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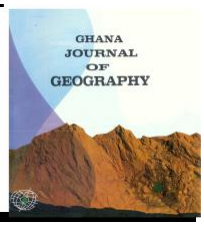

Economic Viability of Beekeeping Practices on Income Generation among Smallholder Beekeepers in Sikonge District, Tanzania.

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abstract

The aim of this study was to assess the economic viability of beekeeping practices among smallholder beekeepers in Sikonge District, Tanzania. Despite various poverty alleviation initiatives focusing on crop and livestock systems, rural poverty continues, and thus, call for alternative income generating activities. Beekeeping as one of the alternative income sources, it provides sustainable livelihood to the rural communities due to its reliance on natural resources such as forests. This research was conducted in Sikonge district, and it involved a sample of 215 small-scale beekeepers of which 92.1% of participants were male, with 7.9 % female. For the purpose of data triangulation, data collection was collected through structured questionnaires, key informant interviews and direct observation while the focus bees' products were honey and beeswax production from both traditional and improved beehives. It was revealed that, improved beehives yielded an average of 66,956 litres of honey and 11,337.5 kg of beeswax annually, compared to 48,783 litres and 6,033 kg from traditional beehives. The benefit-cost ratio (BCR) was 4.8 for improved beehives and 4.1 for traditional beehives, highlighting beekeeping's potential as a profitable project. The study highlights the need for an increased participation from women and youth in beekeeping, along with recommendations for financial support and capacity building. Overall, beekeeping emerges as a promising income generating activity for improving rural livelihoods and economic diversification in the region.

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Introduction

Ecological income generating activities are crucial for poverty eradication in rural environment (Schouten, 2020). For many years, most of the poverty eradication interventions in rural areas focused heavily on crop and livestock systems. However, most of the interventions taken have been unsuccessful and poverty has remained one of the main rural problems in many developing countries (Bank, 2018). Some of the reported causes of crop failures and livestock systems to improve rural livelihood of many developing countries include technical skills (technology), financial capital, close follow up that demand enough time and vulnerability to climate change (Nat Schouten & John Lloyd, 2019). Beekeeping programs in developing countries aim to create alternative income-generating opportunities for the rural poor, enhancing economic stability and providing sustainable livelihoods (Prodanović et al., 2024; Schouten, 2020). These initiatives have gained traction as effective means to improve the financial conditions of rural communities. Beekeeping farmers in developing countries aim to create alternative income-generating opportunities for the rural poor, enhancing economic stability and providing sustainable livelihoods (Schouten & Caldeira, 2021, Adgaba et al., 2014). This is because beekeeping requires relatively less initial capital compared to other agricultural economic activities such as crop cultivation (Schouten, 2020). The World Population Review (2024) estimates that Africa produced approximately 450,000 tons of honey in 2022, representing about 20% of the global honey market. In addition, it was shown that about 80% of honey came from different countries including Tanzania.

The input costs for engaging in beekeeping in most rural areas of developing countries are affordable for most individuals as bees are a free, renewable resource available from the environment. Ownership of land is not required and very little capital is needed (Yap et al., 2015). The indispensable resources requirements for engaging in beekeeping that include bee colonies, land, and forests are naturally available in rural environment. Again, the management of beehives does not need very frequent monitoring that might require high investment cost of money and time. Ali & Jabeen (2015) estimated an average annual labour cost of $33.40 US per beehive in Nigeria. However, it is difficult to quantify the actual costs in beekeeping practices to most of the beekeepers in developing countries, as many of their costs are in-kind.

Beekeepers frequently make profits from limited invested resources as argued by Amulen et al. (2019). Schouten (2020) reviewed 48 publications that examined income of apiculture and found that 88% of the publications revealed evidence of income generation from beekeeping. Generally, the extent of benefits obtained from beekeeping varies among individual beekeepers based on beekeeping practices of the individuals. It should be noted, however, that more benefits from beekeeping are realized by practising modern beekeeping which needs high financial capital for purchasing improved beekeeping equipment such as improved beehives, overall suit, gloves and filtering machines (Tutuba & Vanhaverbeke, 2018).

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On the other hand, factors such as types of beehives, number of hives, income, labour, supplementary feeding, age, education and training of beekeepers have positive influence in making benefits from apiculture (Adgaba et al., 2014; Duah et al., 2017; Ojo et al., 2016; Okpokiri et al., 2015; Shrestha, 2018; Verma et al., 2018).

Additionally, the introduction of new technologies in beekeeping leads to the scaling effect which allows beekeepers to manage and operate faster with fewer costs, maintain quality and leading to increase revenue and high profit (Abas et al., 2025).

In Tanzania, the government has been strengthening the beekeeping sector by taking several initiatives such as formulation of the national beekeeping policy (URT, 1998), establishment of the forests and beekeeping department, enacting 2002 beekeeping Act (URT, 2002) and an establishment of a ten-year national beekeeping programme (MNRT, 2001) to commercialize beekeeping for improving rural people's livelihood. These programs and projects have been reported to have made notable income contribution to beekeepers with small financial capital compared to other economic activities (Jeil et al., 2020; Omondi et al., 2016). There has been variation in the success of beekeepers due to differing production costs associated with various beekeeping practices. For instance, Sikonge District in Tanzania is renowned for its honey production. According to the District Executive Officer and the beekeeping officer of Sikonge District, over 5,912 individuals are engaged in beekeeping, employing diverse approaches. With beekeeping as among of the income-generating activities in Sikonge district, it will be expected to improve the livelihoods of this community. Thus, the economic feasibility of beekeeping practices among smallholder beekeepers requires an investigation. The study was aimed at assessing the costs related to beekeeping activities, returns to beekeeping farmers based on different approaches, and to offer recommendations that could help to improve the beekeeping practices.

Theoretical Framework

This study utilizes the Sustainable Livelihoods Framework (SLF) to analyse beekeeping as a livelihood strategy for smallholder households through various assets (Scoones, 1998; Natarajan et al., 2022). While SLF emphasizes asset access, it inadequately addresses economic choices under cost and risk. Additionally, it overlooks intra-household power dynamics, which lead to low participation of women in beekeeping. The study integrates farm household economic theory, positing that improved beekeeping adoption occurs when benefits outweigh costs (Mendola, 2007). Findings reveal that financial constraints and gendered access significantly limit livelihood outcomes, improving SLF by incorporating power relations in understanding resource-based livelihoods.

Materials and methods

The Study Area

This study was conducted in the Sikonge District located in Tabora region in central Tanzania. This district is one of the leading honey producers in Tanzania. The district is located at 5° 38′ South, 32° 46′ East (Figure 1). The Sikonge district has tropical wet and dry climate with temperatures ranging between 21^{0}C and 32^{0}C with an average rainfall of 770 mm annual. The district is a part of *miombo* woodland that is dominated mainly by *Brachystegia* spp. and *Acacia* spp. The larger area of the district which is, 26,479 km^2 (95%) are forest reserves and are a home of many bee colonies (MNRT, 2020).

Data Collection and Analysis

Structured questionnaires were used to collect data, and a sample of 215 households was selected from small-scale beekeepers using simple random sampling. A smallholder beekeeper in the context of this study is a farming household that practices apiculture on a relatively small scale as part of a household livelihood activity rather than as a large commercial enterprise and often integrate beekeeping with other agricultural activities. The list of beekeepers was obtained from the District Beekeeping Office in Sikonge. Subsequently, the sample size from the households of small-scale beekeepers was determined using the Yamane formula (Chaokromthong & Sintao, 2021). A total of 465 households were included in the calculation, with a margin of error (e) set at 0.05. The questionnaires were designed to collect various socio-economic information of the smallholder beekeepers' cost of investments in the beekeeping, returns from beekeeping enterprises and other related information. Key informant interviews (KIs) were also conducted to gather information on the economic viability of the beekeeping enterprises, as indicated in Table 1 below. These key informants were selected based on their professional and long experiences working within the sector of beekeeping.

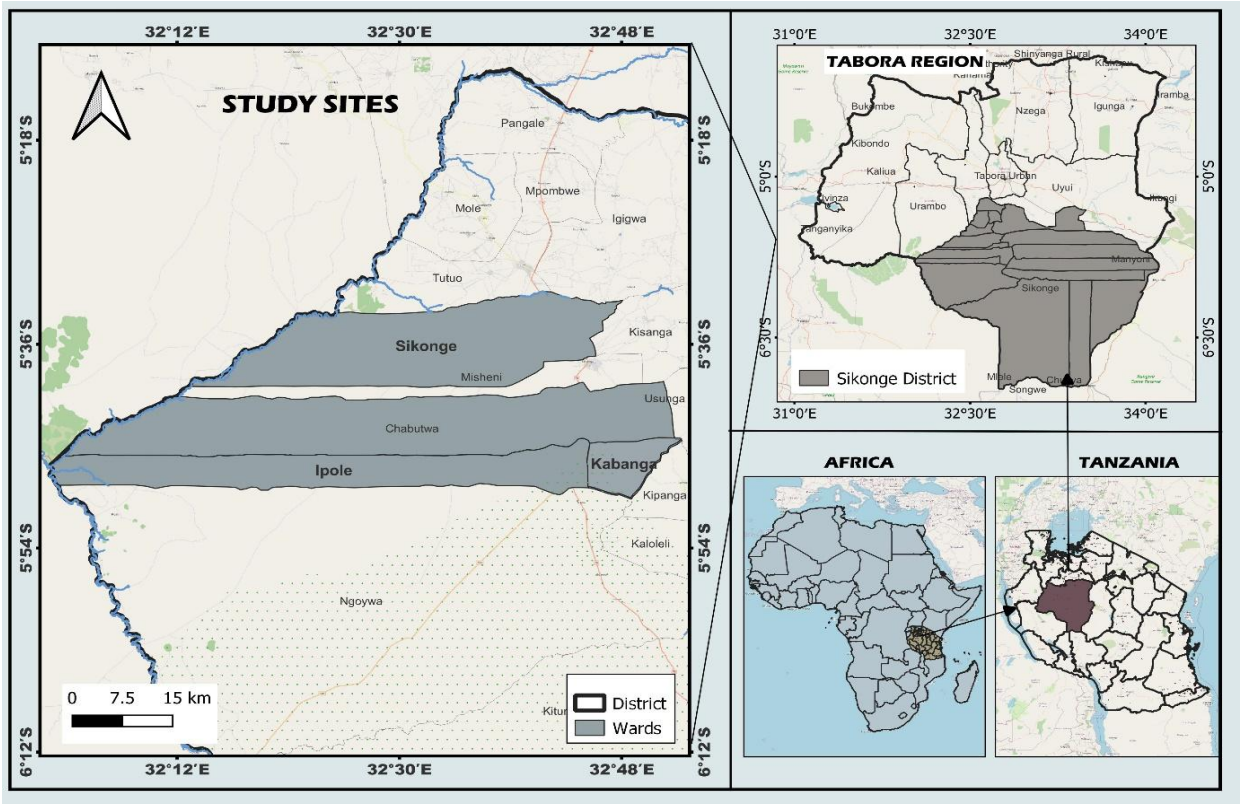

Figure 1: Study villages in Sikonge District in Tabora, Tanzania

Table 1. List of key informants from involved during the study.

S/N	Name	No of KIs
1	Sikonge District executive officer	1
2	Officials from Beekeeping office	4
3	Official from Tanzania Forest Services	2
4	Official from Tanzania Wildlife Association	1
5	Official from NGOs located in Sikonge	4
6	Ward Executive officers	4
7	Village leaders	8
8	Leaders from Beekeeping groups	9
9	Individual Beekeepers with long experiences	5
	Total	**38**

Data from questionnaire were descriptively analysed by using IBM-SPSS version 26. Data on honey and beeswax production (2022/2023) were calculated into minimum, maximum, mean and standard deviation for both low and high seasons of the annual production.T-test analysis was used to test the significant differences in honey production between traditional beehives and improved beehives. Cost and return was calculated by using Benefit Cost Ratio (BCR).

Firstly, we analysed the average cost invested per beehive in a year of production (2022/2023) and computed total cost (TC) from the sum of all costs of the individual beekeepers in the year of production. The cost included prices of beehives, transportation, setting of beehives, protected gears used during the setting of the beehives and harvesting of honey. Other costs include labour charges during harvesting and procuring containers used for packaging. Then, we analysed the average benefits (returns) per beehive from the production of honey and beeswax. The total benefits (TB) was obtained by the sum of average benefits from honey and beeswax production per year from all individual beekeepers. The costs and benefits were calculated from both traditional and improved beehives separately from both low and high seasons of annual production. To calculate BCR, the average total return was divided with total average cost (BCR=TR/TC), where net return (NR) was obtained by subtracting the total costs from total gross return (NR=TR-TC) in the respective year of production.

Results

Socio-Demographic Information of the Beekeepers

The socio-demographic information of the beekeepers is presented in Table 2. The findings revealed that majority of the beekeepers (92.1%) were males. The low-level participation of women compared to men could be explained by various factors including long distance to beekeeping farms and cultural barriers. Majority (42%) were aged between 46- 64 years old, whereas 83% of the beekeepers had primary education. Majority, constituting (76%) of the beekeepers' main occupation is farming. This implies that beekeeping is considered a secondary income-generating activity for farmers in the study area.

Types of Beehives Owned by Beekeepers

Table 3 shows that out of the 5075 beehives owned by 215 beekeepers in the study area, 53.9% were traditional beehives whereas the remaining were improved beehives. This makes an average of the average of 23 beehives per beekeeper.

Table 2: Social Demographic Characteristics of the respondents

Variable	Categories	Frequency	Percent (%)
Sex			
	Male	198	92.1
	Female	17	7.9
Age			
	18- 35	35	16.3
	36- 45	54	25.1
	46- 64	90	41.9
	>64	36	16.7
Education level			
	Primary	178	82.8
	Secondary	37	17.2
Main occupation			
	Farming	164	76.3
	Beekeeping	17	7.9
	Business	34	15.8

Table 3: Types of Beehives and the Number of Beehives in the Study Area

Village Name	Number of beekeepers	Traditional beehives	Improved beehives
Ipole	65	650 (12.8%)	775 (15.3%)
Chabutwa	63	980 (19.3%)	595 (11.6%)
Kabanga	22	400 (7.9%)	150 (3.0%)
Sikonge	65	705 (13.9%)	820 (16.2%)
Total	215	2,735 (53.9%)	2,340 (46.1%)

Some of the beekeepers claimed that they could not afford to buy improved hives within a short time. However, others were of the belief that traditional hives made from local trees were more suitable to attract bees' colony. This was narrated by one of the interviewees:

"*I just use improved hives because the government wants us to use them, but beehives made locally from tree barks and logs are good because they attract bees frequently compared to improve beehives."* (Male respondent [56 years old] from Kabanga ward, Sikonge 3rdMarch 2024)

Honey and Beeswax Production from Traditional and Improved Beehives

Table 4 shows that the overall honey production from improved beehives was higher with mean score of 387 (±230.2) (litre/annum) compared to the traditional beehives that had a mean score of 245.5 (±105.3) (litre/annum). These results were statistically significant *t* (19.313), *df* (86) and *p* (0.00). For the case of seasonal honey productivity, high season had high productivity from both improved and traditional beehives with the mean score of 332 (±230.4) (litre/season) and 205.9 (±97.6) (litre/season) respectively. However, low season had the mean of 109.3(±54.4) (litre/season) for improved beehives and 97.9(±19) (litre/season) for traditional beehives.

Table 5 shows that the annual average beeswax production from improved beehives was 46.4 (±24.8) (kg/annum) while the traditional beehives produced 52.7 (±23.5) (kg/annum). The improved hives had slightly high maximum beeswax production of 96 kilogrammes compared to 95 kilogrammes of traditional hives. The average beeswax productivity during high season from both improved and traditional beehives was 39.4 (±23.8) and 40 (±18) (kg/season) respectively. During the low seasons, the average yield from improved beehives was 14 (±6) (kg/hive/season) and 31 (±8.4) (kg/season) from traditional beehives. Generally, as it was found, production of beeswax was higher during high season because many hives were harvested. It was also found that only few beekeepers were harvesting honey in low season. During the interview with one of the government officials from the office of the Tanzania Forestry Service (TFS), she indicated that:

"During high seasons many of the beehives are colonised by bees and contain many of honeycombs with full of honey. However, during the low season, beehives are colonised by few bees and most of the hives contain immature honey" (female, 35 years old, Sikonge, 10thMarch 2024).

Benefit-Cost Analysis of Honey and Beeswax Production During 2022/2023 Season

The results in Table 6 depict the average honey and wax yield in the production season of 2023/2024 in Sikonge DC. The yields of honey and beeswax from improved beehives was 66,956 litres/annum and 11,337.5 kg/annum respectively. During the data collection, it was found that the average yield per hive was 13 litres while the price of a litre fluctuated between TZS 4500/= (USD 1.67) and TZS 6000/= (USD 2.23). Meanwhile, a price of beeswax kilogram (kg) ranged between TZS 4000/= (USD1.49) and TZS 4500/= (USD 1.67) (Table 6). The results further revealed that the production costs of honey and beeswax from improved beehive was TZS 94,573,628/= equivalent to USD 35193.21. This is approximately TZS 546,668.37/= (USD 203.43) per hive. This production cost resulted in an average gross return of TZS 458,423,482/= (USD 170590.84)

For the case of traditional beehives, the production of honey and beeswax was about 48,783 litres/annual and 6,033kg/annual respectively. The production cost of honey and bee wax was Tshs.79,505,964/= equivalent to USD ($29586.16). This production cost resulted in an average gross return of TZS 322,862,906/= per annual equivalent to USD 120145.36. Note that the price of honey and beeswax from traditional beehives is the same as that from modern beehives. These findings indicate that production of honey using improved beehives is more promising than the use of the traditional beehives. Furthermore, the economic analysis in Table 5 depicts that honey bee products from improved beehives had a net return of TZS.363, 849,622/= equivalent to USD 135397.54 and a net return of traditional beehives was TZS 243,356,943/= equivalent USD 90559.20. The benefit cost ratio is 4.8 and 4.1 for improved beehives and traditional beehives respectively. Note that the benefit-cost ratio was obtained by considering production from both high and low seasons per year. The findings from quantitative information are supported by data from in-depth interview as one of the beekeepers who was a leader of the beekeeping association in Ipole village, revealed that honey yield from improved beehives was higher than those from traditional beehives. However, it was also found that the initial production costs associated with improved beehives were higher, which posed a challenge for the majority of beekeepers.

Table 4: Honey production in the study area for 2022/2023 season

Types of bee hives	Honey production (litre/annual)				Honey productivity (litre/hive/season)							
					High season				Low season			
	Min	Max	Mean	STD	Min	Max	Mean	STD	Min	Max	Mean	STD
Improved (n=173)	120	900	387	230.2	120	900	332	230.4	50	240	109.3	54.4
Traditional (n=215)	63	450	245.5	105.3	63	450	205.9	97.6	60	150	97.9	19

Table 5: Beeswax Production

Types of bee hives	Beeswax production (kg/annum)				Beeswax productivity (kg/season)							
					High season				Low season			
	Min	max	Mean	STD	Min	Max	mean	STD	Min	Max	mean	STD
Improved (n=173)	12	96	46.4	24.8	12	90	39.4	23.8	6	30	14	6
Traditional (n=215)	13.5	95	52.7	23.5	13	90	40	18	15	50	31	8.4

Table 6: Benefit Cost analysis of beekeeping during 2022/2023 season

Types of beehives	No. of beekeepers	Average honey produce (litre/annum) (A)	Average bee wax produce (kg/annum) (B)	Gross return ($) (A+B)	Cost of production ($)	Net Return	BC ratio
Improved	173	66,956	11,337.5	$197,937.6	$40,834.9	$157,102.6	4.8
Traditional	215	48,783	6,033.0	$139,405.4	$34,329	$105076.4	4.1

Note: The price of one litre of honey ranged between TZS 4500 (USD 1.67) to TZS 6000 (USD 2.23) and price of one Kg of beeswax ranged between TZS 4000 (USD 1.49) to TZS 4500 (US D 1.67).

Table 7: Cost of honey and wax production in 2022/2023 season per beehive.

ITEM	COST (TZS) per item		Cost (USD)per item
Fixed cost per season	Improved beehives	Traditional beehives	
Protective gears (capes, gloves, overall suit)	1@120,000	1@120,000	44.66
Container (bucket)	1@5,000	1@5,000	1.86
Container (drum)	1@60,000	1@60,000	22.33
Cost of improved hive	1@120,000		44.66
Cost of traditional hive		1@15,000	1.86
Binding wire	1@2000	1@2000	0.74
Variable cost per hive per season			
Transport of container	250-300		0.093– 1.12
Labor charge	1000-1500		0.37– 0.56
Bee wax processing	600-700		0.22–0.26
Setting of hive	500-700		1.86–0.26

Cost of Each Item Used During Production of Honey and Bee Wax in 2022/2023 Season

The production cost of honey and bee wax was analysed from ten (10) items used in the production as shown in Table 7. The production cost was categorized into fixed and variable ones. The cost of protective gears, drum, and bucket, binding wire, improved hive and traditional hive were considered to be fixed. Note that the cost of production using the improved hives is the same as that of the traditional hives, but the purchase prices of the two types of beehives are different.

Discussion

Socio-Demographic Information of the Beekeepers

The study involved beekeepers of different age groups i.e. young, middle and old. This implies that people of different age groups were willing to participate in beekeeping. However, majority of the beekeepers fell in age group between 46- 64 years old. This is in line with other findings (Siwatu et al., 2024) which reported almost the same age category. The findings indicate that the beekeeping enterprise has not yet attracted majority of the young people. The study further revealed that, more than 92.1% of the beekeepers were males while the participation of women was confronted by various challenges. These include the long distances one must travel to beekeeping farms and various cultural barriers. This finding is consistent with other reports

(Ayansola et al., 2012; Siwatu et al., 2024) indicating that the majority of beekeepers are males. It was further established that the low participation of women was attributed to a lack of awareness, culture related issues and the nature of beekeeping activities (Serda et al., 2015). For instance, in the study areas, the beekeeping apiaries were located far from their homes and were also hung in the trees, which made it difficult for women to engage in these activities. Thus, in beekeeping, men dominating key activities compared to women (Siwatu et al., 2024). Other findings also reported that, in many African countries, beekeeping is traditionally male-dominated (Mburu et al., 2017).

Arguably, rather than attributing low female participation solely to distance and cultural barriers, our findings reflect broader gendered disparities in access to livelihood assets, as articulated in the SLF (Scoones, 1998). Other factors are the limited control of women over physical and financial capital and restricted social networks (Doss, 2013). Additionally, while improved beehives demonstrate higher profitability, their uneven adoption aligns with farm household economic theory, which emphasizes that capital constraints and perceived risk shape technology uptake more than productivity alone (Feder et al., 1985). The findings of this study move beyond descriptive explanation of SLF toward a deeper understanding of how asset access, gendered power relations, and economic incentives jointly influence participation and livelihood outcomes in beekeeping.

Again, more than three quarters (76.3%) of the respondents were practising farming as their main occupation. This implies that most the beekeepers in the study area were taking beekeeping as a secondary source of income. Similar findings were reported (Chanthayod et al., 2017) that beekeeping was widely conducted as an alternative source of income in many rural areas.

Honey and Beeswax Production in the study area

The types of beehives used by beekeepers were key factors in determining the investment costs and the status of the beekeeping enterprises. Most of the beekeepers were using both traditional beehives and improved beehives simultaneously. However, all of the surveyed beekeepers were using traditional beehives particularly, logs prepared from local trees because they were cheap. The improved beehives observed among the beekeepers were top-bar hives made from Cyprus wood. These findings suggest that beekeeping enterprises in Sikonge is in transition from traditional to improved practice. However, its improvement is gradual because of the low financial capacity of the beekeepers to adopt changes (Chanthayod et al., 2017) due to financial constraints. Similar findings were also reported in an earlier study (Schouten & Caldeira, 2021) which indicated that beekeepers faced difficulties in accessing financial capital to invest in improved beekeeping equipment's. In various local communities in Tanzania, the use of improved beehives is associated with government initiatives to transform beekeeping from the traditional to commercial sector with the goal of improving rural people's livelihood (Wagner et al., 2019).Honey production in Sikonge is influenced by climate variability. The high season (June-August) depends on rainfall between March and May, while high rainfall hinders flower development. The low season (January-February) relies on rainfall in November and December. Climate variability disrupts flowering, impacting honey production in Sikonge.Tutuba and Vanhaverbeke (2018) reported that climate variability poses a significant risk to beekeeping.

Generally, honey yield performance from improved beehives was found to be annually higher than the annual yield of the traditional beehives in all seasons. These findings correspond to those of (Kuboja et al., 2016) who found that improved beehives (Tanzania top bar) were more productive than traditional beehives (logs and tree barks beehives).

Furthermore, although improved beehives yield higher returns, their uneven adoption can be explained through technological adoption theory, particularly, Diffusion of Innovations, which posits that uptake depends not only on relative economic advantage but also on affordability, compatibility with existing practices, and perceived risk (Sharma and Mishra, 2014). In this context, high initial costs and uncertainty discourage adoption despite clear profitability, consistent with farm household economic theory, which highlights capital constraints as critical barriers to technology uptake (Feder et al., 1985).

Benefit-Cost of Honey and Beeswax Production in Sikonge

While beekeeping serves as an alternative source of income for many beekeepers, the findings of this study revealed benefit-cost ratios of 4.8 for improved beehives and 4.1 for traditional beehives, respectively. This study indicates that beekeeping promises a reliable source of income to improve rural people's livelihood. Earlier studies have also reported that beekeeping offers rural households a means of income diversification (Ejikeme & Ugwu, 2023; Prodanović et al., 2024), while the substantial market value of bee products, such as honey, beeswax, and propolis, provides multiple revenue (Walia & Kaur, 2023).

However, Kadigi et al. (2021) found lower benefit cost ratio (BCR) that was less than 2. Probably, the differences resulted from the differences in the investment cost between the two areas, since it was observed that the costs of labour, transport and beehives in Sikonge were lower compared to those reported (Kadigi et al., 2021). A similar like that of Schouten et al. (2020) also found that beekeeping was a profitable income-generating activity.

The estimation of production costs were calculated from ten (10) items, which were found to be part of the production process. The items include protective gears, drum used during transportation and storage, binding wire and beehives (improved and traditional hives). These were considered as fixed cost. The cost of transportation of containers, labour charges, bee wax processing and setting of hives were considered as variable coasts. However, the fixed cost of production between the improved and traditional hives were the same expect the cost of hives. In areas where beekeeping is more improved, the operating costs consist of many items including the cost of baiting of hives and buying queens, inspection, honey extractor and feeding. Others are apiary cleaning, queen catcher and queen excluder (Sharma & Das, 2018; Verma et al., 2018). Those operating cost items reflect the level of professionalism in beekeeping, which increases the likelihood of an enterprise producing more honey products such as propolis, bee venom, bee jerry and honey of high quality. These beekeepers are likely to produce more yield, thus, producing high profit in beekeeping enterprises (Meixner, 2010). However, in Sikonge, beekeepers were harvesting only honey and beeswax, to the neglect of other potential products due to a lack of technology for processing them. Other studies have also reported that many beekeepers focus solely on honey and beeswax due to insufficient technology (Eshete & Eshetie, 2018; Shegaw & Edimew, 2021).

The fixed cost and variable cost incurred per beehive determined the operating cost. However, it was difficult to quantify other variables into monetary values in this study to be able to obtain the exact operating costs. For instance, beekeepers were found to use forest reserves to keep their hives. Meanwhile, they were neither buying queens nor baiting hive to attract colony. Besides, beekeepers depend on fodders from vegetation for honey preparation. Such beekeeping practice is difficult to obtain the exact monetary value incurred in production.

The cost-benefit analysis indicates that while the improved beehives offer higher net returns, their significant upfront costs for hives and equipment pose entry barriers for smallholders, and consequently slowing adoption. High fixed costs raise perceived financial risks, leading households to prefer traditional hives for lower returns but reduced capital needs (Feder et al., 1985). Thus, profitability alone does not ensure adoption, factors like affordability and risk, significantly influence technology uptake in smallholder beekeeping (Abdulai & Huffman, 2014).

Conclusions

This study demonstrates the economic viability of beekeeping practices among smallholder beekeepers in Sikonge District, Tanzania. The results indicate that both traditional and improved beehives can generate substantial income, with improved beehives showing notably higher yields of honey and beeswax. The benefit-cost ratios of 4.8 and 4.1 for improved and traditional beehives, respectively, highlight beekeeping potential as a profitable venture. However, existing barriers, including limited access to financial resources and cultural challenges, particularly for women restrict broader participation. The gender disparity in participation, with a predominance of male beekeepers, underscores the need for targeted interventions to encourage women's involvement in the sector.

Recommendations

To maximize beekeeping benefits, it is essential to empower beekeepers with financial support, training, and access to improved technologies. Encouraging the use of improved beehives and advocating for supportive policies for better access to financial capital, such as microfinance for agricultural practices and subsidies for purchasing improved beekeeping equipment and materials, will enable beekeepers to invest in better equipment. Targeted interventions are needed to empower female and youth beekeepers and address their low participation in the sector. To address the high initial costs associated with improved beehives, it is recommended that targeted microfinance schemes with flexible repayment terms be developed specifically for beekeeping equipment, enabling smallholders to invest with manageable financial risk. Supporting local carpenters and artisans to prepare improved beehives using locally available materials could further reduce capital costs and enhance technology adoption

Conflict of interest

The authors declare no conflict of interest.

Authors' contribution

All authors contributed equally to the content, scientific framing and drafting of this paper.

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