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Analysis of Profitability of Sorghum Contract Farming: A Case in Laikipia County

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Abstract
Sorghum farming has been promoted in Kenya as an alternative crop in the semi-arid areas due to its ability to tolerate harsh weather conditions. This study assessed the profitability and the factors influencing the profitability of sorghum farming among the contract farming (CF) participants and non-participants in Laikipia County from 188 respondents selected using a multistage sampling. The study used gross margins approach and multiple linear regression (MLR) to assess profit and factors influencing profitability. The return on investment (ROI) among the participants of CF was 1.69 with an annual net profit per acre of Kes 57170. Among the CF non-participants, the significant determinants of profitability included age, education, and land acreage. The determinants of profitability among the CF participants included education, land acreage, and credit access. The agricultural education extension officers and Necco Fosa Cooperative Society agents should collaborate to encourage more farmers to access credit because it significantly increases the profitability of the enterprise under CF. Department of Social Services of Laikipia county government should formulate strategies to encourage more participation into social groups that may increase profitability of CF farming.
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1. Introduction

Contract farming (CF) is an agreement between a producer and a buyer established and agreed before production of specific quality, quantity, standards, and date of delivery of a product at an agreed fixed price (Setboonsarng, 2008). The five models adopted in CF are informal, nucleus, centralized, intermediary, and multipartite. Most popular being centralized where a buyer acquires large volumes of agricultural produce from a large number of producers. Services such as inputs, extension, and transport are provided in form of credit (Eaton & Shepherd, 2001). Contract farming's importance globally has been due to the need for strengthening vertical coordination between agribusiness firms and producers.

According to Oya (2012), contract farming is essential in mitigating the challenges that Sub-Saharan Africa (SSA) smallholder farmers face which limit their productivity and profitability. Formal contracts between the contracting company and the smallholder farmers are not common in SSA. They have mainly existed among large and commercial farmers who major in the export commerce since it requires production technologies, controlled quality standards, and labor-intensive crops wherein the system demands skilled and hired labor (Meemken & Bellemare, 2020). Fafchamps (2003) alludes those informal arrangements have been utilized for a long time and are also practiced in most of the SSA countries. In the past years the trend is evolving and formal contracts are being practiced among smallholder farmers to enhance commercial farming. In many African countries, CF is demonstrating a successful trajectory in improving diversification, profitability, and productivity although it may not be the absolute solution for numerous market failures in the SSA agriculture (Wainaina, *et al*., 2012).

In Kenya, marketing and production contracts for vertical integration are being practiced in livestock and crop production. Contract farming in the livestock sector is mainly in pig, beef, and poultry products (Mutura, 2015). In crops, CF is widely being practiced in horticulture, and field crops such as sugarcane, tea, coffee, tobacco cotton, canola, soya bean, barley, and lately sorghum.

By mid-1980s, the Kenyan horticultural, tobacco, oilseeds, sugarcane, and tea sectors had over 230,000 households that were engaged in CF schemes for the end commodities. Oya (2012) reports in Kenya, an estimation of over 1 million of 4 million farming households in the maize, vegetable crops, sugarcane, barley, dairy cattle, tea, and coffee sub-sectors were involved in formal CF by the year 2010. Over 80% of Kenyan population resides in the rural areas whose mainstay is agriculture. It is therefore, imperative to improve the market accessibility for these farmers at national and international markets as a livelihood strategy that improves the livelihood of smallholder farmers.

The brewing industry in Kenya has increased the demand for sorghum such that it exceeds the supply from the smallholder farmers (Okuthe, *et al*., 2013). Between 2016 and 2017, the sorghum production increased by

7.14% from 140,000 to 150,000 metric tons (MT). The output was supplemented with 94.4 kiloton (kt) of sorghum imports worth $18.7 million from Uganda, Tanzania, India, and United States (Njuguna, 2018).

According to the Ministry of Agriculture, Livestock, and Fisheries (2015), the crops that are mainly grown under CF in Laikipia County include sorghum, Rhode grass, sunflower, soya bean, and canola the recent years. Sorghum has however proved to produce improved output because of it has a drought tolerance and this has contributed to a remarkable increase in the number of farmers growing it in the county. Therefore, sorghum farmers have an upper hand than those farming other crops because they are likely to meet the demanded quantities set by the organization issuing contracts thus increasing the profit margins.

CF is a scheme that can also be used for agricultural production to develop forward and backward market linkage that can enhance farmers' income. Okuthe *et al*. (2013; Oya (2012); and Wainaina et al. (2012) have provided evidence that CF has a positive impact on farmers' welfare due to increased productivity and profitability. The County Government Laikipia among additional value chain participants such as the East African Malting Limited are executing a CF program for sorghum farmers to enhance their productivity and profitability. Despite the documented profits, the Laikipia county Department of Agriculture (2017) reported a small number of farmers (500) who partook in the CF scheme.

Sorghum is a key cereal required for human food and forage for the domesticated animals. Recently, the cereal has gained commercial use in malting as a replacement for barley. Due to its drought-tolerant nature, there is intensive promotion of sorghum farming as an alternative crop in the semi-arid areas by various value chain actors in Kenya. There has also been promotion of sorghum farming in Laikipia in the recent years to improve the productivity and profitability among the smallholder farmers. Laikipia County Integrated Development plan, 2017-2022 reports that in the past few years, the area under sorghum production has been expanded from 500 to more than 4,000 ha. The Department of Agriculture (2017) indicates that Laikipia county has gained over 3,500 sorghum smallholder farmers producing a mean output of 1 t ha^{-1}. The County Government and the East African malting limited are educating farmers about CF, which can increase the productivity and profitability of sorghum enterprises thereby improving rural livelihoods. Necco Fosa Cooperative Society is the financial partner that is prequalified for extending credit to farmers under CF scheme. Despite the documented welfares gains emanating from the CF scheme in Laikipia, about 500 sorghum smallholder farmers joined the initiative in 2016/2017 (Department of Agriculture, 2017). Nevertheless, profitability and the factors influencing profitability in sorghum contract farming in Laikipia are scantly explored. Understanding these factors can enable the researchers to understand the aspects of profitability that can enhance further acceptance of CF in the county. This study therefore sought to assess profitability and the factors influencing the profitability of sorghum farming among the CF participants and non-participants in Laikipia county.

2. Methodology

2.1 Study area

Laikipia County is in the South Rift region of the country and covers an area of 9,462km^2. The county's population was 541,985 persons by 2018 according to the 2019 population census projections (County Government of Laikipia, 2019). Out of the total landmass, arable land constitutes 1,984km2, non-arable land constitutes approximately 7,456km^2, and urban areas 243.3 Km^2 with the average landholding been 3.33 Ha. The county receives an average of 400mm and 700mm rainfall annually and means annual temperatures of between 16^0c and 26^0c (Ogega, 2017).

2.2 Sampling Procedures and Data Collection

In Laikipia county, the smallholder sorghum farmers are estimated at 3,500 (Ministry of Agriculture Livestock and Fisheries, 2015). Cochran's formula was used to calculate the sample size from the population according to Yamane (1967) as follows:

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

This is at 95% confidence level while p = 0.5, n is the size of the sample, N is the population size, and e is the level of precision of 7%. The study sample was 192 farmers from the calculation of the sample size as follows;

$$\frac{3500}{1+3500(0.07^2)} = \text{n= } 192$$

Multistage sampling was used to select the respondents that were included in the sample. To begin with, Laikipia West and East sub-counties were selected using purposive sampling. Secondly, wards within the two sub-counties were selected by random sampling. Checklists from the County Department of Agriculture were used to identify small-scale farmers who grow sorghum within the wards. Data from respondents for this study were collected using semi-structured questionnaires. The enumerators were subjected to training prior to the onset of the survey. Most of them understood the local dialect that the majority of the farmers in Laikipia county

use. The government agricultural officers with knowledgeable village elders assisted the enumerators in accessing households. The research experienced only four cases of nullified questionnaires due to many unanswered questions.

2.3 Analytical Framework

The annual cost of inputs used for sorghum production per acre was specified to calculate the total production costs in the study;

Total production cost (TC) = Total fixed cost (TFC) + Total variables cost (TVC)..…… (2)

Total annual variable cost per acre included those incurred on equipment, input, chemicals, labor cost, post-harvest, and transportation among others. The total fixed cost included land rent among the sorghum farmers who leased and the opportunity cost (OC) of land forgone for not hiring out the portion of land under sorghum among the farmers with land ownership. The output was calculated as the total value of sorghum yield.

Gross margin (GM) calculation per acre and analysis helped to determine sorghum profitability farming under CF and those not participating based on (Barnard & Nix, 1979). The following calculations were done to get profitability;

Total revenue (TR) per acre = Total sales from (sorghum) + Total sales from stover ……...……...…….……... (3)

The gross margin (GM) = TR –TVC ….....……. (4)

Net farm income (NFI)/Profit (π) = GM –TFC ..... (5)

Return on investment (ROI) = NFI/TC …...……....…...……...… (6)

A multiple linear regression (MLR) analysis was used to determine factors that influence profitability for smallholder sorghum farmers. Profit was the dependent variable that was regressed against different independent variables. A logarithmic functional model was used and the equation is as follows;

$$LnY = X_0 + Q_i + \ldots + X_j Q_j + \mu_i \quad \ldots\ldots (7)$$

where LnY = natural logarithm of profit; X_0 = intercept term; ($Q_1 - Q_i$) represent the independent variables while (X_1-X_i) represents the coefficients of ($Q_1 - Q_i$) respectively. The coefficients were computed as a percentage of the change in Y due to change in X. Subsequently, μi is the disturbance term that caters for unobserved random effects. The errors of this model are assumed to be independent while taking a normal distribution {N (0, σ^2)} and conditional on Q_i. Table 1: presents the variables used for the MLR, their descriptions, measurement units, and the variable types.

Table 1: Variables used in the multiple linear regression model and their description

Variable	Description of each the variable	Measurement unit	The variable type
	Research dependent variables		
PROFT	Annual profit from sales through CF per acre	Kenya shillings	Continuous
	Independent variables		
AGE	Age of the HH head	In Years	Continuous
GENDER	Gender of the HH head	1=Male 0=Female	Dummy
EDUCLVL	Education level	1=None 2=Primary 3=Secondary 4=Tertiary 5=Adult literacy	Dummy
GRPMB	Whether a farmer was a group member and active or not	1=Yes 0=No	Dummy
MRKDT	Distance of the household from the nearest market	Kilometers	Continuous
LNDTNR	Land tenure	1=Owned title 0=Leased	Dummy
LANDSZ	The total land size owned by a household	Acres	Continuous
HHSIZE	The number of members in a household	Persons	Continuous
CDTAC	Whether a farmer sought credit	1=Yes 0=No	Dummy

3. Results and Discussions

3.1 Socioeconomic characteristics among smallholder sorghum farmers in Laikipia County

Table 2 presents the descriptive statistics results for the continuous socioeconomic characteristics of the sorghum smallholder farmers in Laikipia County. To detect mean differences on the socioeconomic characteristics among the participants and non-participants of contract farming (CF), the study run a t-test to determine the significant

differences using p-values.

Table 2: Descriptive statistics results of the socioeconomic characteristics for continuous variables

Variable	CF Non- Participants (N=105)		CF Participants (N=83)		P-Value
	Mean	Std. Dev	Mean	Std. Dev	
Land size (acres)	3.95	3.00	6.73	6.09	0.000***
Farming experience	9.13	6.12	9.04	5.66	0.912
Distance to market (Km)	4.41	2.56	3.79	2.19	0.084*
Land under sorghum (acres)	1.34	0.09	2.24	1.99	0.004***
Distance to town (Km)	27.10	12.11	12.94	8.03	0.000***
Number of extension visits	0.029	0.218	2.012	1.581	0.000***
Age of the household head	45.81	12.93	46.34	10.76	0.765
Education level	3.27	0.82	3.45	0.72	0.119

***, **, *** statistic is significant at 10%, 5% and 1% level respectively**

Total land acreage and acreage under sorghum varieties exhibited strong significant differences ($p<0.01$) among CF participants and non-participants. The significantly higher acreage among CF participants over non-participants in the current study reveals the benefits these groups of farmers accrued from CF in Laikipia County. The CF participants of sorghum farming were about 13 Km from the nearest towns which was significantly ($p<0.01$) shorter than the 27 Km that non-participants traveled to access the towns. The non-participants of CF in sorghum production accessed significantly ($p<0.01$) fewer extension services than their participating counterparts.

The mean age of the household head for the CF non-participants and participants was approximately 46 years. The majority of the farmers who had attained secondary school and tertiary education participated in the CF scheme. The farming experience among the two groups was 9 years. These are the number of years when individual sorghum farmers in Laikipia County made independent decisions to engage in sorghum production as an enterprise. Experienced farmers also understand technology improvement over the years. For instance, they have embarked on improved sorghum varieties (ISV) such as Gadam, Sila, Serena, and Seredo (see Figure 1).

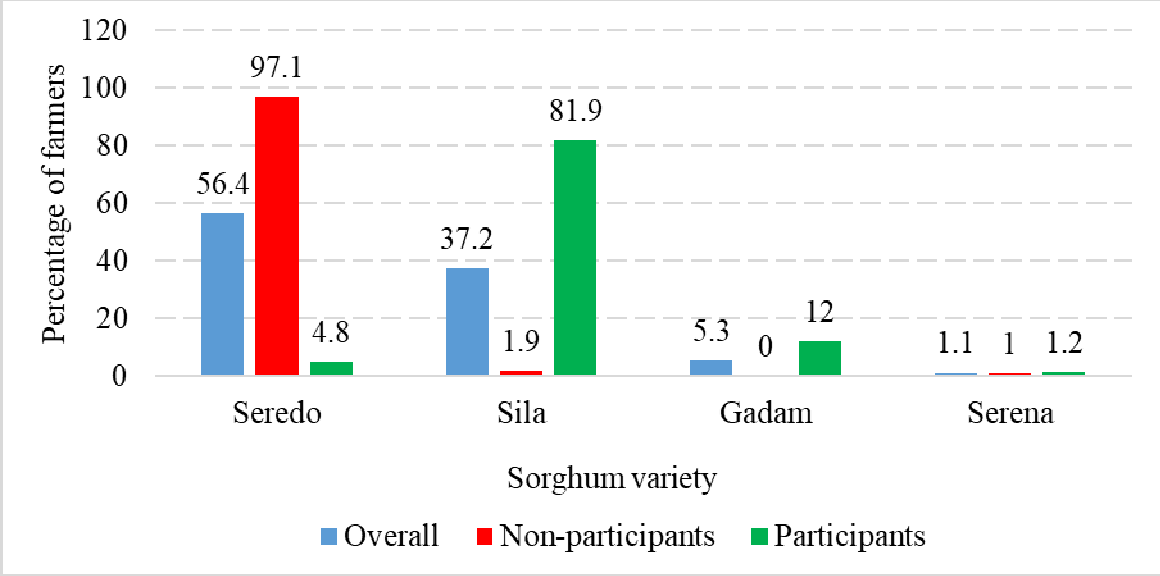

Figure 1: Sorghum variety grown in Laikipia county

Table 3: Descriptive statistics results of the socioeconomic characteristics for the dummy variables

Variable	CF Participation				
	Outcome	**Non-participants (N=105)**	**Participants (N=83)**	**Pearson Chi^2(1)**	**P-value**
Off-farm income	No	86	60		
	Yes	19	23	2.471	0.116
Awareness on CF	No	79	0		
	Yes	26	83	107.71	0.000***
Gender of HH head	Female	30	20	0.476	0.490
	Male	75	63		
Ownership of title	No	104	15		
	Yes	1	68	130.84	0.000***
Access to credit	No	83	54		
	Yes	22	29	4.588	0.032**
Group membership	No	52	10	29.46	0.000***
	Yes	53	73		

***, **, *** statistic is significant at 10%, 5% and 1% level respectively**

Off-farm income did not significantly (p=0.116) differ between participants and non-participants of contract farming of sorghum (Table 3). The CF non-participants (26) who were aware of CF significantly differed (p<0.01) from that of participants (83). The CF non-participants who headed their families among the sorghum smallholder households and were male were 75 and their number was not significantly different from 63 of those men who headed their families among the participants. The number of sorghum CF non-participants who owned land and had their title deeds was significantly (p<0.01) lower than that of participants. Sorghum CF non-participants who accessed credit for sorghum enterprises was lower than that of the participants who accessed credit in Laikipia County. The difference in credit access among participants and non-participants was significant at 5% level (p<0.05). The CF non-participants that belonged to organized social groups were 53 while the participants were 73. The difference in their participation in organized groups among CF non-participants and participants was statistically significant at 1% level (p<0.01).

3.2 Profitability of sorghum farming among CF participants and non-participants

Table 4 shows the results for the calculations of annual profits that smallholder sorghum producers made per acre. A t-test was run to determine the differences in costs and returns among CF participants and non-participants. The annual total variable cost (TVC) per acre constituted 81.46% and 80.11% of the total production cost among the participants and non-participants of sorghum contract farming. The findings of the CF non-participants concurred with the findings of Zalkuwi and Giroh (2014), Vihi *et al*. (2019), Idisi *et al*. (2019) who found that 85.55%, 86.07%, and 82.32% of the TC were contributed by the TVC in the production of sorghum in different parts of Nigeria. In the current study, the contribution of TVC to TC among the CF participants was slightly higher for the CF participants compared to that of non-participants perhaps due to the increased intensification that is associated with contract farming.

Table 4: Profitability of sorghum farming among CF participants and non-participants in Laikipia County

Variable	Non-participants	Participants	P-value
Variable costs (Kes)			
Seeds	1876.30	2602.32	0.022**
Fertilizers	7116.54	9340.42	0.118
Herbicides/Pesticides	1948.70	3795.29	0.020**
Labor	8546.82	10159.02	0.302
Storage costs	242.31	718.26	0.076*
Market costs	683.72	981.35	0.012**
Total Variable Cost (TVC)	**20414.39**	**27596.66**	**0.054***
Fixed costs (Kes)			
Rent on land /OC	5070.01	6280.24	0.057*
Total fixed costs (TFC)	**5070.01**	**6280.24**	
Total production cost (TC) = (TVC+TFC)	**25484.40**	**33876.90**	**0.011****
Returns			
Sorghum sold (90kg bags)	11.46	24.12	0.003***
Sorghum price per 90kg bag	3000	3400	
Sorghum sales (Kes)	34380	22008	0.020**
Stover sold (tons)	1.44	1.86	0.214
Stover price per ton	4770	4860	
Stover sales (Kes)	6866.97	9039.60	0.047**
Total revenue (TR)	**41246.97**	**91047.60**	**0.012****
Gross Margin (GM) = (TR-TVC)	**20832.58**	**63450.94**	
Profit/Net farm income (NFI) = GM-TFC	**15752.57**	**57170.70**	
Return on investment (ROI) = NFI/TC	**0.62**	**1.69**	

Note: *, **, * statistic is significant at 10%, 5%, and 1% level respectively; OC is the opportunity cost of not hiring out the portion of land under sorghum**

From Table 4, fertilizers and labor were the greatest contributors to the total variable costs (TVC) incurred in smallholder sorghum production. For instance, among the participants of CF, fertilizers, and labor constituted 33.84% and 36.81% of TVC respectively. Storage costs were the least contributors of TVC at 2.6%. A study by Vihi *et al*. (2019) that assessed the profitability of smallholder sorghum production in the Plateau State of Nigeria found similar results. The study found that 38.51% of the TVC was contributed by the cost of fertilizer. In other studies, labor was the biggest contributor to TVC. For instance, Zalkuwi & Giroh (2014) and Idisi *et al*. (2019) found that about 60% and 70% of TVC resulted from labor costs. The findings of these studies show how mechanization is needed for a reduction in the cost of hiring many employees in sorghum production activities such as land preparation, planting, weeding, harvesting, threshing, and transportation. Additionally, the storage cost was the least contributor to TVC probably because many sorghum farmers own sorghum stores that help them in gathering their produce before transporting it to the market collection centers.

Herbicides and pesticides contributed to TVC by about 13.75% and 9.56% among the CF participants and non-participants respectively. In a study by Idisi *et al*. (2019) to assess the profitability of sorghum farming among smallholder farmers in the Abuja area of Nigeria, the agrochemicals, including herbicides and pesticides, contributed to TVC by 11.19%. The cost of agrochemicals is important for the enterprise because sorghum faces several pests and diseases (Mundia, Secchi, Akamani, & Wang, 2019). The latter study shows how critical it is for farmers to switch to improved sorghum varieties (ISV) that are pests and disease tolerant.

The cost of seeds contributed to TVC among the CF participants and non-participants by approximately 9.42% and 9.19% of the TVC respectively. Vihi *et al*. (2019) reported similar findings where the cost of seed contributed to TVC by about 10%. The cost of seed may be reduced if farmers embrace the quality declared seeds (QDS) that are produced by authorized farmers. As such, the quality of seeds will be retained while the cost of production will be reduced significantly. Additionally, most of the non-participants of CF may have incurred less cost in seeds probably due to the recycling of previously planted seeds. The major problem with the consecutive recycling of seeds is the dwindling of hybrid vigor. Farmers lose the potential of achieving optimal output and quality.

Market costs contributed to about 3.56% and 3.35% among the CF participants and non-participants respectively. The CF participants may have incurred more marketing costs due to the increased output that may require significantly more trips to the collection centers than the trips made by their non-participating counterparts. Zalkuwi and Giroh (2014) found that smallholder sorghum farmers who specialized in sorghum production in the Nigerian Adamawa State incurred marketing costs that contributed to about 5.4% of the TVC.

These costs include those incurred during transportation of the product to the market and the cost of moving to the major towns to create market engagements before the harvesting is done.

The total fixed costs (TFC) were incurred by smallholder sorghum farmers who paid rent for leasing land and opportunity cost (OC) of owning land (for those who did not lease). TFC contributed to the total production costs by 18.54% and 19.89% among the CF participants and non-participants respectively. The contribution of TFC to TC concurred with the findings of Vihi *et al*. (2019), Idisi *et al*. (2019), and Zalkuwi & Giroh (2014) who found that TFC were contributing to TC by 13.93%, 17.68%, and 14.43% respectively. In the current study, the fixed costs among the CF participants are higher than those reported in the aforementioned studies. A plausible explanation could focus on the availability of a market for sorghum produce such that sorghum farmers are motivated to lease more land to increase the output.

The revenue collected from the sales of sorghum significantly differed among the participants and non-participants of contract farming (CF) at 5% level ($p<0.05$). The CF participants produced more sorghum quantity than their non-participating counterparts probably due to the services they receive from the agronomists of the contracting company and the motivation they receive from a ready market. A significant ($p<0.05$) difference in the sales of stover was revealed by the findings where the CF participants sold significantly more tons than their CF non-participants counterparts. The total revenue (TR) that the CF participants achieved from the sales of both sorghum and stover were Kes 91047.60 which was significantly higher than Kes 41246.97 that the non-participants received. It is a clear indication that CF significantly increases the profitability of sorghum farming.

The return on investment (ROI) was 1.69 and 0.62 among the participants of CF and non-participants respectively. The ROI achieved by the participants was comparable to 1.59 and 1.07 that Idisi *et al*. (2019) and Zalkuwi & Giroh (2014) while that of non-participants agreed with 0.91 found by Vihi *et al*. (2019) found in different parts of Nigeria. In these findings, the net gains outdo the total production costs by more than 100%. Among the participants of CF, the gains from the investment exceed the TC by more than one and a half times. All indicators show that CF among the smallholder sorghum farmers is a lucrative initiative that farmers must be encouraged to partake.

3.3 Determinants of profitability of sorghum farming among the CF participants and non-participants in Laikipia County

The results of the factors that influence the profitability of smallholder sorghum farmers in Laikipia County are presented in Table 5.

Table 5: Factors affecting profitability for sorghum smallholder farmers in Laikipia County

	Pooled		Non-participants		Participants	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Dependent						
Ln Profit						
Independent						
Age	-0.0075*	0.0044	-0.0130**	0.0055	0.0028	0.0071
Gender	-0.0780	0.1001	-0.1718	0.1357	-0.0511	0.1446
Education level	-0.0452	0.0661	-0.1864**	0.0768	0.2127*	0.1101
Km to the market	-0.0383**	0.0157	0.0263	0.0195	0.0309	0.0246
Group membership	0.0824**	0.039	0.4332	0.2876	0.0628	0.042
Off-farm income	0.0866	0.1135	0.2153	0.1623	0.0514	0.1553
Land acreage	0.0957***	0.0187	0.1325***	0.0304	0.0749***	0.0242
Credit access	0.1988*	0.1025	-0.1085	0.1641	0.4516***	0.1329
Land tenure	-0.0423	0.1181	-1.7115	0.5974	0.0933	0.1857
_cons	9.7000***	0.3547	10.4706***	0.4146	8.1551***	0.616

Note: *, **, * statistic is significant at 10%, 5% and 1% level respectively**

From the pooled and CF non-participants' data, as farmers advance in age, their profitability in sorghum production enterprises reduces. The decline was significant at 10% level ($p<0.1$) such that an increase in age by 1 year reduced profits by less than 1%. Teshome *et al*. (2020) also found that farmers' profits were negatively influenced by age in the Central Rift Valley of Ethiopia. The study alluded that younger heads of households can accept new technologies without obstruction better than their elder counterparts. The adoption of technologies improves operation efficiency and reduces costs associated with outdated production technologies thus it increases the profit margins. Advancing in age reduces farmer's capacity to cope with challenges in agricultural

production as well as manual work. However, Mwangi *et al*. (2020) found a positive coefficient of influence of age on profit efficiency. In such a case, the age of the farmer is presumed to come with experience that might reduce unnecessary costs in production thus increasing profitability in sorghum farming.

The CF non-participants' profitability lowered with education, implying that as a farmer mover from one level to another, for instance from secondary to tertiary education, their profitability dropped by 18.64%. Similar findings were reported by Sanyang (2014) who found that the profitability of rice producers was reducing with education level. The study gave a plausible explanation that farmers tend to put more weight on non-farm-related income-generating activities as they achieve higher education levels. Eventually, the profit margins get narrow. On the contrary, the CF participants significantly increased profitability by 21.27% through advancing education to the next level. Akpan *et al*. (2013) reported similar findings in cassava production in Nigeria where the research mentioned that farmers in higher levels of education are likely to understand the crop production and market dynamics, which eventually increases productivity and profits.

Distance to the market was as expected reducing profits significantly at 5% level ($p<0.05$). The findings in Table 5 shows that an increase in distance to the nearest market by 1 Km significantly reduced the profit of sorghum enterprise in Laikipia County by 3.8%. The findings were consistent with those of Mwangi *et al*. (2020), Ntabakirabose (2017) Okeyo *et al*. (2020), and Teshome *et al*. (2020). The studies explain that the longer the distance to the market, the higher the variable costs that a farmer incurs. This implies that apart from the costs of buying inputs an extra cost of logistics to accessing the markets for the product reduces the profit margins. In the current study, a plausible explanation for the reduced profits as a result of longer distances to the market could be the difficulty that a farmer faces during the marketing of their produce due to transport costs and poor infrastructure in the rural areas of Laikipia County.

Membership to an organized group or association significantly influenced the profitability of sorghum enterprises at 5% level ($p<0.05$). The findings imply that joining an organized group increased the profits that smallholder sorghum farmers gained by 8.24%. Farmer members who belong to groups are able to seek government services more easily than individual farmers. For instance, if a farmer belongs to producer or farmer groups, they can seek agricultural training from the government and non-governmental organizations easily compared to an individual farmer seeking the same services. The findings of this study coincide with those of Teshome *et al*. (2020). A group of farmers can enhance information flow and technology adoption among sorghum farmers in Laikipia County. In this regard, farmers in groups can produce efficiently such that their cost of production is minimized while the output is maximized. High output increases the revenue that farmers receive and they can offset the minimized costs thus increasing profit margins.

The land size was a positive determinant of profitability. It influenced profits at 1% level ($p<0.01$) which implies that farmers with an extra acre would increase profits by 9.57%, 13.25%, and 7.49% for the pooled sample, non-participants, and participants respectively. When farmers afford the inputs required in sorghum production, they can expand their output as they expand their land under the crop. These findings are in harmony with the findings of Wickramaarachchi and Weerahewa (2018) in Sri Lanka. Large sizes of the land enjoy economies of scale such that the per-unit cost of production is scaled down. For instance, mechanization becomes expensive on small pieces of land such as a quarter of an acre but becomes of the essence when the acreage increases. In our study, the mean acreage under CF was more than 2 acres that may influence the use of mechanization. Additionally, other studies like Okeyo *et al*. (2020) and Teshome *et al*. (2020) found contrary to the findings of this study. In their cases, farmers who expand land are not able to manage crop production due to the costs involved while farmers with small sizes can comfortably intensify their production.

Farmers who accessed credit significantly increased their profitability. The influence was significant at 10% ($p<0.1$) and 1% ($p<0.01$) levels for the pooled sample and CF participants implying that if a farmer accessed credit, the profits increased by 19.88% and 45.16% respectively. Similar results were reported by Ahmed *et al*. (2015), Haile (2015), Ntabakirabose (2017), and Mwangi *et al*. (2020). When farmers cannot afford some inputs, including mechanization, credit comes in handy. Inputs such as improved seeds and fertilizers enhance agricultural yields and, in that regard, sorghum farmers can maximize their yields and revenues. A study by Karani-Gichimu *et al*. (2015) explained that farmers who have an obligation of repaying credit usually work hard to maximize their output which translates to an improvement in revenue. In this study, an increase in revenue means that farmers will increase their gross margins. However, if farmers are not monitored in their production, they might use credit for other enterprises not related to sorghum production thus not increasing profitability as expected.

4. Conclusion and policy implication

The study concludes that smallholder sorghum production under contract farming was a profitable business. The profit earned by the CF participants differed significantly from that of the non-participants. It is therefore evident that CF in sorghum production is a lucrative initiative. Laikipia County government through the Department of Social Services to strengthen informal and formal farmer groups to enhance more CF participation through the

groups. The County government should ensure that as many farmers as possible attain security of tenure which increases their probability of improving their enterprise profitability. The agricultural education extension officers and Necco Fosa Cooperative Society agents should collaborate to encourage more farmers to access credit because it significantly increases the profitability of the enterprise under CF. Necco Fosa Cooperative Society comes in handy because it is part of the CF scheme through the County government to provide credit to farmers registered under the CF scheme. If the action is taken, the creditors (Necco Fosa Cooperative Society) will recover their money from sorghum sales and the farmers will remain with a substantial profit.

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Conflict of Interest

No potential conflict of interest was reported by the authors.