crop with legume increases grain crop productivity. However, contracted farmers have access to certified seed from EABL and use the recommended seed rate thus achieving high productivity.

Log acres of land planted with sorghum lowers sorghum productivity for both contracted and non-contracted farmers. This implies sorghum productivity declines as acreage of land size planted increases. An increase in farm size is attributed to more input use such as labor and management, which is a constraint to smallholder farmers. This negative association between farm size and sorghum productivity affirms the findings of Abdulrahman *et al.* (2018), Daudi and Omatayo (2018), Okeyo *et al.* (2020), asserted smaller farms are more productive than larger farms.

Membership to a farmer group was found to lower the sorghum productivity of contracted sorghum farmers and increase that of non-contracted farmers. Contracted farmers formed groups with different objectives other than productivity enhancement while the main objective non-contracted farmers is to increase sorghum productivity. Membership to farmer groups by non-contracted farmers can ease access to sorghum inputs, technical assistance, and training on new farming methods which are reflected in enhanced productivity compared to their counterparts. These findings are supported by the results of Abdul-Rahama *et al.* (2020), Deng *et al.* (2020), Lin *et al.* (2022) that membership to farmer groups directly influences farm productivity.

Distance in walking minutes to the nearest extension agent office increases sorghum productivity for both contracted and non-contracted farmers. Farmers located near the extension agent office experience higher sorghum productivity than those far away. Farmers located near the extension agent office could easily acquire information on new production technologies to improve their productivity. These results conformed to the findings of Marwa and Manda (2022), Marwa *et al.* (2019) found a positive relationship between productivity and access to extension services.

An extra walking minutes to the nearest input market lowers sorghum productivity for contracted sorghum farmers. As the distance to the EABL input depots increases, contracted farmers are not likely to acquire quality inputs such as certified seed on time, thus lowering

their productivity. Mujeyi *et al.* (2021) supported the results, by reporting that distance to the input market negatively influences crop productivity.

The lower of Table 4.8 indicates the estimations for correlation coefficient (σ & ρ) of covariance terms of the error term of the selection and outcome equation. The negative sign of ρ indicates the presence of selection bias, thus, farmers with above average sorghum productivity are more likely to engage in contract farming. The result implies that unobservable characteristics that affect farmers' decision to engage in sorghum contract farming influenced sorghum productivity. Therefore, the decision to participate in sorghum contract farming may not have a similar effect on sorghum productivity in non-contracted farmers if they decide to participate in sorghum contract farming.

Table 4.9 presents the ESR model results on impact of contract farming, which shows the log sorghum productivity in kilograms per acre for both actual and counterfactual scenarios. On each outcome variable in the first two rows, the diagonal elements (a) and (d) denote the decision stage, signifying the actual outcome, while (b) and (c) denote the counterfactual outcome. The impact is got by the actual and the counterfactual outcome differences. The average treatment effect on the treated (ATT) is the difference between (a) and (b), while the average effect on the untreated is given by the difference between (c) and (d). The heterogeneity effect is presented for contracted and non-contracted to show the effect of contract farming on sorghum productivity.

Table 4.9: Conditional expectations, treatment, and heterogeneity effects

	Decision Stage		
Treatment effects	**Contracted**	**Non-contracted**	**ATE**
Contracted	(a) 6.29	(b) 5.25	**ATT**=1.04***
	(0.02)	(0.04)	(0.04)
Non-contracted	(c) 6.38	(d) 5.22	**ATU**=1.16***
	(0.02)	(0.04)	(0.04)
Heterogeneity effects	**B1**= -0.09	**B2**=0.03	**TH**=-0.12
	(0.03)	(0.04)	(0.06)

Note: *, **, *** represent significant level at 10%, 5% and 1% respectively. Standard errors in parentheses

From Table 4.9, the observed sorghum productivity for contracted and non-contracted sorghum farmers is 6.29 and 5.22, respectively. The contrast of the actual outcome for sorghum productivity for contracted and non-contracted farmers showed that contracted farmers would

realize 107 per cent more productivity than non-contracted farmers (a) minus (d). The two groups have unobservable heterogeneity between them. Thus, this comparison will be inaccurate. Comparison between (a) and (b) spectacles shows that smallholder sorghum farmers would have substantially lower counterfactual sorghum productivity had they not participated in contract farming. Eventually, the treatment (Contract participation) increased sorghum productivity by 104 percent. On the contrary, non-contracted sorghum farmers would have increased the expected sorghum productivity by 116 percent if they had participated in contract farming.

However, the last row of Table 4.9 presents potential heterogeneity effects between contracted and non-contracted sorghum farmers. If non-contracted sorghum farmers had decided to participate in contract farming, they would be anticipated to have realized more sorghum productivity per acre by 9 percent than currently contracted sorghum farmers. This implies that non-contracted smallholder sorghum farmers would have been better off in contract than current farmers. To realize high sorghum productivity, non-contracted sorghum farmers should join contract farming. The second column indicates that if contracted sorghum farmers decided not to engage in contract farming, they would be anticipated to realize higher sorghum productivity per acre by 3 percent than non-contracted sorghum farmers.

A transitional heterogeneity of -0.12 indicates less impact of contract farming on the sorghum productivity of the current participants. The result reveals that the effect of contract farming on sorghum productivity would have been higher if the non-participants had been allowed to participate. These findings showed that those who participated self-select into the contract based on their advantages over the non-participants based on unobservable heterogeneity within them. These results agree with the conclusions from Marwa and Manda (2022), who found that contract farming had a lesser impact on the current participants' productivity.

Therefore, the study concludes that participation in sorghum contract farming increases smallholder farmers' sorghum productivity. One of the possible reasons why contracted sorghum farmers had a higher sorghum productivity can be attributed to the use of certified seeds and technical assistance in terms of training they received from the EABL. In addition, the EABL delivered timely inputs to contracted farmers for timely planting, which is essential for optimizing favorable weather-related conditions for crop growth. Participation in contract farming enables farmers to acquire new technologies and better inputs provided by the contracting company that improve crop productivity. The contracting firm also provides a description of the standards to be monitored by contracted farmers, and to accomplish quality

standards for the produce, the farmers are guided to use quality inputs such as quality seeds that improve production efficiencies. Also, contracted farmers receive financial assistance such as loans from financial institutions, governments, and NGOs that boost their production proficiencies. These results are consistent with previous studies by Bidzakin *et al.* (2019), Danso-Abbeam *et al.* (2022), Durbbet (2019), Gebiso *et al.* (2023), Nazifi *et al.* (2021), Mabe *et al.* (2019), Marwa and Manda (2022), Obi-Egbedi *et al.* (2022), Pangapanga-Phiri *et al.* (2024), concluded that participation in contract farming significantly increases productivity.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter has four sections namely introduction, conclusions, recommendations and areas of further research. The introduction presents an overview of the chapter contents. Conclusions of the study are presented in section 5.2 and are based on specific objectives. Conclusions provide precise answers to research questions. Section 5.3 presents policy recommendations that are based on specific objectives findings. The last section 5.4 presents areas of further research that are based on gaps identified during the research which were out of the study's scope.

5.2 Conclusions

The general objective of this study was to determine the effect of contract participation on smallholder farmers' welfare. The specific objectives of this study were to determine factors influencing participation in sorghum contract farming, to determine smallholder farmers' preferences for sorghum contract design attributes, and to determine the effect of contract farming participation on smallholder farmers' sorghum productivity. Data was collected using a semi-structured pretested questionnaire to achieve these objectives. A logistic regression model was applied to determine factors influencing smallholder farmers' decision participation in sorghum contract farming, and conjoint analysis was used to assess smallholder farmers' preference for attributes designed for sorghum contracts. Moreover, an endogenous switching regression model was used to estimate the effect of contract farming participation to account for unobservable factors that influence smallholder farmers' sorghum productivity. Conclusions were drawn from the study results as per the objectives as follows.

i. The first objective was to determine factors influencing smallholder farmers' decision to participate in sorghum contract farming; the study concludes farm household age, gender, literacy level, active household members number, membership to farmer group, distance to main road, oxen and bicycle ownership by the farmer positively influenced decision to participate in sorghum contract farming. In contrast, distance to the extension agent office negatively impacted participation in sorghum contract farming. The results show the importance of information access and asset ownership motivates smallholder farmers to participate in contract farming. Contract farming is labor-intensive and requires more family labor to reduce labor costs.

ii. In terms of smallholder farmers' preferences for sorghum contract designed attributes, the study concluded with the provision of financial services. High prices per kilogram of sorghum and payments at later dates are the most attractive attributes influencing smallholder farmers to participate in sorghum contract farming. On the other hand, contract attributes such as input provision, produce market, and contract duration negatively influence smallholder farmers' participation in sorghum contract farming. The study concluded that smallholder farmers should increase the participation rate in contract farming, contract firms should provide financial assistance, and higher flexible prices should be paid to farmers later.

iii. Furthermore, the findings on the effect of contracting farming participation designate that both contracted and non-contracted smallholder farmers would achieve more sorghum productivity had both decided to participate in contract farming than they would have if they had not participated. A comparison between the two groups of farmers indicated that non-contracted smallholder farm households would attain more sorghum productivity than contracted farmers' had they both decided to participate in sorghum contract farming. If both groups chose not to participate in sorghum contract farming, contracted farmers would attain more sorghum productivity than non-contracted farmers. This confirms the presence of unobservable heterogeneity characteristics, such as ability and skills, between the two groups of farmers. Thus, the study concludes that contract farming participation increases the sorghum productivity of smallholder farmers.

5.3 Recommendations

The policy recommendations were based on the study's findings for implementation by various stakeholders. These recommendations would provide a framework for improving the participation of smallholder farmers in contract farming and increasing their productivity in the study area and other areas. The following are the recommendations based on the study results:

i. Contracting firms should consider age, gender, education level, and household labor availability while recruiting farmers into contract farming schemes. Firms should consider giving equal opportunities for both males and females to participate in contract farming. Contracting companies should consider recruiting more youths to create self-employment and provide labor to contracting crops. Assessments are to be done by contracting firms to consider literate farmers who are registered in contract farming to facilitate the success of most contracts.

ii. Furthermore, Membership in the farm group, distance to the nearest extension agent office, and main road significantly influenced contract farming participation. The results support the importance of investing more county and national government funds in local infrastructures such as roads, employing more extension officers, and strengthening farmer groups to easily disseminate information on new agricultural innovations and technologies to farmers.

iii. Smallholder farmers are to be given financial credits at lower rates by financial institutions and contracting firms to acquire necessary agricultural assets, transport facilities, and quality agricultural inputs to increase crop productivity. Contracting firms consider various attributes of contract farming, such as price, services provided, and payment terms, while designing contracts for various crops. Firms should consider offering flexible higher prices on the produce than the spot market price for the contract to attract more farmers. Lastly, smallholder farmers are sensitized by both private and public extension officers to embrace contract farming to increase crop productivity.

5.4 Further Research

i. This study focuses on the factors influencing participation in contract farming by smallholder sorghum farmers in Siaya County. Other studies can be done to determine the extent of the participation in sorghum contract farming in other parts of the country.

ii. The study used conjoint analysis to determine the preferences of smallholder sorghum farmers on sorghum contract designs. Other studies can be conducted using various methods, such as multinomial and mixed Logit, to exploit different contract designs more.

iii. The study analyzes the effect of contract farming on smallholder sorghum productivity in Siaya County. Other studies can be conducted to determine the impact of sorghum contract farming on smallholder sorghum farmers' income.

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APPENDICES

Appendix A: Household Questionnaire

Introduction

My name is Reinhard Bonnke Onyango, an agricultural economics masters' student from Egerton University, studying the analysis of smallholder farmers' preferences to contract design attributes and the effect of contract farming on sorghum productivity in Siaya county. As part of the research work, it is essential to carry out a questionnaire survey. At this moment, I solicit your kind support in this regard, as your opinion on the information supplied below is crucial to the quality of this research and the validity of the outcome. The information you will give will be kept confidential for the research purpose only. Your cooperation will be highly appreciated.

Are you willing to take the survey?

1=Yes 0=No

BASIC INFORMATION

Date of interview	
Name of enumerator	
Name of the respondent	
Respondent Id	
Location	
Sub-location	
Village	
Phone number	
If a farmer is Contracted by EABL Company? 1=yes 2=no	

1.0 FARMERS DEMOGRAPHIC CHARACTERISTICS

Household size	Household member roster	Age	Gender 1=male 2=female	Relation to household head	Marital Status	Highest Education level attained	Main occupation	Secondary occupation other than main	Number of years of experience in farming	Did the member receive income from business/ casual employment? 1=yes 2=no	Did member receive income from salaries employment, pension, remittance, or

											pension? 1=yes 2=no
Hhsiz	**Name**	**Age**	**Gend**	**Rlship**	**Mstatu**	**Educ leve**	**prioc cup**	**Secoc cup**	**Farm exp**	**non-farm**	**Salary**

Occupation: 0=none 1=agriculture 2=permanent employment 3=self-employment 4=temporary employment (casual) 5=business 6=others specify
Marital status: 1=single 2=married 4=divorced 5=widowed 6=others specified
Education level: 1=no formal education 2=primary 4=secondary 5= tertiary college 6=university
Relation to the head: 1= head 2=spouse 3=own child 4=parent 5=brother/sister 6=grandchild 7=employee 8=others specified

2.0 LAND OWNERSHIP BY THE HOUSEHOLD

Acres of land owned by the household	Type of land ownership 1=owned with tittle deed 2=owned without tittle deed 3=owned by parents/relative 4=rented 5=borrowed/share cropping 6=others specified	Acres of land under farming activity	Did you rent any land in 2020 for agricultural use? If yes how many acres?	What is the cost spend on rented land in per year	The person with authority to make decision on land use. 1= head 2=spouse 3= jointly with spouse 4= other family member 5= jointly as a family
Acresown	**Parownshp**	**Acrefarm**	**noparcl**	**parcnam**	**Pardecuse**

3.0 (a) SORGHUM CROPPING FOR THE YEAR 2020

Acres planted with sorghum(**if intercrop indicate other crops in the same field**	Plough means 1=tractor 2= burning 3=oxen 4=min tillage 5=chemical	Seed type 1=certified 2=local variety 3=recycled 4=certified & recycled	seed Variety	Seed quantity used in (Kgs)	Total cost of sorghum used	Main Seed source	Fertilizer Quantity used in Kgs	costs incurred in sorghum field 1.Plough 2.Planting 3.Weeding 4.Harvesting	Innovative practices used during sorghum production	Quantity harvest in kgs	Did you incur any loss on sorghum? 1=yes 2=no If yes what is the Cause

with sorghum)		5=certified & local 6=other specify						5.other costs			of loss
Fildacre	**Ploghmen**	**Sedtyp**	**Sedvaty**	**Sedqty**	**Tsedcos**	**Sedsorce**	**fertqty**	**Tcos**		**qtyharv**	**Lostyp**

Sorghum variety: 1=local variety 2= serena 3=gadama 4=sweet sorghum 5=kari 6=sila 7=seredo 8= karim kama 1 9=karim kama 2
Fertilizer: 1=DAP 2=NPK 3=CAN 4=Mavuno 5= Baraka 6=manure 7=compost 8=UREA
Seed source:1=agrovet 2= own seed 3=other farmers 4=local market 5=farm group 6= EABL company 7= NGO 8= research institution 9=others specified
Loss cause: 1=drought 2=livestock 3=pests 4=diseases 5=too much rain 6=locust 7=birds 8=hailstones 9=others specify
Sorghum innovative practices: 1=seed selection 2=thinning 3=hormones for growth 4=postharvest handling 5=striga weed management through intercropping 6=push-pull technology 6=dough stage harvesting to manage birds 7=sorghum solar drier 8=sorghum thresher 9=community production & marketing system 10= use of bio-pesticides

3 (B) SORGHUM SALES FOR THE YEAR 2020

Quantity of sorghum harvested in kgs	Quantity of sorghum sold in kgs	Price received per kg	Main buyer of sorghum	Any value addition before selling	Quantity of sorghum currently in stock
Qtysorghav	**Qntysold**	**Tsorghsales**	**Mainbuyer**	**Valuadsorghm**	**Qntystock**

Main buyer: 1=broker/middlemen 2=EABL 3=institution (school, church, college) 3=direct consumer 4= local market 3=small traders
Value addition: 1=sorting 2=cleaaning3=storage 4=packaging 5=drying 6=winnowing 7=others specify

4.0 CREDIT SERVICES ACCESS

Did your household received credit for the last one year? 0=yes 1=no	If yes state Credit type 1= in kind 2= cash	If **yes** from which source did you receive credit?	Main use of credit	Amount borrowed	Amount refunded	Repayment period in months	Did you provide collateral? 1=yes 0=no	Collateral type

Credtaces	Credtyp	Credsorce	Credusse	Credamot	credrefund	Credpayperiod	Collat	Colatype

Credit source: 1=EABL Company 2= SACCO 3=Bank 4=agro-dealers 5=self-help groups 6=banks 7=relatives/friends 8= mobile money 9=farm group 10=women group 11=uwezo fund 12=others specify
Main credit purpose: 1=purchase inputs for crop production 2=purchase livestock inputs 3=invests in off-farm business 4=domestic used 5= others specify
Collateral:1=log book 2=title deed 3=group membership 4=product delivery 5= crop 6=pay slip 7=asset 8=guarantor 9=others specify

5.0 GROUP MEMBERSHIP

Do any of the household member belong to any group? 0=no 1=yes	If yes how many groups do you belong in?	Select the groups you are in?	What are the benefits you obtained from the group?
Gropmembshp	**goupno.**	**groutyp**	**gropbenfts**

Groups membership: 1=producer group 2= marketing group 3=credits and savings group 4=women group 5=community based 6=youth group
7= farmers group 8= welfare 9= others specified
Group benefits: 1=credit/loans 2=agricultural trainings 3=saving in the group 4=input provision 5=output market 6=high prices of output 7=others specified

6.0 EXTERNSION SERVICES

Did you receive training/extension service for the last one year? 0=no 1=yes	If yes who is the main provider of training/ extension service?	Through which Channel did you received training / extension service?	Training/extension on which value chain? 1= crop 2=livestock	How many times did you receive training for the past one year from the provider?	Level of satisfaction with the training received? 1=very satisfied 2= moderately satisfied 3=satisfied 4=dissatisfied 5=very dissatisfied	What is the distance to the where you received training in Km?	What is the distance to where you received training in walking minutes?
Exntserv	Exntprovid	Exntchan	Exntcrop	Exntime	Exntsatif	exntdistkm	Exntdistmin

Training source: 1= government extension 2=NGOs 3=research organization 4= Farm groups 5=Agro-dealers 6=Lead farmers 7=input dealer 8=KCSCAP
Channel of training: 1=field days 2=demonstrations 3=seminars 4= group meeting 5=farm visit 6=mobile phone 7=radio/television 8=shows/exhibitions 9= others specified

7.0 MARKET INFORMATION

Did you receive market information in the past one year on sorghum sales? 1=yes 0=no	Where did you obtain the information?	Did you use the information? 1=yes 0=no	What was your level of satisfaction with the information? 1=very satisfied 2= moderately satisfied 3=satisfied 4= dissatisfied 5= very dissatisfied
Maketinform	**Inforsorce**	**Inforuse**	**Informsatf**
Source of market information: 1=field days 2=demonstrations 3=seminars 4= group meeting 5=farm visit 6=mobile phone 7=radio/television 8=shows/exhibitions 9= EABL agent 10= others specified			

8.0 GEOGRAPHICAL LOCATION OF THE FARMER

Facility	**Distance in KM**	**Distance in walking minutes**	**Distance in motorbike if not in walking.**
Crop market			
Mar rum road			
Tarmac road			
Local administration			
EABL agent			
Input market			
Agricultural extension officer			

9.0 OFF-FARM INCOME OF THEHOUSEHOLD

Income source	**Earning per month in KES**	**Earning per year in KES**
Salary		
Business		
Machinery		
Pension scheme		
Rental /Leasing		
Family Remittance		
Others specify		

10.0. FARM ASSETS ENDOWMENT OF THE HOUSEHOLD

10 (a) .How many of the following movable assets do you own for use in the farm?

Asset owned	**Number**
Animal plough	
Tractor	
Oxen	
Farm store	
Hand cart	
Jembe/hoes	
Panga	

Wheelbarrow	
Bicycle/motorcycle	
Car/van/ lorry	
Others specify	

10 (b).Do you own some of the following animals in your farm?

Animal type	Total Number
Cattles	
Donkey	
Goats	
Sheep	
Poultry	
Pigs	
Rabbits	
Chicken	
Others specified	

11.0 FARMERS PREFERENCES FOR SORGHUM CONTRACT ATTRIBUTESS11.0 FARMERS' PREFERENCES FOR SORGHUM CONTRACT ATTRIBUTES-

The farmer to rank the profiles from 1most preferred to 9 least preferred profile. Enumerator was to explain to the farmer the four attributes services offered in the contract, terms of payment, contract duration and the price offered per kilogram of sorghum harvested. The enumerator also have to informed the famers to rate in case they are faced with hypothetical contract profile and assured the farmer that all the situations are hypothetical not reality but find the choice in case faced with the real situation.

11.Conjoint Plan

Profiles	**Services Provided**	**Contract Duration**	**Price per kg of Sorghum**	**Terms of Payment**	**Rank the all cards from 1(Most Preferred) to 9 least preferred**
1	Financial services	More than 1 year	37	After 30 days	
2	Produce market	Yearly	33	After 30 days	
3	Input provision	Yearly	37	Cash at farm gate	
4	Financial services	Per season	33	Cash at farm gate	
5	Input provision	More than 1 year	33	After 14 days	
6	Financial services	Yearly	35	After 14 days	
7	Produce market	Per season	37	After 14 days	
8	Produce market	More than 1 year	35	Cash at farm gate	
9	Input provision	Per season	35	After 30 days	

Thank you for your time and participation

Appendix B: Ethical Clearance

EGERTON UNIVERSITY

TEL: (051) 2217808
FAX: 051-2217942

P. O. BOX 536
EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DVC/009
Approval No. EUISERC/APP/208/2022 ***19th December, 2022***

Reinhard Bonnke Onyango
P.O. Box 9-40109,
Sondu,
Kenya
Telephone: +254728806568
E-mail: rbonnke90@gmail.com

Dear Reinhard,

RE: ETHICAL APPROVAL: ANALYSIS OF SMALLHOLDER FARMERS' PREFERENCES TO CONTRACT DESIGN ATTRIBUTES AND IT'S EFFECT ON SORGHUM PRODUCTIVITY IN SIAYA COUNTY, KENYA

This is to inform you that ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/208/2022***. The approval period is ***19th December, 2022 –20th December, 2023***.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.
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 ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be

reported to *Egerton University Institutional Scientific and Ethics Review Committee* within 72 hours.

v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to *Egerton University Institutional Scientific and Ethics Review Committee*.

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

Yours sincerely.

Prof. R. Ngure

CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE

RMN/BK/

Appendix C: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 697736

Date of Issue: 04/January/2023

RESEARCH LICENSE

This is to Certify that Mr.. Reinhard Bonnke Onyango of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Siaya on the topic: ANALYSIS OF SMALLHOLDER FARMERS' PREFERENCES TO CONTRACT DESIGN ATTRIBUTES AND IT'S EFFECT ON SORGHUM PRODUCTIVITY IN SIAYA COUNTY, KENYA for the period ending : 04/January/2024.

License No: NACOSTI/P/23/22903

697736

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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See overleaf for conditions

Appendix D: Contingency Coefficient Test

```
corr EducLevel HHDGender GroupMembership FarmStoreOnership BicycleOwnership
OxenOwnership
(obs=240)
             | EducLe~l HHDGen~r GroupM~p FarmSt~p Bicycl~p OxenOw~p
-------------+------------------------------------------------------
   EducLevel |   1.0000
   HHDGender |   0.3524   1.0000
GroupMembe~p |   0.1271   0.0517   1.0000
FarmStoreO~p |   0.1552   0.0899   0.3701   1.0000
BicycleOwn~p |   0.1042   0.1999   0.0318   0.1050   1.0000
OxenOwners~p |   0.1382   0.0529   0.2103   0.2678   0.1848   1.0000
```

Appendix E: Heteroscedasticity Tests

```
 estat imtest, white
White's test
H0: Homoskedasticity
Ha: Unrestricted heteroskedasticity
   chi2(54) = 89.34
Prob > chi2 = 0.0018
Cameron & Trivedi's decomposition of IM-test
---------------------------------------------------
              Source |       chi2     df         p
---------------------+-----------------------------
  Heteroskedasticity |      89.34     54    0.0018
            Skewness |      35.20      9    0.0001
            Kurtosis |      50.07      1    0.0000
---------------------+-----------------------------
               Total |     174.61     64    0.0000
```

Appendix F: Logistics Regression on Factors Influencing Participation in Contract Farming

```
.logit ContractPart i.EducLevel HHDGender HHDAge HH15to64 HHAgelessa15greater64 lnLandAcres
lnOffarmIncome     GroupMembership     DistAgricExtMin     DistMainRoadMin     DistInputmktMin
FarmStoreOnership BicycleOwnership OxenOwner> ship LivestockTLU i.NameofWard
Iteration 0:   log likelihood = -164.47541
Iteration 1:   log likelihood = -112.81631
Iteration 2:   log likelihood = -111.13452
Iteration 3:   log likelihood = -111.11539
Iteration 4:   log likelihood = -111.11538
Logistic regression                                     Number of obs =    240
                                                        LR chi2(18)   = 106.72
                                                        Prob > chi2   = 0.0000
```

```
Log likelihood = -111.11538                              Pseudo R2     = 0.3244
------------------------------------------------------------------------------
         ContractPart | Coefficient Std. err.      z    P>|z|     [95% conf. interval]
----------------------+-------------------------------------------------------
            EducLevel |
              Primary |    1.52667   .8449619     1.81   0.071    -.1294254    3.182764
         Post-Primary |   .8594593   .8835163     0.97   0.331    -.8722007    2.591119
            HHDGender |   .9433121    .431448     2.19   0.029     .0976895    1.788935
              HHDAge |   .0353291   .0140044     2.52   0.012     .0078811    .0627772
             HH15to64 |   .2057183   .0957337     2.15   0.032     .0180837     .393353
HHAgelessa15greater64 |   .0597182   .0986404     0.61   0.545    -.1336133    .2530498
           lnLandAcres |   .0071877   .3776349     0.02   0.985    -.7329632    .7473385
       lnOffarmIncome |   .0382046   .0353632     1.08   0.280    -.0311059    .1075152
      GroupMembership |   1.229894   .4097093     3.00   0.003      .426879     2.03291
      DistAgricExtMin |  -.0040556   .0025376    -1.60   0.110    -.0090292    .0009179
      DistMainRoadMin |   .0161359   .0059604     2.71   0.007     .0044538    .0278181
      DistInputmktMin |   .0017364   .0025433     0.68   0.495    -.0032484    .0067211
    FarmStoreOnership |   .5985642   .3960398     1.51   0.131    -.1776596    1.374788
     BicycleOwnership |     1.3746   .3839421     3.58   0.000     .6220869    2.127112
        OxenOwnership |   1.553852   .5454148     2.85   0.004     .4848584    2.622845
         LivestockTLU |  -.0518492   .0485435    -1.07   0.285    -.1469926    .0432942
           NameofWard |
         North Sakwa  |     1.7877   .5253934     3.40   0.001     .7579478    2.817452
          West Sakwa  |    .388578   .4585308     0.85   0.397    -.5101258    1.287282
                _cons |  -7.263279   1.441285    -5.04   0.000    -10.08815   -4.438412
------------------------------------------------------------------------------
```

Appendix G: Estimations of Marginal Effect of Factors Influencing Participation in Contract Farming

```
margins, dydx (i.EducLevel HHDGender HHDAge HH15to64 HHAgelessa15greater64 lnLandAcres
lnOffarmIncome
GroupMembership DistAgricExtMin DistMainRoadMin DistInputmktMin FarmStoreOnership
BicycleOwnership
OxenOwnership LivestockTLU i.NameofWard)
Average marginal effects                                    Number of obs = 240
Model VCE: OIM
Expression: Pr(ContractPart), predict()
dy/dx wrt:  2.EducLevel 3.EducLevel HHDGender HHDAge HH15to64 HHAgelessa15greater64 lnLandAcres
            lnOffarmIncome GroupMembership DistAgricExtMin DistMainRoadMin DistInputmktMin
            FarmStoreOnership BicycleOwnership OxenOwnership LivestockTLU 2.NameofWard
------------------------------------------------------------------------------
                     |            Delta-method
                     |      dy/dx   std. err.      z    P>|z|     [95% conf. interval]
---------------------+--------------------------------------------------------
            EducLevel |
              Primary |   .2153596   .1031256     2.09   0.037     .0132371     .417482
```

```
        Post-Primary  |   .1150533   .1110883     1.04   0.300    -.1026757    .3327822
            HHDGender |   .1441973   .0636033     2.27   0.023     .0195372    .2688574
              HHDAge |   .0054005   .0020397     2.65   0.008     .0014028    .0093982
             HH15to64 |   .0314467   .0141243     2.23   0.026     .0037636    .0591298
HHAgelessa15greater64 |   .0091287   .0150425     0.61   0.544     -.020354    .0386114
          lnLandAcres |   .0010987   .0577249     0.02   0.985    -.1120401    .1142375
       lnOffarmIncome |   .0058401   .0053605     1.09   0.276    -.0046664    .0163465
      GroupMembership |    .188005   .0583623     3.22   0.001      .073617     .302393
      DistAgricExtMin |    -.00062   .0003818    -1.62   0.104    -.0013684    .0001284
      DistMainRoadMin |   .0024666   .0008605     2.87   0.004       .00078    .0041532
      DistInputmktMin |   .0002654   .0003876     0.68   0.494    -.0004943    .0010252
    FarmStoreOnership |   .0914982   .0595521     1.54   0.124    -.0252219    .2082182
     BicycleOwnership |    .210125   .0526908     3.99   0.000     .1068529    .3133971
        OxenOwnership |    .237526   .0780716     3.04   0.002     .0845085    .3905435
         LivestockTLU |  -.0079258   .0073549    -1.08   0.281    -.0223412    .0064895
           NameofWard |
         North Sakwa  |    .273859   .0718298     3.81   0.000     .1330752    .4146428
          West Sakwa  |   .0595707    .070405     0.85   0.397    -.0784205     .197562
------------------------------------------------------------------------------------------

Note: dy/dx for factor levels is the discrete change from the base level.
```

Appendix H: Output on Test for Admissibility of The Instruments (ESR)

```
.reg lnSorghumProductivity i.EducLevel HHDGender HHDAge HH15to64 lnLandAcres
OffarmincomeReceived SorgIntercrop LogSorghumSeedkgs_PerAcre LogSorghumACRES
GroupMembership DistMainRoadMin DistAgricExtMin DistInputmktM in
BicycleOwnership OxenOwnership FarmStoreOnership LivestockTLU if ContractPart==0
      Source |       SS           df       MS      Number of obs   =       135
-------------+----------------------------------   F(18, 116)      =      3.49
       Model |  28.7607192        18  1.59781773   Prob > F        =    0.0000
    Residual |  53.0357294       116  .457204564   R-squared       =    0.3516
-------------+----------------------------------   Adj R-squared   =    0.2510
       Total |  81.7964486       134  .610421258   Root MSE        =    .67617
------------------------------------------------------------------------------
    lnSorghumProductivity | Coefficient Std. err.      t    P>|t|     [95% conf. interval]
--------------------------+---------------------------------------------------------------
                EducLevel |
                  Primary  |  -.0651094   .2090735    -0.31   0.756    -.4792058     .348987
            Post-Primary  |  -.2320673   .2606103    -0.89   0.375    -.7482389    .2841043
                HHDGender |    .113606   .1393769     0.82   0.417    -.1624475    .3896595
                  HHDAge |   .0090948   .0043923     2.07   0.041     .0003953    .0177943
                 HH15to64 | -.0203144   .0386633    -0.53   0.600     -.096892    .0562632
               lnLandAcres | -.1193959   .1369295    -0.87   0.385    -.3906022    .1518103
     OffarmincomeReceived |   .1627094   .1646294     0.99   0.325    -.1633599    .4887787
            SorgIntercrop |   .2180827   .1471211     1.48   0.141    -.0733092    .5094746
LogSorghumSeedkgs_PerAcre |   .3722991   .1109985     3.35   0.001     .1524527    .5921456
          LogSorghumACRES | -.7542653   .2458667    -3.07   0.003    -1.241235   -.2672952
```

```
          GroupMembership |    .453646   .1282418     3.54   0.001     .1996469     .707645
          DistMainRoadMin |   .0002033    .002193     0.09   0.926    -.0041402    .0045468
          DistAgricExtMin |   .0016494   .0006891     2.39   0.018     .0002846    .0030142
          DistInputmktMin |   .0012768   .0008485     1.50   0.135    -.0004038    .0029575
         BicycleOwnership | -.0076048   .1351422    -0.06   0.955     -.275271    .2600614
            OxenOwnership |    .027707    .257403     0.11   0.914     -.482112    .5375261
        FarmStoreOnership | -.0738015   .1719384    -0.43   0.669    -.4143472    .2667441
             LivestockTLU |    -.00322   .0159187    -0.20   0.840     -.034749    .0283089
                    _cons |   4.160932   .4644572     8.96   0.000     3.241016    5.080848
------------------------------------------------------------------------------

. testparm DistMainRoadMin BicycleOwnership
 ( 1)  DistMainRoadMin = 0
 ( 2)  BicycleOwnership = 0
       F(  2,   116) =    0.01
            Prob > F =    0.9923
```

Appendix I: FIML Endogenous Switching Regression Estimations Output

```
 xi:movestay  lnSorghumProductivity  i.EducLevel  HHDGender  HHDAge  HH15to64  lnLandAcres
OffarmincomeReceived> orgIntercrop LogSorghumSeedkgs_PerAcre LogSorghumACRES GroupMembership
DistAgricExtMin     DistInputmktMin     OxenOwnership     FarmStoreOnership     LivestockTLU,
select(ContractPart= DistMainRoadMin BicycleOwnership)
i.EducLevel       _IEducLevel_1-3 (naturally coded; _IEducLevel_1 omitted)
Fitting initial values .....
Iteration 0:   log likelihood = -234.53027 (not concave)
Iteration 1:   log likelihood = -231.13788
Iteration 2:   log likelihood = -230.6708
Iteration 3:   log likelihood = -230.66279
Iteration 4:   log likelihood = -230.66264
Iteration 5:   log likelihood = -230.66264
Endogenous switching regression model             Number of obs   =        240
                                                  Wald chi2(16)   =      67.04
Log likelihood = -230.66264                       Prob > chi2     =     0.0000
------------------------------------------------------------------------------
                         | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------------------+----------------------------------------------------------------
lnSorghumProductivity_1  |
            _IEducLevel_2 |  -.1410566   .1482805    -0.95   0.341     -.431681    .1495677
            _IEducLevel_3 |  -.1297425    .152815    -0.85   0.396    -.4292544    .1697694
                HHDGender |   .0921031   .0689378     1.34   0.182    -.0430124    .2272186
                   HHDAge |  -.0056581   .0024419    -2.32   0.020    -.0104441   -.0008721
                 HH15to64 |  -.0095361   .0114942    -0.83   0.407    -.0320643    .0129921
              lnLandAcres |  -.0884501   .0642223    -1.38   0.168    -.2143234    .0374233
     OffarmincomeReceived |  -.1211442   .0562124    -2.16   0.031    -.2313185     -.01097
            SorgIntercrop |   -.070331   .1138772    -0.62   0.537    -.2935261    .1528642
LogSorghumSeedkgs_PerAcre |   .0420485   .0689184     0.61   0.542     -.093029     .177126
          LogSorghumACRES |  -.4427957   .1152905    -3.84   0.000    -.6687609   -.2168305
          GroupMembership |  -.1718046   .0710983    -2.42   0.016    -.3111547   -.0324545
```

DistAgricExtMin	.0007955	.0004384	1.81	0.070	-.0000637	.0016548
DistInputmktMin	-.0006989	.0003925	-1.78	0.075	-.0014681	.0000704
OxenOwnership	-.12086	.0752744	-1.61	0.108	-.2683951	.026675
FarmStoreOnership	-.0303646	.059075	-0.51	0.607	-.1461495	.0854203
LivestockTLU	.0082758	.0081288	1.02	0.309	-.0076563	.0242078
_cons	7.459373	.2821906	26.43	0.000	6.906289	8.012456
lnSorghumProductivity_0						
_IEducLevel_2	-.1132473	.1973839	-0.57	0.566	-.5001126	.273618
_IEducLevel_3	-.2628284	.2425519	-1.08	0.279	-.7382213	.2125645
HHDGender	.0724276	.1347097	0.54	0.591	-.1915986	.3364537
HHDAge	.0077804	.0043073	1.81	0.071	-.0006617	.0162224
HH15to64	-.0315532	.0371924	-0.85	0.396	-.1044489	.0413425
lnLandAcres	-.1357005	.129304	-1.05	0.294	-.3891317	.1177307
OffarmincomeReceived	.1421715	.1546776	0.92	0.358	-.160991	.4453341
SorgIntercrop	.2735272	.148164	1.85	0.065	-.016869	.5639233
LogSorghumSeedkgs_PerAcre	.3724416	.1038204	3.59	0.000	.1689574	.5759258
LogSorghumACRES	-.7834639	.229237	-3.42	0.001	-1.23276	-.3341675
GroupMembership	.4179687	.1221601	3.42	0.001	.1785393	.6573981
DistAgricExtMin	.0018499	.0006738	2.75	0.006	.0005293	.0031705
DistInputmktMin	.0012069	.0007832	1.54	0.123	-.0003281	.0027418
OxenOwnership	-.0112081	.2413583	-0.05	0.963	-.4842618	.4618455
FarmStoreOnership	-.088227	.156124	-0.57	0.572	-.3942245	.2177705
LivestockTLU	-.0032877	.0145824	-0.23	0.822	-.0318687	.0252933
_cons	4.247962	.4393975	9.67	0.000	3.386758	5.109165
ContractPart						
_IEducLevel_2	.9133181	.455515	2.01	0.045	.0205251	1.806111
_IEducLevel_3	.7346524	.4743187	1.55	0.121	-.1949951	1.6643
HHDGender	.3336174	.2324071	1.44	0.151	-.121892	.7891269
HHDAge	.0133862	.0075164	1.78	0.075	-.0013456	.0281181
HH15to64	.0873772	.0473798	1.84	0.065	-.0054855	.18024
lnLandAcres	.1123031	.2193347	0.51	0.609	-.3175851	.5421913
OffarmincomeReceived	.1210394	.2170758	0.56	0.577	-.3044214	.5465001
SorgIntercrop	-.6855974	.2963913	-2.31	0.021	-1.266514	-.1046812
LogSorghumSeedkgs_PerAcre	.1110085	.2106026	0.53	0.598	-.3017649	.523782
LogSorghumACRES	.5082477	.3817775	1.33	0.183	-.2400224	1.256518
GroupMembership	.6830563	.2201318	3.10	0.002	.2516058	1.114507
DistAgricExtMin	-.0033782	.0014641	-2.31	0.021	-.0062477	-.0005086
DistInputmktMin	.0011381	.0013764	0.83	0.408	-.0015597	.0038358
OxenOwnership	.4241938	.3175305	1.34	0.182	-.1981545	1.046542
FarmStoreOnership	.2117724	.2183506	0.97	0.332	-.2161869	.6397317
LivestockTLU	-.0194292	.0266916	-0.73	0.467	-.0717438	.0328854
DistMainRoadMin	.0066068	.0029642	2.23	0.026	.000797	.0124166
BicycleOwnership	.6045042	.1855388	3.26	0.001	.2408548	.9681535
_cons	-3.470801	.8262158	-4.20	0.000	-5.090154	-1.851448

```
-------------------------+------------------------------------------------------------------
       /lns1 |  -1.228421   .1130167   -10.87   0.000     -1.44993   -1.006912
       /lns2 |  -.4433807   .0766943    -5.78   0.000    -.5936986   -.2930627
         /r1 |  -1.583684   .5037725    -3.14   0.002    -2.571059   -.5963077
         /r2 |  -.3457609   .3283838    -1.05   0.292    -.9893813    .2978596
-------------+----------------------------------------------------------------
     sigma_1 |   .2927545   .0330861                      .2345868    .3653453
     sigma_2 |   .6418628   .0492272                      .5522808    .7459754
       rho_1 |  -.9191752   .0781436                     -.9883774    -.534417
       rho_2 |  -.3326107   .2920548                     -.7570984    .2893527
------------------------------------------------------------------------------
LR test of indep. eqns. :            chi2(1) =     8.70   Prob > chi2 = 0.0032
------------------------------------------------------------------------------
```

Appendix J: Estimation Output for Effect of Contract Farming on Sorghum Productivity

```
.  mspredict mymills1, mills1
. mspredict xx, yc1_1
. mspredict xy, yc1_2
. mspredict yy, yc2_2
. mspredict yx, yc2_1
. ttest xx=xy
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
      xx |     105    6.292983    .0168371    .1725288    6.259594    6.326372
      xy |     105    5.250975    .0354494    .3632483    5.180678    5.321273
---------+--------------------------------------------------------------------
    diff |     105    1.042008    .0360709    .3696168    .9704778    1.113538
------------------------------------------------------------------------------
     mean(diff) = mean(xx - xy)                                    t =  28.8878
 H0: mean(diff) = 0                             Degrees of freedom =      104
 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest yy=yx
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
      yy |     135    5.216496    .0400817    .4657078    5.137222    5.295771
      yx |     135    6.377031    .0194168    .2256031    6.338628    6.415434
---------+--------------------------------------------------------------------
    diff |     135   -1.160535    .0410839    .4773515   -1.241791   -1.079278
------------------------------------------------------------------------------
     mean(diff) = mean(yy - yx)                                    t = -28.2479
 H0: mean(diff) = 0                             Degrees of freedom =      134
 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. ttest xx=xy, unpaired
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
      xx |     105    6.292983    .0168371    .1725288    6.259594    6.326372
```

```
      xy |     105    5.250975    .0354494    .3632483    5.180678    5.321273
---------+--------------------------------------------------------------------
Combined |     210    5.771979    .0410119    .5943187    5.691129    5.852829
---------+--------------------------------------------------------------------
    diff |            1.042008    .0392447                .9646394    1.119376
------------------------------------------------------------------------------
    diff = mean(xx) - mean(xy)                                    t =  26.5515
H0: diff = 0                                     Degrees of freedom =      208
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest yy=yx, unpaired
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
      yy |     135    5.216496    .0400817    .4657078    5.137222    5.295771
      yx |     135    6.377031    .0194168    .2256031    6.338628    6.415434
---------+--------------------------------------------------------------------
Combined |     270    5.796764    .0417823    .6865526    5.714502    5.879026
---------+--------------------------------------------------------------------
    diff |           -1.160535    .0445372               -1.248222   -1.072847
------------------------------------------------------------------------------
    diff = mean(yy) - mean(yx)                                    t = -26.0577
H0: diff = 0                                     Degrees of freedom =      268
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. ttest xx == yy, unpaired
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
      xx |     105    6.292983    .0168371    .1725288    6.259594    6.326372
      yy |     135    5.216496    .0400817    .4657078    5.137222    5.295771
---------+--------------------------------------------------------------------
Combined |     240    5.687459     .041879    .6487874     5.60496    5.769959
---------+--------------------------------------------------------------------
    diff |            1.076487    .0478301                .9822622    1.170711
------------------------------------------------------------------------------
    diff = mean(xx) - mean(yy)                                    t =  22.5065
H0: diff = 0                                     Degrees of freedom =      238
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest xy == yx, unpaired
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
      xy |     105    5.250975    .0354494    .3632483    5.180678    5.321273
      yx |     135    6.377031    .0194168    .2256031    6.338628    6.415434
---------+--------------------------------------------------------------------
Combined |     240    5.884382    .0407894    .6319071    5.804029    5.964734
---------+--------------------------------------------------------------------
    diff |           -1.126056    .0382284               -1.201365   -1.050747
------------------------------------------------------------------------------
    diff = mean(xy) - mean(yx)                                    t = -29.4560
H0: diff = 0                                     Degrees of freedom =      238
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. gen xxxy = xx-xy
(135 missing values generated)
. gen yyyx= yy-yx
```

```
(105 missing values generated)
. ttest xxxy == yyyx, unpaired
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
    xxxy |     105    1.042008    .0360709    .3696168    .9704778    1.113538
    yyyx |     135   -1.160535    .0410839    .4773515   -1.241791   -1.079278
---------+--------------------------------------------------------------------
Combined |     240   -.1969224    .0759947    1.177306   -.3466274   -.0472173
---------+--------------------------------------------------------------------
    diff |            2.202543    .0564174                2.091401    2.313684
------------------------------------------------------------------------------
    diff = mean(xxxy) - mean(yyyx)                                t =  39.0401
H0: diff = 0                                     Degrees of freedom =      238
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

Appendix K: Conjoint Output for Estimating Smallholders' Farmers' Preferences to Contract Designed Attributes

Model Description		
	N of Levels	Relation to Ranks or Scores
Services	3	Discrete
Duration	3	Linear
Price	3	Linear
Terms	3	Linear
All factors are orthogonal.		

Utilities			
		Utility Estimate	Std. Error
Services	Financial services	.539	.281
	Input provision	-.392	.281
	Produce market	-.147	.281
Duration	Per season	-.126	.243
	Yearly	-.253	.486
	More than 1 year	-.379	.730
Price	33	.214	.243
	35	.428	.486
	37	.642	.730
Terms	Cash at farm gate	.150	.243
	After 14 days	.300	.486
	After 30 days	.450	.730
(Constant)		4.522	.866

Importance Values	
Services	48.692
Duration	13.227

Price	22.384
Terms	15.698
Averaged Importance Score	

Coefficients	
	B Coefficient Estimate
Duration	-.126
Price	.214
Terms	.150

Coefficients	
	B Coefficient Estimate
Duration	-.126
Price	.214
Terms	.150

Appendix M: Research Publication Paper

Determinants of Participation in Contract Farming among Smallholder Sorghum Farmers in Bondo Sub-County

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This paper analyzed the socioeconomic and institution factors influencing participation in sorghum contract farming by smallholder farmers in Bondo, siaya county, Kenya. The study results are anticipated to encourage smallholder farmers to participate in sorghum commercialization rather than producing for subsistence.
Study Design: The study applied quantitative research design to determine factors that influences participation in sorghum contract farming by smallholder farmers.

Place and Duration of Study: The study was conducted in Bondo Siaya county Kenya. Targeted group were smallholder farmers producing sorghum either as contracted or non-contracted. The data was collected on sorghum production during 2020/2021 production year.

Methodology: A multistage sampling technique was used to sample 135 non-contracted and 105 contracted smallholder sorghum farmers for the study. The data was collected using semi-structured questionnaire which was pretest prior to actual data collection. Data collected was analyzed using t-statistics and chi-squire for the descriptive statistics. While econometric analysis applied logistic regression model to determine factors influencing smallholder farmers' participation in sorghum contract farming.

Results: Findings revealed that post-primary education level ($\beta = 0.215; P = 0.04$), age ($\beta = 0.005; P = 0.00$), gender ($\beta = 0.144; P = 0.02$), number of active household members ($\beta = 0.090; P = 0.03$), group membership ($\beta = 0.188; P = 0.00$), distance to the nearest main road in walking minutes ($\beta = 0.021; P = 0.00$), ownership of bicycle ($\beta = 0.210; P = 0.00$) and ownership of oxen ($\beta = 0.238; P = 0.00$) positively influence participation in sorghum contract farming. In contrarily, distance to the nearest extension agent office negatively influence participation in sorghum contract farming ($\beta = 0.004; P = 0.01$).

Conclusion: The results suggest the need to increase access to extension services, implement policies for empowering women and youths to engage in contract farming, sensitize farmers to form groups to enhance working collectively to acquire input and output market. National and county governments should invest in physical infrastructure, such as roads, to improve access to agricultural information on new interventions.

Keywords: Participation; contract farming; sorghum, binary logit; smallholder farmers; Kenya.