Socio-economic Determinants of Sugarcane-Soybean Intercropping among Smallholder Farmers in Awendo Sub-County, Kenya

Abstract

Global climate change and decreases in available land are significant challenges humans currently face. Alternative management approaches for sugarcane fields have great potential to help mitigate these problems in Kenya. Intercropping as a crop diversification strategy is a crucial coping mechanism for agriculture's income, production, and marketing risks. The main purpose of this study was to analyze the determinants of sugarcane-soybean intercropping among sugarcane farmers to inform policymakers about policy adjustment. The study used primary data collected from 246 households using structured questionnaire. Data were analyzed using a descriptive and logistic regression model. Results showed that 63% of the respondents had adopted sugarcane monocropping compared to only 37 % who adopted sugarcane-soybean intercropping. Specifically, the study found that sugarcane farming experience ($p =<0.10$), production acreage ($p =<0.10$), land ownership ($p =<0.10$), and divorced as marital status (($p =<0.05$) had negative and significant effects on sugarcane – soybean intercropping, while farmers' age ($p =<0.10$) and widowed as a marital status ($p =<0.01$) depicted a positive and significant association with sugarcane – soybean intercropping. From the interviews, lack of credit for farm operations and the high cost of farm inputs also emerged as a barrier to adoption of sugarcane intercropping systems. Based on the results, the study suggests the need for government to promote the development of agricultural policy that supports the shift from non-diversification to crop diversification through developing guaranteed access to inputs and subsidies on farming input resources with priority given to smallholder farmers.

Keywords: Climate Smart Agriculture, Sugar cane, Soybean, Intercropping, climate change

1.0 Introduction

Sugarcane (*Saccharum officinarum L.)* is an important crop for sugar and bioenergy worldwide (do Amaral & Molin, 2014; Surendran et al., 2016) and is widely grown in tropical and subtropical regions. It contributes to 86 % of sugarcane production (FAOSTAT, 2018) and 35 % of ethanol production worldwide (Luo et al., 2016). However, sugarcane production and productivity under smallholder farming systems are constrained by biotic, abiotic, and socio-economic factors. Climate change, lack of drought-tolerant varieties, limited access to credit facilities, and inadequate research and extension support are key deterrents to sugarcane production(Livingston et al., 2014; Tena et al., 2016).

According to FAOSTAT (2019), the global production of sugarcane stands at 1949.31 million tonnes, with Africa and Kenya having a share of 97.33 million and 4.61 million tonnes, respectively (Table 1). In Kenya, while sugarcane production has shown a relative decrease from 5.61 to 4.61 million tonnes, between 2009 and 2019, there has been an increase in acreage under production from 0.066 to 0.072 million hectares in the same period.

Table 1. Trends in Sugarcane Production Acreage and Output between 2009 and 2019

	World		**Africa**		**Kenya**	
Year	Production (Million	Acreage (Million ha)	Production (Million	Acreage (Million	Production (Million	Acreage (Million

	Tonnes)		Tonnes)	ha)	Tonnes)	ha)
2009	1672.96	23.69	88.99	1.41	5.61	0.066
2010	1677.92	23.65	87.09	1.40	5.71	0.069
2011	1789.88	25.49	87.88	1.39	5.31	0.079
2012	1826.94	25.97	89.52	1.43	5.82	0.087
2013	1899.04	26.82	95.58	1.48	6.67	0.086
2014	1886.69	27.08	94.86	1.50	6.41	0.072
2015	1875.76	26.58	91.93	1.49	7.16	0.078
2016	1881.08	26.58	90.36	1.48	7.09	0.087
2017	1835.46	26.26	91.37	1.48	4.75	0.068
2018	1930.51	26.49	95.84	1.52	5.26	0.073
2019	1949.31	26.78	97.33	1.58	4.61	0.072

Source: FAOSTAT, 2019

Exacerbated by climate change impacts, sugarcane production is likely to decline further due to their long production life span, typically non-irrigated cropping pattern, and the inability to easily switch crops due to high upfront capital costs (Gunathilaka et al., 2018; Zhao & Li). As a result, the sector requires appropriately designed adaptation strategies to cope with ongoing climate change. Comprehensive knowledge of available adaptation mechanisms is of utmost importance if sugarcane farmers are to counteract production losses from climate change shocks and maintain the competitiveness of sugarcane in the global market.

According to Manda (2016), climate-smart agriculture (CSA) is one of the most suitable and sustainable agricultural practices that can make households withstand the deleterious effects of climate change and variability among smallholder farmers. This entail approaches such as crop diversification through rotations and intercropping, conservation tillage, water harvesting, cultivation of drought-resistant crops, and integrated soil fertility management, among others (Makate et al., 2016). These will help improve farmers' resilience, enhance proper water, nutrients, and light utilisation and reduce inorganic fertiliser use. (Xu et al.,2008), (Zhang & Li, 2003) (Mao et al., 2016). Planting two or more crops in the same season in the field is known as intercropping (Matusso & Mugwe, 2013). could reduce s. Consequently, this will result in a higher yield and more stability than a mono-system (Waswa et a., 2009; Neamatollahi et al., 2013; Hossain et al., 2003).

Sugarcane is planted with wide row spacing (80-140 cm) and initially has a slow growth rate at the seedling and tillering stage (Li et al., 2013; Chen et al., 2014). Hence wide row spacing and other natural resources such as water, nutrients, and sunlight can successfully be utilised for intercropping with legumes in sugarcane fields during the long juvenile period (Manimaran et al., 2009). In addition, sugarcane is a perennial crop requiring high quantities of nutrients under continuous planting (Begum et al., 2017). After sugarcane emergence (5–6 weeks), it remains dormant for 3–4 months due to low temperature. To drive benefits from its slow growth and better use of resources, intercropping of some short-duration crops (leguminous crops) can be explored (Nadeem et al., 2020; Gameiro et al., 2016). Some studies have shown that a legume intercropping system can induce legumes to fix more atmospheric N_2 by increasing competition with neighboring intercropped crops (Nasielski et al., 2015; Lacerda e al., 2015). Intercropping of sugarcane with legumes is also considered to be an effective measurement for reducing N_2O emissions in the emission in the field because it can reduce nitrogen input (Beaudette et al., 2010; Mutuo et al., 2005) through the benefit of complementary N use (Li et al., 2013).

Several studies have shown the potential of sugarcane intercropping with pulses such as soybean (Teshome et al., 2016; Shimming & Gliessman, 2015; Shukla, 2017), common bean (Bolonhezi., 2010), cowpea, and white lupin (Ramouthar et al., 2013), lentil (Nadeem et al., 2020); oil seeds such as rapeseed and mustard seed (Kaur et al., 2016); cereals such as maise (Pillay& Mamet, 2008). Soybean (*Glycine max L.)* is currently the world's most important food protein source and hence crucial for food security. It is the main source of high-quality vegetable protein for the production of food of animal origin(Speedy, 2002; Thornton, 2010). It is one of the emerging value chains in Awendo Sub-County, Kenya, with the potential for alleviating food and nutrition insecurity, poverty, and unemployment among the rural households in Kenya. Sugarcane-soybean intercropping has been recognised as a potential system for the augmentation of productivity over space and time in subsistence farming due to the high utilisation efficiency of light, stability of yields, resilience to perturbations, and reduction of N-leaching (Luo et al., 2016; Yang et al., 2013). Previous studies have shown that sugarcane can benefit from soybean in the intercropped systems because the highly efficient nitrogen fixation can improve soil fertility and ecological field conditions (He et al., 2006; Tang et al., 2005; Singh, 2020).

Several studies have evaluated the impact of climate change on sugarcane production and other annual crops focusing on the agronomic aspects (Liangsheng et al., 2021; Mulianga et al., 2017; Pipitpukdee et al., 2020; Singels et al., 2014; Wang e al., 2020; Hussain et al., 2018) However, little has been done to assess farmers' socio-economic effects on Sugarcane-Soybean Intercropping. To the best of our knowledge, there is a dearth of information on the drivers of Sugarcane-Soybean Intercropping in Kenya. This study aimed to examine the drivers of sugarcane-soybean intercropping as a climate-smart agriculture strategy among smallholder farmers in Awendo sub-county, Kenya. The findings of this study can reduce the information gap on sugarcane crop diversification and contribute to income stability, food security, and poverty reduction among smallholder farmers. Further, a sound understanding of the socio-economic characteristics of smallholder farmers and how they influence their crop diversification decisions would help policymakers craft appropriate measures for promoting crop diversification, considering growing land, climate change risks, water and labor scarcity, and other ongoing issues and trends.

2.0 Methodology

2.1 Study area

This study was undertaken in Awendo Sub-County, located in Migori County in the South Western part of Kenya (Figure 1). The sub-County consists of four wards: North Sakwa, South Sakwa, West Sakwa, and Central Sakwa. Specifically, this study focused on Awendo Sub-County in the South Nyanza Sugarcane belt, where the SONY Sugar Company operates because of its significant contribution to the sugar industry in Kenya (CIDP, 2013). The sub-county covers an area of 261.90 km2 (KNBS, 2010). The sub-County enjoys a bimodal rainfall pattern ranging from 700mm to 2,200mm (PRSP, 2004). The long rains are usually experienced between February and June, while short rains occur between July and November. Temperatures range between 21^0C and 35^0C. The soil type ranges from deep red clay loam soils to black cotton soil. Therefore, the climate and soils are suitable for the cultivation of sugarcane. Other major crops include soybean, tobacco, and beans. According to the 2009 national census, the sub-county population stands at 117,290 persons (KNBS, 2019). The main economic activities in the sub-county include agriculture, manufacturing, and mining.

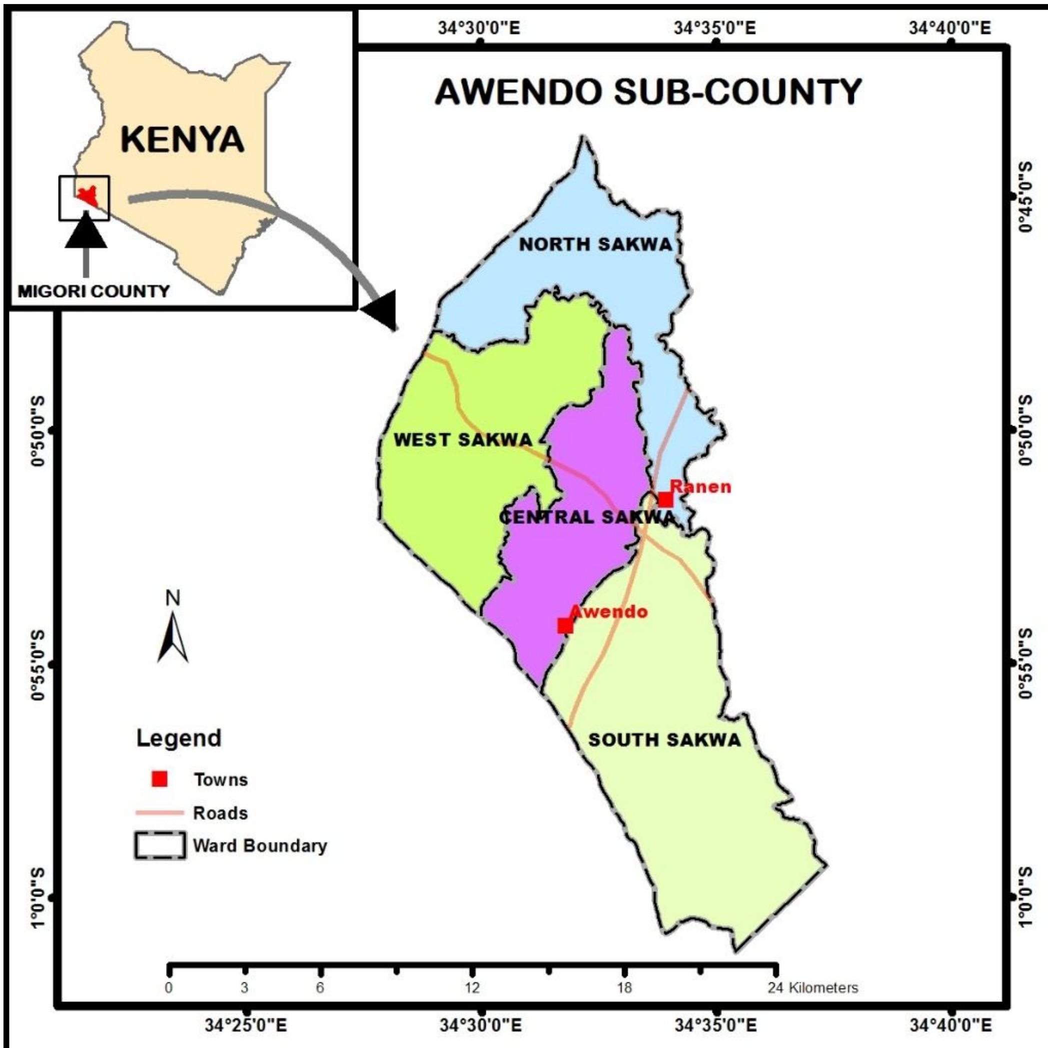

Figure 1. Study area

2.2 Sampling Procedure

The population of interest constituted all farmers who practice sugarcane monoculture and sugarcane-soybean intercropping in Awendo Sub-County. A multistage sampling technique was used to get the study sample where the household was the sampling unit in this study. The first stage was the purposive selection of Awendo Sub-County, the region that harbours' a higher potential for sugarcane and soybean production in the County (CIDP, 2013). All four wards in the sub-county were included in the study that is North Sakwa, South Sakwa, West Sakwa, and Central Sakwa. Afterward simple random sampling technique was used to select the respondents from all the wards proportionally according to size based on the list of sugarcane and soybean farmers given by the sub-county extension officers at the ward headquarters in Awendo Sub-County. Using the 2009 Kenya National Bureau of Statistics (KNBS) data on the population of the four wards of interest (clusters) as reported by the Kenya Population and Housing Census, a proportionate population size (PPS) of respondents for each ward was computed to arrive at 246 respondents.

2.3 Methods of data collection

Cross-sectional data collected from randomly selected sample households in Awendo Sub-County, Kenya, was used in this study. The study used both primary and secondary data. A semi-structured questionnaire consisting of open and close-ended questions in line with the study's objective was developed, refined, and administered to sampled households by trained enumerators to collect primary data on household characteristics, asset holdings, crop production, marketing, and access to institutional services. The android smartphones and tablets were pre-loaded with the survey questionnaire designed in Kobocollect. The data collection application has an in-built range and consistency checks to ensure good quality data. The data obtained was downloaded from Kobocollect as Comma-separated values (CSV) files and exported to STATA for analysis. A pretest was conducted to check the questionnaire's understand-ability and validity before data collection. This pretest was to help in assessing the ease of respondents' understanding of the questions and their appropriateness under the study context. In addition, the pretest helped verify the tool's validity and reliability. The secondary data for comparative analysis, gap identification, identifying, and deciding on analytical and research methods was gathered from statistical abstracts, publications, government and non-governmental reports, and journals.

2.4 Conceptual framework

The study focused on drivers of choice of sugarcane cropping systems among smallholder farmers. There was a need to examine the relationship of various factors and their effect on farmers' adoption of sugarcane-soybean intercropping as a crop diversification strategy. It was hypothesised that farmers' adoption of sugarcane-soybean intercropping would be determined by different socio-economic, demographical, and institutional factors. The socio-economic factors comprised household size, farm income, farmer group membership, and farming experience, land ownership, and land size whereas demographic factors included household size, marital status and age. Besides, institutional factors were access to credit services, access to market, access to extension, and market information

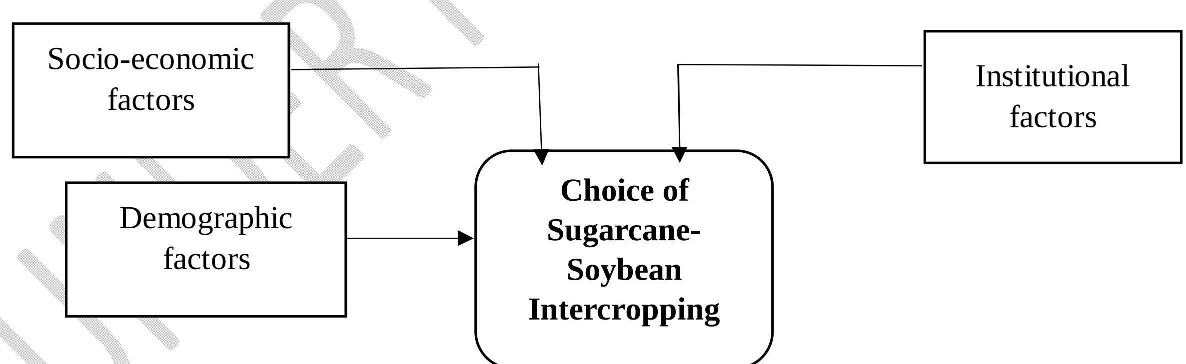

Figure 2. Conceptual framework of choice of sugarcane-soybean intercropping

2.5 Data analysis

2.5.1 Descriptive analysis

The study's objectives were achieved using two types of statistical analysis: descriptive and inferential (econometrics). The descriptive-analytical tools such as arithmetic means, frequency, t-test, and chi-square test were estimated to summarise the study's findings. The t-test was used to compare the mean values of continuous variables, while the chi-square test was used to test the association between dummy variables.

2.5.2 Econometric model

According to Gujarati & Porter (2003), the Binary logit regression model was used for analysing the effect of different variables on the choice of the sugarcane cropping system. A logit regression model was chosen because widespread literature shows that farmer choices can be analysed using this model. According to Greene & Hensher (2010), the logistic distribution is better in applied research over the probit model because of computational complexity arising from the lack of a closed form for the normal cumulative density function on which the probit model is based. The logistic regression analysis employs a maximum likelihood estimation (MLE) which runs an iterative procedure for finding the maximum likelihood to effectively obtain estimated models along the number of parameters relative to the potentially high observations (Hautsch et al., 2014). The model's dependent variable represents whether a farmer is an integrator or a non-integrator of sugarcane and soybean crops. The variable was coded as 1 for sugarcane and soybean intercropping or 0 for sugarcane monocropping. The independent variables with their values are shown in figure 2. This model predicts the response variable (inter-croppers) from the independent variables.

The likelihood of the farmer intercropping sugarcane and soybean is predicted by odds (Y=1); that is, the ratio of the probability that Y=1 to the probability that Y≠1;

$$Odd\, Y = P(Y = 1)/(1 - P(Y = 1)) \qquad 1$$

The binary logit regression model is specified in Equations 2 and 3.

The natural log of odds gives the logit (Y);

$$\ln\left\{\frac{p(Yi=1)}{1-p(Yi=1)}\right\} = \log Odds = Logit\,(Y) \qquad 2$$

This can be expanded as

$$Logit(Y) = \propto + \sum\beta 1X1 + \sum\beta 2X2 + \cdots + \sum\beta nXn + \varepsilon i \qquad 3$$

Where Y = dependent variable (integrator) with 1= sugarcane and soybean intercropping and 0= otherwise;

$\propto$= intercept

εi= error term

$\beta 1, \ldots, \beta n$= coefficients of the independent variables

$X1, \ldots, Xn$= the independent variables (as in the conceptual framework)

$p(Yi = 1)$= probability of sugarcane and soybean intercropping

$1 - p(Yi = 1)$= probability of sugarcane monocropping

and ln= natural log

2.6 Model diagnostic tests

To ensure that explanatory variables included in the model were not correlated with each other, a multicollinearity test was done through a variance inflation factor (VIF) computation. A simple ordinary least square (OLS) regression was estimated with the dependent variable with the rest of the explanatory variables. The VIF quantifies the severity of the multicollinearity in an ordinary least squares regression. According to Gujarati (2004), VIF shows how the presence of multicollinearity inflates the variance of an estimator. The calculation of VIF follows the following formula:

$VIF = \frac{1}{1-R_i^2}$

Where R_i^2 is the R^2 of the regression with the ith independent variable as a dependent variable. Table 2 presents the results of the VIF. The results from the VIF test depicted that the mean VIF is 1.21. the VIF of the explanatory variables ranges from 1.02 to 1.50. The independent variables' VIF is less than five. No significant correlations between independent variables were established, ruling out the possibility of multicollinearity.

Table 2. Variance inflation factor results

Variable	**VIF**	**1/VIF**
Sugarcane Farming Experience	1.50	0.6682
Group membership	1.47	0.6794
Distance to feed source	1.26	0.7936
Credit access	1.11	0.9041
Age	1.06	0.9462
Knowledge of existing feed	1.03	0.9664
County	1.02	0.9846
Mean VIF	**1.21**	

3.0 Results and Discussions

3.1 Socio-Economic characteristics of Intercroppers and Monocroppers

3.1.1 Association of Household Characteristics by Farmer Type (Dummy Variables)

The findings revealed that most farmers were practising sugarcane monocropping (63%) while only 37% were practising sugarcane -soybean intercrop (Figure 3).

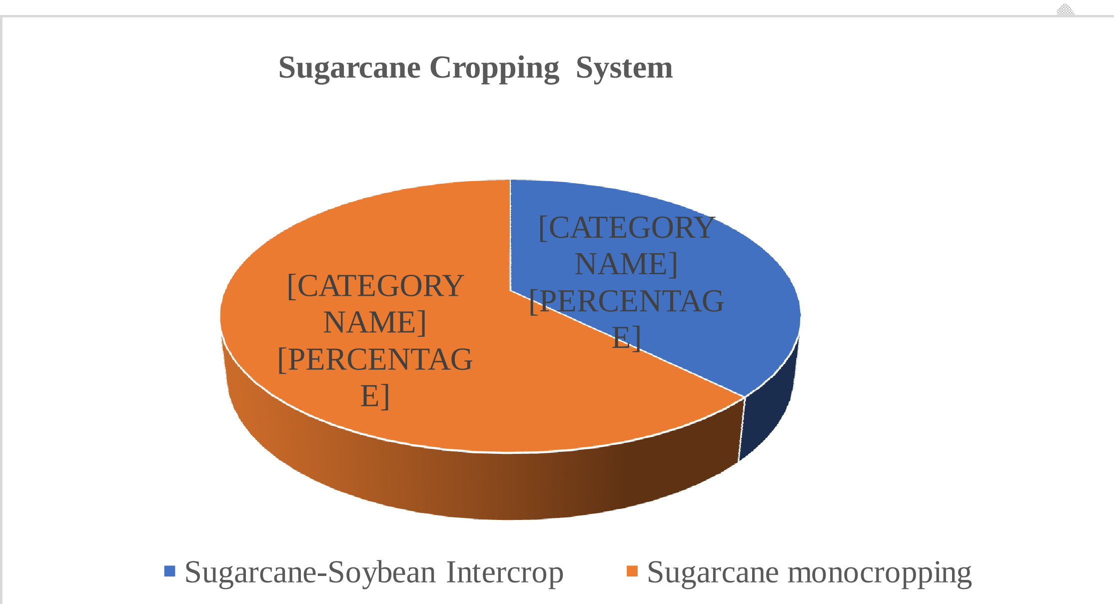

Figure 3. Distribution of respondents per cropping system

Regarding gender, marital status, education level, employment, household head, and sugarcane zone, Table 3 presents the characteristics of farmers who grow sugarcane in monoculture and intercropping with soybeans (intercropped) and intercropping only with sugarcane (mono-croppers). Male farmers made up 65.4% of the farming population, while female farmers made up 34.6%. However, among male farmers, intercropping made up 41.0%, monocropping made up 59.0%, and among female farmers, intercropping made up 30.6%, while monocropping made up 69.4%. Males have higher mobility freedom and involvement in various meetings due to numerous sociocultural values and norms, and as a result, they have better access to information. According to a study by Ong'ayo et al. (2020) assessing factors influencing the adoption of clean seed potatoes, men are more likely to participate in training and activities that deliver information than women because of gender roles set by society. This suggests that men pursue cash-oriented businesses while women spend more time growing food crops. The chi-square test, however, demonstrates that this association was not significant.

Table 3: Association of Household Characteristics by Farmer Type (Dummy Variables)

Variables		Intercroppers (%)	Monocroppers (%)	Aggregate (%)	Chi-Square
Gender	Female	30.6	69.4	**34.6**	**2.57**
	Male	41.0	59.0	**65.4**	
Marital status	Married	40.0	60.0	**75.2**	**1.79****
	Single	43.5	56.5	**9.3**	
	Divorced	9.1	90.9	**8.9**	
	Others	55.6	44.4	**3.7**	
Education level	None	20.0	80.0	**4.1**	**11.29****
	Primary	38.4	61.6	**56.1**	
	Secondary	39.2	60.8	**32.1**	
	Tertiary	33.3	66.7	**4.9**	
	University	28.6	71.4	**2.8**	
Occupation	Farming only	37.1	62.9	**47.2**	**0.603**
	Farming and off-farm business	35.6	64.4	**36.6**	
	Farming and salaried	41.2	58.8	**6.9**	
	Farming and others	43.5	56.5	**9.3**	
Household Head	No	37.8	62.2	**15.0**	**0.004**
	Yes	37.3	53.3	**85.0**	

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

According to their marital status, 75.2% of farmers were married, 9.3% were single, 8.9% were divorced, and 3.7% were in other categories like widowed or a relationship. The 8.9% divorce rate suggests that farmers comprise solid households. Productivity may be impacted because a stable household can concentrate more on production than an unstable one. Farmers who are divorced make up 9.1% of inter-croppers and 90.9% of mono-croppers, while married farmers make up 40.0% of inter-croppers and 60% of mono-croppers. Of the remaining categories, 55.6% of farmers are inter-croppers, and 44.4% are mono-croppers. Compared to single, divorced, or separated households, married households are better equipped to make rational decisions because of varied ideas within the family. The chi-square results showed that the link between farmers who intercrop and those who do not was significant at the 5% level in terms of their marital status.

Regarding education, the majority of farmers (56.1%) had completed primary school, followed by secondary school (32.1%), tertiary school (4.9%), no further education (4.1%), and university (2.8%). At the university level, inter-croppers comprised 28.6% of the population, while mono-croppers made up 71.4%. Because farmers with higher levels of education tend to get more involved in other off-farm activities as their education level rises, the low percentage of farmers with a university education can be linked to this phenomenon. It is generally known that education levels affect how fast people adopt new technology. According to Mishra's (2010) findings, farmers with greater levels of education have easier access to knowledge and information that is useful for their enterprises. Similarly, farmers' knowledge level affects their willingness to learn about new technology and their capacity to comprehend the regulations and programs that might impact the new farming practice (Woldenhanna, T., & Oskam, 2001; Sani, 2017).

Additionally, they frequently have more excellent analytical skills regarding the information and expertise needed to deploy new technologies and achieve desired results successfully. Therefore, having a better education enables farmers to make effective adoption decisions and be the first users of new technologies, reaping the rewards. Additionally, the adoption of sugarcane-soybean intercropping may be influenced by education's role in raising awareness of new technologies.

The results revealed that 47.2% of the households had farming as their sole source of income, while 36.6% had farming and off-farm businesses, 6.9% had farming and salaried work, and another 9.3% had farming and other activities. 37.1% of farmers who relied only on farming for income were inter-croppers, while 62.9% were mono-croppers. The need to subsidise income from employment, protect households from shocks brought on by common business cycles related to volatile sugarcane prices, which is the area's main cash crop, and also protect households from the risks associated with agriculture, which directly or indirectly employs the majority of households, could all be reasons why households have multiple jobs.

85.0% of farmers were in the authority of their households, compared to 15.0% who were not. 37.3% of farmers who were also family heads practised intercropping, while 62.7% practised monoculture. It was acknowledged that non-household heads suffer more difficulties in agricultural output than their peers who are household heads. This results from the fact that non-household heads in rural Kenya, particularly women, are responsible for various duties, such as gathering firewood from the field, carrying water from distant rivers, raising children, and managing the household.

3.1.2 Mean Difference of Household Characteristics by Farmer Type (Continuous Variables)

Table 4 displays the average variations in household characteristics by farmer type. The mean age of inter-croppers and mono-croppers was 42 years, respectively, while the mean age of the entire population was 42 years. The age of the household head significantly influences the adoption of new technology. This might be explained by the older farmers' unwillingness to adopt new practices and their continued use of the outdated ones (Langyintuo and Mulugetta, 2005). Therefore, it is possible to consider the farming households to be youthful and to belong to an economically engaged group.

The aggregate mean household size was six persons, slightly above the national average of 4 members (KNBS, 2019). However, the mean household size of inter-croppers and mono-croppers farmers was 5 and 6, respectively. Household size has been linked to the availability of "own" farm labour in adoption studies. Amsalu and DeJan (2007) found that household size had a significant and positive effect on the determinants of adoption. The argument was that larger households could relax the labour constraints required when introducing new technologies.

While inter-croppers farmers only had 12 years of sugarcane farming experience, non-inter-croppers had 13 years of experience. However, the t-test results showed that the difference in years of experience between the two categories of farmers was statistically significant at 10%. The assumption might be made that mono-croppers are resistant to new technology. Less experienced inter-croppers can experiment with change. This outcome is consistent with research on adopting better wheat varieties, as shown by Kassie et al. (2013).

Table 4 : Mean Difference of Household Characteristics by Farmer Type (Continuous Variables)

Variable	Intercroppers n=92		Non-Intercroppers n=154		Aggregate n=246		t-value
	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.	
Age	41.54	1.17	41.19	0.96	41.32	0.74	-0.221
Household size	4.97	0.27	5.20	0.21	5.11	0.17	0.682
Sugarcane farming experience (yrs.)	11.19	0.92	12.81	0.77	12.20	0.59	1.313*
Soybeans Farming Experience (yrs.)	3.22	0.15	0.00	0.00	1.20	0.12	-26.217*

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

3.1.3 Institutional Characteristics for Discrete Dummy Variables

As shown in Table 5, out of the farmers in the group, 38.5% were intercropping, while 61.5% were mono-croppers. 55.1% of the farmers were members of various groups, while 44.9% were not. Being a group member enables farmers to share ideas and discover the advantages of different cutting-edge technologies. Group members can also easily organise and receive training on various agricultural technology concerns that affect the decision to intercrop sugarcane and soybeans. Participating in a group increases group bargaining power, knowledge sharing, resource mobilisation, and innovation adoption in a good and meaningful way (Shiferaw et al., 2006).

Table 5 : Institutional Characteristic for Discrete Dummy Variables

Variable		Intercroppers %	Monocroppers %	Aggregate	Chi-Square
Group Membership	Yes	38.5	61.5	55.1	0.120
	No	36.4	63.6	44.9	
Extension	Yes	39.4	60.6	26.8	0.153
	No	36.7	63.3	73.2	
Credit	Yes	42.1	57.9	23.7	0.600
	No	36.4	48.5	76.3	

*, **, ***: significant at10%, 5% and 1% level respectively

Farmers highlighted that access to credit (31.30%) was the major benefit of participating in group (Figure 4). Access to credit, pooled labor, joint input purchases, group marketing, group training, advocacy for beneficial agricultural legislation, and unity among member farmers are all advantages of group participation (Owuor et al., 2004). Similary, according to Kassie et al. (2013), membership to a farmer group boosts a farmer's social capital, promoting the sharing of pertinent agricultural knowledge among farmers.

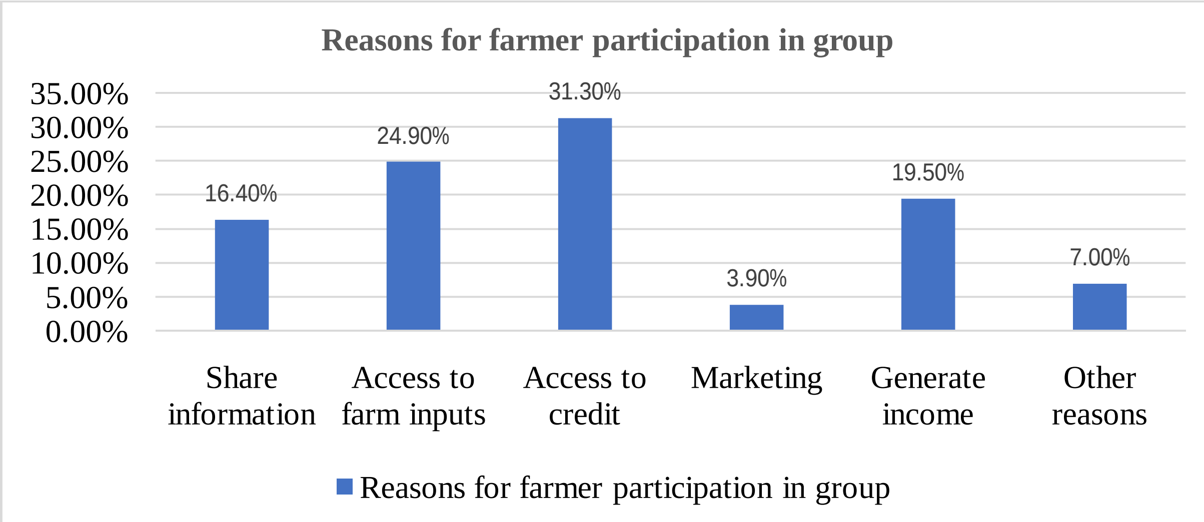

Figure 4. Reasons for participating in groups

The vast majority of farmers (73.2%) lacked access to extension services(Table 5) . Access to extension services was limited to 26.8% of the farmers. 39.4% of farmers who had access to extension services practised intercropping, whereas 60.6% practised monoculture. There is no denying that farmers still have limited access to extension services. Extension services are crucial because they offer the knowledge, expertise, and information necessary for farmers to understand and utilise technology. Extension services are essential to supporting institutional mechanisms created to promote the distribution of information among farmers and demonstrate benefits from new technology (Baidu-Forson, 1999;Thornton, 2010). Access to extension services has favoured the adoption and continued usage of agricultural technologies (Knowler and Bradshaw, 2007).

Similarly, it was discovered that visits by development and extension agents significantly impacted whether or not farmers chose to employ modern agricultural technology. The community can take advantage of the extension officers' guidance on crop management, crop pest control, and the availability of agricultural inputs, among other services. Extension services would educate and empower farmers, enhancing their knowledge and lowering their level of decision-making ambiguity.

Like other entrepreneurial ttendeavours, credit service is required to expand and develop farming operations. For increased business expansion, credit is required. Only 23.7% of the farmers could access credit facilities, leaving roughly 76.3% of the farmers without access to credit to improve their agriculture. 42.1% of the farmers that had access to financing practices intercropped, while 57.9% used monoculture. It is clear that credit availability is still low overall and that inter-croppers have less access to credit than mono-croppers.

3.2 Drivers of sugarcane cropping system

Determining whether the model is adequate to describe the relationship between the dependent and independent variables under examination requires an understanding of the model's fitness.
The pseudo-R squared, the model's P-value, and the Loglikelihood are three of the most important factors that must be taken into account when evaluating a model's fitness. According

to Mbachu et al. (, 012) a pseudo-R squared value of between 0.20 and 0.40 is regarded as exceptionally good while a significant P-value is deemed to be sufficient. This study fulfilled all the minimum criteria necessary to present the findings, i.e., Pseudo – R^2 = 26.22%, %, Prob > chi2 = 0.00159 and Log likelihood = -146.6438. The model summaries demonstrate that the chosen model provided the best match. The logistic regression coefficients demonstrated that a one-unit increase in the predictor variable resulted in log-odds change. The conclusion from this study is consistent with other findings, as shown by studies of statistically significant explanatory variables, which are addressed below.

Table 6: Socio-economic characteristics influencing the decision to integrate or not

Variable	dy/dx	Std. error	Z	P>|z|	X
Sugarcane Farming Experience	-0.0080	0.0044*	-1.83	0.067	12.1577
Age of the farmer	0.0057	0.0034*	1.66	0.097	41.3568
Land acreage under production	-0.0112	0.006*	-1.88	0.061	6.68817
Credit Access	0.1181	0.08259	1.43	0.153	0.2365
Household Head	-0.0573	0.0971	-0.59	0.555	0.8465
Married _Marital status dummy	-0.0279	0.1207	-0.23	0.817	0.7552
Divorced _Marital status dummy	-0.2533	0.1227**	--2.06	0.039	0.0290
Widowed _Marital status dummy	0.3296	0.0727***	-4.53	0.000	0.9129
Other _Marital status dummy[1]	0.0985	0.2095	0.47	0.638	0.0373
Land Ownership	-0.1716	0.9535*	-1.80	0.072	0.8423
Farmer_ Occupation dummy	0.0324	0.0732	-0.44	0.658	0.3734
Farming & Salaried_ Occupation dummy	-0.0007	0.1340	-0.01	0.996	0.0664
Farming & Others_ Occupation dummy[2]	0.0849	0.1258	0.67	0.500	0.0913

*, **, ***: significant at 10%(p =<0.10) , 5% (p =<0.05) and 1%(p =<0.01) level respectively; [1] and [2] are dummies

The intercropping of sugarcane and soybeans was negatively correlated with the variable sugarcane farming experience, which was significant at the 10% significance level. Contrary to what was predicted, the sign indicates that the likelihood of integrating sugarcane and soybean growing reduces as the sugarcane farming experience increases. One more year of sugarcane farming experience reduces the likelihood of intercropping by 0.008 percent. A plausible explanation is that some farmers have mastered sugarcane farming due to their experience and knowledge gained over a long period of observation and experimentation. Combined with their advanced age, these farmers are likely to be more risk-averse and less willing to change their cropping systems to include sugarcane soybean intercropping. Adopting sugarcane-soybean intercropping may also be hindered by unfavorable past experiences with sugarcane intercropping. These findings corroborate that of Bonabana-wabbi & Taylor (2002), who noted that expanded use of intercropping cowpeas with cereal crops as an IPM technique in Kumi District, Uganda, was discouraged due to earlier experiences with intercrops' subpar performance.

Age is seen as a primary latent feature in technology adoption decisions, according to Mugwe et al. (2012). The intercropping of sugarcane and soybeans positively correlated with the farmer's age, which was significant at the 10% significance level. As household age rises, the indicator shows a higher likelihood of intercropping sugarcane and soybeans. Older household heads may have amassed more resources and expertise necessary for technology adoption than younger household heads over time may help explain the positive influence of age on intercropping sugarcane and soybean. Nchinda et al. (2010) and Tassew & Oskam (2001) reported similar findings. However, some studies have indicated the opposite; for instance, Shahbaz et al. (2017) discovered a negative association between crop diversification and age.

The variable land ownership and land acreage had a 10% statistical significance and detrimental effect on sugarcane and soybeans' intercropping. The likelihood of engaging in sugarcane-soybean intercropping was 17.1% lower among farmers who owned the land utilised for agricultural production. Similarly, a unit more land would result in a 1.1% lower chance of engaging in soybean-sugarcane intercropping. This trend can be explained by the fact that landowner farmers frequently have preferences for crops, focusing on ones like sugarcane that they view as lucrative. This was contrary to previous finding such that of Everlyne et al. (2013) who found that farm size had a positive influence on technology adoption. It has been claimed that the high fixed costs of small farms hinder them from embracing new technologies.

Divorced and widowed farmers had statistically significant differences of 5% and 1% compared to single farmers. According to Wood et al. (2008), a fast-expanding body of research suggests marriage has various benefits, such as improving an individual's financial situation, physical and mental health, and the well-being of their children.

3.3 Challenges affecting sugarcane- soybean production

In this study, the high cost of farm inputs(29.70%), and lack of credit for farm operation(35.8%), among other factors(38.5%), are the major challenges affecting sugarcane production in Awendo sugar belt. A study by Adrian et al. (2013) on the factors affecting sugarcane production in Pakistan identified the cost of inputs; land preparation, fertiliser, seed cane, weeding, and irrigation as key determinants of sugarcane returns. The study identified the high price of inputs, low price of outputs, delay in payments, and lack of scientific knowledge as major problems in sugarcane production. Tilman et al. (2002), in their study on Agricultural sustainability and intensive production practices, observed that incentives are necessary to enable farmers to carry out more farming activities

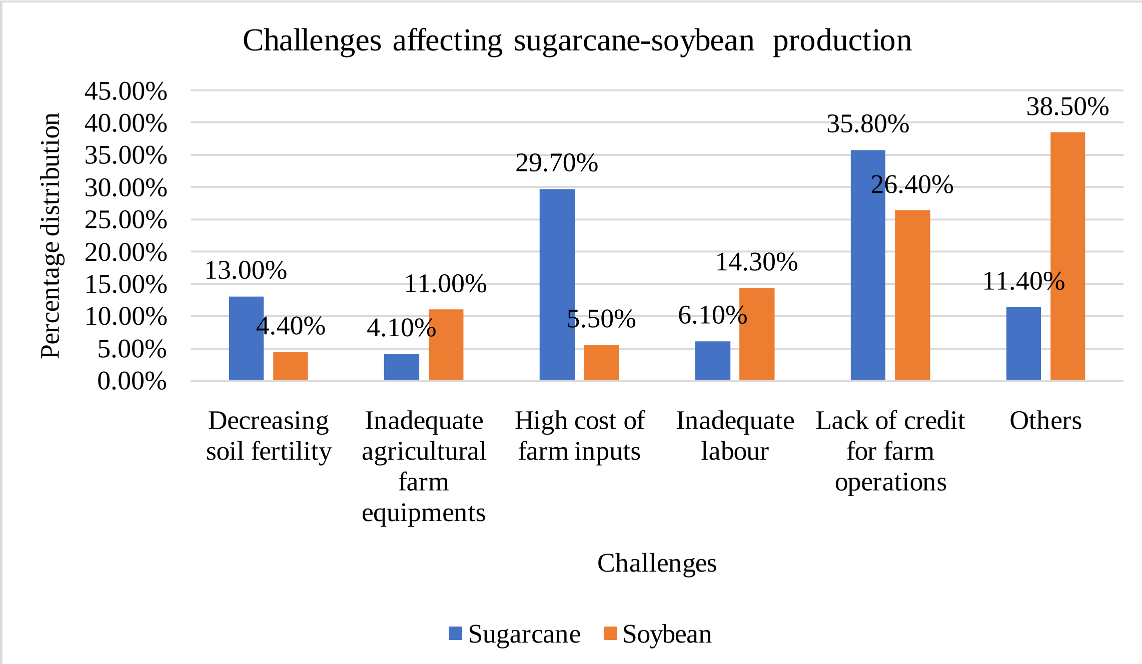

Figure 5. Challenges affecting sugarcane - soybean production

4.0 Conclusions and recommendations

This study provides policymakers, academics, and extension workers with information about the development of effective smallholder farmer intervention strategies. Despite the numerous studies that have demonstrated the advantages of soybean in sugarcane production systems, policymakers must understand the impact of different socio-economic factors, such as sugarcane farming experience, age of the farmer, land acreage under production, marital status (divorce and widowed), and land ownership, have on farmers' decisions to adopt sugarcane-soybean intercropping. Further,the study revealed that high cost of farm inputs and lack of credit for farm operation are the major challenges affecting sugarcane production in Awendo sugar belt

From the empirical results, since age was affecting the choice of sugarcane cropping system, stakeholders in the agricultural sector need to devise initiatives to draw more young into agricultural production to provide employment. Additionally, policies are required to address the lack of farming experience by delivering targeted training programs that would fill in the knowledge gaps of such farmers on better intercropping practices. The production of sugarcane and soybeans should be increased by encouraging mono-croppers to use inter-cropping technology by educating them on its advantages.

Therefore, the study suggests that enhancing the value chains for soybean and sugarcane crops can promote using multiple cropping systems based on legumes. The study recommends thus that future studies should assess other factors influencing adoption; cost-benefit analyses of the adoption of sugarcane cropping systems should be conducted to dispel any skepticism among smallholder farmers likely to adopt sugarcane-soybean intercropping systems; and effective policies should be put in place to improve farmers' knowledge and skills, strengthen their capacity to cover associated costs.

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