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The Impact of Cooperative membership on Adoption of Modern Technology by Bee farmers in Kenya.

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ABSTRACT

The main aim of this research is to examine the impact of cooperative membership on adoption of modern technology by bee farmers in Kenya. This study's data comes from a bee farmers survey in Baringo County, Kenya using a sampling size of 201 households. Probit, logit and Instrumental variable models were incorporated to test for the estimation of relationships and the information generated imported into the SPSS computer application (SPSS 2015) and STATA MP 17 for statistical analysis. The results show that education has a negative significant predictor of cooperative membership at a 5% significance level. Attaining secondary levels did not contribute to farmers' decision to join cooperative membership. Older farmers were more likely to join cooperatives, unlike the young farmers. Using neighbors in cooperatives as an instrumental variable, the findings indicate that farmers with neighbors who were already in cooperative membership were more likely to join cooperatives. In addition, the majority of adopters of modern bee farming technologies had access to both credit and markets and reported to have experienced an increase in income from bee farming. The adoption of modern beekeeping technologies, such as protective gears, and honey extractors, enabled the farmers to produce more and better-quality honey, which fetched higher prices in the market. Cooperative membership increased the probability of adopting modern beekeeping technology. As such, the study recommends that cooperatives should provide more incentives and support to their members, such as training, subsidies, quality assurance, and market linkages to promote the adoption of modern bee farming technologies.

Keywords: cooperative membership, modern technology, bee farmers, Instrumental variable

INTRODUCTION

Background

Bees and their valuable produce, honey, play a vital role in sustaining ecosystems and supporting agricultural systems worldwide. The production of honey or beekeeping offers several benefits. Many goods (including beeswax, propolis, bee colonies, pollen, royal jelly, bee venom, pollen, package bees, and bee brood) are sources of income. Since bee farming does not compete for land or other resources, like labor, it promotes environmental conservation, which has a positive impact on climate change, and requires comparatively little capital investment. It plays a significant role in biodiversity and crop yield improvement.

Since 2000, honey production volume has increased by more than 40% globally and reached about 2 million metric tons in 2023 (UNEP, 2023). Devkota (2020) notes that beekeeping provides an important source of income for several rural livelihoods and contribute directly to food security. Bee farming requires low-cost investment with a natural resource base (Mohammed & Hassen, 2021). Most people sell their honey immediately after harvest to cater for their living expenses.

According to several studies (Giliba et al., 2010), beekeeping has significant potential to help developing countries tackle poverty. The honey bee has no competition for natural resources with any other agricultural industry. Research has demonstrated that beekeeping can maintain productivity and ecological stability (Mancuso, Croce, & Vercelli, 2020).

Beekeeping is a relatively inexpensive agricultural endeavour that has the potential to significantly improve household livelihoods and the overall economy (Tadesse et al., 2021). Both the domestic and international markets offer opportunities. However, some of the major issues facing the sub-sector are inefficient technologies, insufficient knowledge, environmental deterioration, and low production (Andika Gilbert, Eran'Ogwa Bronson, & Cheptarus, 2023).

Rural cooperatives serve as the primary means of encouraging the adoption of agricultural practices and small-scale agriculture in many developing countries (Ma & Abdulai, 2016). As a result, farmers have realized how crucial it is to implement innovations through collective action, which can assist farmers in achieving safe output (Nwankwo, Peters, & Bokelmann, 2009). The distribution of agricultural inputs, the gathering and selling of members' outputs, the provision of business loans, and the provision of training to members are all examples of collective acts that are crucial to delivering various agricultural services (Spielman et al., 2010).

Overview of honey production in Kenya

Honey is beneficial to people's lives because it helps improve digestion, provide energy, and boosts the immune system. The demand for honey in Kenya is high, making bee farming a profitable venture. Apiculture has been practised in Kenya for many years, but its potential remains untapped. Kenya is Africa's 3rd important honey producer after Ethiopia and Tanzania (KIPPRA, 2019). Recent studies show that over 90,340 beekeepers in the country own about 2 million hives (Muhati & Warui, 2022). Similar to the majority of Africa, 84.6% of Kenya's 2 million hives are traditional hives, which provide the majority of the country's honey (Sagwa, 2021). This suggests that the traditional practices beekeepers use result in low yields and poor-quality honey (McMenamin et al., 2017).

Despite the largely traditional beekeeping practices, Kenya produces approximately 100,000 metric tons of honey annually. However, this is just about 20% of the country's potential since 80% of Kenya comprises arid and semi-arid lands (Barons, Nichols, & Maria, 2023). These regions have abundant factors, including the availability of acacia trees capable of supporting beekeeping. On average, one beehive can produce up to 80kg of honey annually, which goes for about 800 Kenyan shillings ($6) per kilogram, depending on environmental factors, the strength of the colony, and the available bee forage. A farmer can earn up to Sh64,000 ($441) from each hive yearly.

According to Mwirichia & Ndirangu (2023), Kenya's honey production fell by 41% between 2015 and 2018, from 34,759 to 20,525 tons respectively. These numbers show that the industry is performing poorly. With cooperative membership, farmers can boost their productivity by adopting modern honey technology, hence improving their livelihoods. According to Moahid et al. (2021) research, one of the options that can improve farm productivity involves enhancing access to agricultural loans. Farmers can buy the right recommended inputs and adopt agricultural technologies that increase honey yields and other farm resources required to increase honey production when they have adequate access to agricultural credit. The Kenyan government and non-governmental organisations (NGOs) have assisted beekeepers and agribusiness owners in enhancing their beekeeping procedures and productivity by implementing modernised hives such as the Langstroth and Kenyan top bar hives (Hecklé et al., 2018; Jimi et al., 2019).

Statement of the Problem

The slow adoption of modern honey methods in Kenya raises several concerns. First, traditional techniques are labor-intensive and time-consuming, requiring substantial physical effort and prolonged processing periods. This not only limits the scale at which honey production

can be carried out but also places additional burdens on already resource-constrained smallholder farmers. Second, the quality of honey produced through traditional methods tends to be lower compared to modern techniques, affecting its market value and reducing the income potential for farmers. Third, the lack of technical efficiency resulting from the reliance on outdated practices undermines the overall productivity and profitability of the beekeeping sector in the study area.

Given the potential benefits of adopting modern beekeeping technology, it is imperative to investigate cooperatives' role in influencing farmers' decisions to adopt these techniques. Understanding the underlying factors, such as farmers' socio-economic characteristics, access to information and resources, perceptions of modern methods, and institutional support, can provide insights into the barriers that hinder adoption. Additionally, exploring the impacts of cooperative membership on the adoption of modern technology will shed light on the potential improvements and economic benefits that can be realised by smallholder bee farmers in the study area.

By addressing these research gaps and investigating the determinants and impacts of cooperative membership on the adoption of modern beekeeping technology, this study will contribute valuable insights to the field of beekeeping and agricultural development. Thus, the research focused on cooperative membership, a crucial supply-side policy tool for influencing agricultural productivity in Kenya.

Research objective

1. To analyze the factors influencing bee farmer's decision to join cooperatives
2. To analyze the impact of cooperative membership on the adoption of modern beekeeping technology

Research questions

1. What are the factors influencing the bee farmer's decision to join cooperatives?
2. What is the impact of cooperative membership on the adoption of modern beekeeping technology?

Significance of the study

A significant proportion of the rural dwellers in Kenya rely on beekeeping as a source of income to support their way of life. Previous research has highlighted the importance of cooperative membership in agricultural development. Cooperatives can facilitate the dissemination of improved farming practices and technologies. Furthermore, the adoption of new technologies has been linked to increased agricultural productivity and income. Despite the importance of the beekeeping industry in Kenya, there is a significant knowledge gap regarding the impact of cooperative membership on the adoption of modern beekeeping technology. Previous studies focused on general beekeeping aspects related to honey production. There is a lack of comprehensive research examining the impact of cooperative membership and its impact on the adoption of modern beekeeping technology. This research filled this gap and offered valuable insights into this grey area.

LITERATURE REVIEW

Beekeeping Practices and Modern Technology in Kenya

Kenya's beekeeping industry first attracted the attention of the British colonial government in the mid-19th century. A memorandum was signed for the development of the bee farming sector (van der Wal, Gedi, &

Spottiswoode, 2022). Most beekeepers use traditional production methods, which mostly involve hollow log hives. There are approximately 1,273,000 hives, with 73% of them located in the east. Honey harvesting is typically done at night, and it occasionally entails stripping down before scaling the trees from which the hives are hanged.

Honey bee populations in East Africa are essentially untamed; swarms of migratory bees take over empty hives, and beekeepers typically only disturb colonies during honey collection. Colonies then disappear (stop rearing brood, consume all food stores, and leave the hive) and move to a new location. Therefore, most beekeepers' main management choice is the type of hive (Kiprono et al., 2022). Traditional Log hives, which have fixed combs like in a natural colony; Lang stroth hives, which are the standard Western-style hives with move able frames; and the Kenyan top-bar (KTB) hive, which uses movable top bars rather than frames, are the three hive types most commonly used by East African beekeepers (McMenamin et al., 2017). The aim of operating a modern hive is to ensure the farmer moves individual combs for honey collection or inspection and then replace them without damaging the colony.

Improved technology that is simple to use and manage is used in modern beekeeping techniques (Tarekegn & Ayele, 2020). The two most common types of hives are move able frame hives and movable comb hives. The smoker, hive tool, bee brush, catcher box, protective clothes, and equipment for extracting and refining honey are additional items that go along with modern beekeeping. Better management techniques, which include artificial feeding, pest control, colony division, and seasonal management, are also a component of better beekeeping technology (Kiingwa, Philomena, & Joseph, 2020).

An exception is when hives need to be relocated, as in migratory beekeeping, in which case combs may shatter unless extra support is built into the top bar design. Built-in queen excluders, which keep the queen bee in a brood area while giving workers access to the rest of the hive, further enhance these hive tools. This enables the removal of the combs holding fully-capped honey but no pollen or brood, allowing for the harvesting of honey and beeswax. Kiprono et al. (2022) found that beekeepers in Baringo continue to practice traditional beekeeping methods despite introducing modern beekeeping methods in Kenya.

Impact of cooperative membership on the adoption of modern technology

Cooperatives can influence technology adoption and well-being in a variety of ways. First, cooperatives can ease farmers' liquidity constraints by offering credit to their members. Cooperatives also influence adoption and welfare by providing market information and, possibly, a higher market price for their products. Zhang et al. (2020) study on the impact of cooperative membership on agricultural technology adoption in China using propensity score matching found that Cooperative membership positively affects technology adoption. Similarly, Ahado et al. (2021) study on whether cooperative membership impacted the efficiency and yield of smallholder potato farmers in Mongolia using a stochastic frontier framework showed that participation in agricultural cooperatives was linked to increased technical and yield efficiency. The researchers compared group-specific frontiers and indicated that members in a cooperative society perform better than non-members.

Using the difference-in-difference model and inverse probability weighted regression, Manda et al. (2020) study on whether cooperative membership accelerates agricultural technology adoption found that cooperative membership enhanced the likelihood of technology adoption in Zambia by 11%–24%. The average time to adoption was about eight years but shorter for cooperative members. Li et al. (2021) leveraged the same methodology to estimate the effects of cooperative membership on farmers' safe production behaviours in China's rice sector. They found that Cooperative membership impacts safe production in the rice sector. Li et al. demonstrated that without participating in cooperatives, the members' adoption of the green control techniques was reduced.

Lecoutere's (2017) research on the impact of agricultural cooperatives on women's empowerment in Uganda using quasi-experimental empirical analysis found that cooperative membership had a significant positive impact on economic well-being, adoption, and knowledge of agronomic practices, particularly among women. Serra & Davidson's (2021) study on the Benefits of Cooperatives to Women Honey Producers in Ethiopia using propensity score matching and coarsened exact matching established that cooperative membership increased production quantity and market price, while the average effect on the product market share was statistically insignificant.

The adoption of cooperatives generated employment, boosted food production, empowered the marginalised, especially women, and reduced poverty (Mhembwe & Dube, 2017). Ji et al. (2019) examined the impact of cooperative membership on farmers' safe production behaviours in China's pig industry and found that the effects are heterogeneous across key cooperative, household, and farm attributes. Cooperative membership has a positive and significant influence on farmers' propensity to adopt safe production practices.

METHODOLOGY

Data Source

This study's data comes from a bee farmers survey in Baringo County, Kenya in the period October–November 2018. A multistage sampling technique was applied in generating our sample size. The initial stage was the purposeful selection of the Baringo South sub-county based on its potential for honey production in four wards namely Marigat, Mukutuni, Mochongo and Ilichamus. A random sample technique was used to choose bee producers from the sub-county's four wards. Four hundred and six households made up the sampling frame for the investigation. Using Yamane's (1967) formula, the sampling size was calculated to 201 households. by using Eq.

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

Where n is the size of the sample, e is the error term (0.05 or 5%), and N is the population size for this research (N = 406).

The well designed 201 questionnaires were used for the collection of data from rural farm households by trained enumerators. These bee farmers included both cooperative and non-cooperative members. However, 9 out of the 201 questionnaires administered were found to be not accurate enough for the analysis and were thus withdrawn. In all, 147 cooperatives and 45 non-cooperative members were used for the analysis. Primary data sources were used in this study to generate quantitative data types for analysis by use of Questionnaires. The information was imported into the SPSS computer application (SPSS 2015) and STATA MP 17 for statistical analysis. Descriptive statistics like percentages, frequency tables, and means were employed to organise and compile the data.

Estimation models

To identify the factors that influence farmers' decisions to join or not join cooperatives, the study used logit model. This model is mostly used when the outcome variable is binary that is the decision of a bee farmer to join or not join cooperatives. The equation is expressed as follows:

$$Prob(Y_i = 1) = C_i = F(Z_i) = F(\alpha + \sum \beta_i X_i) = \frac{1}{1 + e^{-Z_i}} \quad (2)$$

where C_i is the probability that a farmer participates in the cooperative, X_i represents explanatory variables; and α and β are parameters to be estimated.

To analyze the impact of cooperative membership on adoption of modern technology, two-stage least squares (2sls) model using probit model and instrumental variable was used. The first stage was to estimate the relationship between neighbours who are cooperative members and cooperative membership using neighbours as the instrumental variable address endogeneity issues and self-selection bias, illustrated in Eq (3) The instrumental variable is poised to affect farmer's participation in cooperatives rather than the adoption of modern technology. The equation is expressed as follows:

$$M_i^{\wedge} = \beta S_i + \alpha Z_i + \varepsilon_i \quad (3)$$

where $M_i^{\wedge}$ refers to cooperative membership, S_i is a vector of instruments, Z_i is as defined previously; β and α are pamaters to be estimated; and ε_i is an error term. The instrumental variable is not correlated with technology adoption variable but is correlated with the choice of cooperative membership variable.

The second stage, used probit model to estimate the probability of a bee farmer adopting the modern technology the equation will be estimated as follows in Eq.4

$$Pr(Y = 1|x) = \beta_0 + \beta_1 M_i^{\wedge} + \beta_2 Z_i + \varepsilon_{ii} \quad (4)$$

Where Y represent the probability of adopting modern technology by bee farmers with Y=1, indicating adoption and Y=0, showing non-adoption. M_i^ is the predicted value of cooperative membership derived from Eq. 3, Z_i is the set of control variables β_0, β_1 and β_2 are the parameters to be estimated; and ε_{ii} is an error term.

RESULTS AND DISCUSSION

Factors Influencing Farmers' Decisions to Join Cooperatives

Factors influencing farmers' decisions to join cooperatives were determined. Table 1 indicates the coefficients, standard errors, t-values, p-values, and significance levels of the predictor variables in the log it model. The response variable is the membership status of the bee farmers in cooperatives. As shown in Table 1, secondary education was a negative significant predictor of cooperative membership at a 5% significance level (β = -1.213, t = -2.14, p = 0.033). Attaining secondary levels did not contribute to farmers' decision to join cooperative membership. This probably implied that more educated farmers had formal employment with higher incomes which made them less dependent on cooperative membership to support their bee-keeping enterprises. Gender was a positive significant predictor of cooperative membership at a 5% significance level (β = .069, t = 2.26, p = 0.024). Older farmers were more likely to join cooperatives, unlike the young farmers. Farmers with more experience were more unlikely to join cooperative membership. For every one-year increase in experience, the odds of joining a cooperative decreased by 3.4%, holding all other variables constant. The increase in the bee-keeping land size did not contribute to farmers' decision to join cooperatives. Membership of the neighbours in cooperatives was a positive significant predictor of cooperative membership at a 5% significance level (β = 1.894, t = 3.84, p = 0.00). Farmers with neigh bours who were already in cooperative membership were more likely to join cooperatives.

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Table 1: Determinants of Cooperative membership

Membership	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
None	-2.06	1.17	-1.76	.079	-4.35	.240	*
Secondary Education	-1.21	.568	-2.14	.033	-2.33	-.101	**
Tertiary Education	-1.12	.646	-1.73	.084	-2.39	.149	*
Age	.069	.031	2.26	.024	.009	.129	**
Experience	-.034	.033	-1.03	.301	-.099	.030	
Land size	-.402	.211	-1.90	.057	-.816	.012	*
Neighbours in Cooperatives Membership	1.89	.493	3.84	000	.929	2.86	***
Constant	-.974	1.158	-0.84	.4	-3.245	1.296	
Mean dependent var	0.766		SD dependent var		0.425		
Pseudo r-squared	0.189		Number of obs		192		
Chi-square	39.584		Prob > chi2		0.000		
Akaike crit. (AIC)	185.508		Bayesian crit. (BIC)		211.568		
*** p<.01, ** p<.05, * p<.1							

Cooperative Membership and Adoption of Bee Farming Modern Technologies

Adoption of some of the modern bee-farming technologies was also considered in the study. The number of farmers who had adopted protective gears, KTBH, smokers and honey extractors were as indicated in the table below. However, the number of farmers who owned traditional log hives was also included in the table for discussion.

Table 2: Descriptive Statistics on Adoption of Bee Farming Technologies

	Frequency	Per cent
Protective the gears	37	19.5
KTBH, Lang stroth	148	77.1
Smokers	28	14.6
Honey extractors	3	1.6

The majority of the bee farmers (N = 148, 77.1%) owned at least one modern bee hive. The farmers preferred log hives because they had many benefits, such as low cost, easy maintenance, suitability for the local climate, and simple construction. Modern hives such as KTBH and Lang stroth were less popular because they needed an apiary, technical skills, and capital to set up. Log hives were also easier to open and harvest since they had smaller and more manageable colonies than other hives. Furthermore, log hives produced more wax than modern hives, which was another reason why some farmers chose them over other types of bee hives. Most farmers did not own honey extractors as the majority sold their honey unprocessed while the rest used the natural means of subjecting honey to the sun's heat. The findings were in agreement with Yator's (2021) study that found that the majority of the bee farmers in Baringo were using log hives. Only 19.5%, 14.6% and 1.6% of the farmers had adopted protective gear, smokers, and honey extractors respectively. The farmers cited the high cost of modern technologies as the reason for failure to adopt the new technologies. This was consistent with the findings of Kiprono, Lagat, & Gitau (2020) research that revealed the status of modern bee-keeping technologies in Baringo County is still low.

The study went further to determine whether there was an increase in honey quality, better market

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accessibility, increased income from bee farming, and better credit access among adopters of modern bee farming technologies. Descriptive statistics were computed and tabulated as shown below;

Table 3: Descriptive Statistics of Honey Quality, Market Accessibility, Bee Farming Income, and Credit Access among Adopters of Modern Bee Farming Technologies.

		Freq	Percent (%)
Honey quality	Yes	4	2.8
	No	140	97.2
Market access	Yes	106	73.6
	No	38	26.4
Bee farming Income	Yes	80	55.6
	No	64	44.4
Credit access	Yes	112	77.8
	No	32	22.2

The majority of adopters (77.8% and 73.6%) of modern bee farming technologies had access to both credit and markets, respectively. This is consistent with findings by Chelagat (2022) which found that the majority of the adopters of modern bee farming technologies had access to credit. Most adopters (55.6%) also reported to have experienced an increase in income from bee farming. However, on the question of whether modern technologies increased the honey quality, most farmers (97.2%) indicated that the honey quality did not have any difference with the honey harvested from log hives. This was possibly true based on the fact that farmers in Baringo county had adopted mainly modern bee technologies such as KTBH and Langstroth, and not the protective gears and honey extractors which had low adoption rates. According to Yator (2021), the adoption of modern beekeeping technologies, such as protective gears, and honey extractors, enable the farmers to produce more and better-quality honey, which fetch higher prices in the market.

The study established the relationship between neigh bours who were cooperative members and joining cooperative membership by bee farmers using ‘neighbours in cooperatives’ as the instrumental variable to address end ogeneity issues and self-selection bias. The probit and IV results are presented below;

Table 4: Cooperative Membership and Adoption of Modern Bee Farming Technologies Decision of Simple Regression Probit Model Result

Adopters of modern bee farming technologies	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
Membership	1.843	.244	7.56	.000	1.365	2.321	***
Constant	-.493	.195	-2.52	.012	-.876	-.11	**

Mean dependent var	0.771	SD dependent var	0.421
Pseudo r-squared	0.305	Number of obs	192
Chi-square	63.018	Prob > chi2	0.000
Akaike crit. (AIC)	147.676	Bayesian crit. (BIC)	154.191
*** p<.01, ** p<.05, * p<.1			

The simple regression results of the probit model indicated a positive and statistically significant relationship between cooperative membership and the adoption of modern bee farming technologies (β = 1.843, t = 7.56, p = 0.000). This means that farmers in cooperatives are more likely to adopt modern bee farming technologies as compared to bee farmers who are non-members. According to Tarekegn & Ayele (2020), cooperative membership and extension contact had significant effects on technical efficiency of farmers. This could imply that farmers in cooperative membership have more access to information, extension services, and credit services that help them improve their beekeeping practices and adopt new beekeeping technologies.

The multiple regression results of the probit model where other covariates were included ascertained the significance of membership in cooperatives in influencing modern bee farming technologies adoption. The regression coefficient of adoption of modern technology on cooperative membership is still statistically significant even after controlling for possible endogeneity between membership and neigh bours in cooperative membership (β = 2.092, t = 6.63, p = 0.000). None of the other covariates significantly influenced adoption (p > 0.05) indicating that cooperative membership was a key predictor.

The table below shows the results of multiple regression of Cooperative Membership and Adoption of Modern Bee Farming Technologies using the Probit Model. The included controls are cooperative membership, age, education levels, farming experience, land size and neighbours in cooperative membership. Variables that only responded to cooperative membership were dropped.

Table 5: Cooperative Membership and Adoption of Modern Bee Farming Technologies Decision of Multiple Regression Probit Model Result

Modern Bee-Keeping Technologies Adoption	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Cooperative membership	2.09	.316	6.63	.000	1.47	2.71	***
Primary Education	-.267	.768	-0.35	.728	-1.77	1.23	
Secondary Education	-.732	.821	-0.89	.372	-2.34	.877	
Tertiary Education	.833	.884	0.94	.346	-.899	2.57	
Age	-.004	.015	-0.24	.814	-.033	.026	
Experience	-.011	.018	-0.63	.526	-.047	.024	
Land size	.049	.110	0.44	.658	-.167	.264	
Neighbours in Cooperatives	.060	.361	0.16	.869	-.648	.767	
Constant	-.146	1.106	-0.13	.895	-2.31	2.02	
Mean dependent var	0.771			SD dependent var		0.421	
Pseudo r-squared	0.379			Number of obs		192	
Chi-square	78.332			Prob > chi2		0.000	
Akaike crit. (AIC)	146.363			Bayesian crit. (BIC)		175.680	
*** p<.01, ** p<.05, * p<.1							

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The table indicates that cooperative membership has a significant positive association with the adoption of modern bee-keeping technologies. This is supported by the high t-value of 6.63, suggesting that cooperative membership influences the adoption of these technologies. The positive coefficient aligns with Khasanah et al. (2022) study that emphasizes the role of cooperatives in enhancing access to resources, knowledge sharing, and collective decision-making. According to Khasanah et al., the cooperative setting facilitates the exchange of information, resources, and collaborative learning, fostering a conducive environment for the adoption of modern bee-keeping technologies.

On the other hand, educational levels did not appear to be significant predictors of technology adoption. The coefficients for primary, secondary, and tertiary education are not statistically significant, suggesting that a person's educational attainment did not play a significant role in influencing their adoption of modern bee-keeping practices. This finding contrasts with Takahashi, Muraoka, & Otsuka's (2020) study which identified education as a significant factor in technology adoption in agriculture. In addition, age, experience, and land size did not show significant relationship with technology adoption, indicating that these factors were not decisive in predicting the adoption of modern technologies.

Table 6: Cooperative Membership and Adoption of Modern Bee Farming Technologies Decision from Instrumental Variables (2 SLS) Simple Regression

Modern bee farming technology adoption	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Membership	.606	.175	3.46	.001	.262	.949	***
Constant	.307	.136	2.25	.024	.040	.574	**
Mean dependent var	0.771		SD dependent var	0.421			
R-squared	0.366		Number of obs	192.000			
Chi-square	11.944		Prob > chi2	0.001			
*** p<.01, ** p<.05, * p<.1							

The results from simple regression indicate that bee farmers in cooperative membership had higher modern technology adoption rates. The results indicated a positive and statistically significant (β = 0.606, t = 3.46 p = 0.001) relationship between cooperative membership and the adoption of modern beekeeping technologies. Cooperative membership increased the probability of adopting modern beekeeping technology by 60.6%, holding all other factors constant.

The multiple regression including other covariates ascertained the significance of cooperative membership in influencing the adoption. The results were as tabulated below:

Table 7: Cooperative Membership and Adoption of Modern Bee Farming Technologies Decision from Instrumental Variables (2 SLS) Multiple Regression

Modern Bee Farming Adoption	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Cooperative Membership	.648	.191	3.39	.001	.274	1.023	***
Primary	-.021	.132	-0.16	.872	-.28	.237	
Secondary	-.122	.144	-0.85	.397	-.405	.161	
Tertiary	.139	.151	0.92	.355	-.156	.435	
Age	000	.003	0.06	.950	-.006	.006	
Experience	-.004	.004	-0.97	.334	-.011	.004	

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Landsize	.013	.027	0.49	.626	-.039	.066	
Constant	.328	.231	1.42	.155	-.124	.780	
Mean dependent var	0.771			SD dependent var	0.421		
R-squared	0.414			Number of obs	192.000		
Chi-square	40.628			Prob > chi2	0.000		
*** p<.01, ** p<.05, * p<.1							
Included controls: Cooperative membership, age, education levels, farming experience, and land size. Variables that responded to cooperative members only were dropped.							

The regression coefficient of adoption of modern technology on cooperative membership was still statistically significant even after controlling for possible endogeneity between membership and neighbours in cooperative membership ($\beta = .648$, $t = 3.39$, $p = 0.001$). None of the other covariates significantly influenced adoption ($p > 0.05$) indicating that cooperative membership was a key predictor.

Summary of the Findings

The majority of bee farmers were relatively young, ranging from 20 to 79 years old while the participant household size implied large families ranging between 1 to 11 members. The majority of farmers in the Baringo South sub-county attained at least basic education, where the majority studied at secondary school levels. The majority of bee farmers had access to ready markets compared to farmers who could not access ready markets. Few farmers were able to sell their bee products through cooperatives. It was a possible indication of exploitation by middlemen who acquired bee products from farmers at low prices because of a lack of clear and formal markets. Bee farmers had relatively small sizes of land for bees with a moderate number of bee hives, while the number of bee hives occupied by bees was more.

The majority of bee farmers were in cooperatives. Few farmers were not in any cooperative citing leadership conflicts in cooperatives as the reason for non-membership. Other reasons for unwillingness to join cooperatives were the unavailability of cooperative societies in their surroundings, complexity in accessing cooperative membership, self-farming conditions being less than those of cooperative membership, high subscription fees, being used to traditional bee farming and that the expected profits from cooperative membership were not optimistic. Bee farmers in cooperative membership received varying services from their respective cooperatives. The most commonly received services were technical guidance, access to information on bee farming, extension services, access to inputs, access to markets, and access to credit, respectively.

Several factors were found to influence farmers' decisions to join cooperatives. Secondary education was a negative significant predictor of cooperative membership level implying that attaining secondary school levels did not contribute to farmers' decision to join cooperatives. It could as well imply that more educated farmers had formal employment with higher incomes which made them less dependent on cooperative membership to support their bee-keeping enterprises. Gender was a positive significant predictor of cooperative membership where older farmers were more likely to join cooperatives, unlike the young farmers. Farmers with more experience were more unlikely to join cooperative membership. An increase in the bee-keeping land size did not contribute to farmers' decision to join cooperatives. Membership of the neighbours in cooperatives was also a positive significant predictor of cooperative membership at a 5% significance level ($\beta = 1.894$, $t = 3.84$, $p = 0.00$). Bee farmers with neighbours who were members of cooperatives were more likely to join cooperatives.

Bee farmers in Baringo South sub-county have adopted modern bee farming technologies. The majority of the bee farmers (N = 148) owned at least one modern bee hive. Modern hives such as KTBH and Langstroth were less popular compared to log hives. Log hives were easier to open and harvest since they had smaller and more manageable colonies than other hives. Furthermore, log hives produced more wax than modern hives, which was another reason why some farmers chose them over other types of bee hives. Most farmers did not own honey extractors as the majority sold their honey unprocessed meaning quality was not their key concern.

The majority of adopters of modern bee farming technologies had access to both credit and markets. Most modern technology adopters experienced an increase in income. The relationship between cooperative membership and the adoption of modern bee farming technologies was positive and statistically significant ($\beta = 1.843$, $p = 0.000$). It implied that farmers in cooperatives are more likely to adopt modern bee farming technologies as compared to bee farmers who were non-members. This could imply that farmers in cooperative membership have better access to information, extension services, and credit services that helped them adopt modern beekeeping technologies

CONCLUSION

Cooperative membership influenced bee farmers' decision to adopt modern bee farming technologies. The majority of the bee farmers in Baringo South Sub County were in cooperative membership. The farmers in cooperatives accessed information, credits, market, extension services and inputs which contributed to their adoption of modern bee farming technologies. Log hives were more preferred by farmers as compared to KTBH and Langstroth hives, with farmers citing hot weather conditions as the reason behind bees disliking the latter. Secondary education was a negative significant predictor of cooperative membership. Attaining secondary levels did not contribute to farmers' decision to join cooperative membership. Gender was a positive significant predictor of cooperative membership at a 5% significance level. Older farmers were more likely to join cooperatives, unlike the young farmers. Farmers with more experience were more unlikely to join cooperative membership. Land size for beekeeping did not influence farmers' decision to join cooperatives. Farmers with neighbours who were already in cooperative membership were more likely to join cooperatives

RECOMMENDATIONS

1. Cooperatives should provide more incentives and support to their members, such as training, subsidies, quality assurance, and market linkages to promote the adoption of modern bee farming technologies. The cooperatives should also encourage non-members to join by highlighting the benefits of cooperative membership and addressing the barriers to entry.
2. Cooperatives should educate the farmers on the advantages of modern bee hives and technologies to increase their preference and suitability over the log hives. The cooperatives should support this by providing technical assistance and climate adaptation strategies to the farmers to overcome the challenges of hot weather conditions affecting the modern bee hives such as KTBH and Langstroth.
3. To increase modern bee farming technology adoption rates, cooperatives need to provide opportunities for continuous learning and skill development to bee farmers, regardless of their education levels.
4. To address the gender gap in the cooperative membership, cooperatives should put measures such as equal access to information, credits, inputs, and markets among women to empower them to participate in decision-making and leadership roles within the cooperatives.
5. Cooperatives can attract the younger and less experienced farmers to cooperative membership through mentorship and networking programs where they can receive knowledge from the more experienced farmers. They can also achieve this by providing incentives and recognition to the young and innovative farmers who adopt modern bee farming technologies and contribute to the cooperatives' goals.

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