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Circular agricultural practices among smallholder farmers in Nakuru County, Kenya: Defining the determinants

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Abstract

Efficient use of resources, recycling, and reusing agricultural wastes improves agricultural productivity. However, most smallholder farmers continue to use the principles of the linear economy, which affects the environment and agricultural productivity. To bridge this gap, this study examined the variables influencing the adoption of circular agriculture practices among smallholder farmers in Nakuru County, Kenya. This research focuses on three circular agriculture practices: mixed crop-livestock, intercropping, and organic farming, among others. Primary data was collected using semi-structured questionnaires through a survey approach. Using a multistage sampling technique, 384 respondents were sampled, and a multivariate probit model was used to determine the factors influencing the adoption of circular agriculture practices. The results from the multivariate probit model revealed that farming experience, farm size, group membership, and access to credit had a positive and significant influence on the adoption of circular agricultural practices, while age, education, land tenure, group membership, and distance to the market negatively influenced the adoption of circular agricultural practices. Therefore, farming experience, farm size, group membership, and access to credit have a significant influence on the adoption of circular agriculture practices among smallholder farmers. Policies focusing on knowledge and information transfer to smallholder farmers should give priority to educating smallholder farmers and influencing their decisions towards circular agronomic practices. This paper therefore recommends support programs in the form of credit access for the adoption of circular agriculture. This research therefore recommends support programs for group membership to disseminate information, as well as strategies to trigger the widespread adoption of best circular agriculture practices

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1. Introduction

One of the expected global challenges in the future will be ensuring that resources are available, accessible, and able to meet the needs of all living beings. With the ever-increasing world population, the pressure on extraction and usage of resources is expected to continue growing. Furthermore, it is predicted that the world population will require 35% more food in 2030 than it does today (Coopers, 2016). To ensure that all living human beings and animals will live healthy and have access to resources, it is necessary to examine how resources are being used in this generation. In today's economy, the linear economic model is the mainstream method of production where resources move from extraction to use and disposal without the recycling of resources. Tonnes of raw resources are extracted and used globally without circularity of resources (Oberle *et al*., 2018). The widespread use of finite resources at an alarming rate is not economically feasible, as it will have severe effects on all living organisms and the future generation (CSIRO, 2021).

To revert this trend, it is necessary to reconsider how resources are used to minimize resource depletion and environmental damage (Hassan *et al*., 2019). This can be accomplished by shifting the economy away from the present "take-make-waste" model and towards the circularity model, which emphasizes reuse and recycling. As the degradation of the environment and depletion of resources continue to proliferate, the need for a circular economic model that emphasizes reuse and recycling is growing (MacArthur Foundation, 2014; MacArthur, 2017). A circular economy is a closed-loop system in which commodities destined for waste are reused, recycled, or reprocessed (Koszewska, 2018). In a circular economy, consumables such as wood, humus, and living creature waste that are made of biological materials can be returned to the biosphere. In addition, these products can biodegrade over time, returning nutrients to the environment (WEF, 2021). For a long time, principles of circular economy have been applied to the farming sector. Interestingly, most of the problems being addressed by the principles of the circular economy are interconnected and relevant to the farming sector (Nattassha, 2020). Circularity in agriculture involves recycling and regenerating waste from plants and animals into reusable materials such as manure. As a result, a new value may be produced from resources that were previously considered waste. The principle of circularity in agriculture seeks to ensure nutrient recycling and minimize the necessity for using external inputs (FAO, 2021). Circular agricultural practices, which allow farmers to reuse resources and reduce reliance on external inputs, can help increase productivity and decrease their exposure to climate variability (De Boer & Ittersum, 2018; Helgason *et al*., 2021).

Circularity is closely related to mixed crop-livestock farming, which is characterized by growing crops and rearing livestock (Helgason *et al*., 2021). In mixed farming, farmers use resources more efficiently by using crop remains as manure and livestock feed, while using remains from livestock as manure for crops. This demonstrates the interdependence between the two enterprises. This has a natural effect of promoting carbon and nutrient recycling in soil-crop-animal systems (Bista *et al*., 2024). Mixed farming can reduce the need for external inputs, thereby increasing resource use efficiency (Rayns *et al*., 2021).

Circularity in agriculture can also be practiced by practicing organic farming that focuses on reducing the use of chemical fertilizers, pesticides, and plastics. Organic farming also requires a wide knowledge of the interrelations of plants and animals to manipulate their properties to wade off pests. Although it has arguably been a persistent debate whether pests tend to be higher in numbers under organic agricultural practices or conventional practices, the chemical-laden conventional management systems where synthetic fertilizers are used to promote growth and pest control tend to have a negative effect of threatening non-target organisms, thereby impacting species composition and modifying global biodiversity in particular ecosystems (Koh *et al*., 2021).

Circularity in agriculture can also be promoted by practicing intercropping. Intercropping practices involve the planting of more than one crop on the same plot, where the growth of one crop provides favorable conditions for other crops (Helgason *et al*., 2021). This relation among plants can help farmers to use less resources, such as water and fertilizer. Furthermore, with intercropping, farmers can harvest better yields from the different crops being grown. This practice is closely related to permaculture. Although not a focus of this paper, permaculture is not only sustainable but also improves the properties of soil and is inclusive of a wide variety of vital green activities. Most importantly, it is a strategy most fitting in these times of climate change due to its high retention of desperately needed moisture in the soil (Vovk & Buheji, 2018).

Transitioning to circular agriculture practices should not be viewed as a return to traditional farming but rather as a means to farm with nature while maximizing earnings and actively utilizing scientific discoveries (Helgason *et al*., 2021). Circular agriculture practices, which promote the efficient use of resources, can increase productivity per acre as well as protect the environment. Therefore, circular agriculture practices are necessary for farmers to address the needs of a continuously increasing population without causing harm to the environment. This has a strong connection with the ideals of the Sustainable Development Goals, especially the idea of making sure that future generations have access to land resources in their time.

As the government of Kenya implements policies and programs in line with circularity in agriculture, aimed at increasing productivity, protecting the environment, and ensuring sustainability, smallholder farmers need to take advantage of this opportunity by adopting circular agriculture practices. Poor agricultural practices and unsustainable practices that involve linear practices severely affect the environment and agricultural productivity due to resource depletion and high input costs. Therefore, efficient use of resources, recycling, and reusing agricultural wastes is needed to improve agricultural productivity. The application of circularity in agriculture follows farming practices such as mixed farming, organic farming, and intercropping. Most smallholder farmers continue to operate following the principles of the linear economy, especially as it relates to growing specialized commodities such as maize and other crops. This has, and was, greatly influenced by the introduction of cash crop and export crop farming to Africa in the 1900s (Bjornlund *et al*., 2020). This increased the hectarage under crops, promoting the over-extraction of natural nutrients to a point where supplementary feed for the soil was necessary for effective productivity as a result, undermining environmental quality.

Research about the circular economy has primarily focused on its relationship with environmental protection. Several researchers have not explored the factors that influence the adoption of circular agricultural practices. Consequently, there is limited information regarding factors that influence the adoption of circular agriculture practices. Investigation into the factors that influence the adoption of circular agriculture by smallholder farmers in Kenya will be the motivating factors for the Kenyan government and other supporting non-governmental organizations to develop programs, policies, and support that will ensure a full transition to circular agriculture practices. This study aims to identify circular agricultural practices and determine the factors that influence the adoption of circular agriculture practices among smallholder farmers in Kenya.

2. Materials and Methods

2.1 Study Area

The study area was Nakuru County, Kenya. The study location was purposively selected because 60% of the households in Nakuru County are dependent on farming as their major occupation. The county lies along the longitudinal coordinates of 35°28' and 35°36' east and the latitudinal coordinates of 0°13' and 1°10' south. Nakuru comprises 11 sub-counties: Njoro, Gilgil, Bahati, Naivasha, Nakuru Town West, Nakuru Town East, Kuresoi South, Kuresoi North, Molo, Rongai, and Subukia. The county's agricultural industry encompasses several activities, such as beekeeping, fishery, crop production, and livestock production. The county's designated land area for food crops is 243,711.06 hectares, while the area allocated for cash crops is 71,416.35 hectares.

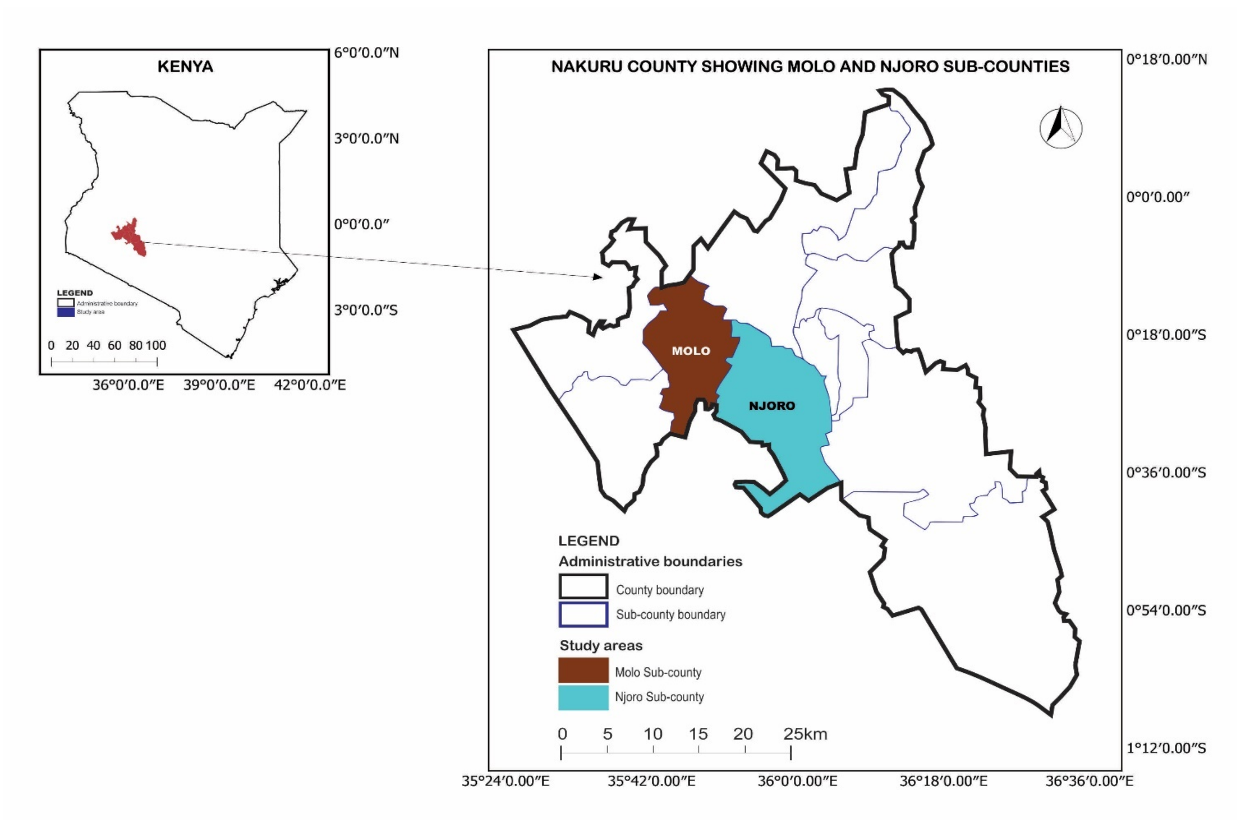

Figure 1: Map of the Study Area

a. Sampling Design

To determine the sample size of the research, a multistage sampling technique was employed. The initial step involved selecting Nakuru County, where 60% of the population engages in farming. Additionally, smallholder farmers in this area have not yet fully adopted circular agriculture practices. Furthermore, in support of circularity in agriculture, organizations such as the Kenya Organic Agriculture Network (KOAN) and other non-governmental organizations have trained extension agents and offered extension services to approximately 5,000 farmers in Nakuru County to promote these practices. In the second step, Njoro and Molo sub-counties were chosen due to their high farmer populations. The third stage consisted of systematic sampling within each sub-county, using the Kth sampling interval as provided by the sub-county agricultural officer.

. $K - \frac{N}{n}$ K- is the sampling interval. N – is the total number of farmers in the cluster n- is the sample size in each Cluster.

2.3 Sample design and Data sources

The study used primary data collected using semi-structured questionnaires that were directly administered to the farmers in the study area. The questionnaires included both closed and open-ended questions. The researcher employed semi-structured questionnaires to enable respondents to elaborate in particular on issues of circular agricultural practices.The study used descriptive statistics to determine the common circular agricultural practices as well as the characteristics of the respondents. In addition, a multivariate probit regression model was used to determine the factors that influence the adoption of circular agriculture practices.

2.4 Multivariate Econometric Model Specification

A multivariate probit regression analysis was used to determine the factors that influence the adoption of circular agriculture practices among smallholder farmers. This model was appropriate because smallholder farmers practice different methods of circular agriculture. Farmers tend to differ in the choices of circular agriculture practices they adopt since they have different adaptive capacities, preferences, and objectives (Banerjee *et al*., 2014). Faced with various circular agriculture practices, it is possible that the number of circular practices that are adopted will not be independent but interdependent. To maximize expected utility under these circumstances, farmers must choose a set of farming practices that best suits their needs. In this study, the multivariate regression probit model is appropriate because individual smallholder farmers can choose more than one circular agricultural practice. The multivariate probit model econometric analysis simultaneously estimates the influence of all explanatory variables on different circular agriculture practices. In this model, unmeasured factors and unobserved factors are freely correlated (Belderbos *et al.*, 2004; Lin *et al.*, 2005).

A smallholder farmer I chooses a given circular agricultural practice based on the expectations of maximizing utility (i.e., profit) he or she expects to gain by practising circular agriculture. Smallholder farmers decide to choose a particular circular agricultural practice or not by evaluating the expected returns in utility, considering the related transaction cost and investments. Smallholder farmers select the circular agricultural practice that shows the most positive utility. According to Greene (2012) a multivariate probit regression model is specified as follows:

$$Y_{ij}^{*} = X_{ij}\beta_j + \varepsilon_{ij}\,, \quad (j = M,O,I) \text{.................Equation 1}$$

The equation for each choice of Circular agriculture practices adopted by households is given as:

$$Y_{ij} = \begin{cases} 1 & if\, Y_{ij}^{*} > 0, \\ 0 & otherwise \end{cases} \text{...............................Equation 2}$$

Assuming that we have different circular agriculture practices mixed farming, organic farming and intercropping that are represented by $J = M, O, I$. In this circumstance, i^{th} smallholder farmer chooses to adopt J^{th} circular agriculture practices. *Yij* also represents a preference for using j^{th} practices of circular practices. This latent variable was presumed to be a linear combination of observed characteristic X_{ij} that influences the adoption of circular farming techniques, in addition to the unobserved elements that are expressed using a stochastic error term ε_{ij}. In this model, the vector of the parameter estimated can be represented using β_j. Considering the nature of the latent variable, estimations used in this research estimations in this study are based on observable binary discrete variables Y_{ij}, that now show whether a smallholder farmer has adopted or not adopted a circular agriculture practice. Assuming the adoption of more than one circular agriculture practice co-occurs, in this case, the error terms follow a multivariate normal distribution i.e.

$$(\varepsilon_{i1}, \varepsilon_{i2}, \varepsilon_{i3})' \backsim MVP\left(0, \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{21} & 1 & \rho_{23} \\ \rho_{31} & \rho_{32} & 1 \end{bmatrix}\right) \text{..............} \quad \text{Equation 3}$$

Where ρ_{mj} represents the pairwise correlation coefficient of the error terms of the estimated adoption equation of circular agriculture practices. The implicit functional form of the variables that influence the adoption of circular agriculture practices among smallholder farmers was estimated as:

$$Y_{ij} = \beta_0 + \beta_1 age + \beta_2 gender + \beta_3 Ed + \beta_4 \text{Hhsz} + \beta_5 \text{Fsize} + \beta_6 ExSv + \beta_7 \text{Grpm} + \beta_8 Pp + \beta_9 ACC + \beta_{10} Dist + \beta_{11} Ac + \beta_{12} Lt + \beta_{13} Coo + \beta_{14} Ex + \varepsilon_i$$

.... Equation 4

Table 1: Description of Variables in the Table and Expected Signs in the Multivariate Probit Model.

List of Variables	Descriptions	Measurement	Expected Sign
Dependent variable	Circular Agriculture practices (1=organic farming, 2=mixed farming, 3=intercropping)	1=yes, 0=otherwise	
Independent	**Variables**		
Age	Age (years) of the farmer	Number of Years	+/-
Gender	Gender	Dummy 1=Male 0=Female	+/-
Ed	Educational Level	Number of years	+
Hhsz	Household Size	Number of individuals	+/-
Fsize	Farm size (acres)	Acres	+/-
ExSv	Extension per season	Dummy 1=Yes 0=No	+
Grpmber	Group membership	Dummy 1=Yes 0=No	+
Pp	Personal preference	Dummy 1=Yes 0=No	+/-
Acc	Credit access per season	Dummy 1=Yes 0=No	+
Dist	Distance (Km) to farm	Distance in kilometres	+/-
AI	Access to information	Dummy 1=Yes 0=No	+/-
Instelec	**Land tenure**	**Dummy 1=Yes 0=no**	+/-
Coo	**Cooperation**	**Dummy 1=yes 0=No**	+/-
Ex	**Experience (years)**	**Dummy 1=Yes 0=No**	+/-

3. Results and Discussion

3.1 Socioeconomic Characteristics of the Respondents

Table 2 shows the socioeconomic characteristics of smallholder farmers practicing circular farming practices. Many of the key informants of all the circular agriculture practices were male respondents. This is probably because traditional gender and cultural norms often place women in submissive positions in farming households.

Nkansah-Dwamena (2023) pointed out that gender often constrains women to an unequal position in society when it comes to making agricultural decisions, such as practicing circular agriculture farming practices. The findings of the study in Table 2 show that all the participants in circular agriculture practices were educated. Specifically, it is noted that most of the research participants had reached the secondary level of education. Additionally, the findings regarding marital status reveal that most of the participants were married and that most of them lived in households with four to six members.

Furthermore, a significant number of the farmers in circular agriculture also had more than 11 years of farming experience. Results of landholding revealed that all respondents had a landholding in the range of 1 acre to 10 acres, and on average, a smallholder farmer had a land size of 2.30 acres. A good proportion of the participants had a land size ranging from 1 to 2 acres. The results show that the majority owned land, while fewer of the respondents rented land. Besides that, some participants stated that they owned land at the same time as renting land. Land tenure security is a catalytic advantage that motivates farmers to adopt and invest in farming practices (Soma, 2020). The majority of the respondents grow different crops, with most growing maize and common beans. The participants in circular agriculture practices also rear several kinds of livestock, which are cattle, sheep, goats, and chicken birds. mixed crop-livestock farming, intercropping, and organic farming.

Lastly, the results indicate that the circular agriculture farming practices being carried out by smallholder farmers are mixed farming, intercropping, and organic. Among these farming practices, intercropping was discovered to be the most practiced circular agriculture practice. It was also found that a minority of the participants practice organic farming.

Table 2: Socioeconomic Characteristics of the Respondents in Circular Agriculture Practices

Variables	Frequency	Percentages (%)
Gender	**(N) =384**	
Male	210	55
Female	174	45
Age of Respondents	**(N) =384**	
21-30 Years	36	9
31-40 Years	128	33
41-50 Years	155	40
Above 50 Years	65	17
Education Level	**(N) =384**	
Primary school	114	29
Secondary school	196	51
College	65	17
University level	9	2
Marital Status	**(N) =384**	
Single	16	4
Married	342	89
Divorced	10	3
Widowed	10	3
Separated	6	2
Household size	**(N)=384**	
1-3	69	18
4-6	199	52

7-9	103	27
Above 9	13	3
Farming Experience	**(N)=384**	
Less than 3years	6	2
3-5 years	53	14
6-8years	40	10
9-10 years	64	17
11years	221	58
Farm Size (acres)	**(N)=384**	
1-2	259	68
Above 2-4	89	23
Above 4-6	27	7
Above 6	9	2
Land Ownership	**(N)=384**	
Land owned	305	76
Rented Land	49	13
Both rented and owned	30	8
Livestock name	**(N)=384**	
Cow	285	74
Sheep	163	43
Goat	40	10
Poultry birds	121	32
Crop name	**(N)=384**	
Maize	384	100
Beans	347	90.36

3.2 Factors influencing the adoption of Circular Agriculture Practices among Smallholder Farmers.

To analyse circular agriculture practices, the study used independent variables that were drawn from socioeconomic factors, bio-physical factors, farm characteristics, farmer characteristics, and institutional factors. The respondents to circular agriculture in the study area include farmers practicing mixed farming, organic farming, and intercropping. To better understand the variables that influenced the adoption of circular agriculture practices, a multivariate probit analysis was used. The results from the multivariate analysis are presented in Table 3. The use of a Wald x2 test (x2(3) = 44.0088, p =0.0000) indicated that the subsets of the model's coefficients were jointly significant. Based on the Wald Chi-square test results, all the variables that were used in the model had satisfactory explanatory power, suggesting that the use of a multivariate probit model was appropriate in this study. Results from the study shows that, the null hypothesis of the different circular farming practices being independent, was rejected at a 1% significant level. The multivariate probit analysis was significant; the null hypothesis of a choice of the three circular farming practices is independent, and it was rejected at a 1% level. The likelihood ratio test in the analysis (x2 (3) =44.0088) prob > x2 =0.0000 was significant, showing that circular farming practices choices and decisions were interdependent (rho21=rho31= rho32 =0); this shows a joint correlation for the estimated coefficients across the equations. The significant correlation coefficient in the error term indicated a normal distribution with a mean of 0. Hence, the decision to use one circular agriculture technique influences the decision to use another. Several variables were hypothesized to evaluate the variables that influence the adoption of circular agricultural practices. Farm size, group membership, credit access, and farming experience had a positive and significant impact on circular agriculture practices. In addition, the age of the farmer, the level of education group membership, and the distance between the farm and the marketplace negatively influenced circular practices and was significant.

Table 7: Results of the Multivariate Probit

	Mixed Farming		Organic Farming		Intercropping	
/ atrho21	.3074	.1228				
Variables	**Coeff.**	**Rob.Std. Err**	**Coeff.**	**Rob. Std. Err**	**Coeff.**	**Rob.Std. Err**
Age	-.1022	.0907	.2880***	.1098	-.0150	.0970
Gender	.0747	.1437	.0808	.1697	.0369	.1547
Household Size	.0993	.0871	-.0007	.1145	-.1103	.0860
Education	.1156	.0993	.0708	.1108	-.4041***	.1072
Farming Experience	.1680**	.0722	.0024	.0825	-.1234	.0825
Farm Size	.3556***	.1027	.0682	.0462	-.0615	.0472
Land Tenure	-.3353***	.1174	-.0868	.1373	.0875	.1192
Training	-.1501	.2212	.1460	.2498	-.5241**	.2258
Extension Service	.1867	.1711	-.0446	.1956	-.0289	.1738
Access to Information	-.2149	.2103	-.0669	.2427	.2518	.2029
Group Membership	.2546**	.1281	.2957**	.1393	-.2436*	.1401
Access to credit	.1288	.2016	.3322*	.1959	.5776***	.2100
Distance to the market	.0023	.0100	-.0105	.0095	-.0165**	.0066
_cons	-.5683	.4519	-.2.7792	.6653	2.7820	.5303
/atrho31	-.3984	.1055				
/atrho32	-.5391	.1111				
rho21	.2981	.1119				
rho31	-.3786	.0904				
rho32	-.4923	.0841				

*, **, ***, denotes significance level at 10%, 5% and 1% respectively,

Likelihood ratio test of rho21 = rho31 = rho32 = 0 :

Chi2 (3) = 44.0088 prob > chi2 = 0.000

At a 1% significant level, the farmer's age positively and significantly influences the adoption of organic farming. This shows that older farmers are more comfortable with practicing organic farming. The cultural belief that organic farming improves and preserves soil fertility is one of the reasons older farmers adopt organic farming practices. The research findings correspond with those of Ntshangase *et al*. (2018), who concluded that older farmers were more involved in growing crops organically. However, the study findings are contrary to Nkonki-Mandleni *et al*. (2022) and Okon and Idiong (2016), who suggested that a farmer's age is negatively related to the uptake of conservation farming and organic vegetable farming, respectively.

Additionally, education level negatively and significantly influences the adoption of intercropping as a circular agriculture practice. This implies that the more years of education a farmer receives, the lower the probability of adopting intercropping. This is probably because farmers consider intercropping an old practice they have been practicing since the early years, and therefore most of the farmers have been educated and shifted to modern agriculture that emphasizes a more market-related economy, which tends to favor intensive monocropping systems. In support of this, Kanyenji *et al*. (2022) found that intercropping was negatively and significantly influenced by educational level. Furthermore, Kanyenji *et al*. (2022) reported that farmers in Kenya have been practicing intercropping since the early 1970; however, as farmers got educated, they considered intercropping an old practice of farming and opted for new farming methods such as inorganic fertilizer applications. Furthermore, as a farmer gets more educated, they are more likely to get extra income from the job, which will provide enough disposable income to purchase fertilizers.

At a 5% significant level, farming experience positively and significantly influences the adoption of mixed farming as a circular practice. Agricultural technologies and innovations are more likely to be adopted by farmers with much experience. Farmers who are more experienced in farming can take the risk of adopting farming practices. Many years of farming tend to give more practical experience, therefore promoting the adoption of a farming practice. Similarly, Bongole *et al*. (2022) found that farming experience positively and significantly influences the use of multiple climate smart-agriculture practices. Additionally, Moshi *et al*. (2016) reported that practicing legume intercropping is positively and significantly influenced by prior practical experience in maize production.

The adoption of mixed farming was positively and significantly influenced by farm size. This suggests that farmers who own larger land sizes engage in crop-livestock mixed farming. Mixed farming involves more than one enterprise, mainly crop and livestock production, which tends to require a large piece of land. Research by Shahbaz *et al*. (2017) also concluded that mixed farming is positively and significantly impacted by farm size. Furthermore, Tamirat (2022) and Serote *et al*. (2021) also reported the scale of operations having a significant effect on the adoption of Climate-Smart farming and irrigation technologies, respectively. However, the findings differ from those of Njuguna (2022), who reported a negative and significant influence on the uptake of climate-smart agriculture practices. In contrast, a report by Samiee *et al*. (2009) found farm size has an insignificant or neutral relation with the adoption of farming practices.

The results indicate that mixed farming practice is negatively and significantly associated with land ownership at a 1% significant level. This means that ownership of land by smallholder farmers reduces the likelihood of practicing mixed farming by 33.5%. In as much as smallholder farmers wish to practice mixed farming, the majority of the smallholders who own land have between 1-2 acres. The small land holdings make it less suitable since production capacity is greatly affected on a small land area. Some farmers reported animals destroying the crops grown for both consumption and sale, influencing their decision to detach themselves from practicing mixed farming. Feed scarcity for animals was also reported by farmers since small land holding is only prioritized for food and cash crops rather than fodder or animal feeds. This is consistent with findings from Mekuria and Mekonnen (2018), who reported that the larger the land area owned by smallholder farmers, the higher the possibility to diversify to crop-livestock farming in Ethiopia and vice versa. Additionally, Baker *et al.* (2023) argue that ownership of limited land sizes hampers the ability of smallholder farmers to practice mixed farming.

At a 5% significant level, training related to circular agriculture negatively and significantly affects the adoption of intercropping. The more the farmers got the training, the less they would embrace intercropping. The plausible explanation is that these farmers received training on other agricultural practices other than intercropping. The study findings tend to corroborate the results of Nkonki-Mandleni *et al*. (2022), who reported that training farmers negatively and significantly affected the adoption of conservation agriculture. Bazezew (2015) also found that training negatively and significantly affects farmer's ability to adopt new farming innovations. Other studies have contradicted the findings. For example, Ferrer (2023) found that attendance at training sessions for climate-smart agriculture technologies was highly significant and positively impacted adoption. In a study by Ouya (2019) and Udensi (2012), training had a neutral effect on farmer's decisions to adopt farming practices.

At a 5% significant level, group membership positively and significantly affects the adoption of organic farming. Furthermore, group membership also influenced the adoption of intercropping negatively and significantly at a 10% level. Farmers in a group have a higher likelihood of implementing organic farming than intercropping. This is because participating in a group enables farmers to share knowledge, pool resources, and take collective action. In research by Mulimbi *et al*. (2019), group participation was found to influence the adoption of conservation agriculture positively and significantly. The formation of several circular agriculture-related farmers' groups can be used to encourage the uptake of circular agriculture practices. Furthermore, these groups can be used as a medium for knowledge sharing and promoting circular agriculture practices. According to a study by Hove and Gweme (2018), the development of woman-related farming groups that provide opportunities to participants was found to increase women's adoption of conservation agriculture. Bassa and Mechare (2021); Dhraief *et al*. (2019); Ntshangase *et al*. (2018); Kanyenji *et al*. (2020); Kyaw *et al*. (2018) reported similar findings to our results. At a 10% significant level, group membership negatively and significantly affects the adoption of intercropping. This can be a result of members of the group not exchanging and sharing information about intercropping.

Access to credit positively influences organic and intercropping at 10% and 1% significance, respectively. Credit enables farmers to buy the agricultural inputs required for farming. The more farmers acquire credit, the greater the possibility of practicing intercropping and organic farming practices. Credit is essential in relaxing the financial burdens for smallholder farmers (Nkonki-Mandleni *et al*., 2022). These results align with findings reported by Bassa and Mechare (2021) that access to credit funds encourages farmers to adopt food crop technologies. A study by Ullah *et al*. (2020) found that adopting improved farming technologies is strongly and significantly correlated with having access to credit. The study findings also collaborate with Abdallah (2016) and Sedem *et al*. (2019). Contrary to this, Gikonyo (2019) reported that accessing credit funding has a negative and significant influence on motivating farmers to choose farming practices. They further argued that smallholder farmers tend to have a fear of using debt capital or loans on farm developments in fear of losing their collateral in cases of failing to pay them back. In this case, they prefer using their capital for investments. Making use of their finances is preferred. Results from a study by Mukundente (2021) showed access to credit had a neutral or insignificant effect on the uptake of agroforestry.

Distance to the market negatively influences intercropping at a 5% significant level. Intercropping will be adopted by small-scale farmers closer to the marketplace than those far away. In a study by Min et al. (2016), the distance between farms and the marketplace was found to influence the adoption of intercropping negatively and significantly. A study by Bassa and Mechare (2021) also found that market distance negatively and significantly influenced the use of agrotechnology. Kyaw *et al*. (2016) also reported that the distance between the farm and the marketplace is negatively correlated with marketing activities among smallholder farmers. Gebresilassie and Bekele (2021) reported in a different study that fertilizer use was negatively and significantly connected to the distance to market centers. However, other authors have found results that are different from this. Tefera (2016) found that the distance of the farmer to their market positively and significantly impacts the uptake of maize and teff technologies. Kanyenji et al. (2020) also reported that the distance between the farm and the marketplace was statistically insignificant when practicing multi-soil enhancing practices.

Conclusion

The most widely and commonly used circular agriculture practice in Nakuru County, Kenya, is intercropping, followed by mixed farming and lastly organic farming. Age, education, farming experience, farm size, land tenure, training, credit access, group membership, and the distance between the farm and the marketplace are the factors that significantly influence the adoption of circular farming practices in Nakuru.

Recommendation

Therefore, any public or public interventions aimed at promoting the adoption of circular agricultural practices should target socioeconomic factors such as age, education, farming experience, farm size, land tenure, training, credit access, group membership, and the distance between the farm and the marketplace. In addition, the government and other NGO partners can support circular agriculture practices through the provision of credit facilities that are tied to specific circular agricultural practices. Implementing these principles will ensure the widespread adoption of the practice, and also its effectiveness will guarantee that no resources are wasted and at the same time promote residual flows in circularity. Lastly, there is a need to intensify training on circular agriculture practices while emphasising its contribution to food, income, and environmental security, especially during these times of climate variability and change (which are regarded as threat multipliers) and have been observed to cause hardships among smallholder farmers relating to lack of inputs.

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Conflict of interest

The authors have no conflict of interest to declare.

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