



Bee Keeping and Coffee Production as Potential Alternative Livelihoods for Coffee Farmers in Sheema District

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Abstract

To ensure sustainable living standards for coffee farmers, integrating coffee plantations with bee keeping would be a potential alternative livelihood option since beekeeping contributes additional incomes from the sale of honey and other bee products without compromising coffee production. Therefore, the study aimed at assessing the contribution of integrating coffee and bee keeping to coffee farmers' incomes, attitude and perception of farmers on integrating coffee with bee keeping, technologies coffee farmers use while integrating coffee with bee keeping and the challenges farmers face while integrating bee keeping. The study utilized a cross section research design and a sample of 210 respondents was chosen using simple random sampling and questionnaire, interviews and observation were used to collect primary data from the respondents. It was established that adoption of bee keeping integration resulted in an improvement in income from 6.7% in 2020 to 7.1% in 2021 and this was statistically significant ($P < 0.05$). Farmers had a positive perception of integrating bee keeping with coffee and majority perceived it as source of additional income, require few resources to commence, the necessary skills can be quickly transferred, hives are made from local resources and not labour intensive 210 (100%). The study findings also established that most farmers were not using innovative technologies and the major technologies farmers were using included; possession of top bar or Langstroth $p=0.022$, provision of supplemental feeds $p=0.04$ and engaging in bee pollination services and pollen collection $p=0.046$ as compared with the time spent while integrating bee keeping in coffee plantations.

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The study further established the challenges farmers face while integrating coffee with bee keeping as; poor management skills, shortage of honey forage, diseases pests and predators, lack of awareness about valuable contribution of bees, lack of trainers and training opportunities, lack of new research information, inadequate bee keeping equipment, price fluctuations and lack of grading system, bee hive theft, weak producer organizations and lack of clear policies to protect the producers from pesticide poisoning. The study recommended provision of constant trainings, formulation of participatory policy that would encourage conservation of pollinators and farmers to be equipped with knowledge and tools to enable them to make informed decisions.

Keywords: Bee keeping; livelihoods; integration.

1. Introduction

Dependence on subsistence agriculture has depleted the natural vegetation and has been less effective in improving the living standards of communities. Implementation of livelihood activities through a strategic mix of community participation in conservation is very essential. Improved beekeeping is identified as strong profitable economic incentive to promote conservation and rehabilitation in the face of demand for cultivated land [1]. Beekeeping is taken into account when the economic importance of trees is being calculated [2,3]

Beekeeping preserves nature, agriculture, sustains livelihoods, and provides food security through, increasing beekeepers participation in regeneration of different bee forage species and at the same time increasing flowering plant and crop pollination [4]. Despite its important roles, the potential of beekeeping is apparently not exploited and quantified as economic incentive in forestry, plantation farming and watershed conservation through harvesting of organic bee product. Bee products provide health, high-nutrient food, safe medicines and raw material for pharmaceuticals and cosmetics industries [5]. It is proved as a reliable source of income generation for small and marginal farmers, women and other vulnerable society who are depending on charcoal production. When beekeepers are supported with improved beekeeping technologies and have access to good markets for their products, they are motivated to support local conservation efforts.

Beekeeping offers direct and indirect benefits to the rural people. Directly, beekeeping substantiates household income from hive product sales, provides food, safe medicines, and raw materials for industries [6]. These income benefits have been reported to have high impact among marginalized and small income earners such as women, orphans, and other vulnerable groups within the society [7]. Indirectly, beekeeping contributes to water shed-management, forest conservation and crop pollination. Reference [8] found that bees are responsible for one third of food crops produced for human consumption. Honeybee pollination improves quality, quantity, and market value of food crops [9]. Thus, honeybees are central in ensuring food security. With all the above benefits, it is believed that beekeeping can improve living standards of the rural poor. Yet productivity and beekeeping adoption remains low among rural farmers in Uganda.

Small scale coffee farmers livelihoods are shrinking as farmers only access income during harvesting season, limited yields due to use of poor management practices, low prices and poor marketing channels and this limits

them to continuously access basic needs when the coffee season is off. Therefore, adopting integration with alternative enterprise would bridge this gap hence bee keeping would be one of the best alternatives since bees help in coffee pollination hence increasing yields and provides additional incomes from the sale of bee products. The income provided from the sale of bee products would be used by farmers to access basic needs during coffee off season and acquiring different inputs like fertilizers, pesticides, and fungicides that would enhance yields. Therefore, there are few studies that have clearly documented on the contribution of integrating coffee and bee keeping as a potential alternative for diversified coffee farmers' livelihoods and it's against this background that the current study is geared towards ascertaining the contribution of integrating coffee and bee keeping as a potential alternative for diversified coffee farmers' livelihoods in Sheema district.

The study findings will provide an exciting opportunity to advance our knowledge on potential areas of intervention for policymakers and other interested stakeholders (both public and private) to understand the functioning of integrating coffee with bee keeping besides establishing ways to improve farmers' livelihoods along the coffee value chain.

The study findings will offer some important insights into the extent to which the coffee actors are aware of the contributions of integrating coffee and bee keeping as entrenched in the process and use the information to enhance the incomes and livelihoods of households.

2. Statement of the problem

In Uganda, approximately 20% of foreign revenues come from coffee which therefore makes it the most eminent agricultural crop in the nation [10]. Coffee is mostly produced on small farms. There are about 1.7 million coffee farmers in the country [11]. In Uganda, the coffee industry is vital, but it is facing many challenges and is distinguished by restricted access to land and knowledge [10]. Furthermore, there are few and low farm investments. These limitations have led to coffee farmers buying uncertified planting materials and input with bad quality [11, 12]. Other challenges faced are low post-harvest involvement, inadequate technical improvement, managerial issues, and lack of youth entering the profession. This always discourages small scale farmers to perform different agronomic activities since the income from coffee is seasonal. In order to bridge this gap, farmers need to integrate some enterprises that would provide some incomes when the season of coffee is off, and bee keeping would be the alternative potential enterprise.

Although coffee farmers are earning considerably good incomes from coffee sales, this income is seasonal, yields are low, price fluctuates due to unstable forex exchange market and a small market share where the local market is largely influenced by seasonal production performance of external big players like Brazil, Vietnam, Colombia, and this has limited farmers from continuously accessing basic needs, hence they experience low standards of living. Therefore, to ensure sustainable living standards for coffee farmers, integrating coffee plantations with bee keeping would be the potential alternative since Beekeeping contributes additional incomes from the sale of honey and other bee products. This can be facilitated by the shade trees planted in the coffee plantations/gardens which would act as forage. It is from this basis that this research will be conducted to

assess the effect of integrating coffee and bee keeping as a potential alternative for diversified coffee farmers' livelihoods in Sheema district.

According to [13] 70% of farmers in Sheema district are involved in the coffee farming industry. Coffee is susceptible to high degree of fluctuation in its prices, leaving a tremendous number of those people vulnerable. Part of the solution to this may be diversification. Diversification can give farmers a steadier income, as well as helping to make the coffee industry more stable. When coffee farmers carefully manage the ways, multiple crops are planted together (intercropping) and properly manage multiple enterprises on farm (Mixed farming), this also promotes biodiversity, as certain other crops release byproducts complementary to the growth of other crops. Therefore, adopting the integration of bee keeping in coffee farming in an age where the continued use of sprayed chemicals in weed and pest control has dramatically reduced bee population than have been ever before, the introduction of bee keeping along coffee agribusiness is timely.

3. Methodology

Description of the study area

The study was conducted in Sheema district. Sheema District is bordered by Buhweju District to the north, Mbarara district to the east, Ntungamo District to the south, Mitooma District to the southwest and Bushenyi District to the west. Kibingo, where the district headquarters are located, lies approximately 33 kilometres (21 mi), by road, west of Mbarara, the largest city in Ankole sub-region [14]. The coordinates of the district are: 00 32S, 30 24E [14]. The main economic activity in the area is farming where banana and coffee are the main enterprises where people derive a living. The area was selected for the study because most of the farmers were involved in coffee production; hence, they had accurate and reliable information about the contribution of integrating coffee with bee keeping as alternative source of livelihoods. The District experiences a bi-modal pattern of rain seasons, which normally occurs from March to May and mid-August to October. On average the annual rainfall is about 900 mm.

Study design and sampling frame

A cross section study was conducted to collect data on the contribution of integrating coffee and bee keeping as a potential alternative for diversified coffee farmers' livelihoods and the study was conducted between January to July 2022. Sheema district was purposively selected for being among the highest coffee producing district in Ankole region. The district was also selected for the reason that the farmers of the district have adopted integrating bee keeping in coffee plantations compared to other districts in the region. In order to get an understanding of the contributions of integrating coffee and bee keeping to coffee farmer's livelihoods, coffee farmers were randomly sampled and data was collected using questionnaire and interview were conducted with 17 key informants who were purposively selected. Four sub-counties of Kakindo, Kigarama, Masheruka, and Kyangyenyi were purposively selected from the district because of being the highest coffee producing sub-counties in the district and farmers have adopted integrating bees in their coffee plantations. The sampling frame therefore included all coffee growing households in the four selected sub counties.

Sample selection and sampling technique

To obtain the desired sample, a simplified formula for the proportions by [15] that assumed a 95% of confidence level and precision of 0.05 was adopted for this study that gave a sample size of 193 respondents distributed in the four selected sub counties.

In addition, 17 key informants were identified since they were the ones responsible for disseminating information on the role of integrating coffee and bee keeping to farmer's livelihoods and these provided qualitative data and they included local leaders and sub-county agriculture extension workers. Walks along community routes/roads and household coffee plantation visits were also made in the study areas and observations were made in those communities.

A standard structured questionnaire was self administered to a total of 193 respondents who were randomly selected, including all households that had adopted integrating bee keeping in their coffee plantations from the four of the study sub-counties to collect quantitative data.

For this purpose, a list of coffee farmers was prepared in consultation with the sub-county agriculture extension personnel and local leaders of the each respective sub-county and villages and questionnaires were administered to the selected farmers separately.

Data analysis

Qualitative data was obtained through key informants' interviews and observations was organized and meaningfully reduced into themes and contents that were in line with the objectives and the concept of the study according to [16]. Quantitative data was edited, coded, entered in the computer and cleaned to ensure accuracy, consistency, uniformity and completeness.

The data was then analyzed using Statistical Package for Social Scientists (SPSS) version 20 to generate descriptive statistics and regression analysis.

Analysis of variance (ANOVA) was run to determine significant relationships. Regression analysis was used to examine the relationship between a set of independent variables as the factors that influence the probability of integrating bee keeping with in coffee plantation and the technologies used.

4. Results and discussion

4.1 Demographic characteristics of respondents

The demographic characteristics of respondents included gender, age, education level and marital status.

Table 1: Demographic characteristics of respondents.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-2.178	1.322		-1.647	.105
Gender of respondents	1.604	.359	.606	4.471	.000
Age of respondents	-.104	.361	-.032	-.288	.002
Education level of education	.384	.317	.148	1.212	.008
Marital status of respondents	.910	.573	.176	1.589	.118

a. Dependent Variable: time spent while growing coffee

Gender is very crucial in determining the different roles and responsibilities performed by different gender groups in the adoption and implementation of different activities in the enterprise. A p-value less than 0.05 were obtained when gender of respondents was regressed with the time taken when growing coffee. This implies that integrating coffee with bees would be significantly influenced by gender since men owned most of coffee plantations compared to women. Although it was established that most of the agricultural activities and field practices like; land preparation, planting, weeding, and decision on crop rotation cycle were carried out by females, males were the ones responsible in making decisions concerning which enterprises that could be integrated in coffee plantation. Age of an individual determines the number of years spent by an individual while practicing an enterprise and hence their experience. A p-value less than 0.05 was obtained when age of respondents was regressed with the time spent while growing coffee. This implies the time spent while growing coffee would provide an experience on the role of integrating other enterprises in coffee plantations. This is because farmers would opt to increase their incomes after integrating the bees in their coffee plantations. Decisions taken at household levels on the adoption of different technologies are determined implemented by all the members within the household especially husband and wife who are the top most decision makers in the household. A p-value greater than 0.05 was obtained when marital status of the respondents and time spent while growing coffee. This implies that coffee growing would be adopted by different people with different marital status and even integrating it with bee enterprises could not depend on the marital status but on the favorable willingness and perception about such farming system. The level of education of the farmer indicates the degree at which a farmer can adopt a technology or technologies. This is because a higher level of education motivates the farmer to adopt different technologies used in coffee production. A p-value less than 0.05 was obtained when education level of the respondents was regressed with time spent while growing coffee. This implies that technically, information acquisition, as well as the capacity to process, understanding and using the technical aspects and returns related to alternative and complementary technologies, is largely determined by formal education and indigenous knowledge. Hence, educated farmers are often more likely to adopt a new technology including integrating bees in coffee plantations and improve on the productivity levels than uneducated. This means that respondents were able to fully adopt the different field management practices responsible in ensuring a sustained coffee- bee integration system and methods that would result in increased yields hence increased incomes among the farmers.

4.2 Contributions of integrating coffee and bee keeping to coffee farmers'

The contributions of integrating coffee and bee keeping to coffee farmers were assessed basing on the level of yields and incomes attained by farmers before and after integrating bee keeping in their coffee plantations.

Yields in kilograms obtained from coffee plantation before integrating bees for the last two years

Table 2: Yields in kilograms obtained from coffee plantation before integrating bees for the last two years.

Responses	Year 2020	Percent	2021	Percent
1 - 100	14	6.7	12	5.7
101 - 200	17	8.1	21	10
201 - 300	29	13.8	32	15
301 - 400	15	7.1	6	2.9
401 and above	5	2.3	9	4.3
Missing values	130	62	130	62
Total	210	100	210	100

Source: Authors' computation from field survey data 2022

The study findings established that 29 (13.8%) and 32 (15%) of the respondents obtained between 201-300 kilograms before integrating bees in their coffee plantations (Table 2). This is because coffee plantations were managed using conventional methods which did not ensure increased yields.

Yields in kilograms obtained from coffee plantation after integrating bees for the last two years

Table 3: Yields in kilograms obtained from coffee plantation after integrating bees for the last two years.

Responses	Year 2020	Percent	2021	Percent
1 - 100	9	4.3	12	5.7
101 - 200	4	1.9	13	6.2
201 - 300	20	9.5	18	8.6
301 - 400	33	15.7	22	10.5
401 and above	14	6.7	15	7.1
Total	80		80	
Missing values	130	62	130	62
Total	210	100	210	100

Source: Authors' computation from field survey data 2022

The study findings established that coffee yields increased slightly after integrating bees in coffee plantation and 33 (15.7%) and 22 (10.5%) of the respondents obtained between 301-400 Kilograms of coffee in 2020 and 2021 respectively (Table 3). This slight increase was brought about by farmers adopting some of the conservation practices especially mulching and application of organic manure after integrating bees in their coffee plantation. Although support for any production systems should be oriented towards solving farmers' problems that inhibit productivity, the transformational change occurs with the adoption of some innovative technologies including integrating bees in coffee plantation by farmers but a new challenge is created since majority of the farmers lack

necessary skills and knowledge to establish and maintain good bee infrastructures in coffee farming. Therefore, farmers need support to understand new concepts and principles, enable an intellectual change in mind-set, commit to a longer-term process of change in their production system, test and adapt new practices, and change equipment and machinery.

Amount earned in a year before integrating bees in coffee plantation

Amount of money earned before integrating bees in coffee plantation indicates that coffee sales after selling coffee products only.

Table 4: Amount earned in a year before integrating bees in coffee plantation.

Amount earned in year before integrating bees in coffee plantation in shillings.	Frequency	Percent
100,000 - 200,000	5	2.4
210,000 - 400,000	34	16.2
410,000 - 600,000	20	9.5
610,000 - 800,000	11	5.2
810,000 - 1,000,000	4	1.9
1,000,000 and above	6	2.9
Total	80	38.1
Missing value	130	61.9
Total	210	100

Source: Authors’ computation from field survey data 2022

The study established that out of 80 respondents who were integrating bees in their coffee plantation, majority of them 34 (16.2%) were earning between Shs 210,000 - 400,000, 20 (9.5%) were earning between Shs. 410,000 - 600,000, 11 (5.2%) were earning between Shs. 610,000 - 800,000, 4 (1.9%) were earning between Shs. 810,000 - 1,000,000, and only 6 (2.9%) were 1,000,000 and above.

Amount earned in a year after integrating bees in coffee plantation

Amount of money earned after integrating bees in coffee plantation indicates that coffee sales after selling both coffee products and bee products.

Table 5: Amount earned in a year after integrating bees in coffee plantation.

Amount earned in year after integrating bees in coffee plantation in shillings.	Frequency	Percent
100,000 - 200,000	3	1.4
210,000 - 400,000	14	6.6
410,000 - 600,000	19	9.1
610,000 - 800,000	30	14.3
810,000 - 1,000,000	3	1.4
1,000,000 and above	11	5.2
Total	80	38.1
Missing value	130	61.9
Total	210	100

Source: Authors' computation from field survey data 2022

The study established that 3 (1.4%) of the respondents were earning between Shs.100,000 -200,000, 14 (6.6%) mentioned between Shs. 210,000 - 400,000, 19 (9.1%) mentioned between 410000 - 600000, 30 (14.3%) mentioned Shs. 610,000 - 800,000, 3 (1.4%) mentioned 810,000 - 1,000,000 and only 11 (5.2%) mentioned Shs. 1,000,000 and above. The study from table 5 and 4.8 above indicates that there was a slight increase on the earnings of farmers after integrating bees in coffee plantations since additional income was acquired from the sale of both coffee and bee products. The incomes acquired were used in acquiring both basic needs and basic assets.

It was established that in Sheema District, integrating bees was not statistically significant on coffee yields since p was greater than 0.05 ($P > 0.05$) For example, in Kakido Town Council integration of bees in coffee plantations was estimated to result in a reduction of coffee yields among farmers who were using it on small plots of land from 9.5% in 2020 to 8.6% in 2021 (Table 5). Positive results were observed where adoption resulted in an improvement in the 6.7% in 2020 to 7.1% in 2021 and this effect was statistically significant ($P < 0.005$). Possible reasons for the insignificant of integrating bee keeping in coffee plantation impact on yields could include the small land areas currently and the failure to implement the full complement of practices necessary to set off the biophysical process that are expected to drive yield increases.

4.3 Attitude and perception of farmers on integrating coffee with bee keeping

Farmers perceive integrating coffee with bee keeping different and their attitude and perceptions determines their level of adopting the technology.

Table 6: Attitude and perception of farmers on integrating coffee with bee keeping.

Attitude and perception of farmers on integrating coffee with bee keeping	Strongly agree	Agree	Disagree	Strongly disagree
Beekeeping can be practiced as an additional source of income for small scale coffee farmers	154 (73.3%)	56 (26.7%)	00 (00%)	00 (00%)
Require few resources to commence	109 (51.9%)	101 (48.1%)	00 (00%)	00 (00%)
The necessary skills can be quickly transferred from one generation to another	20 (9.5%)	190 (90.5%)	00 (00%)	00 (00%)
Traditional be hives are made from local resources	60 (28.6%)	150 (71.4%)	00 (00%)	00 (00%)
It is not labour intensive and harvesting takes lean time	195 (92.9%)	15 (7.1%)	00 (00%)	00 (00%)
Bee keeping can be used in the development of other activities	33 (15.7%)	177 (84.3%)	00 (00%)	00 (00%)

Source: Authors’ computation from field survey data 2022

Coffee farmers perceived beekeeping as an additional source of income as mentioned by 154 (73.3%) and 56 (26.7%) who strongly agreed and agreed respectively and also were aware that integrating bee keeping in coffee require few resources to commence as revealed by 109 (51.9%) and 101 (48.1%) who strongly agreed. The acquired income from the sale of such products would be used in acquiring different resources required to enhance coffee yields like fertilizers that would ensures increased coffee yields. This implies that coffee farmers would have to sources of income using the same plot of land and this enable them improve on their standards of living. This can be compared with [17] who pointed out that beekeeping can provide enough income to the coffee farmer, as well as does not require the cost of feed (feed zero cost) when integrated with coffee, honey can be harvested every two weeks or seven months of the year. Chances are very high that the market demand of honey in the country per year still has not been fulfilled so as to meet the shortage of honey and this gap can be eliminated by integrating bee keeping and this can enable small scale coffee farmers enjoy improved livelihoods especially when coffee seasons are off. Coffee farmers perceived integrating bee keeping in coffee as a technology that required few resources to commence as mentioned by 109 (51.9%) and 101 (48.1%) who strongly agreed and agreed. integration of bee keeping in coffee plantations require majorly the hives which can be placed in some coffee trees hence the only costs are for hives. However, farmers perceive integrating bees in coffee as a disastrous practice since bees would limit the farmers while carrying out different practices like coffee pruning and thinning. This is in line with [4] who pointed out that bee-reserves can be established in different small-scale coffee plantation using few resources. Beekeeping can also be introduced in shade trees, paying special attention to the use of native shade trees that provide a rich and varied source of nectar and pollen. Beekeeping can also be promoted as an alternative activity for communities engaged in coffee production hence facilitating the rehabilitation and restoration of neglected coffee plantations. Coffee farmers revealed that bee keeping is not labour intensive and harvesting takes lean time as revealed by 195 (92.9%) and 15 (7.1%) of the respondents who strongly agreed and agreed. Different bee keeping tasks do not required heavy labour hence it not labour intensive. This is implying that even both women and men can practice such enterprise hence the enterprise being gender sensitive. Beekeeping can be practiced by both men and women and it can quickly be taken up again after a crisis period. The necessary beekeeping skills are easily transmitted

from one generation to another. Traditional hives are made from locally available material such as hollowed-out tree trunks or clay pots and, in general, are easily stocked with bees during swarming periods, especially in tropical areas and in forest areas where bees are still abundant in their natural habitat. This can be compared with [18] who pointed out that beekeeping is not a labor-intensive activity and honey harvesting generally takes place during lean periods in agriculture (when most farmers have reduced pressure from farm work). The collected bee products can be sold to generate additional income to pay for school fees or health expenses, especially during periods of reduced income from agriculture. Beekeeping can eventually also lead to the development of other activities within the community such as making of protective gear, smokers, and beehives; or the production of value-added products such as honey beer, beeswax candles or wood polish. On the other hand coffee farmers knew that traditional bee hives were made from local resources as revealed by 60 (28.6%) and 150 (71.4%) of the respondents who strongly agreed and agreed respectively. Different local resources like local timber, populous lids and cow dung can be used in making local hives. The use of such locally available resources would motivate different farmers to construct such hives. However, due to limited skills farmers do not use such materials hence discouraging them from adoption. In addition coffee farmers perceived that bee keeping is not labour intensive and harvesting takes lean time as revealed by 195 (92.9%) and 15 (7.1%) who strongly agreed and agreed. Different bee keeping tasks do not required heavy labour hence it not labour intensive. This is implying that even both women and men can practice such enterprise hence the enterprise being gender sensitive.

4.4 Technologies coffee farmers use to successfully integrate coffee with bee keeping

For farmers to have an effective integration system, different technologies have to be adopted and these depends on level of knowledge and skills farmers have to enable them incorporate such technologies in the coffee- bee cropping system.

Table 7: Technologies coffee farmers use to successfully integrate coffee with bee keeping.

Technologies used	VHU	HU	MU	LU	NUAA	MS
Provision of supplement feeds	00(00%)	00(00%)	00(00%)	10(4.7%)	70(33.3%)	0.43
Engaging in bee pollination services and pollen collection	00(00%)	00(00%)	00(00%)	33(15.7%)	47(22.4%)	0.54
Possession of top bar or Langstroth hives	00(00%)	00(00%)	63(30%)	17(8.1%)	00(00%)	1.07
Using assorted bait materials	00(00%)	00(00%)	00(00%)	43(20.5%)	37(17.6%)	0.59
Using pests and disease control technologies	00(00%)	00(00%)	48(22.9%)	20(9.5%)	12(6.0%)	9.3
Engaging in laboratory services	00(00%)	00(00%)	00(00%)	00(00%)	80(38.1%)	0.4
Processing and packaging of bee products	00(00%)	80(38.1%)	00(00%)	00(00%)	00(00%)	1.5

Source: Authors’ computation from field survey data 2022; VHU very highly used, HU highly used, MU moderately used, LU least used, NUAA not used at all, MS Mean Score.

The study findings established that most of the respondents who had adopted integrating bee keeping with coffee were using almost conventional methods. It was established that out of 80 coffee farmers who were integrating bees in their plantations, majority of them 70 (33.3%) of the respondents were not providing the supplement feeds at all, 47 (22.4%) had not engaged in bee pollination services and pollen collection, 63 (30%) mostly used top bar or langstroth hives, 43 (20.5%) were using assorted bait materials least, 48 (22.9%) had moderately adopted pests and disease control technologies, 80 (38.1%) had not engaged in laboratory services at all and 80 (38.1%) highly adopted processing and packaging of bee products. This can be compared with [19] who pointed out that due to a lack of improved skills and knowledge on artificial queen rearing, still, bee colony swarm catch by hanging bait hives on long trees is a major means of colony obtaining. Unwise use of agrochemicals, seasonal shortage of bee forage, bee pests and undesirable characteristics of the bees (absconding, swarming), and lack of adequate and appropriate extension services are identified as major challenges of beekeeping development in the areas. Great emphasis should be given to training and extension programs for the beekeepers focusing on the practical aspects of general beekeeping and more specifically on honeybee management, pest and predator prevention, and/or control methods.

Relationship between time spent while integrating bee keeping with in coffee plantation and the technologies used

Table 8: Coefficient results showing the relationship between time spent while integrating bee keeping with in coffee plantation and the technologies used.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.604	2.176		3.035	.003
	Provision of supplemental feeds	-.499	.241	-.177	-2.070	.040
	Engaging in bee pollination services and pollen collection	-.495	.246	-.155	-2.010	.046
	Possession of top bar or langstroth hives	.483	.209	.191	2.314	.022
	Using assorted bait materials	.448	.245	.136	1.825	.069
	Using pests and diseases control technologies	-.034	.135	-.019	-.252	.801
	Processing and packaging of bee products	-.113	.206	-.043	-.551	.582

Source: Authors’ computation from field survey data 2022; a. Dependent Variable: time spent while integrating bees in coffee plantation

A p-value of less than 0.05 (p-value=0.000) was obtained when possession of top bar or langstroth p=0.022, provision of supplemental feeds p=0.04 and engaging in bee pollination services and pollen collection p=0.046 was compared with the time spent while integrating bee keeping in coffee plantations. This implies that for

sustainable integration of bee enterprise in coffee these technologies have to be adopted and implemented hence ensuring increased yields and incomes as they are significant in sustaining the coffee - bee cropping system.

From Table 8 above the findings indicate that a p-value great than 0.05 was obtained when using assorted bait materials $p=0.069$, processing and packaging of bee products $p=0.582$ and using pest and disease control technologies. This implies that coffee farmers would even integrate bee in their plantation irrespective of the access and availability of such technologies.

Relationship between time spent while integrating bees and using different bee keeping technologies

Table 9: ANOVA for the relationship between time spent while integrating bees and using different bee keeping technologies.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29.943	6	4.991	2.962	.009 ^b
	Residual	341.981	203	1.685		
	Total	371.924	209			

a. Dependent Variable: time spent while integrating bees in coffee plantation.

b. Predictors: (Constant), processing and packaging of bee products, provision of supplemental feeds, engaging in bee pollination services and pollen collection, using assorted bait materials, using pests and diseases control technologies, possession of top bar or langstroth hives.

A p-value of less than 0.05 was obtained.

This implies that for farmers to continue integrating bees in their coffee plantations, information on different innovative technologies like provision of supplement feeds, engaging in bee pollination services and pollen collection, using assorted bait materials, using pest and disease control technologies and possession of improved bee hives like top bar hives have to be accessed and adopted.

This can be full achieved when farmers access different information from different source especially through agriculture extension officers.

4.6 Challenges farmers face while integrating coffee with bee keeping

There are different challenges farmers face while integrating coffee with bee keeping and these are categorized as production, institutional, economic, technical and social challenges. Respondents were asked about the challenges farmer face while integrating coffee with bee keeping and the responses were recorded in Table 10 below;

Table 10: Challenges farmers face while integrating coffee with bee keeping.

Challenges farmers face while integrating coffee with bee keeping	Agree	Not sure	Disagree
Poor management skills	193 (91.9%)	10 (4.8%)	2 (0.9%)
Shortage of honey forage	197(93.8%)	00 (00%)	13(6.2%)
Diseases pests and predators	204 (97.1%)	00 (00%)	6 (2.9%)
Lack of awareness about valuable contribution of bees to life	210 (100%)	00 (00%)	00 (00%)
Lack of trainers and training opportunities	210 (100%)	00(20%)	00 (00%)
Lack of dissemination of new research information	210 (100%)	00 (00%)	00 (00%)
In adequate bee keeping equipment	210 (100%)	00 (00%)	00 (00%)
Price fluctuations and lack of grading system	183(87.1%)	27 (12.9%)	00 (00%)
Bee hive theft			
Weak producer organisations and lack of policies to protect the producers	160 (76.2%)	50 (23.8%)	00 (00%)
Pesticide poisoning	210 (100%)	00 (00%)	00 (00%)
	155 (73.8%)	00 (00%)	55 (26.2%)

Source: Authors’ computation from field survey data 2022

The study findings established poor management skills among the challenges farmers face while integrating coffee with bee keeping as agreed by 193 (91.9%) of the respondents. Most of the farmers lack enough skills on site selection, the type of hives to be used and routine practices necessary in management of hives. This discourages them from integrating bee keeping in their coffee plantations. In connection to the above results a number of key informants said that

“Farmers lack skills of integrating bees in the coffee plantation and how different hive management practices are carried out to ensure increased productivity”

This can be compared with [20] who pointed out that bee production system experiences many challenges that reduce production and productivity of the subsector and among this is poor management skills. Therefore, many efforts should be made in generation, modification and dissemination of beekeeping technologies that increase production and productivity and maximize benefit from beekeeping in line with sustainable natural resource conservation. This can be facilitated by different actors especially agriculture extension workers who would disseminate different information on technologies that would improve the management of both bee and coffee enterprises integrated together.

The study findings also established shortage of honey forage among the challenges farmers face while integrating coffee with bee keeping as agreed by 197 (93.8%) of the respondents. Majority of the farmers do not acquire high yields from the bee enterprise after harvesting. This is because of lack of honey forage and lack of supplemental feeds provided to the bees. This further reduces the income acquired hence affecting farmers livelihoods. In addition to the above a number of key informants said that;

“Most farmers do not provide supplemental feeds to bee enterprise. This is because farmers have a negative perception that bees usually search for their own feeds and providing supplementary feeds is wastage of

resources. Due to this most of the harvests are negatively affected hence resulting into low incomes achieved from the enterprise”

This can be compared with [20] who pointed out that the annual crude honey yield per traditional bee keeping methods is 5-7kg. It is very low in quantity and quality compared to national average of improved box hive coupled with improved management practices including feed supplementation which is and 20-25kg. To reduce this gap employing improved beekeeping technologies with its accessory and full packages enable the beekeeper to produce surplus honey.

Research findings also established diseases pests and predators among the challenges farmers face while integrating coffee with bee keeping as agreed by 204 (97.1%) of the respondents. It is difficult for most of the farmers to identify the symptoms of bee diseases and this limits the level of prevention and control of such disease. In connection to the above a number of key informants said this;

“Most of the farmers have the perception that bees are not affected by different diseases hence they do not take any prevention and control measures of both diseases and even pests. This sometimes limits the level of harvests farmers get from the bee enterprise hence discouraging the level of investing in bee keeping enterprises” This can be compared with [19] due to a lack of improved skills and knowledge on artificial queen rearing and poor control measures of diseases and pests that leads to bees absconding, swarming reduces the level of productivity of bee enterprise.

The study findings also established lack of trainers and training opportunities, lack of dissemination of new research information and lack of awareness about valuable contribution of bees to life among the challenges farmers face while integrating coffee with bee keeping as agreed by 210 (100%) of the respondents. There is limited information dissemination about the contributions of integrating bees in coffee by both government and non-government extension workers because most of them concentrate on disseminating information concerning crop production and livestock production. This creates a death of knowledge by farmers since such sources do not provide information about bee keeping management practices. In addition to this key informants said that;

“Most trainings organised by agriculture extension workers concentrate on the adoption of major crops management practices and livestock practices neglecting those concerning bee keeping. This limits farmers to acquire different technologies and skills of integrating bees in the coffee plantations. Such knowledge gap also discourages farmers to take up the enterprise or use improved technologies and practices hence limiting the harvests”

This can be compared with [21] who pointed out that most beekeepers lacked knowledge on the use of modern hives and how to determine the right time for harvesting. Although beekeeping does not require high technology in practice, capacity building is required to train beekeepers on relevant management practices. Capacity building is usually impeded by high illiteracy levels of beekeepers. Illiterate beekeepers are also unable to keep proper records per colony while this is vital for proper management of apiaries.

Research findings also established inadequate bee keeping equipment among the challenges farmers face while integrating coffee with bee keeping as agreed by 210 (100%) of the respondents. There is limited access to different equipment like modern hives and harvesting equipment by farmers and this discouraging them from adopting such enterprise. Even though local materials can be used while making some hives, farmers lack skills of making such hives and yield capacity is also low for such hives. This also discourages farmers while adopting bee keeping enterprise. This can be compared with [1] who pointed that most farmers lack access to different modern technologies and equipment necessary in bee keeping and this discourages the farmers to quickly adopt the enterprise.

The study findings also established weak producer organisations and lack of policies to protect the producers among the challenges farmers face while integrating coffee with bee keeping as agreed by 210 (100%) of the respondents. Bee farmers are not organised in strong organisation and this limit the level of marketing and development of the enterprise. Lack of organised organisations would limit farmers' access different services and access equipment at subsidized prices. In connection to the above a number of local leaders said that;

“Due to uncoordinated nature of the bee producers, different financial and government institutions have failed to recognize these stakeholders in facilitating them with different equipment and financial support and this discourages the rate of adoption of bee enterprise”

This can be compared with [22] who pointed out that availability of this information would attract and give confidence to potential investors and guide preparations of bankable beekeeping programs and projects. This would also facilitate the provision of credit to beekeepers, processors, traders and manufacturers of beekeeping equipment and products. Progressive beekeepers' associations were also found to face institutional challenges that included lack of commitment by the group members and difficulty in maintaining partnership with various agencies.

The study findings also established price fluctuations and lack of grading system among the challenges farmers face while integrating coffee with bee keeping as agreed by 183 (87.1%) of the respondents. Lack of proper packaging materials and harvesting materials limits the quality of bee products produced by different farmers and this result in price variation in different markets. This is in line with [23] who pointed out that market inaccessibility, price fluctuations and lack of grading systems that deny beekeepers an incentive to produce good quality products. Additionally, the same study reported that bee products' prices widely varied based on goodwill of various buyers. Other marketing constraints reported by other studies included absence of organised market channels, transportation problems, low involvement of the private sector in market development and lack of appropriate technologies for processing and packaging bee products.

5. Conclusions

It was concluded that there is a positive relationship between integrating coffee and bee keeping on farmers' incomes since additional incomes could be acquired from the sale of different bee products in combination with coffee sales. The income acquired would be used to acquire basic needs like food, education and assets and

basic assets like plots of land, motorcycle, solar products and building commercial houses. This enables farmers to improve on their standards of living.

It was concluded that coffee farmers perceived integrating coffee with bee keeping as, additional source of income for small scale coffee farmers, required few resources to commence, the necessary skills can be quickly transferred from one generation to another, traditional beehives are made from local resources not labour intensive and harvesting takes lean time and that it can be used in the development of other activities.

It was concluded that although farmers were not using different technologies to successfully integrate coffee with bee keeping, A p-value of less than 0.05 (p-value=0.000) was obtained when possession of top bar or langstroth p=0.022, provision of supplemental feeds p=0.04 and engaging in bee pollination services and pollen collection p=0.046 was compared with the time spent while integrating bee keeping in coffee plantations. This implies that for sustainable integration of bee enterprise in coffee these technologies have to be adopted and implemented hence ensuring increased yields and incomes as they are significant in sustaining the coffee- bee cropping system. However, a p-value greater than 0.05 was obtained when using assorted bait materials p=0.069, processing and packaging of bee products p=0.582 and using pest and disease control technologies. This implies that coffee farmers would even integrate bees in their plantation irrespective of the access and availability of such technologies.

Therefore it was also concluded that maintaining coffee- bee cropping system requires understanding of different innovative technologies that would be economically optimal.

It was concluded that farmers face different challenges while integrating coffee with bee keeping and among these included; poor management skills, shortage of honey forage, diseases pests and predators, lack of awareness about valuable contribution of bees to life, lack of trainers and training opportunities, lack of dissemination of new research information, in adequate bee keeping equipment, price fluctuations and lack of grading system, bee hive theft, weak producer organizations and lack of policies to protect the producers and pesticide poisoning.

6. Recommendations

Providing constant trainings to bridge knowledge gaps among farmers and improve understanding of the relationship between management activities and integration in crop production.

There is a need for farmers to be equipped with knowledge and tools to enable them to make informed decisions about their farm management practices and be empowered with information about better alternatives for incomes that they can employ on farm. Both farmers and beekeepers need to understand the major role of bees in crop production rather than focusing only on honey production and related hive products. Meanwhile, their role as pollinators in improving crop production is largely neglected at a policy level.

Formulation of participatory policy would encourage conservation of pollinators at national level since it will enable circulation of information among communities of coffee farmers and beekeepers.

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